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Valuing Nature

An investigation into the methods used for valuing ecosystem services in the Recharge.green project

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Joanne Soo Ping Heng

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Introduction

Nature and the environment are undoubtedly valuable to human existence and life on earth. But how does one calculate its worth? When decisions regarding conflicting natural issues arise, trade-offs need to be assessed in order to make evaluations and decisions that will ultimately lead to practical actions. Often, such cases can involve a range of factors to be considered - there are the economic considerations, technical and logistical aspects, the need to adhere to international and regional environmental treaties and conservation laws, as well as considering the views and opinions of the communities that may be affected. How these varying facets are ordered and ranked – and in this sense, valued – will impact on how such environmental decisions are made.

Environmental valuation methods are continually evolving. Ecologists and environmental scientists have often struggled to make the value of nature and biodiversity visible, and as such, a range of economic environmental approaches have been developed in an attempt to make environmental worth more easily understood by policy makers and governments. Often these approaches employ a market-like approach involving the trade of goods and services and having all items commensurable to a single unit of exchange – most commonly in monetary units. However, this has raised several debates regarding the ways in which to go about applying a market logic and framework to valuing the environment and the components that make it up (Fourcade, 2011; Azqueta and Sotelsek, 2007; Dempsey and Suarez, 2016; Robertson, 2006). How does one calculate the value that a forest provides, write down a monetary figure for a fish population or put a price on a view of a pristine landscape? Is there one unit of measure that can encompass all of these factors in a way that allows them to be comparable?

Following the United Nations Millennium Ecosystem Assessment in 2005 that highlighted the decline in biodiversity and ecosystems across the globe, initiatives were developed in order that these naturally-occurring entities could be valued. Specifically, methods were developed in order to demonstrate environmental values in economic terms (MA, 2005). The introduction of the global initiative called The Economics of Ecosystems and Biodiversity (TEEB) in 2010 saw an increase these efforts in making nature and its components visible in economic terms. TEEB initiatives provided a structured approach to the valuation of biodiversity and ecosystem services

(http://www.teebweb.org/about/the-initiative/). The ecosystem services approach to environmental valuation is thus a valuation methodology in which entire ecosystems are subdivided into a range of ecosystem services (defined as benefits people obtain from the environment) which are then valued using an economic approach to assess their worth in monetary units, in order that they are able to be comparable and different environmental trade-offs can be assessed.

One of the main issues in using market-based approaches for valuing nature is that firstly, many environmental entities are not commonly traded in markets. This then presents the issue of needing to create such a market, and in doing so, involves a range of other requirements for its operation such as: decisions regarding how to measure the value of different entities, which unit of measure is most appropriate for valuing the environment, as well as how to classify environmental entities in order that they can be clearly defined and amenable for valuation. Much has been written in STS about markets and their creation – the performativity involved in markets and the effects that markets and their devices can have, has been extensively discussed by Callon and colleagues (Callon, *et al.* 2011; Caliskan and Callon, 2009; Caliskan and Callon, 2010). There has also been a large body of work discussing the implications and consequences that have resulted as economic practices are being applied to a range of realms outside its original field. Specifically, the rise in market fundamentalism and its impacts on governments has been widely discussed, particularly by Foucault with his work on governmentality (Foucault, 1991, Peters, 2008). Following Machlup's conceptualization of the knowledge economy, there has also been much written regarding the application of economic logic to knowledge production practices (Shore and Wright, 2000; Lamont, 2012; Burrows, 2012; Müller, 2014). Most notably, the rise in audit culture in higher education has been extensively discussed – ranging from how it has impacted on the structural organization of academic institutions, to the rise in performance indicators to measure and rank academics. Subsequently, studies have also looked at how the rise in audit culture has impacted on academic work practices within these institutes as well as how academics conceptualize themselves under the increased emphasis on performance and measurement.

The rising prominence of economic practices being applied in environmental valuations has seen a body of work begin to grow in the field of STS. In particular, discussions often surround the issues (and consequences) of valuing nature in economic terms – often described as the commodification of nature. With the introduction of

environmental assessments such as the Millennium Ecosystem Assessment and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), this also raises the issue of knowledge and power, the implications it can have on political and economic rationalities as well as the potential issues that can arise with multi-scale assessments such as these.

Given that values and methods of valuation are entirely socially constructed, how nature is categorized into the services and the methods used to value them, can reveal a lot about the performativity of these methods as well as how nature is being enacted. The practices involved for measuring these ecosystem services – as well as being attentive to what aspects are actually being measured - can provide a lot of insight into where value is placed and how this then impacts on decision-making processes. Furthermore, in applying an economic valuation for environmental aspects that do not always have a clear-cut monetary value, this also requires a series of transformations in order to convert them into a form that allows for comparison. The transformations and translations involved in these valuation methods (not to mention, the instruments and devices employed to make this possible) can also reveal much about the mechanisms involved in which nature is made measurable.

The analytical focus of this thesis centres around the methods and practices that are used for valuing ecosystem services. A case-study approach lends itself well to this type of analysis as it permits a more fine-grained analysis of how natural aspects are being measured and valued whilst providing a specific context to work within. For this thesis, the case study selected as a focal point for analysis was a project called Recharge.green that ran between October 2012 and June 2015. The project's main aim was to facilitate decision-making processes regarding renewable energy production in the Alps. One important aspect to this project was seeking a balance between increasing renewable energy use as a strategy to reduce CO_2 emissions whilst also preserving the rich biodiversity in these Alpine region. Thus, in order to evaluate sites for renewable energy production facilities, decisions regarding tradeoffs between conflicting environmental factors had to be addressed. To help evaluate these potential trade-offs, the project employed the ecosystem services approach to help in the decision-making process. This thesis will seek to analyze the methods used within the ecosystem services approach that were applied to the specific context of the Recharge.green project.

The outline of this thesis firstly presents the state of the art where it first describes how nature and environmental issues have been conceptualized within the field of STS. The points raised particularly pertain to the changes in how these aspects have been conceptualized as a result of the rise in globalization. Furthermore, it outlines the implications this has had in how the environment (and issues pertaining to it) is viewed and the knowledge practices that have thus resulted, emphasizing the entanglement of scientific, technological, social and political factors. Valuation is then introduced, highlighting its social constructedness and outlining studies that have discussed practices involved in valuation processes. It then goes on to discuss the rise on economization and marketization, touching upon the types of debates that have been raised regarding the creation of markets and the production of values, particularly in economic terms before introducing the ecosystem services approach to environmental valuation and some of the debates that have arisen regarding this assessment framework.

Within the sensitizing concepts section, firstly the notion of performativity is discussed. Given that methods are themselves performative, this is an important point to be attentive of regarding valuation methods used within the case study. Following this, there is an outline of the Actor Network Theory with a specific focus on the notions of translation and black-boxing. The main research question of this thesis - How was nature valued in the ecosystem services approach used in the Recharge.green project? - is explained, along with the four sub-questions that make up the core interest of this thesis research. With a brief introduction to the details of the Recharge.green case study, there is a brief overview of the entire project and its aims, and also details of one of the pilot sites (the Mis and Maè valleys in Veneto) that was used as the specific focus for how valuation was done for two of the ecosystem services selected (i.e. recreational services and intrinsic value). The main analytical method used for this thesis is document analysis. The documents selected for detailed analysis are listed as well as a rationale for why these specifically were selected is provided. Qualitative interviewing was also used as a complementary method to the document analysis, with the Recharge.green lead partner interviewed as part of this research. Both the documents and the interviews were analyzed using a grounded theory approach.

The main results section of the thesis has two main parts. Firstly there is a section that analyzes how the project was represented to the public with an analysis of public relations material in the form of a perpetual calendar. This was a means by which to see

how the project and its methods and outcomes are explained for a general audience and furthermore, serves as a juxtaposition to the formal project reports that make up the bulk of the documents analyzed and discussed in the main results sections. Beginning the document analysis from the formal reports, there is first an outline of the general approach used by the partners to valuing ecosystem services. Following this, there is a more detailed examination of the methodologies used within the project to value four selected ecosystem services. For this thesis, the four ecosystem services that were selected for in-depth analysis of their methods of valuation were: 1) provisioning services (although strictly speaking, this is classified as a whole category within the ecosystem services approach), 2) protection against natural hazards (falling under the category of regulating and maintenance), 3) recreational values (cultural services) and 4) intrinsic values (also cultural services). These four ecosystem services were chosen as they were all valued using different methodologies and thus would provide a selection of different methods for valuing different environmental aspects as well as allow for comparisons between the various valuation methodologies employed. The second half of the results section will detail the steps involved in valuation for each of the four ecosystem services. In the discussion, the different methodologies for valuing ecosystems are compared. The focus here is on comparing the different methods that were used and the steps and translations that were involved in each of the valuation processes, as well as discussing how commensurable the different ecosystem services were. Additionally, there is a brief discussion highlighting the differences in how the project aims and valuation processes were presented when comparing the formal documents with the public relations material. The conclusion discusses the implications of using the ecosystem services approach to valuing nature and the role that devices play in these decision-making processes. Furthermore, it seeks to outline the kinds of enactments of nature evident and the multiple realities that arise as a result of these valuation methods.

State of the art

Conceptualizations of nature and the environment

Since the 1960s, environmental concerns have increasingly become a focus of global contemporary issues. Often highly complex, dynamic in nature and involving a high degree of uncertainty, these issues are increasingly being looked at in STS, particularly with regard to debates over how humans and society should respond to the global environmental change (Beck, *et al.*, 2017). In investigating and seeking to investigate the causes and consequences of environmental changes, STS scholars have focused predominantly on how scientific knowledge reflects social influences and institutional choices, and in turn, how this socially-shaped knowledge impacts on how environmental issues are understood and the ways in which solutions are subsequently proposed and adopted (Beck, *et al.,* 2017).

The conception of the environment as being a global and interconnected system has often been attributed to the rise in ecological concerns in the 1960s. However, there have also been arguments – such as by Doel (2003) that have also expressed the idea that the power that the military influences can also contribute to this rise in interest. In his article, he argues that the US military's attempt to gain the "ability to predict and even control" (pg. 636) the global environment could be said to have been a major contributing factor to the increase of governmental funds into geophysical sciences. Jasanoff (2001) has also discussed the formation of the global environmental consciousness. Using a co-production lens, she examines the relationship between image and imagination and argued that in the last three decades of the 20th century "images of connection, of dissolving boundaries, began to supplement, and at times crowd out, division in our visual and imaginative space (pg. 310). In her interpretation of this image of planet earth and the imaginations that it has triggered, she argues that this can be image can be seen as "contributing to the interpretive turn in international relations theory by attempting to understand better the role of ideas in promoting transnational cooperation and conflict" (pg. 311). Within the article she also explores how knowledge about nature can be mediated by visual representations and how image making has the ability to "foster shared social and political awareness" (pg. 311-312).

Related to seeing the environment as global, there have also been works that deal with nature at its different spatial scales. Lachmund's (2004) work on nature conservation in urban settings brings together the two notions of what it means to be 'local' and 'global'. By paying close attention to 'local' and 'global' settings, Lachmund states that

environmental agendas – whilst global in their nature – remain "embedded in and shaped through the particularities of local settings" (pg. 241). Thus this nicely highlights the duality that is always present regarding many environmental issues in terms of its spatial nature. Lachmund highlights that places are not perceived as enclosed spaces with stable essential identities, but rather in the globalized space of contemporary societies, these locations are dynamic entities in which identities are constituted with networks of global social relations and understanding (Lachmund, 2004). This duality can also be a source of tension when dealing with environmental issues. Often with environmental issues one is asked to 'think globally and act locally' – however this at times can mean that the designations of these scales can be ambiguous and subsequently, the ways in which issues are framed can have scalar consequences. Efforts to promote green-energy strategies for mitigating climate change are important changes that need to be made for global benefits, but often the negative impacts are borne by the local communities. Yong and Grundy-Warr (2012) highlight such as example with the Mekong dam in which they highlight how the costs of hydropower and nuclear energy are disproportionately born by local communities. The issue of scale as also been addressed by Blok (2010) who applied an ANT lens and looked at the relational scalar analytics of spatial practices, technoscience and power using climate change as his empirical example. More broadly, the interactions between global and local forms of knowledge and political action have been discussed by those such as Jasanoff and Martello (2004) in their book *Earthly Politics, Local and Global in Environmental Governance.* For STS scholars – and in line with what Lachmund has mentioned – categories of "global" and "local" should not be taken for granted by instead considered as outcomes of specific forms of knowledge-making.

This brings up another important point that has been raised by STS scholars – the ways in which the framing of knowledge-making can also impact on they ways in which environmental issues and perceived, and also acted upon. Shackley and Wynne (1995, 1996) have studied how communities of climate modelers interact with policy makers during political agenda setting and as part of their findings they observed that there is a mutual construction of scientific knowledge for policy. Similarly, policy makers have also a significant role influencing the content and structure of research programs or influence how scientist try and make their research policy relevant. Blok and colleagues (2014) used the examples of the Millennium Ecosystem Assessment (MA) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) to highlight the relationships between knowledge and power. While they also bring

discuss the important relationship between scale and power, they raise an important point in that while assessment as often meant to achieve unbiased and rational solution, there is always an inherent connection of these assessments to the distribution of power and to implicit forms of delegation.

With a lot of the work discussed above, the wider implications of these point to the observation that science, nature and politics are not separate fields. This entanglement of scientific, technological, environmental and political factors are of particular interest in STS and have been discussed extensively by many STS scholars. Specifically, in Latour's (2004) *Nature of Politics* he notes that when dealing with nature and politics, one can either distinguish between questions of nature and questions of politics, or treat these two sets of questions "as a single issue that arises for all *collectives*" (pg 1, Latour, 2004). He seeks to reconstitute the relation of science, public life and politics which he claims has been inhibited by the institutional division of nature and society. Work by Lövbrand and Stripple (2011) applied Foucault's concept of governmentality when exploring how climate governance is accomplished. They point out that in practices such as carbon accounting, carbon is being transformed into objects of governance, they also illustrates the ways in which stocks and flows of carbon come to be amenable to government regulation and take on forms of political and economic rationality. Along similar lines, Cooper (2015) also examined the practices of measurement and its role in the function of emissions trading markets, arguing that measurement systems such as those used in markets in greenhouse gas emissions are not just sites of economic relations but also of governance relations.

These different strands of research point to the fact that *how* environmental issues are framed and subsequently responded to, is very much linked to the *practices* that are involved in both understanding and knowing these environmental issues. As has been well-acknowledged in STS (and will be discussed in the sensitizing concepts in more detail), practices are performative processes (Law, 2009; Callon 2007; Turnhout, 2009)– they can foreground specific aspects, they can be manipulated to produce a different outcome and involve the use of specific technologies. As such, environmental issues have as much to do with attending to the role of scientific knowledge and technology for its understanding, as it has to do with the power relations, networks and organizational structures that are involved. Additionally, connected to this is the fact that environmental issues are also highly situated – these issues do not exist outside the places and histories that helped shaped them, nor without the social and political

meaning imbued upon them by the locations to which they are applied (Ashwood, *et al.*, 2014; Wynne, 1996; Irvin and Stansbury, 2004). Ultimately, what environmental issues are known, the ways in which they are known, and how they are acted upon depends very much on choices, where value is being placed and ways in which values are assessed.

Valuation and Value

Value can be understood as "having the capacity to be measured and compared against another thing" (pg. 68, Bigger and Roberston, 2017). The processes of valuation are becoming ubiquitous in our society and various forms of valuation are carried out on a regular basis. From assessing forest carbon stocks (Ehrenstein and Muniesa, 2013), ranking academic performance (Burrows, 2012), to asking what makes a good tomato (Heuts and Mol, 2013) – the processes of valuation can be seen as a acts of sense-making, acts that can be are constructed for specific occasions/circumstances, can be formalized through laws, rules and contracts and as such, embody systematic methods and their outcomes can participate in the ordering of society (Dahler-Larsen, 2012; Helgesson and Muniesa, 2013). With a multitude of ways in which to compare and measure things, the act of valuing is based on choices regarding what is to be counted, visible and present. They can be viewed as a set of knowledges, methods, and ways of thinking capable of travelling across time and space and be applied to various other social practices (Dahler-Larsen, 2012). As such, the process of valuation can be considered to be entirely social. As stated by Helgesson and Muniesa (2013), valuation is "performed by highly complex socio-technical orderings involving several actors and instruments" (pg. 3, Helgesson and Muniesa, 2013). Bigger and Robertson (2017) also allude to this same point stating, "value is found, affirmed, realized, or destroyed through ongoing social performances of comparison and measure (pg. 71).

Within the field STS, valuation studies have tended to focus on the social constitution of systems of valuation. In this way, valuation studies has drawn from the work done in economic sociology that pays attention to the social elements of economic action as well as the socio-technical arrangements that allow for this (Moor and Lury, 2011). Deeply bound with economic valuation processes are other aspects of social organization such as law, politics and economic expertise. As pointed out by Fourcade (2011), "economic valuation processes are eminently contingent - on local politics, time period or social context" (pg. 1724). Topics that are prominent within the field of valuation often centre

around ways in which monetary value is established and intertwined with qualifications of what money is able to buy (Fourcade, 2011; Azqueta and Sotelsek, 2007; Dalsgaard, 2016). This is now particularly becoming an increasingly prominent topic regarding environmental valuation as nature is increasing seen to be commodified and there is more often than not, the use of money as the metric to assess nature's worth (more on this in section on economizing nature and the ecosystem services approach).

There are four key factors to every valuation: 1) the person(s) doing the valuation, 2) the assessment based on specific criteria, 3) the systematic approach or methodology used to collect information about how the valuator performs/uses the specific criteria, and 4) the purpose or intended use of the valuation (Dahler-Larson, 2012). Keeping these in mind, one must be aware that processes of valuation are not always carried out in the same contexts, by the same people and they do not have the same consequences. Differences in any or all of these factors can thus drastically alter how value is perceived. Thus, valuation studies are particularly interested in exploring the varieties of practices regarding how values are negotiated and ordered – often being attentive to the sub-processes such as categorization and legitimation as well as the procedures for both establishing values, sustaining hierarchies as well as being aware of the consequences of such processes (Lamont, 2012).

There have been a number of studies that have looked into how value is produced, assessed and institutionalized across a range of settings. Economic sociologists have extensively analyzed the workings of markets as well as the commodification process (Caliskan and Callon, 2009). Whereas within higher education, the rise in evaluation and audit culture have shown how the outcomes of valuation can have re-ordering effects - as has been demonstrated by how initiatives implemented to measure research productivity can influence and redistribute funding (Shore and Wright, 2000). Even valuation practices involving what makes a good tomato have been discussed by Heuts and Mol (2013). In their study, they were able to differentiate between five registers of valuing – these had to do with money, handling, historical time, naturalness and sensual appeal. Thus valuation does not only occur in monetary terms (despite there being a growing incidence of market economics being applied to different fields). From the range of studies into valuation, an important point is raised: markets and monetary terms are not the only context in which the processes of valuation are occurring (although studies into these have been extensive and will be discussed below).

Valuation is a situated activity aimed at establishing a value for a particular actor and/or purpose. Thus, it is important to keep in mind that valuation systems are not all designed with the same ends in mind, nor are they necessarily aimed at the same actors or audiences (Moor and Lury, 2011). How valuation systems are designed, for whom and for what purpose are all factors than can influence the outcome, and as such, the act of valuation can be considered a product of a given sociopolitical reality (Dahler-Larsen, 2012). However, in the same way in which valuation can be considered a product of a particular sociopolitical reality, so too can these processes involve the construction of future states of the world. Ehrenstein and Muniesa's (2013) highlight this in their investigation into the valuation of a carbon offsetting reforestation project. Carbon offsetting projects rely on the establishment of procedures for their prospective assessment of a forest's capacity to become a carbon sink as a means to encourage climate change mitigation. This therefore requires the imaginings of possible worlds and assessing their plausibility – two future states of the world are compared against each other and the value of the project is derived from that interplay. Similarly, Moor and Lury (2011) looked at financial brand valuation and how it is used to imagine and model different courses of action. In this way, one can see how valuation can be linked to notions of performativity and enactments of specific realities.

The rise of economization and marketization

In exploring how to make things calculable, the social sciences have done much study into markets and economics. Callon (1998) coined the term 'economization' – the process by which activities, behaviours and fields are established as being economic, and this had led to a growing body of empirical investigations that analyze the processes and consequences involved in economization (Callon, 1998; Callon, *et al.,* 2007; Fourcade-Gourinchas, 2001). Specifically, these processes include how to agree upon what kinds of phenomena should be qualified as economic, the subsequent approaches that have resulted to address such disputes, as well as exploring the institutional arrangements and material assemblages that facilitate these processes (Caliskan and Callon, 2009).

Markets are an integral aspect of this economic phenomenon, described by Caliskan and Callon (2010) as "institutions that favour the creation and the production of values" (pg. 3). A market has three characteristics according to Caliskan and Callon: 1) they organize the conception, production and circulation of goods, 2) they are an arrangement of

heterogeneous constituents that have rules and conventions, technical devices, logistical infrastructures, discourses and narratives and also in addition to technical and scientific knowledge, also draw on the competencies and skills of people, 3) they delimit and construct a space of power struggles (Caliskan and Callon, 2010). Given these characteristics, they have been described by Callon and colleagues (2002) as hybrid forums as they are public spaces with a variety of heterogeneous actors involved and also because the questions they raise concern not just with the economy, but also politics, ethics, law and science. It is important to note that markets are also highly reflexive – as Callon, *et al.* (2002) note, "actors concerned explicitly question their organization and, based on an analysis of their functioning, try to conceive and establish new rules for the game."

Marketization is seen as being one particular form of economization, one that corresponds to the establishment of markets. The study of marketization is aimed at describing, analyzing and making sense of the socio-technical arrangements and dynamics of markets. Muniesa and colleagues (2007) have pointed out that given the infinite ways of configuring how to make things calculable, how to calculate said objects and the development of material devices to make all this possible, markets can offer opportunities for agency and political agenda. Thus markets have been extensively analyzed through a sociological lens – not only regarding their construction and their performativity (Thévenot, 2001), but also through analyzing 'market devices', materials that assist in the construction of markets (Muniesa 2007). The configurations of how markets operate as well as the processes of marketization have multiple trajectories available, further highlighting their contingence on political culture as well as cultural-institutional factors (Caliskan and Callon, 2010; Fourcade, 2011).

Economics practices have made their way into numerous different realms and considerably shaped how they function (a more detailed discussion of how it has entered the environmental world will be detailed in the next section). The introduction of economics into the practices of politics has been widely discussed by Foucault in his governmentality studies (Peters, 2008). Governmentality is the approach to social regulation and control that include strategies that rely on individuals' voluntary compliance with the interests and needs of the state. Citizens are positioned in governmental discourses as active rather than passive subjects of governance, so rather than being externally policed by agents of the state, the individuals police themselves, "they exercise power upon themselves as normalized subjects who are in pursuit of

their own bests interests and freedom" (pg. 88; Lupton, 1999). In his research into neoliberal governmentality he presupposes that there are no universals such as 'state', 'civil society', 'sovereign' and 'subjects' and once doing away with them, tries to understand how practices, discourses and events are formed. Using this lens, Foucault thus considers that the emergence of 'economy' means the appearance of new forms of knowledge and power (Cotoi, 2011).

With neoliberalism and the increase in market fundamentalism, knowledge has also been recognized as a driver for productivity and economic growth – resulting in what is known as the 'knowledge-based economy (OECD, 1996). In the wake of this, the application of economic logic has impacted greatly on knowledge production practices, particularly in academic settings where the rise of audit culture in higher education – transferred from the financial domain - has resulted in sweeping changes in the types of practices that now occur within the field (Shore and Wright, 2000). Audit culture in higher education refer to the spread of technologies of accountability that have transformed and re-shaped academic work practices, impacted on institutional activities as well as seen the development of new public management tools to quantitatively measure performances (Lamont, 2012). Nowadays, with the development of a 'citation industry', tools such as commercial online databases such as Thomason-Reuters' *Web of Knowledge,* Elsevier's *Scopus* and *Google Scholar* that rank academic journals and have resulted in bibliometrics becoming a key measure in 'academic knowledge'. Furthermore, there are H-indexes that use these databases to score individual academic performances based on publications, and for journals, impact factors (based on the number of citations received by the articles they publish) are also becoming increasingly reified (Burrows, 2012). From a Foucauldian perspective these 'audit technologies' that have been introduced into higher education are instruments for new forms of governance and power, creating self-managing individuals who render themselves auditable (Shore and Wright, 2000).

Economizing nature and the ecosystem services approach

Since the environmental movement in the 1960s, economists have been making efforts to assign value to environmental assets. Initial approaches such as the cost-benefit analysis adhered to a more traditional economic model focused on market growth and increasing marketed goods and services (Balest, *et al*., 2015b). However, there is growing acknowledgement that the natural environment and their ecosystems play a

fundamental role in the human well-being, livelihoods and economies. Thus, since the 1990s, environmental scientists have advocated for the use of economic valuation of ecosystem services (defined as benefits people obtain from ecosystems) as a means to better communicate the value and importance of biodiversity. This has meant increasing efforts to value ecosystem services in monetary terms and to articulate such values through markets as a means to create economic incentives for conservation (Gomez-Baggethun and Ruiz-Perez, 2011).

The development of such strategies grew in popularity particularly after the UN Millennium Ecosystem Assessment when it became apparent that ecological life-support systems were declining worldwide (MA, 2005). Given that traditional conservation strategies had failed to reverse biodiversity and habitat loss, in 2010, the Economics of Ecosystems and Biodiversity (TEEB) was introduced as a structured approach to valuation of biodiversity and ecosystem services. It employs a tiered approach in analyzing and structuring valuation as is guided by three core principles: 1) recognizing value in ecosystems, landscapes and aspects of biodiversity, 2) demonstrating value (in economic terms) and 3) capturing value (this involves the introduction of mechanisms that incorporate the values of ecosystems into decision-making through incentives and price signals, e.g. payment of ecosystem services) (http://www.teebweb.org/about/the-initiative/). Since the introduction of the TEEB, several countries have initiated TEEB studies to demonstrate the economic value of their ecosystems. The MA framework is based on the idea that biodiversity cannot by assessed purely on a global level, but that it requires a multi-scale assessment. In choosing to explicitly address the issue of scale, this design choice has itself been a source of debates regarding how to bridge both different scales and epistemologies (Miller and Erickson, 2006). Within such a multi-scale assessment framework and with the approach requiring interdisciplinary work, there is a need to allow epistemic pluralism in which there can be many ways of knowing, however this can prove to be a point of tension when there is a need to push for a unified voice for the framework and its approach as a whole.

However the use of economic valuation methods - such as the ecosystem services approach - to value the environment, has led to differing opinions regarding the use of these strategies to solve environmental problems (Gomez-Baggethun and Ruiz-Perez, 2011). Within the last few decades, advocates of the economic valuation of ecosystem services has seen it as a pragmatic short-term strategy that allows for the communication of the value of biodiversity in a language that reflects dominant political

and economic views. However, given that economic agents aim to position the products they design, produce, distribute or consume, in relation to others (Callon, *et al*, 2002), the establishment of an economic model to value the environment has meant inclusion of new ecosystem functions into pricing systems and market relations (Gomez-Baggethun and Ruiz-Perez, 2011). It also involves the creation of calculative mechanisms that need to be put in place in order provide the accounting visibility so that ecosystem functions can be measured (Callon and Muniesa, 2005). The consequences of such processes has been discussed by the likes of Robertson (2012) who has raised the point that whilst viewing the environment in terms of service commodities might be more easily understood by environmental regulators and development planners, it also results in "an environment that can be defined as potential commodities in nearly every aspect of its material existence, and at every scale from the atmospheric to the biochemical" (pg. 387, Robertson, 2012).

In order for markets to trade their goods and services, there needs to be a basis for exchange made possible. However, when market trade expands into previously non-marketed areas, processes of commodification are required. This process refers to the expansion of market trade to previously no-marketed areas and involves the conceptual and operational treatment of goods and services as objects meant for trading. Robertson (2012) argues that result of commodification of nature has been the creation of new social worlds – it requires boundary work that involves deciding not only what to commodify, but also what to decommodify. However, it is important to remember that this process of commodification is not necessarily unidirectional or irreversible. Bakker (2005) notes, 'objects move in and out of, and back and forth from, commodity status' – with prominent examples such as the abolition of slavery, commodification can thus be seen as being contested and transient (Bakker, 2005).

Specifically regarding the commodification of ecosystem services, Gomez-Baggethun and Ruiz-Perez (2011) describe four stages: economic framing, monetization, appropriation and commercialization – noting that these stages do at times overlap and are not always concomitant. In the first stage, the economic framing of ecosystem functions began with the anthropocentric interpretation of ecosystem functions and having them being defined as ecosystem services that benefit human well-being. The second stage of monetization occurs when the use of values that are embedded within the ecosystem services are then expressed as exchange values through pricing. Appropriation of ecosystem services operates through the formalization of property

rights on specific ecosystem services, often involving privatization in which ecosystems that were previously communal or public property now turn into private property. The final stage of commodification consists of the commercialization of ecosystem services which refers to the creation of institutional structures that allow for these services to be exchanged and traded. Within the ecosystem services approach, examples of such institutional structures include Payments for Ecosystem Services (PES) which are defined as voluntary transactions where a well-defined ecosystem services is bought by a buyer if the provider secures provision of such service – common PES schemes include local initiatives for conserving watershed services and regional and local markets for carbon sequestration services (Kosoy and Corbera, 2010).

Thus the process of economizing and commodifying nature is already becoming well-established within today's society. As the ecosystem services approach has become more firmly settled in international policy agenda, this has resulted in the need to develop standardized classifications of ecosystem services, which has subsequently entailed the creation of methods with which to measure and compare these services. While the ecosystem services framework emphasizes the need to consider ecosystems as a whole and stresses that changes or impacts on one part of an ecosystem can have consequences for the whole system (DEFRA, 2007), in order to value ecosystem services, the Millennium Ecosystem Assessment has distinguished four categories of ecosystem services – within these categories are an extensive list of working definitions and descriptions within (MA, 2003). Within the ecosystem services approach, these services are typically divided into four categories:

1) provisioning services: material or energy outputs from an ecosystem such as food production (e.g. fish, meat honey) or raw materials (e.g. timber, wood for bioenergy, water resources)
2) regulating services: this includes benefits that are due to the regulation of ecosystem processes such as water and climate regulation, pollination and soil erosion control.
3) cultural services: non-material benefits people obtain such as the recreational and historical aspects of the environment
4) supporting services: these are necessary for the production of other ecosystem services and include photosynthesis, soil formation and nutrient cycling (Paletto, et. al., 2015)

As part of the commodification process, there is also the need for commensuration – defined as being the transformation of different qualities into a common metric (Espeland and Stevens, 1998). Espeland and Stevens (1998) describe it as a form of valuation that create relations between objects that are compared, and can also turn qualities into quantities. They note that "commensuration can render some aspects of life invisible or irrelevant" (pg. 314). Carbon markets are a prime example of marketization of environmental matters – they have been specifically designed and framed, and have required the need to develop systems for measurement, commensuration and commondification. As noted by Cooper (2015), markets for greenhouse gas emissions "rely on the construction of robust rules for measurement, quantification, and accounting before they can function as regulatory instruments" (pg 1787). Using the example of emissions trading markets, Cooper (2015) argues that measurement and commensuration are inherently political and are sights of political contestation. Similarly, MacKenzie (2009) has also analyzed the issue of commensurability about gases and highlights that in creating a carbon market, one needs to bring a new commodity into being – this involves specifying both legal and technical definitions, allocating market participants and also to be made transferable and tradeable. Focusing on how different gases are made commensurable, he brings up the issues around classification of a new commodity and notes, "how to classify an item (not just an accounting item, but an item of any kind) is always implicitly a choice" (pg. 447). He goes on to say that when items are not easily classified, "those involved have consciously and explicitly to decide what classification is appropriate" (pg. 447). This issue of classification also applies to ecosystem services, where standard definitions are still being contested (Boyd, and Banzhaf, 2007; Wallace, 2007). With regards to ecosystem services, what is counted and who makes the decisions regarding this are equally sites of debate and contestation. What methods are chosen to be used for valuation, how devices are designed and used for measuring value – these factors highlight how the methods used can perform a specific representation of nature.

Sensitizing Concepts

Performance and Performativity

Within the field of STS, the focus on embodied knowledge has usually been linked with the notion of performance and performativity. This attention to performativity in STS is due to the fact that it can be used to highlight the tension between representations and objects and processes in the world. The sociotechnical construction of phenomena, the power of actants – both human and non-human, and also the question of material agency all involve performativity in some respect (Salter, *et al.*, 2017).

The word 'performance' was originally used to describe actions, happenings and time-based events, however, in the 1960s, there was a performative turn in which the term 'performative' began to describe speech as enacting rather than simply describing a situation (Salter, *et al.*, 2017). These performative aspects of language have been explored by Szerszynski (1999) in order to understand the issues of risk and trust among lay communities. Using Brian Wynne's (1996) analysis of lay risk assessments, he discusses the performance of trust, juxtapositioning Wynne's interpretation of empty performances of trust - which are a performance of trust in which the feelings of trust are not accompanied – with his alternative own interpretation of uses of 'trust' language which he describes as "hybrid speech acts, 'directive declarations; which are declarations which also have the quality possessed by directive of trying to get a party to do something they otherwise would not." (Szerszynski, 1999).

As this thesis will be focusing on how methods are used to value nature and what conceptions of nature are enacted through these methods, the conceptual frame draws from the works particularly by Law, Latour and Mol – all of whom have looked at practices, performativity and modes of producing reality (Law, 2004; Law, 2009; Law, 2011; Law and Urry, 2004; Latour and Woolgar, 1979; Mol, 2002). Knowledge practices generate workable knowledge and as such the realities to match. Law and Urry (2004) write, "methods are never innocent and that in some measure they enact whatever it is they describe *into* reality" (pg. 403). For them, methods have effects, they craft arrangements and gatherings of things. However, it can also be argued that methods also help to bring what it discovers into being, "methods are protocols for modes of questioning or interacting which also produce realities as they extend sets of relations" (pg. 395; Law and urry, 2004). This is where the notion of ontological politics comes in – different objects enacted in different sets of relations and contexts is no longer about

perspective but has to do with multiple realities and how they relate or co-exist. This has been discussed by Mol (2002) in *The Body* Multiple with regards to the diagnosis and treatment of atherosclerosis where she looks at the multiplicity of ways in which the disease is discussed and observed. Work by Moser (2008) has also looked at Alzheimer's disease along similar lines. In her study, Moser explores Alzheimer's from a number of locations and compares how the disease is 'mattered'. She highlights the numerous ways in which the disease is enacted through a variety of locations and practices and makes the point that different versions of the disease do not simply co-exist but also interfere with one another in complex ways that contribute "to make certain enactments present or absent, visible or invisible, dominant or marginal, more real or less real." (pg. 109; Moser, 2008).

Thus, methods can be seen as being relational or interactive – Law and Urry (2004) write that, "they *participate in, reflect upon,* and *enact* the social in a wide range of locations including the state" (pg. 392; Law and Urry, 2004). While these comments refer to social science methods, given that the process of valuation is a social practice in itself, it is also very much applicable to environmental valuation and the last few years has seen this concept recognized as being of particular relevance to the field of environmental studies (Verran, 2013; Whatmore and Landström, 2011). Thus while STS has tended to focus on the performativity of economic methods – for example, Callon (1998) has argued that the theories of markets have been a critical influence in helping to produce the realities that they seek to describe – topics regarding environmental change are increasingly being used as settings within which to explore how scientific hierarchies are shifting and the performative conceptions of nature that can arise (Asdal, 2014).

In the context of the analysis of specific methods used to value ecosystem services, this highlights the need to be attentive to what practices are being used, how these specific practices can result in a certain performativity, and to also question *how do these methods used for valuation enact a certain reality for environmental value?* This is particularly important as the ecosystem services approach is purely anthropogenic, and as such ecosystem services are analyzed only in the context of human use and well-being. What performances occur when such logic is applied to such operations of valuing ecosystem services is in line with the works by Dalsgaard (2016, 2013) in which he attempts to make sense of the value of carbon in amongst its entanglement in

different spheres of natural or social circulation as well as the numerous discourses that it is involved in – political, economic and moral.

Attending to matters concerning practices, this then involves ontology and ontological politics and not just epistemology (Moser, 2008; Law, 2004). For Mol, the use of the word 'ontology' in STS is not only a way to talk about methods used in sciences, but also addresses "what the sciences made of their *object*" (Mol, 2014). Mol (1999) argues that there is a shift in notion of reality and rather than an object being seen by a diversity of perspectives while remaining untouched in the centre, "reality is manipulated by means of various tools in the course of a diversity of practices" (pg. 77; Mol, 1999). Furthermore, this means that activities that perform an object do not reveal one or another characteristic of an object, but through her use of examples such as cutting, weighing or viewing with an ultrasound – Mol demonstrates the body can be seen to be multiple forms of reality itself. Additionally, Mol's (2002) studies of hospital realities details how atherosclerosis is enacted in different spaces with a hospital (e.g. in a waiting room, the consulting room, the pathology lab), highlighting that differences in realities can also be mutually exclusive. Similarly, Law has also written about how practices enact realities and in his article about collateral realities (Law, 2011), he describes practices as "detectable and somewhat ordered sets of material-semiotic relations (pg. 1). For Law, methods select, juxtapose, rank and frame realities, thus his point regarding collateral realities is that they are often unintentional and are "being done incidentally and along the way, without any kind of fuss at all" (pg. 14; Law, 2011). This thesis seeks to investigate how value is measured in a specific context – this will therefore require being attentive to how values (specifically, the values being placed on different ecosystem services) have the ability to enact specific realities whilst also cognizant that these might be multiple, mutually exclusive and also have unintended realities as well. It is hoped this can therefore reveal some insight into the politics of nature and perhaps the possible ontological multiplicities that are evident when valuing it.

For Latour (2004), Nature is defined through professions, disciplines and protocols. Drawing upon this notion, Asdal (2008) has used ideas from actor-network theory (see below for more information) to analyze how nature is enacted within politics and administration using an empirical case study of the European critical load project about mapping the problem of acid rain. Her point that "nature is not the starting point, but rather the outcome - a consequence of a series of practices and transformations" (pg.

124, Asdal, 2008) is also relevant to the case study in this thesis. Regarding the Recharge.green project, in addition to analyzing how the value of natural aspects was measured, it will also be of interest to see how nature as a whole was broken down into measurable components and what practices and transformations were necessary during this process.

The choices regarding how ecosystem services are valued also require standards, classification systems as well as decisions about what is considered to be of value. Bowker and Star (1999) have discussed classification and its consequences and have explored the role of standards in shaping the modern world. Drawing on Bowker and Starr, Timmermans and Epstein (2010) have looked at standardization from a sociological perspective and define standardization as "a process of constructing uniformities across time and space, through the generation of agreed-upon rules" (pg. 71). Brunsson and Jacobsson (2000) have argued that the enforcement of standards can be a type of social regulation – while they are often designed and circulated by experts, they can also come to function as an alternative to expert authority. Often scientific and technological expertise play a role in standard creation, thus their creation is fundamentally a social act – most standards are built collectively and in order to work, require that others comply and agree to these settings (Timmermans and Epstein, 2000). The creation of standards and classification systems can thus be thought of as "the meeting of numerous parties with the aim of obtaining legitimate coordination, comparability, and compatibility across contexts." (pg. 75; Timmermans and Epstein, 2010).

One important aspect in classifications and standards are that they involve the construction of boundaries – related to inclusions and exclusions. Boundaries have the ability to demarcate, and what they can do is bring to the front certain elements, whilst others remain in the background. Turnhout (2009) describes ecological indicators as tools that assess an ecological quality using a limited set of measurable parameters and thus "push forward selective preferences of what nature is and/or should be" (pg 404). The representation of nature is therefore malleable where categories, definitions, social actors and methods all have a role in what reality of it eventuates.

Actor Network Theory

As this thesis will be focused on the study of methods of valuation, the notions of translation and black-boxing are particularly relevant. These are terms derived from the framework, Actor Network Theory (ANT). ANT is a theoretical framework developed by Callon, Latour and Law in the late 1980s. It was developed originally in an attempt to understand science and technology and is used for exploring sociotechnical processes (Sismondo, 2010). Within this framework, the actants are heterogeneous and include both human and non-human entities. Having no methodologically significant distinction between them, ANT presupposes that all entities achieve significance in relation to others and therefore seeks to study and characterize how actants generate associations, and how they then form a web of relations to form networks. This was famously demonstrated in Callon's (1986a) study about the scallops, fisherman and scientists of Saint Brieuc Bay in which he details the negotiations between scientists and fisherman to create non-fishing zones. In this study, Callon treated all actors equally – he did not differentiate between the scallops, fisherman and scientists – and in this way wanted to highlight that all actors are capable of enrolling others in their schemes and are also shaped by their relations to other actors.

Actants within a network act together and depending on how they were brought to work together, it can mean changing the ways in which they act or perform – this can imply being moved or changed, and where interests can be translated in both place and form. As such, from an analytical perspective, ANT is interested in describing and understanding the dynamics and internal structures of these associations and networks. It analyzes how networks overcome resistance and are strengthened internally, how they gain coherence and become stabilized (Law, 2009a; Law, 1992). While ANT scholars do not generally assume that actors 'possess' power, the purposes of analyzing these aspects is to trace how actors influence other actors (both human and non-human) as well as make durable a pattern of association amongst other actors (Michael, 2017). In this respect, the networks of associations that are generated entail a process of 'translation'.

The ANT lens thus focuses on relations – how they are produced, reproduced, ordered and disordered. These relations are heterogeneous and thus are attentive to the roles of both humans and non humans. Furthermore, in studying the processes of ordering and

disordering, this also entails circulation – the circulation of people, objects, nature as well as culture (Michael, 2017). In order to fully understand these relations and circulations, they need to be studied in their specificity – case studies therefore present themselves as ideal candidates in which to study these relations, circulations and entities in detail.

Translation

A core concept of ANT is that of translation. According to Callon, "the notion of translation makes it possible to describe the mechanisms by which actor-worlds are constructed" (pg. 33; Callon, 1986b). Callon's definition of translation involves four moments – problematization, intéressement, enrolment and mobilization. Problematization is when an actor or actors defines a problem in order that other actors also recognize it as their own problem – this is a strategy often employed for rendering a particular technology as indispensable (Callon, 1986b). Intèressement involve the devices through which actors lock allies into the problematization. Following this, enrolment is the successful outcome of problematization and intèressement resulting in more allies. And finally, mobilization refers to the maintenance of the network where the actors' interests are successful persuaded to be aligned with those of the translator. This translator - also known as a translator-spokesman - is seen as an influential player that enlists actors in order to sustain the network (Callon, 1986b). The translation process therefore maps out necessary points of passage for a particular technology in order for it to continue to exist and develop (Callon, 1986). While groups and individuals within a network will all have different value systems, successful translation among these actors is necessary for the network to be stabilized. Thus the process of translation requires that an entity "consent to a detour" (Rhodes, 2009, pg 5). During this process there are continual negotiations and stability and network alignment are achieved through the translation of interests and the enrolment of actors. For the purposes of this thesis, the definition of translation used will be as described by Law (1992) whereby translation as a process that "'generates ordering effects such as devices, agents, institutions, or organisations" and "which implies transformation and the possibility of equivalence, the possibility that one thing may stand for another" (pg. 5).

Another important aspect to keep in mind regarding translation it that it can also occur at different scales. In Latour's (1983) 'Give me a laboratory and I will raise the world', he uses the case study of Pasteur's work on microbes and within this piece focuses not

just on the laboratory itself, but also on "the construction of the laboratory and its position in the societal milieu" (pg. 143). In this way, he shows ways in which the laboratory and the outside world are not separate entities but instead are highly porous. Additionally, by moving between the micro (i.e. the microbes) and the macro (i.e. farms, herds and cities) scales, he seeks to point out that science can use the micro to reshape the macro – in this example he has traced an instance in which a scientist doing lab experiments on microbes "ends up modifying many details of the whole of French society" (pg. 169; Latour, 1983).

Inscription devices

The role of non-humans is a central aspect to ANT. The role of technological non-humans in the building of specific orderings reflects both their emergence from, and their position in, their respective actor-networks (Michael, 2017). As such, devices and instruments can play an important role in defining actants and the relationship between them. For Latour, he saw technologies as having their own world, "full of organizations, negotiations, calculations, metaphysics, and even morality" (pg. 9; Latour, 2013). Similarly, Akrich has also discussed technical objects and writes, "technical objects have political strength. They may change social relations, but they also stabilize, naturalize, depoliticize, and translate these into other media" (pg. 222; Akrich 1992). Devices and technical objects thus have a use for which they have been designed for, but at the same time, they form part of a long chain of people, products, tools, machines and money – as such, Akrich (1992) notes that "technical objects and people are brought into being in a process of reciprocal definitions in which objects are defined by subjects and subjects by their objects" (pg. 222).

Inscription devices are systems for producing traces out of materials that take other forms. They can be any item of apparatus or constitute a particular configuration of items that have the ability to transform data or materials into another form. For this thesis, the methods for valuation can be viewed as a device in itself as the methods for valuing ecosystem services constitute a particular configuration of steps that transform data from one form into another. Furthermore, these methods can also be transferred to other sites as the methods used for valuing ecosystem services are able to be applied to other case studies outside the Recharge.green project. While inscriptions are said or assumed to have a direct relation to the original object/substance/entity, Latour and Woolgar (1986) also argue that realities are intimately intertwined with how inscription devices are used to create their particular products (1986). A key study that applies the

ANT approach and pays attention to inscription devices is *Laboratory Life* (Latour and Woolgar, 1979), based on a two year study on Roger Guillenmin's laboratory at the Salk Institute. In this study, Latour and Woolgar trace how scientists in a laboratory construct their facts through arguments, text and experiments. Here, the authors pay particular attention to how inscription takes place and describe examples of both literary inscriptions in the form of documents produced both inside the laboratory as well as outside, and also how the use of inscription devices such as bioassays are involved in a series of transformations that occur within a particular laboratory setting (Latour and Woolgar, 1979).

Black-boxing

Black-boxing can occur during translation and is described by Latour as "the way scientific and technical work is made invisible by its own success" (pg. 304; Latour, 1999). In this way, black-boxing and inscription devices are often linked as inscription devices are also involved in and partake in the processes of translation and transformation.

Black-boxing was a concept originally used in information science to make opaque the inner complexity of technologies and reduce it down to its inputs and outputs (Cressman, 2009). In this way, all that is of interest regarding a black box are its inputs and outputs. In the process of black boxing, messy and often highly complex processes can become stabilized and become part of the background. They are then said to be taken for granted as completed projects and are considered to contain that which no longer needs to be considered. When Latour and Woolgar (1986) describe literary inscriptions, they allude to how readers can become persuaded by the existence of facts and that various items of knowledge can become taken for granted, "merged imperceptibly into a background of routine enquiry, skills, and tacit knowledge" (pg. 76). This is in essence how a black box functions – there occurs a shift where what originally might be a hotly contested discussion, turns into a well-known non-contentious fact. While black boxes might appear to stabilize facts, it must be remembered that black boxes can always be reopened. Networks are not stable and are in continual flux as order is always provisional. Thus, opening of black boxes are a way in which to investigate how social and technical elements are brought together.

With regards to this thesis, the processes of valuation will be analyzed – specifically the focus in on understanding and trying to outline the methods that were used to value

specific ecosystem services. This entails knowing the steps that occurred during the valuation process as an ecosystem service was being transformed into an economic value (or otherwise). These steps involve translations, and as such, information (in whatever form it begins with) must be adapted and change form as economic valuation involves transformation into the monetary unit. Being attentive to these processes will certainly highlight moments of translation, however, it is also likely to point to the existence of black boxes – moments where input data and output data are in different formats but how exactly this has occurred may not be clear. These instances will be particularly important to point out as valuation of ecosystem services into economic values are still highly debated. If there are instances where information has been transformed and it is unknown how or why this is the case, it will be important to highlight these and ponder their consequences/implications for the overall valuation process.

Research questions

Main research question

For this thesis, an opportunity to delve deeper into an environmental topic was the aim from the outset. Thus, upon finding a case study that was involved in developing tools and strategies for decision-making processes regarding renewable energy expansion in the biodiversity-rich Alps, it presented itself as an interesting case to study empirically.

More details of the case study will be provided later in the thesis, however, the interest in this specific case study was due to the fact that it involved what the project partners refer to as a green-on-green conflict: increasing renewable energy production is a strategy promoted by the EU to reduce CO_2 emissions, however, at the same time, building the facilities and infrastructure for renewable energy production sites can impact negatively on the local environment, particularly in regions such as the Alps that are rich in biodiversity. Siting decisions within this project would thus have had to consider many different (and possibly conflicting) aspects - there are the economic considerations, technical and logistical aspects, the need to adhere to international and regional environmental treaties and conservation laws, as well as ensuring that the livelihoods of the local inhabitants are also considered.

It was of interest to investigate in greater detail what were the strategies that were involved in developing the tools that would assist in the decision-making processes. The overall approach used within the Recharge.green project to assist in this process was the ecosystem services approach. This approach has been increasingly used in environmental impact assessments as a means to assess the trade-offs that could occur when there are proposed changes being made to the environment. The ecosystem services approach is a means by which to assess the value of various ecosystem services, subsequently allowing for their comparison that can then be used to help inform decision-making processes regarding environmental issues.

Thus, specific to this case study, the main research question for this thesis is:

How was nature valued in the ecosystem services approach used in the Recharge.green project?

In asking this, it is hoped that one can glean insight into the methods by which different aspects of nature were assessed within the project. Nature and the various parts that make it up do not have a clear-cut value. Given that value is anyway socially-constructed, the ways in which value is attributed to nature can be done so in vastly different ways. This will depend on who is doing the valuation but will also be influenced by temporal and context-specific contingencies (Fourcarde, 2011). Thus, within the context of the Recharge.green project, it is of interest to learn the ways in which value is attributed to different natural aspects and also how this value is made measurable and then in turn, how value is then being measured in this specific case. In learning about how nature was valued using the ecosystem services approach within the project, it can then inform about how nature was being conceptualized by the Recharge.green partners. In gaining an understanding about how nature is valued in this instance, it can also provide insight into how these valuations contribute to decision-making processes regarding environmental issues where there are conflicts and trade-offs that need to be taken into account.

Sub-questions

The first sub-question for this thesis is:

1) ***How is nature being valued in the different ecosystem service categories within the project?***

Within the Recharge.green project, there was a list of nine Alpine-specific ecosystem services that were selected for valuation. These nine ecosystem services were divided into three different categories of ecosystem services: 1) provisioning services, 2) regulating and maintenance services, and 3) cultural services (details and definitions of these ecosystem services are provided later in the thesis). As these categories contain very different kinds of ecosystem services, in asking this first sub-question, the aim is to find out specific details for how different ecosystem services are actually valued within the project.

This will involve a detailed analysis in order to outline the methods that were used to value selected ecosystem services within the Recharge.green project. Four different ecosystem services were selected that all involved employing a different methodology for valuation. The aim is to find out what were the steps necessary in the four selected methodologies in order to understand how value was assessed for different ecosystem services.

The second sub-question for this thesis is:

2) ***What transformations and translations were necessary to make the valuation of different ecosystem services quantifiable and comparable?***

As the ecosystem services approach is an economic approach to value environmental aspects, this question seeks to find out the ways in which different ecosystem services are made quantifiable by economic terms. Given that the four different ecosystem services are so different in nature, it is of interest to understand how different ecosystem services are then transformed from a service into a monetary value (in instances where this was applicable in the methods selected). In order to do this, this process will involve transformations as ecosystem services are being converted into a monetary unit. This question aims to find out what transformations are occurring during the valuation processes of the four selected methodologies. In doing so, one can then trace the ways in which seemingly different ecosystem services are quantified and made to be comparable by being converted into the same unit of measure.

The third sub-question for this thesis is:

3) ***What instruments and devices were employed to assist in the valuation process and how did these instruments and devices make values visible?***

As the valuation for the different methods involved processes that required transformation from an ecosystem service into a monetary value, a relevant line of research, particularly if one is using a Latourian approach, is to then ask what instruments and devices were involved in this process? Latour would argue that devices and instruments have the ability to shape the relationship between actants, furthermore he and Akrich have also has argued that devices themselves require negotiations and complex organizations and have the potential to impose their own politics (Akrich, 1992; Latour, 2013). Being attentive to the tools that were involved is thus an important consideration when wanting to understand how nature is being valued. Specifically for this case study, this will involve looking at tools that were used (and in some cases, also developed during the course of the project) by the Recharge.green partners to assist in the valuation. By understanding how the devices and instruments developed, one can get some insight into the types of choices that were faced when wanting to create a device that measures value. This involves knowing what forms of data are amenable for use in these devices, and also, complementary to the second sub-question, it will also involve knowing if and how information is altered,

transformed either in order to be used by these measuring devices, or as a result of the devices at work.

Additionally, while Latour's and Akrich's devices are predominantly technological, Muniesa *et al.,* (2007) have discussed the notion of 'market device' and define it as "a simple way of referring to the material and discursive assemblages that intervene in the construction of markets" (pg. 2). This broader interpretation of the word 'device' will also be applied and in this case will refer to the methods for valuing ecosystem services. Just like market devices are material and discursive assemblages that can be transferred to different sites, so too are the methods developed to value ecosystem services. With this interpretation, the focus will be to highlight the ways in which value is made visible through these 'devices' (i.e. methods of valuation).

The final sub-question for this thesis is:

4) ***What concepts of nature were enacted in the valuation processes for ecosystem service valuation in the Recharge.green project?***

The methods used for valuing ecosystem services are essentially a set of practices – practices that have been crafted and arranged in a way that could have been done so differently. Law and Urry (2004) have argued that methods are not innocent and that they have a capacity to enact what they describe into reality. Thus, this final sub-question seeks to look at the enactments of nature that are evident from the different valuation methods that have been used within the Recharge.green project. In asking this, one wants to see how nature is being portrayed and presented through the lens of the Recharge.green partners. As much as these enactments depend on the methods used to value ecosystem services, this also has been shaped by the choices made by the Recharge.green partners, how they went about doing these valuations and also what aspects of nature are made more or less prominent during these processes. This final question then hopes to tie together the findings from the previous three sub-questions in order to gain an understanding about how nature has been conceptualized and subsequently performed within this project.

Case study background

For this thesis, it was decided that the research would focus on a specific case study. Miles and Huberman (1994) define a case as "a phenomenon of some sort occurring in a bounded context. The case is, in effect, your unit of analysis" (pg. 25). A case study approach was selected in order to have clearly defined boundaries within which the research takes place. The parameters of a case study can be delimited by: 1) time and place, 2) time and activity 3) definition and context (Baxter and Jack, 2008). With regards to this thesis, a case study selected for analysis was a project called Recharge.green that ran between October 2012 and June 2015 (http://www.recharge-green.eu/project/). All the data used for analysis for this case study were linked directly to this project – either in the form of documents generated directly by the partners involved in the Recharge.green project and also interviewing the lead partner for the project.

Broad overview of the Recharge.green project

This masters thesis research is focused on a case study called the Recharge.green project whose main goal was to facilitate decision-making processes regarding renewable energy expansion in the Alps. Co-financed by the European Regional Development Fund in the Alpine Space Programme, this project assessed the potential for four kinds of renewable energy: wind, hydropower, biomass and solar, and it employed different methods to assess the suitability for these renewable energies across six pilot sites. As part of the project, its 16 partners (members of national parks, local government, academia, civil society and the private sector) sought to develop ways to make decisions regarding renewable energy siting options in regions of rich biodiversity – this included assessing and ranking the potential trade-offs/conflicts, developing online tools to spatially map various parameters to assist in siting decisions, as well as employing different approaches (such as participatory approaches with local communities) to evaluate which regions in the Alps would be amenable to renewable energy expansion, and which ones should be kept exempt (http://www.recharge-green.eu/project/).

Mis and Maè valley pilot sites of the Recharge.green project

This thesis maps the broad overview of evaluation processes used in the Recharge.green project as well as looks at the valuation of four ecosystem services used within the project. Particularly for mapping the participatory approach, and the analysis of how

intrinsic valuation was done, documents and sections of larger documents pertaining to the pilot site of the Mis and Maé valleys were used. The Mis and Maè valleys are located in the Veneto region in Italy and these sites were representative of the south-eastern part of the Alps for the Recharge.green project. Both regions have small local communities that manage forests and pastures, with the Mis Valley covering an area of 11,800 hectares with a population of around 4000 inhabitants, and the Maè valley covering an area of 23,300 hectares with a total of around 8000 inhabitants (Balest, *et al.*, 2015b). The regions contribute important ecosystem services that include: provision of forest and agricultural products fresh potable water, ecological habitats, as well as aesthethic and recreational value (Recharge.green, 2015). Additionally, the region has large forest areas and hydropower has also been an important energy resource for these areas. These valleys have a lot of value as tourist sites and also contain protected areas that are part of the Natura 2000 Network and also consist of Dolomiti UNESCO sites (Balest, *et al*., 2015b).

Materials and Methods

Developing a research focus

In developing a research focus for this masters thesis research, it was decided from the onset that a case study-based approach would be preferable in order to have a clear means for demarcating the limits of the research focus. The search for an appropriate case study did take a long while. At its core, this author wanted to find case study that was based around an environmental issue – initially these searches were based on urban-based environmental projects however finding one that adequately captured interest were few and far between. The Recharge.green project was happened upon during a visit to the Research Institute of Wildlife Ecology in Vienna. While the purpose of the visit was to experience and see first hand the research that occurred at this institute, the lead partner of the Recharge.green is a lab head at this institute and the project was mentioned as part of the work that the institute had been involved in. Given that the project was interested in decision-making processes concerned with renewable energy siting in the Alps, it was decided that this would therefore be the case study for the masters thesis.

In deciding what the specific focus for the thesis would be, this firstly involved becoming familiarized with the project – the perpetual calendar (document 5 of the main documents analyzed in this thesis, listed below) was obtained from the excursion to the Research Institute of Wildlife Ecology. This document - as well as visiting the homepage for the project, http://www.recharge-green.eu/ - were used as an initial resources to learn more about the project findings and the various aspects that were involved. The website contained numerous documents that were generated both during the project as well as finalized project reports. One document in particular, the Recharge.green Handbook (document 1 of main documents analyzed, listed below) was very useful in the beginning to learn about the different aspects of the project and the different approaches used in the pilot sites (of which there were six in the project).

The interest in the specific case study was initially triggered by the fact that the title of the calendar was "Energy & nature in the Alps: a balancing act" – it suggested that decisions would need to be made regarding preferences between energy production and protecting nature. With this author's particular interests in environmental decision-making, the next task was then to decide which specific aspect would be the focus of the thesis in order to understand how indeed decisions regarding this interesting conflict

were tackled within this project. Initially, there were ideas to focus on either the Decision Support System that was developed during the project and how it was designed and implemented, or to select one of the Pilot sites and do a detailed analysis for how decisions were made at one specific site. The pilot site of the Mis and Maè valleys was considered to be used as a specific focus as the approach used within this project involved a participatory approach with local stakeholders invited to partake in the decision-making process.

Another aspect to be taken into consideration in selecting a focus for the thesis also centred around deciding which method would be most appropriate and feasible in order to obtain the necessary data required. Given that the project was already completed, document analysis presented itself as a method that would provide the least issues with regards to access to data as all the documents produced during the project were accessible through the project's website. However, given that contact had been made with the lead partner, it was also considered that the lead partner could provide an avenue through which to get in touch with additional involved partners if interviewing was selected as the main form of data collection. In the end, for ease of data, it was decided that document analysis would be the preferred method employed for this thesis research.

As a result of this decision to use document analysis, this therefore ruled out the idea to focus on the ways in which the participatory approach was carried out at the Mis and Maè pilot sites as there were not many documents available on the website that would provide enough detailed information about the events. Furthermore, it not being feasible to attend the events (given they had already happened), this line of research was not pursued further. Focusing on the development of the DSS was then considered as a potential option as there was a detailed document solely pertaining the DSS development and modeling done in the project (document four of the main documents analyzed, see below) in addition to a chapter within the Recharge.green handbook (document one). Additionally, the Recharge.green partners responsible for the development of one of the DSS used in the project was based in Vienna at IIASA therefore also presenting the option to use interviews to supplement the document analysis. In the end, having the focus purely on the DSS development was decided against as initial document analyses presented a lot of technical information that this author felt would detract too far away from her interest in understanding conflicts of interest. Thus, finally after a lot of deliberation, it was decided to find a focus that would

allow for an investigation into how nature was valued in the project. In order to do this, it was decided that this could be achieved by investigating the various methods that were employed within the project for valuing different types of ecosystem services. Given that the project had a list of nine Alpine-specific ecosystem services that were assessed and valued as part of this project, it was decided that selecting four of these and then performing a detailed analysis to outline the steps that were involved, would be the primary focus for this thesis. Initial readings of Recharge.green documents highlighted a variety of different methods being employed for valuing ecosystem services. Thus it was decided to select four ecosystem services that were evaluated using different methodologies – in this way one could detail the ways in which specific ecosystem services were made measurable, and additionally, it would also provide a point for comparison between the valuation methods used for different ecosystem services.

The final outline for this thesis is as follows: Firstly, the thesis will analyze the public relations material (i.e. the perpetual calendar) to see how the project aims were presented to a general audience. Following this, the broad evaluation processes of Recharge.green will be mapped using the formal final project reports. Assessing how the project is represented in the formal reports versus the public relations material will provide a means to analyze if and how the project is presented and explained differently depending on the intended audiences. There will then be a detailed analysis of four specific methods that were used in the project to value different ecosystem services. These will be analyzed by using document analysis and also with interviewing of the lead partner of the Recharge.green project. Finally, there will be a section in the results that looks at the role of the Decision Support System in valuing and visualizing ecosystem service values and how this contributed to generating potential scenarios that were then used for further decision-making.

The methodology selected for this thesis research involved two complementary approaches: document analysis and semi-structured interviews.

Document analysis

Documents are situated products and have been described by Prior (2007) to "enter into episodes of social interaction in a dual manner. In the first place, they enter as receptacles of content and in the second they enter as functioning agents in their own

right." (pg. 346). Similarly, Shankar and colleagues (2017) state that documents do more than represent the world, they also can "refer to the practices, objects, rules, knowledge, and organizational forms that produce them" (pg. 62). For this analysis, as the focus was on understanding the methods for valuation, the documents were seen predominantly as 'receptacles of content' and their content was analyzed (details below) in order to build an understanding of the processes involved in valuation used within the project. However, it is crucial to be reflective upon the fact that documents are in fact manufactured products. Documents are a means by which an exchange of information is made possible – and as Prior writes, not only do they facilitate the flow of information, "but also mark out channels and boundaries of social influence" (pg. 356). Given the fact that they are manufactured and facilitate flow of information, this also means that documents are never inert and have both fluid and fixed aspects (Shankar, *et al.*, 2017). As Prior (2007) describes them, "they frequently serve as active agents in schemes of human interaction – agents to be recruited, manipulated, scorned or hidden'" (pg. 358). As such, the ways in which information is recorded and documented can be seen as a means for providing translations (Prior, 2007). Documents communication through representations and language and therefore how documents relay information will certainly makes certain aspects visible whilst others remain less visible. As such, they have the power to specify desired connections among people, objects, times, places and events and also to structure relevant discourse, in this way they are able to direct people to which specific parts are to be brought into focus. Thus, while the content within the document can provide data for analysis, it is also important to consider how it was put together – being attentive to "how the rules and principles of composition were called upon, and the ways in which the raw materials were woven into a final 'report'" (pg. 358; Prior, 2007).

During the course of the Recharge.green project (it ran between Oct 2012 and June 2015), a number of documents were generated and made available for download at: http://www.recharge-green.eu/downloads/. There are detailed reports, conference presentation, posters and newsletters, with both progress reports as well as finalized project reports available.

Main documents used for analysis

The main documents from the Recharge.green project used for analysis are:

1. ***Sustainable Renewable Energy Planning in the Alps. A handbook for experts & decision makers.*** **(2015).** (121 pages).

This handbook details the project approach as well as provides details about results from the project regarding certain tools that were developed for valuation and also specifics from the five pilot sites that were used as test sites for the project (each pilot site looked at the decision making process of a different renewable energy source and also had a variety of landscape and community issues to contend with). It was the final report generated at the end of the project and has four extensive chapters about 1) the ecosystem services approach, 2) decision support systems, 3) impacts of renewable energy on ecosystem services and 4) details specific results from the Pilot sites.

This document was selected for detailed analysis as it presented an entire overview of the entire project. It was thus a vital resource in helping to understand the wider context of the project as well as present an overall view of what was achieved for specific aspects of the project. Within this handbook, there were also extensive references that could be followed up upon for additional information.

2. ***Renewable Energy and Ecosystem Services in the Alps. Status quo and trade-off between renewable energy expansion and ecosystem services valorization.*** **(2015).** (96 pages).

This report contains a lot of information regarding ecosystem services and how the impacts of renewable energy expansion in Alpine areas were considered. In the context of the research for this thesis, this document contained a lot of relevant information regarding how each renewable energy was considered and the ways in which renewable energy can be assessed as impacting on ecosystem services. Additionally, this document contained details about how ecosystem services were evaluated at the pilot sites as well and information on economic evaluation and how they performed the spatial mapping of ecosystem services. In the end, this document was one of the main resources relied upon for the analysis of this thesis topic.

3. ***Report about round tables for the pilot areas Mis and Maè Valley, Balancing Alpine Energy and Nature.*** **(2015).**

The project had five pilot sites that were considered using different renewable energy types as well as approaches. For this thesis, it was decided to focus on the Italian pilot site at the Mis and Maè valleys – the reason behind selecting this pilot site was because there were details regarding how intrinsic value was assessed and this was of particular

interest for the author. Thus, this particular document was selected as it pertains to the work done at the Mis and Maè valleys, and provides specific details for how intrinsic value was assessed.

4. ***Modeling and visualization of optimal locations for renewable energy production in the Alpine Space with a special focus on selected pilot areas.*** **(2015).** (33 pages).

As part of the Recharge.green project, two Decision Support Systems were developed – one that used a broader Alpine Bow region for modeling of potential renewable energy sites called BeWhere, and a second one called r.green that was used specifically for the pilot sites within the project. The development of the DSS was an important tool for spatially mapping the ecosystem services in order to generate potential scenarios that could be considered for renewable energy siting options – as such, as part of this thesis research, it was important to understand details about how the DSS was designed, what were the aims of this tool, as well and seeing examples of it being applied within the project.

This document was selected for detailed analysis as an important aspect of this masters research was to understand how instruments and devices were used within the Recharge.green project to help in the valuation process. A specific focus on the DSS used at the pilot sites was selected for analysis and this particular document was able to provide more details and examples of its application at the pilot sites compared with the previously mentioned documents.

5. ***Energy & nature in the Alps: a balancing act.*** **(2015)**

This document was a perpetual calendar made by the Recharge.green partners as a public relations material. Intended for a general public audience, it calendar uses each month to explain a different facet of the project – explaining first the project goals and what factors needs to be considered when wanting to increase renewable energy in Alpine regions. It uses a fictitious town called Alpine Vale and uses the 12 months to present scenarios and explain some of the decision-making aspects that would have been encountered during the course of the project. The calendar used both written text and cartoon graphics as a means for representing and explaining the project aims.

This document was included in the analysis as a means for providing a comparison between what was presented in the formal reports (which would have been presented

to the governmental funding bodies) to how the project was presented for a more general audience.

Qualitative interviewing

Complementary to the document analysis, a semi-structured qualitative interview was conducted with the lead partner of the Recharge.green project, Dr. Christian Walzer - a Professor at the Research Institute of Wildlife Ecology. While document analysis is the main form of analysis to elicit details regarding the methods for measuring environmental value and provided information regarding *what* components were included for measurements of a particular ecosystem service as well as certain details regarding *how*, it provides less information about *why* those specific components were selected or the reasons pertaining to why a certain methodology was selected in preference over another. Gubrium and Holstein (2003) describe the interview as an opportunity "to derive, as objectively as possible, the respondent's *own* opinions of the subject matter in question" (pg. 26). The interview is thus an opportunity to either clarify or corroborate the document analysis or to try and fill some of the holes in the information that could not be gleaned by document analysis alone.

Interviewing the lead partner allowed for the opportunity for clarification of specific aspects of the document analysis and also to probe deeper into contextual aspects of the project. A qualitative interview is an opportunity to ask for specific details regarding certain valuation processes such as, what (if any) constraints were present, what limitations had to be overcome? These are aspects that cannot be gleaned simply by analyzing finalized or working project reports. Real-life constraints that had to be contended with during the project will not appear in the finalized documents so the interviews will contextualize the process of valuation in the Recharge.green project. While the document analysis can outline the processes required for a particular valuation method, the interview allows for greater insight as to when and where decisions needed to be taken (e.g. why was a certain parameter chosen, why certain elements were included/excluded from quantification).

With qualitative interviewing, there are seven stages involved in the process, these are: 1) thematizing, 2) designing, 3) interview situation, 4) transcription, 5) analysis, 6) verification, and 7) reporting (Kvale, 2007). Thematizing involves deciding and understanding the purpose of the interview and how it contributes to the research

question. Specific to this masters research, it was decided that interviewing the lead partner would allow for questioning regarding the broad overview of the Recharge.green project and learning more about how the project came into being, what decisions had to be addressed as part of the process. Furthermore, it was hoped that he would be familiar with the details of how the four ecosystem services were being specifically analyzed in this thesis and thus could provide some clarification. The second stage - designing - involves organization of the interview itself, choosing the location and time for the interview to take place, preparing the informed consent forms and the recording devices, and to also ensure that the researcher secures the confidentiality of the research subjects. Initial contact and consent to being interviewed was not an issue, however organizing an interview date did require a few attempts of re-scheduling. The interview itself was done and recorded at the Research Institute of Wildlife Ecology on the 26th of January, 2017 and lasted 46 minutes. Following the interview, the entire interview was transcribed verbatim. The analysis of the interview content was done using the grounded theory approach (as described below) with *in vivo* quotes highlighted and memos written. The interview results were incorporated with the document analysis and reported in the results section of this thesis.

Grounded Theory

Documents were analyzed using Grounded Theory as outlined by Charmaz (2006). This theory consists of "systematic, yet flexible guidelines for collecting and analyzing qualitative data to construct theories 'grounded' in the data themselves" (pg. 2; Charmaz, 2006a). This approach requires being open to what is can be learnt from the data at hand – in whatever form that may be. Right from the initial stages of data collection and reading of documents, the data was separated and sorted into order to synthesize the data through qualitative coding. This coding process involved attaching labels to segments of data that depict and explain what each segment was about. Specifically for the document analysis of the Recharge.green documents, this meant going through the main selected documents and finding all sections that were relevant to any sort of valuation process. These then needed to be sorted into categories – either pertaining to broad processes that related to the entire project, or to specific instances of valuation done for as part of the methodology for assessing the value of a specific ecosystem service. Through these initial codes and groupings of instances of valuation evident in the documents, the research focus was able to be honed in on – through these early stages of coding, it highlighted the different methods of valuation that were

evident for the various categories of ecosystem services that were assessed. Thus, the eventual four ecosystem services that were selected for detailed analysis of their methods for valuation came out of this early analytical stage.

There are different kinds of coding as outlined by Charmaz (2006a): word-by-word coding, line-by-line coding, coding incident to incident, or *in vivo* codes. Given that the documents were quite extensive with the number of pages ranging between 30-120+ pages, word-by-word or line-by-line coding was deemed inappropriate for this research as it would break up the data too much into small pieces. Instead, incident to incident was deemed more appropriate. In addition to incident to incident coding, often *in vivo* codes were highlighted and memos were written. Memo writing is an intermediate them between data collection and writing of results, the point of them is to trace and categorize data, describe how categories emerge and change, identify beliefs and assumptions as well as make comparisons (Charmaz, 2006b). This was a critical step in the process and also was very important for the compiling the figures and schematics presented in the text (those that were not taken directly from Recharge.green documents).

Results

Recharge.green overview – the public representation

A perpetual calendar (Ciolli, *et al.* 2015) made by the project partners presented the overall aims of the project and how the partners engaged in the decision-making process. This material is a useful way in which to see how the partners present the project to a general audience. The aim of the calendar is described on its first page as follows:

> *"This perpetual calendar explains the main project findings, in particular to decision-makers from local to Alps-wide level. It takes readers through the decision-making process that the fictional town of "Alpine Vale" goes through when discussing the potential use of renewable energy"*

The calendar uses a fictitious town, "Alpine Vale" and constructs a scenario in which the town – "idyllically situated between a lake and surrounding mountains", has an economy mainly driven by tourism but with "two fairly large protected areas…located east and west of the own outside the municipal boundaries". As part of the scenario, the town's mayor considers option to produce energy from renewable sources and the remainder of the calendar then uses both visual cartoon graphics and also written text to highlight some of the aspects that are involved in the decision-making process for such a scenario.

The months of February to May explain each of the renewable energy sources. What is made quite clear in these explanations is that there is an explicit explanation for how each renewable energy type can potentially impact biodiversity. An excerpt from the calendar for each renewable energy's description and how it impacts on biodiversity is provided below:

- For hydropower, it is stated: "biodiversity and water quality improvement must guide all interventions in both the modernization of old plants and the planning of new plants".
- Wind power: "Windmills may however have a negative impact on landscape quality and biodiversity, especially when located near protected areas"
- Solar energy: "Solar energy potential is extremely high, but large solar fields conflict with the local landscape and biodiversity."
- Biomass: "Producing energy from forest biomass must rely on material that is sourced locally. Sustainable forest management will preserve soil and protect biodiversity."

These statements were in a larger font compared to the remainder of the text that explains each renewable energy – thus it is clear from this that the Recharge.green partners want to emphasize the ways in which biodiversity must be taken into account when looking to expand renewable energy production.

The months of June, July and August then presents scenarios for how the different categories of ecosystem services are potentially impacted by each particular renewable energy: provisioning ecosystem services and hydropower, regulating & maintenance ecosystem services and forest biomass and cultural services and wind power. In each of these sections, the main points being highlighted are how expanding use of renewable energy needs to be balanced with other considerations. The calendar has statements such as "Expanding the use of renewable energy needs to be balanced with the use of other resources", "Expanding renewable energy needs to be balanced with biodiversity conservation and a functioning ecosystem" and "Expanding renewable energy needs to be balanced with human wellbeing". All these statements suggest that expansion of renewable energy involves finding a balance between conflicting issues. Again, the importance of taking biodiversity into account in the decision-making process is also being heavily emphasized.

The month of September discusses the importance of a participatory approach that includes local stakeholders and there is a brief account provided regarding stakeholder involvement at the Mis and Maè valleys. In the calendar it discusses about how to deal with potential environmental and social impacts (in the excerpt below) with the theme of finding a balance again emphasized:

> *"The enhanced use of natural resources – such as water, wind, forest biomass and solar radiation – for energy production requires a delicate balance to be found between the various uses of several ecosystem services. Exploitation of these resources for energy purposes will produce environmental and social impacts at the local scale, while the benefits will be distribute more widely. This is the basis of potential social conflicts that can be dealt with and resolved only through a participatory approach, involving local communities in the decision-making processes" (Ciolli, et al., 2015)*

Given that the project involved development of a Decision Support Systems to assist in the decision-making process, the month of October provides a brief description of what it is. Decision Support Systems are described as "tools designed to create plausible scenarios that can be used to feed discussion during consultation phases and to propose

final scenarios once the pathway is identified" (Ciolli, *et al.*, 2015). Their explanation of what scenarios are, describe them as being "like stories about the future, but can include detailed quantitative information about a system and its interactions. They are not predictions, but a way for people to understand the interactions between things" (Ciolli, *et al*., 2015). Importantly, they mention that "the scenarios attempt to provide a holistic range of possibilities" and that "policymakers and other stakeholders are able to set different levels of ecosystem protection" (Ciolli, *et al*., 2015). There is also a description about the importance of multi-level governance with the month of November used to explain the different levels of stakeholder involvement in decision-making processes such as those undertaken by Recharge.green. From the level of town council, to regional and national discussions, right up the European level, the project is presented as being part of a wider strategy for renewable energy production. Finally, the month of December provides an outcome following the decision-making process and presents a "sustainability package" that outlines how Alpine Vale has decided to increase renewable energy production. Again, the importance of protecting biodiversity is emphasized with the following statement:

> "All forms of energy have some impact on the environment – but by using the right planning processes and tools you can minimize this impact and protect ecosystems and landscapes enough to safeguard biodiversity and human well-being." (Ciolli, *et al*., 2015)

From this public relations material, some core themes are repeatedly emphasized – in particular, the importance of protecting biodiversity as well as the need to find a balance when deliberating about what will be the best course of action. Almost every page of the calendar mentions the protection of biodiversity – usually further emphasized in larger font at the top of the page. This therefore suggests that biodiversity is a key consideration for the Recharge.green partners when assessing renewable energy options.

Additionally, the images accompanying the written text are colourful cartoon graphics (see Figure 1 for examples taken from the calendar). It is interesting to note that each graphic for every month always contains aspects of nature such as trees and animals, alongside townspeople and some form of renewable energy. This again is an attempt to emphasize the many aspects that must be taken into consideration for such decision-making processes.

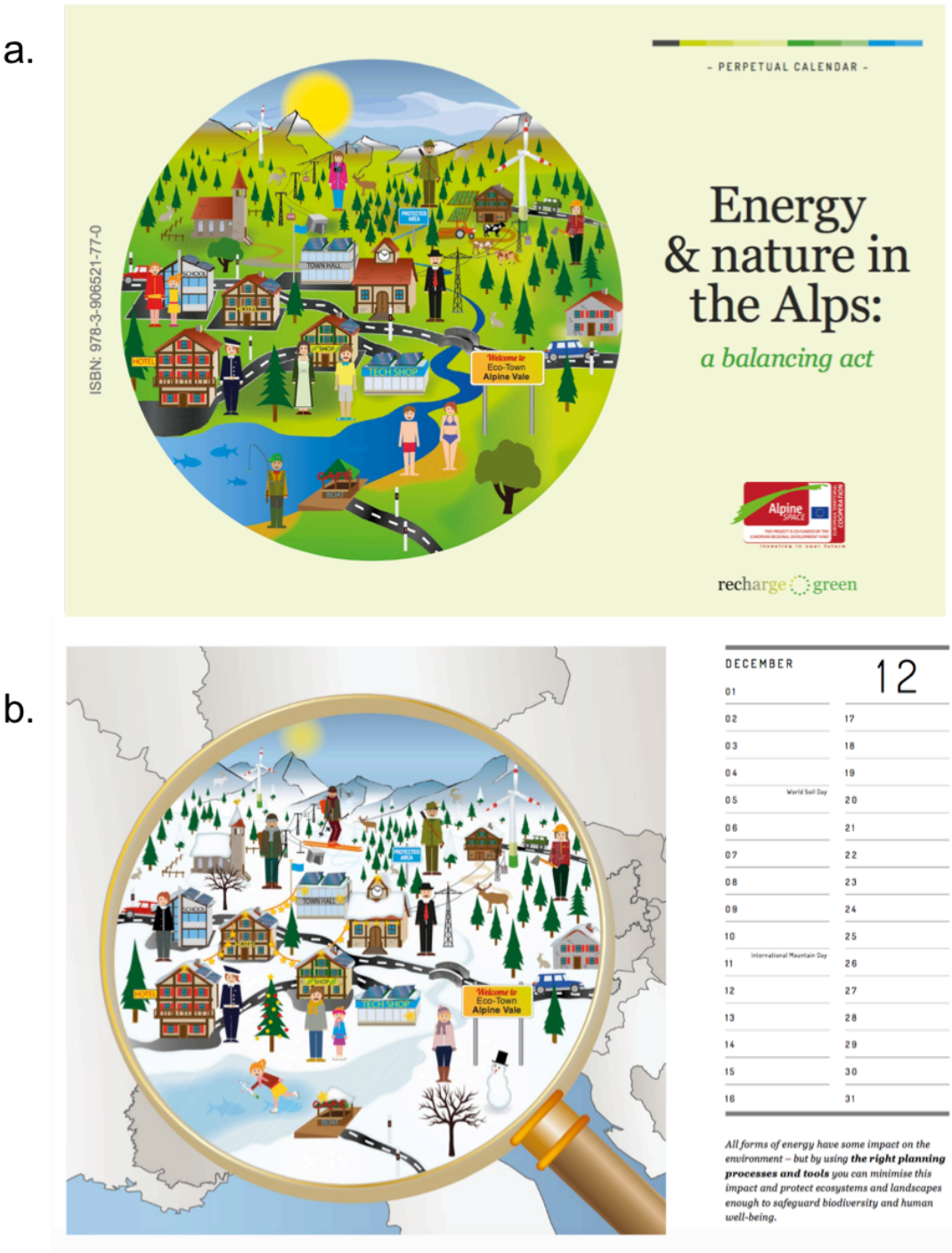

Figure 1. Images from the perpetual calendar made by Recharge.green. (Taken from Ciolli, et al., 2015)

a. *Front cover of the perpetual calendar*
b. *Final image of the calendar depicting how planning processes can help to minimize impacts on the environment and communities.*

Recharge.green project overview – formal reports

The Recharge.green project had three key challenges it sought to address: 1) identifying the potential for renewable energy in the Alps, 2) choosing the right renewable energy (e.g. solar, wind, hydro or biomass) in the right area, and 3) taking into consideration the need to protect the environment. To assist in the decision-making regarding renewable energy siting in Alpine regions, the Recharge.green partners decided to adopt the ecosystem services approach.

> *"I would think we spent about six months discussing it amongst the group. Not everyone always participates in them but we had at least six months of discussion about this. And, you know, the opinions are quite varied. I am personally not a big fan of ecosystem services valuation process, the way it's done now….especially some of the new things like the MAES* [Mapping and Assessment of Ecosystems and their Services, a framework for mapping ecosystem services in order to identify synergies and trade-offs between different ecosystem services and to aid visualization of valuable ecosystem services (http://biodiversity.europa.eu/maes)] *mapping, you know, I think it's a bit ridiculous, but I do also see that it has some applications….but even within my own group here at the institute, it's quite interesting that how, how, disparate, disparate? The opinions were." (Lead partner interview, 26th Jan 2017)*

The overall approach to the Recharge.green project is outlined in Figure 2, with specific details regarding how stakeholder participation was incorporated with regards to the Veneto Pilot site. While this is a multi-step process, for the scope of this thesis, the steps pertaining specifically to how ecosystem services were valued and subsequently, how were these ecosystem services then spatially mapped will be investigated in detail.

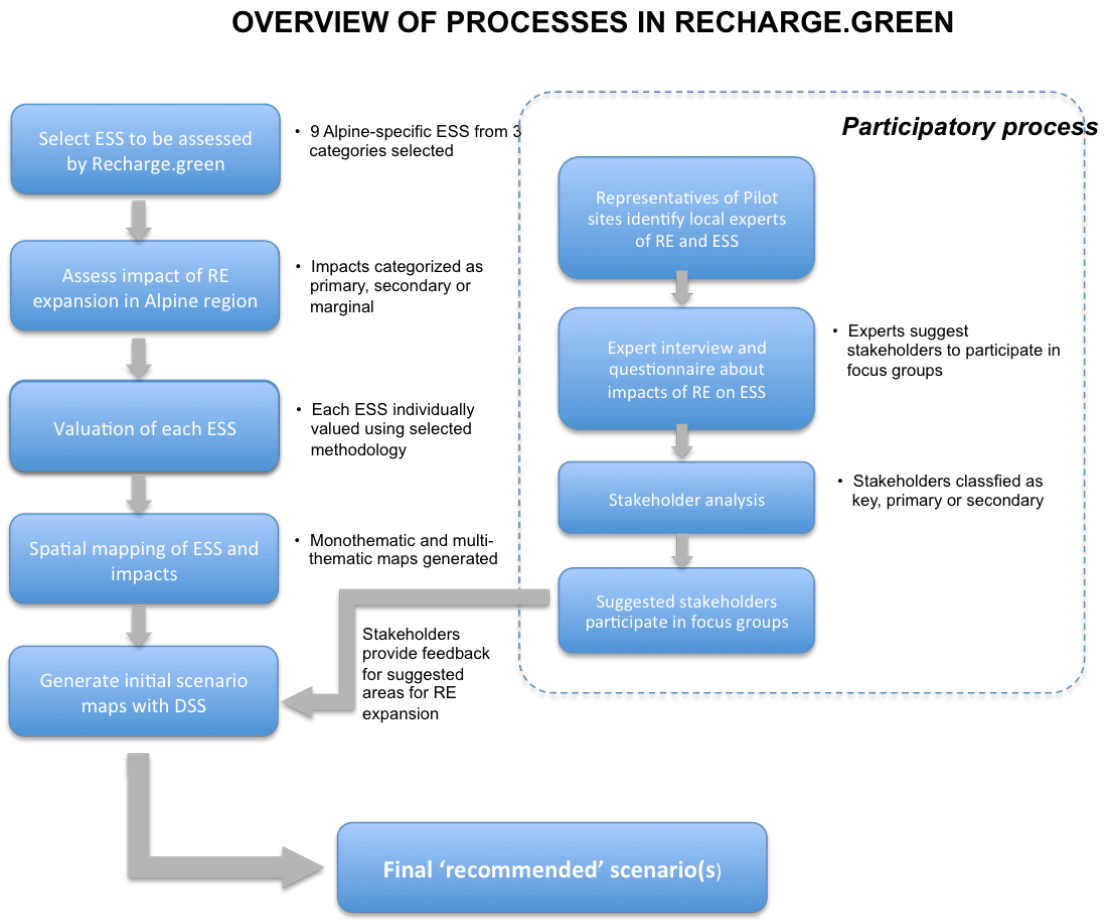

Figure 2. Overview of evaluation process used in the Recharge.green project for pilot sites. (Author's construction based on document analysis)

For the Recharge.green project, the project partners developed a list of nine Alpine-specific ecosystem services (Table 1). These ecosystem services were evaluated as part of the project, with the ultimate aim being to "formulate effective strategies and choose optimal locations for renewable energy that can preserve the environment and at the same time produce renewable energy efficiently" (Balest, *et al.*, 2015b). During the interview with the lead partner, when questioned about how these nine were selected, it turns out that these nine ecosystem services were actually used in a previous project. By asking the person involved in the previous project (that had assessed the same nine ecosystem services for Alpine regions) to come aboard the Recharge.green project, this then enabled Recharge.green to adopt a similar approach. According to the Recharge.green lead partner, this therefore "saved us a lot of deliberations and discussion" (Lead partner interview, 26th Jan 2017).

> *"The selection of those nine ecosystem services which we thought were a priority comes from another project." (Lead partner interview, 26th Jan 2017)*

Table 1: Alpine Ecosystem Services considered in the Recharge.green project

Provisioning services
Provision of forest and agricultural production
Provision of fresh or potable water
Regulating and maintenance services
Protection against natural hazards
Air quality regulation
Carbon sequestration in vegetation and soil
Ecological habitat quality
Cultural services
Aesthetic values
Recreational values
Intrinsic values

While ecosystem services are typically divided into four categories - provisioning services, regulating and maintenance services, cultural services and supporting services, the partners decided to only select services from three of the four ecosystem categories – this already highlights then a choice that the partners made regarding what aspects of nature would be made visible and which ones weren't.

> *"Three categories of ecosystem services were evaluated from the economic point of view (provisioning, regulating and cultural services), while supporting services were not included in order to avoid double counting of value" (Balest, et al., 2015a)*

Following the valuation of ecosystem services, the ecosystem services were mapped geographically so that the estimated value of the different services could be visualized spatially. This is an important step of the process as ecosystem services are viewed as being strictly linked to the spatial dimensions of the region in which these services are provided (Busch, *et al*., 2012). While the details for how specific ecosystems were mapped will be discussed their respective sections, a general overview will be provided here.

For the Recharge.green project, spatial mapping was seen to be fundamental component of the valuation process as it provides "a clear overview of the share of ecosystems under pressure and to avoid further depletion of the environment" (pg. 98, Balest, *et al.,* 2015b).

> *"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"* (pg. 21; Balest, *et al.,* 2015b)

It is interesting that whilst the mapping was used to provide an overview of "ecosystems under pressure…to avoid further depletion of the environment", this was assessed through an economic lens, as evident in the above quote. How they 'take into account' ecological characteristics when valuing the environment from an economic perspective is a tension that is not openly addressed in the brief description describing why spatial mapping is an integral part of valuing ecosystem services.

In order to map the ecosystem service values at each of the pilot sites, the project partners developed a Decision Support System (DSS) called 'r.green'. DSS are technological tools that assist in the comparative assessment and selection of options for change. The role of r.green in the decision-making process and how it was used was described in the reports as follows:

> *"In the recharge.green project, a spatially explicit Decision Support System (DSS) r.green, developed in open source software, identified and quantified, based on sustainability and land conservation criteria, the areas suitable for installation of the main renewable energy systems. The software generates maps that can be discussed with the stakeholders and provide a description of different scenarios of renewable energy development."* (pg. 21; Kraxner, *et al.,* 2015)

From the above quote, it states that identification and quantification of sites amenable for renewable energy production is the main function of the DSS. This quote suggests both identification and quantification occur. However, as will be made evident in later analyses, what is actually meant by 'quantification' and how this is achieved within the project is often lacking in details regarding methodology and actual results.

Maps were generated according to thematic layers that could then be overlapped to analyze the spatial distribution of ecosystem service values. These thematic layers corresponded to 'key variables' and were: 1) land uses, 2) forest types, 3) altitude, 4)

forest tracks and paths, and 5) river and stream network. This then generated the resulting maps, "characterized by a number of polygons which express the values of the ecosystem services supply" (pg. 21; Balest, *et al*., 2015a).

> *"Once the maps are prepared it is possible to understand the loss in monetary terms of the ecosystem value, which is created by the harvesting of renewable energy. Such an approach allows the identification of the most suitable sites that could be exploited for energy production without damaging the environment"* (pg.1; Grilli, *et al.,* 2015)

What is evident from the description provided by Recharge.green partners, is that monetary losses and gains are used to assess and identify the suitability of renewable energy production sites. However, this in turn implies that a monetary assessment of ecosystem values is a way in which damage to the environment can be measured and minimized. The implications of viewing ecosystem services only through an economic perspective, is that it can obfuscate the non-economic value of ecosystem services, thus in this case, one must be mindful of what aspects of an ecosystem services are made visible when environmental protection is viewed only through the lens of the monetary unit.

It is important to note that in developing the DSS to assist in decision-making, there are numerous stages at which developers can influence the outcome of scenarios being generated. As described in one report: "Several modules were developed for each natural source that allowed consideration of theoretical, technical, and financial variables, and the recommendation of stakeholders" (pg. 21; Kraxner, *et al*., 2015). Each module has both mandatory data input and optional data input. These were listed in the document as being:

"Mandatory data input:

- *Forest stand map with yield and increment values*
- *Forest management and treatment*
- *Ordinary and forest road network*
- *Water network*
- *Digital elevation model*

Optional data input:

- *Soil data (texture, depth, fertility)*
- *Lakes*
- *Protected areas*
- *Fire risk*
- *Costs and marketed price of different wood typologies*

- *Level of mechanization adopted" (pg. 22; Kraxner, et al., 2015)*

Thus the process involves: data collection, data analysis, GIS modeling and the formulation of scenarios – all of which involve negotiations and decisions about how and what should be included, as well as transformations of information from one form into another. Clearly as a technical instrument, the DSS is used to assist in evaluating renewable energy siting options, but as Caliskan and Callon (2010) write when discussing instruments, "they contribute actively to making the realm that constitutes the action itself as a possibility" (pg. 11). The practices and methods for calculation clearly will influence the scenarios and therefore the realities that can ensue. The specifics of these will be discussed in the individual valuation process of specific ecosystem services below.

Detailed analysis of four valuations methods for assessing ecosystem services

The nine Alpine-specific ESS of the Recharge.green project were valued using different kinds of economic valuation methods. The definitions of these ecosystem services and the selected methodologies used are depicted in a table, shown below in Figure 3 (taken from pg 19, Balest, *et al.*, 2015a). What is evident is that there are a number of different methodologies were used to valued different ecosystem services. Interestingly, despite intrinsic value being one of the nine ESS assessed in the Recharge.green project, a definition and methodology of valuation is not specified within this table.

TABLE 2: ALPINE ECOSYSTEM SERVICES DEFINED FOR THE RECHARGE.GREEN PROJECT

ECOSYSTEM GOOD AND SERVICE		DEFINITION ADOPTED	
Provisioning services			
Timber	Market price	Hay production	Market price
Wood for energy	Market price	Livestock	Market price
NWFP (hunting products, berries and mushrooms)	Market price		
Water provision	Market price		
Regulating services			
Protection against natural risks (direct and indirect protection)	Replacement cost method	Protection against natural risks (indirect protection)	Replacement cost method
Carbon storage (living and non-living forest biomass)	Voluntary market price	Carbon storage in living biomass	Voluntary market price
Cultural services			
Outdoor recreation (hiking, walking, pic-nicking, etc..)	Benefit transfer method	Outdoor recreation (hiking, walking, pic-nicking, etc..)	Benefit transfer method

Figure 3. Table showing the alpine ecosystem services defined for the Recharge.green project. (Taken from pg. 19, Balest, et al., 2015a).

For this thesis, four out of the nine Alpine-specific ecosystem services will be selected for detailed investigation and are listed below:

1) Provisioning services (to be assessed as an entire category to see what was included/excluded from the 'provisioning' classification)
2) Protection against natural hazards
3) Recreational values
4) Intrinsic values

Strictly speaking, provisioning services is a category and within the Recharge.green project was subdivided into two ESS, 'provisioning of forest and agricultural production' and 'provisioning of fresh or potable water', however, for this thesis, both will be analyzed together. It should also be noted that for investigating the valuation for both cultural ecosystem services, the specific details regarding valuation have been obtained from documents relating to the Veneto Pilot sites (the Mis and Maè valleys).

The aim of the investigation is to understand the practices used to value these different services and the translations that were involved during each valuation process within

the specific context of the Recharge.green project. Furthermore, it will also seek to analyze and compare the different ESS valuations methodologies and address issues regarding how commensuration was achieved. This will involve an exploration regarding the entanglement between these seemingly distinct valuation methodologies and the ways they were then made comparable to each other.

Valuation of provisioning services

Provisioning services are defined as material or energy outputs from an ecosystem – these include food products such as fish, meat and honey, or raw materials such as timber, wood for bioenergy and water (Paletto, *et al.*, 2015). For this category of ecosystem service, boundaries had to be drawn regarding what was included or excluded in the estimations of the provisioning goods or services. The following paragraphs outline how the Recharge.green partners defined this ecosystem service category and details how each of the components were monetarily valued.

The provisioning services category was firstly defined into two sub-categories: 1) provisioning of forest and agricultural production and 2) provisioning of fresh or potable water. Project partners defined forest and agricultural provisioning as:

> *"products obtained directly from ecosystems such as agricultural products, forest products and aquaculture products. If relevant, could also include extractable products (e.g. mushrooms, natural medicines, peat, etc.)"* (pg. 9, Balest, *et al.*, 2015a)

A final list of the items valued in the provisioning services category (visualized in Figure 4) contained six products: timber, wood for energy, non-wood forest products, water provision, hay production and livestock.

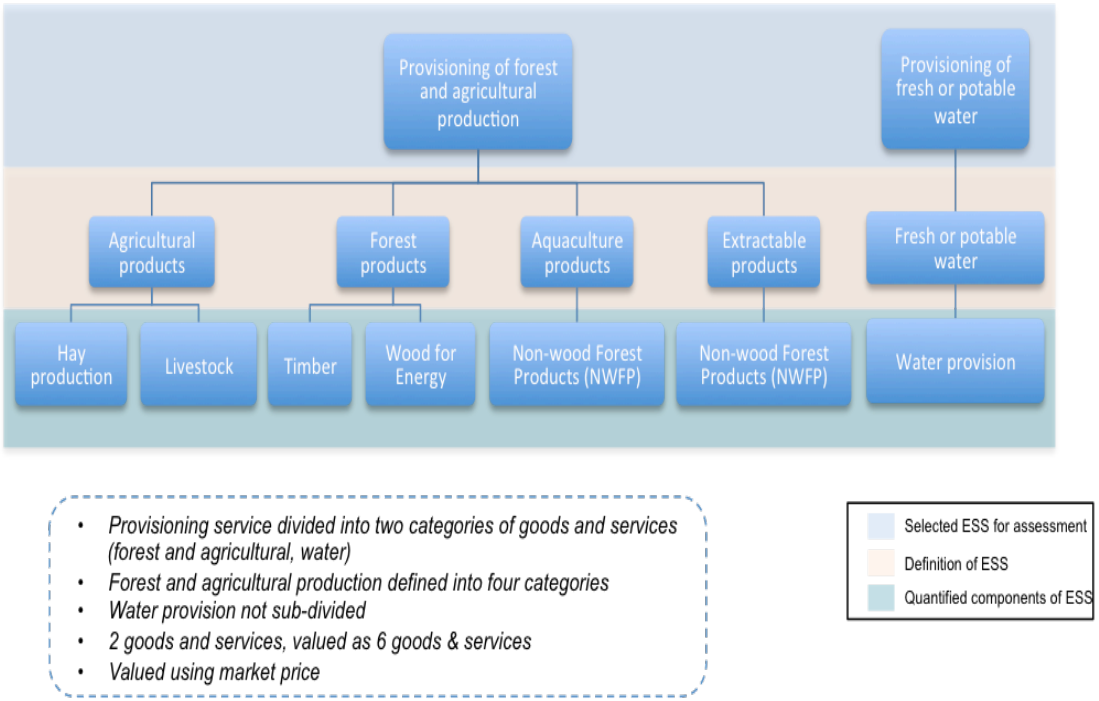

Figure 4. Provisioning services valued in the Recharge.green project. (Author's construction based on document analysis)

The economic valuation "of all benefits derived from ES [ecosystem services] have been made in reference to the 2012 year." (pg. 19; Balest, *et al*., 2015a). Timber and fuelwood production were estimated "considering the local market price and the annual harvested volume subdivided by forest types" (pg. 19; Balest *et al.*2015a). From the excerpt below, the partners do list where they obtain the information regarding prices and volume harvested for these products, however, it is unclear how 'local' the market prices being used are and the sub-division of forest types are not mentioned.

> *"Where a merchantable value could be attributed, the databases of the official related organizations where [sic] consulted (i.e. timber prices for the different essences [sic]: National Institute of Statistics ISTAT online database"* (pg. 23; Balest, *et al.*, 2015a)

The provisioning of water was valued by "considering the average annual consume [sic] of water pro capita taking into all water uses (agricultural, domestic, energetic and industrial uses) and the average price of water" (pg. 20; Balest, *et al*., 2015a). Again, what is not made explicit is how 'local' the data being used to make these calculations are.

The provisioning services supplied by grasslands were valued by estimating hay production and livestock. Hay production was evaluated using the annual hay production and local prices of hay – the same method used to value timber, where total volume and a 'local' market price were used to calculate its economic value. However, in order to value the annual livestock grazing in pasture areas, this was described simply with the following excerpt:

> *"The value of annual livestock grazing in the pasture areas was estimated taking into account the Livestock Units (LUs) per hectare and an average price for each unit."* (pg. 20; Balest, et al., 2015a)

This description does little to explain what a Livestock Unit actually is, thus the reader must either have previous knowledge of this agricultural reference unit or find out this information with additional research. According to the definition used by the European Union, one Livestock Unit is the grazing equivalent of "one adult dairy cow producing 3000kg of milk annually, without additional concentrated foodstuffs" (European Union, 2013). This reference unit is used to assess the overall effect on grazing land of different types of animals, with a specific coefficient assigned to various species and

ages of livestock based on their feed requirements in comparison to an adult dairy cow. For example, a dairy cow has a coefficient of 1.000 whilst goats have a coefficient of 0.1000 (European Union, 2013). "Livestock Units per hectare" are known as stocking rates and are a way in which the grazing of different farm animals provides an indication of the total forage yield in pastures (DEFRA, 2011). As the Recharge.green reports do not clarify nor provide any citation referring to what a Livestock Unit actually is, there are many transformations that are not made visible. While this lack of clarification already imposes a certain degree of opaqueness regarding how the valuation was done, the use of the Livestock Unit itself is a clear example of a black box as the reference unit and subsequent coefficients for different livestock are theoretical estimates. These are standardized values obtained through a range of calculations and approximation that are not specific to the Pilot sites involved. Coefficients for different livestock will differ depending on regions (e.g. Livestock Unit ratios are different for livestock in tropical regions compared to temperate regions) as factors such as the type of plant used for grazing, the land management practices and the inputs with the land are. This brings about the question regarding how representative of the 'local' conditions the selected reference and coefficient units used to estimate this provisioning service are – a question that has arisen often in the calculation of the economic value for products within the provisioning services category. By failing to reference what data sets for Livestock Units are being used in the calculation present in the reports (as well as for timber, water, and other services being valued in this category), this further obfuscates the transformations and calculations that had occurred in order to obtain the final monetary value and highlights the this tension that exists between the claims of valuing ecosystem services for a specific area/region whilst needing to rely on the use of non-local data.

The final sub-category valued in the provisioning services was the non-wood forest products. The final components valued in this sub-category were estimated by "considering the main products supplied by Alpine forests" (pg. 20; Balest, *et al.*, 2015a) and consisted of hunting products, berries, mushrooms and truffles (breakdown of components depicted in Figure 5). Valuation of these products was described in the report as follows:

> *"The value of hunting products was calculated from the data of annual animals hunted (ungulates, other mammals and birds). Three components of animal were considered, especially meat for all comestible animals, skin for all ungulates, and trophy only for the male of ungulates (e.g. red deer,*

roe deer and chamois). The quantity of berries and mushrooms collected were accounted taking into account the local household." (pg. 20; Balest, et al., 2015a)

Here they provide specific details regarding which hunting products are valued as well as for which animals are included. The report also stated that for berries, only bilberries and raspberries were included and that for mushroom provisioning, they used a methodology developed by the Italian Institute for Environmental Protection which only considered certain *Corine* species. In addition to the constraint of measuring provision of only certain mushroom species, the methodology also took into consideration the land slope, and distance from roads in order to measure the accessibility for mushrooms (Balest, *et al.*, 2015a). What is evident here in valuing non-wood forest products is that each of the four categories (i.e. hunting, berries, mushrooms and truffles) had to be clearly defined prior to being valued. Decisions would have been made to decide what would be classified as falling under these categories – thus there was the need to create distinctions, distinctions that were performed by the project partners within the particular context of what was considered as products pertaining to Alpine forests.

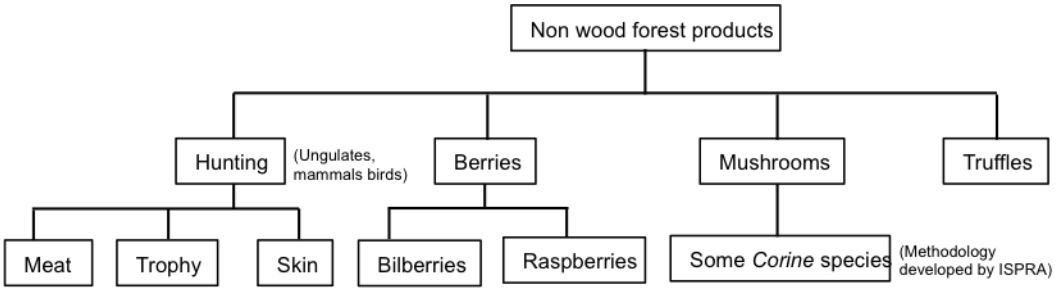

Figure 5. Components of non-wood forest products used for economic valuation as part of the provisioning services evaluation in the Recharge.green project. (Author's construction based on document analysis)

Summary:

For some of the products within this category (e.g. timber, water, wood for energy and hay) economic valuation required the total volume harvested/consumed and the market price in order to calculate a monetary value. While this appears as a rather straightforward method to value the products, the reports provide no information for what is meant by 'local data'. Given that how the partners choose to construct their definition of 'local market price' involves a degree of translation by not being clear whether the data used to make these calculations are specific to the Pilot sites, or are rough estimations using regional/national sources, it highlights a level of black-boxing

as it is not made visible how exactly the value for provisioning services is calculated specific for each pilot site. The valuation methodology to calculate how livestock impacts on grasslands requires additional complexity, with the need to employ a standardized reference unit (proposed by governmental bodies) to estimate how different animals graze. Clearly calculating the precise amount of grassland used to feed the livestock in the specific pilot sites is not a realistic requirement and therefore a pre-determined standardized unit was used - however, this is therefore a clear example whereby non-local data is again used to approximate value for quite specific areas. From these examples, there is a tension between the claim to measure value of these services at a local level, whilst clearly requiring the use of non-local data to approximate the value. One must then question how accurate and specific to a region this method of economic valuation can be considered. Furthermore, the implications of relying on non-local data in assessing economic value for a specific region is that its value can also potentially be drastically under- or over-valued, which in turn can skew assessments further down the line that require the need for these economic values to assess trade-off or conflicts with other ecosystem services.

For the valuation of non-wood forest products, distinctions were necessary in order to decide what products would be included for valuation. However, at the same time, this methodology did also need to rely on estimations (e.g. how many berries and mushrooms were foraged), as it would not be feasible to truly know how much of each product was removed from forests. Thus, in addition to devising boundaries as to what would be included for valuation, local data records can really only be approximations as they can only be as good as what locals are willing to report. Another example for the need to employ estimation was for estimating the value of foraged mushrooms and berries, where landscape features and the presence of certain plant species in forest were added constraints incorporated into the methodology (and therefore not relying purely on reported foraged amounts from records).

Within the methodology used to value the provisioning services category, it was necessary to employ a breakdown of 'wholes'. Ultimately, this ecosystem service category was valued using six sub-categories and within each of these sub-categories, there was also the need for additional breaking down of wholes (e.g. non-wood products consisted of seven components for valuation). Each product had to be specifically defined in order to know what was actually being valued. Thus, in addition to the breakdown of wholes, what was also evident was the need to specify what was and was

not included in provisioning services, akin to what Altvater (1993) has described as "the splitting of complex ecosystems which simplified them into legally definable and economically tradeable property rights" (pg. 185). In order to calculate a monetary value for provisioning services, there was a need to make explicit what products were included in the calculation - this required decisions regarding inclusions (and consequently, exclusions) from this category – essentially a question of constructing boundaries. One must then be mindful that these boundaries defined here by Recharge.green partners, essentially constructs an abstract space that now defines what is to be considered as a 'provisioning service' in the context of this project. The products included for valuation in this ecosystem service could have been otherwise, therefore the final list of products used can be considered a performativity of what Recharge.green partners considers a provisioning service in the context of renewable energy expansion in the Alps.

While the reports do state how spatial data - such as land slope and distance from roads – was used to measure accessibility of mushrooms, there is little information provided regarding how many of the other provisioning services products were mapped. For example, the reports have no mention regarding the scale or level of detail used with which to spatially map the distribution of provisioning services such as water, hay, or timber. Thus, in addition to the lack of clarification regarding the use of 'local' data, the resolution of how many of the components of the provisioning service category was spatially mapped is also black boxed. From the information available from the document analysis and interview, it is not at all made visible what components are mapped and there are no maps providing examples of how any of the items listed in the provisioning services category is made spatial explicit. Thus, this can be considered to be a black-boxing event by the Recharge.green partners as readers of these reports are not shown how the transformation from collected data to spatialized maps is done – one cannot see the messy processes involved in how these ecosystem services were mapped. Often in cases of black boxes the only parts visible are the inputs and outputs – in this instance, even the output (i.e. the maps showing how provisioning services are spatialized) is not made visible to the readers of the report.

Valuation of protection against hazards

Regulating services are the benefits that are due to the regulation of ecosystem processes. Out of the nine Alpine specific ecosystem services assessed by the Recharge.green project, four of them fall into this category – one of them being

protection against hazards. Ecosystem services in the regulating and maintenance category are not typically sold or bought in markets (although, the development of carbon trading is one example where a market has been developed to trade natural products) and thus people do not pay for these services directly. Valuing of services in this category usually employs an indirect method to estimate their value – known as replacement cost method or shadow pricing (DEFRA, 2007).

Natural hazards protection is considered a key function of Alpine forest and are evaluated with respect to protection from avalanches, landslides, erosion, mudflow, rock falls or floods (Balest, *et al*., 2015b). When applying the replacement cost method, the approach "assesses the cost incurred by replacing ecosystem services with artificial substitutes" (pg. 20; Balest, *et al*., 2015a).

> *"Generally the artificial substitutes are choice [sic] considering type and degree of protection. In this study, the costs for replacing hydrogeological protection with artificial substitutes were considered distinguishing between direct and indirect protection"* (pg. 20; Balest, *et al*., 2015a)

This description indicates that there is a 'degree of protection' assigned to sites, however how this is decided or the ways it has been assigned are not mentioned in the reports. Searching through a cited reference – Notaro and Paletto, 2012, one will learn that the protection score is calculated using forest data obtained from forest management plans, however how this is calculated is not elaborated on. What this does indicate is that there is a transformation whereby ecological and topographical data is translated into a protection score along this valuation process.

While the Recharge.green partners do differentiate what is meant between 'indirect' and 'direct' protection, there are no examples of the types of artificial substitutes that are selected mentioned within the reports. In the end, to achieve an economic value, the total costs of maintaining the different artificial substitutes was "taken into account to calculate an annual cost per unit area (hectare)" with each pilot site having different artificial substitutes chosen "based on the site characteristics and levels of protection" (pg. 20; Balest, *et al*., 2015). Again, how the costs are calculated are not detailed in the reports, and it is only through further investigation for information (that was not cited in the reports) that it is mentioned in an article published in relation to the Recharge.green project. Replacement costs for protection of natural hazards were calculated using the following formula:

$$A = \frac{C \cdot r}{(1+r)^t} + M$$

where A= the annuity, C= total setting up costs (€), r= the environmental discounting rate (%), t= the lifetime (number of years) and M= the maintenance costs (€) (Paletto, *et al.*, 2015). Given that the report provides formulas for how other regulating ecosystem services was calculated, it should have also been possible to provide additional information for how natural hazards were valued. Clearly this valuation involves the use of calculations that black boxes certain steps, and by not providing this information in the reports further obscures how the final economic costs were obtained.

What is apparent when assessing this valuation is that the methodology uses collected ecological and physical data and eventually translates it into economic data (see Figure 6). Firstly, extensive ecological and physical data of the region being evaluated has to be obtained. Examples of the types of data needed included: species of trees present, the slope of the land, soil organic matter and soil depth (Notaro and Paletto, 2012). Detailed forest plans are necessary for these assessments and thus the level of information available from the data can be an influencing factor in how accurate an assessment can be made. While the Recharge.green project partners selected pilot sites that had "high compliance, good data" (interview with lead partner, 26th Jan 2017), information bias and misspecification bias are common issues that are encountered when valuing these ecosystem functions. Once a protection score is calculated using forest data, a hypothesized man-made structure must be suggested for the appropriate level of protection. Finally, estimating the maintenance cost for the chosen artificial substitute is calculated in order to obtain a monetary figure (Notaro and Paletto, 2012).

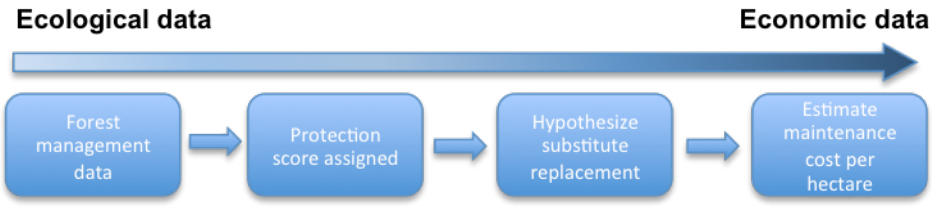

Figure 6. Translations involved when applying the replacement cost method. (Author's construction based on document analysis)

Regarding how regulating services were spatially mapped was described in the Recharge.green report simply as follows:

> *"The regulating services value of forests was mapped assigning a value per forest type. The value of indirect protection against natural risks was assigned taking into account type and level of protection*." (pg. 21; Balest*, et al*., 2015a)

This description provides little information regarding how the regulating services were assigned a value per forest type, nor do they mention how forest types are subdivided. Furthermore, following on from the excerpts about how this ESS was economically valued, there still remains little elaboration regarding what is actually meant by 'levels of protection'. From the description, one assumes that the resolution is based on one forest being assigned a single value – however it is difficult to know based purely from what is written in the reports.

Clearly, there are limitations with this methodology of economic valuation. Firstly, specifying compatible man-made substitutes is a difficult task, and being theoretical (i.e. there may be no intention to actually building this man-made structure), it is not always a true substitute. It has been acknowledged that estimating and measuring these services are not straightforward and often they are under-valued as they also contribute indirectly to other ecosystem services (Notaro and Paletto, 2012). However, this method is often used for economic valuation as obtaining information for the cost of artificial substitutes is easier and less time-consuming than other valuation techniques. Within the Recharge.green project, there were limitations with what could be done with the time and money allocated, as well as having to spread the workload over six pilot sites instead of more detailed analysis on fewer sites. Thus, it is possible that the replacement cost method was selected for its ease in application for economic valuation.

Regarding the replacement cost method for valuing hazard protection, enactment occurs in a very literal sense as the method involves selecting a man-made structure to fulfill the role of a naturally-occurring function. Given the regulatory ecosystem services often have multiple functions, the degree to which the selected man-made structure is able to 'replace' the functions of the ecosystem service is likely to be impacted on extraneous factors such as time and monetary constraints. Thus, depending on what specific constraints are applied (i.e. where the boundaries are drawn regarding what constitutes 'natural hazard protection'), the valuation for this ecosystem service can indeed vary and therefore enact different realities.

Valuation of recreational values

Cultural ecosystem services supplied by forests are defined by the European Union as non-material benefits people obtain through spiritual enrichment, cognitive development, recreation and aesthetic experience (Maes, *et al.,* 2012). The recreational values considered in the Recharge.green project in relation to forest recreation included activities such as walking/hiking, picnicking, jogging and landscape viewing and was evaluated using the Benefit Transfer (BT) method (Balest, *et al*., 2015a). This methodology involves using results (i.e. economic value estimates) of surveys undertaken at 'study sites' and then transferring them to a similar unstudied site (known as the 'policy site') (Rosenberger and Loomis, 2001). It is important to note here that the premise of this methodology is based on using non-local data as a starting point for the valuation as there is no local data at hand. While the practical and logistical reasons for doing this are often that there is no data available for the proposed site to be valued or that obtaining such required information would be too time-consuming or require more resources than are available, this is another example where non-local data is being used to value a specific site in economic terms. This therefore raises the question of how accurate or site-specific these valuation methods (and in this case, the benefit transfer method) truly are.

The methodology selected by Recharge.green partners to calculate this transference of economic value was the 'average value transfer' method, which was described in their report as follows:

> *"The average value transfer method uses a measure of central tendency of all subsets of relevant studies as the transfer measure for the policy site issue. In this study, we used the method of average value transfer choosing study sites as much similar as possible to the policy site (i.e. mountain forests in Europe).* (pg. 21; Balest, *et al.*, 2015a)

There is further mention of a "meta-analysis" being done and final statement that outdoor recreational values were estimated and transferred "according to forest types (mixed forests, pure conifer forests and pure broadleaves forests) and altitude (above and below 1,000m a.s.l.)" (pg.21, Balest, *et al.*, 2015a).

To a reader unfamiliar with the Benefit Transfer method, there are a number of components of the evaluation process from this description that are black-boxed. Firstly, there is no reasoning or rationale provided as to why recreation is transferred

according to forest type and altitude. While the reasoning is provided in a cited reference – the reason being "because they are related to the tourist attractiveness of an area" (pg. 164; Paletto, *et al*., 2015) – this could have been easily included in the Recharge.green reports to provide some additional clarification. Secondly, there is no elaboration regarding what is actually involved in the average transfer methodology. This is in fact a seven-step process according to Rosenberger and Loomis (2001), outlined in their publication as follows:

1. Identify the resources affected by the proposed action
2. Translate resource impacts to changes in recreational use
3. Measure recreation use changes
4. Identify relevant study sites from the literature
5. Assess relevance and applicability of study site data
6. Find the average value of subset of study measures (meta analysis)
7. Multiply benefit measure by total change in recreation use

Looking at this seven-step process, there are clearly numerous translations occurring when calculating the 'average value transfer' - step 2 even states translation as part of the process explicitly. Assuming the Recharge.green partners did follow the Rosenberger and Loomis seven step process – which is difficult to ascertain from the purely from the documents – then the first three steps of 1) identifying affected resources, 2) translating impacts into changes in recreational use and then 3) measuring recreation use changes, would all have involved elements of boundary-making and performativity – all of which are made invisible to the reader. Thus, in order to understand how recreation was valued in Recharge.green, one would also need to ask 'what sorts of resources were identified?' and related to that, 'what criteria was used in order to identify these resources?'. Furthermore, without knowing the Recharge.green definition of 'recreational use', it is impossible to know how the translation from resource impacts to recreational use occurred – what 'units' were used to measure recreation use changes? The lack of elaboration for what a 'meta-analysis' actually involves, conceals the fact that this itself is a multi-step process whereby data from numerous studies are statistically analyzed prior to being translated into a single monetary value for recreation (Grilli, *et al.*, 2014). How these studies were collated and analyzed would clearly impact on the final value calculated – but without any information available, this is made invisible to readers of the documents. Clearly, there are many questions that remain unanswered regarding how recreation was valued in the project using the 'average value transfer' method. It highlights a limitation when

using document analysis as a main analytical method as many of these black-boxes are unable to be opened when analyzing only finalized reports. Many of the translations and transformations involved during the data gathering and compiling of the data sets (e.g. for the meta-analysis) are not made explicit in the documents. Furthermore, additional details were not obtained in the interview with the lead partner as he was not directly involved in the valuation process of this specific ecosystem service. Thus several questions remain unanswered regarding what exactly was being valued as 'recreation' in the Recharge.green project using the documents selected for analysis.

Additionally, for the Veneto Pilot sites, fishing was also included as a recreational service. The reports described the valuation of fishing as a recreational ecosystem service as follows:

> *"The basis is the fish map provided by the Province of Belluno, where the streams are classified considering their usability in fishing activities. A numeric value was given to each of these classes and then translated into a qualitative index of "sporty value", from "null" to "very high".* (pg. 23; Balest, *et al.*, 2015a)

While it is stated that streams are classified based on the level of fishing activities taking place, the range of this numeric scale is unknown and not mentioned within the documents. Furthermore, there is no basis provided regarding how the classification for the level of fishing activities was performed – was 'usability' based on number of people fishing at the streams? Or was it based on amount of fish caught in streams or assessed using user surveys? It could be based on something entirely different, however this is something that cannot be determined from the documents selected as this single sentence above is the only description provided. With little information about how streams were classified - and by whom - there is also no explanation provided as to why there was the need to translate the numeric value into the qualitative index of "sporty value". How this translation occurs – as well as why it is necessary - is unclear and thus becomes another black box where the processes of valuation are hidden.

Valuation of intrinsic values

Intrinsic value was one of the three ecosystem services within the 'Cultural services' category to be valued in the Recharge.green project. The definition used by the Recharge.green partners - elaborated from definitions provided by the Millennium Ecosystem Assessment and the European Environment Agency – is as follows:

> *"Value of ensuring the particular character of an ecosystem for future generations*" (pg. 9; Balest*, et al.*, 2015a)

Classified as a 'non-use value', valuation of intrinsic value often requires a more qualitative approach, typically involving asking people to explain or discuss why they behave in a particular way or hold a particular point of view. Value is subsequently assessed from these discussions and/or surveys (DEFRA, 2007).

To assess the intrinsic value at the Veneto Pilot sites, the Recharge.green reports did not explicitly state a methodology, thus it should be noted that the process for intrinsic value assessment described here has been compiled by analyzing the various reported activities pertaining to the Mis and Maè valley published by Recharge.green. As part of this process, stakeholders were selected from the two valleys and invited to participate in round table events held 4-5 weeks apart (separate round table events were held for each valley). Given the selection of stakeholders invited to participate at these events can influence the outcomes of the valuation process, the Recharge.green partners did a stakeholder analysis that was "aimed at identifying and classifying the stakeholders in order to determine the extent of their future involvement in the decision-making process" (pg. 19; Balest, *et al*., 2015b).

> *"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)."* (pg. 19; Balest*, et al.*, 2015b)

From the reports, stakeholders were classified either as being "key", "primary" or "secondary" and while there is mention that "the stakeholders were also analysed from the relational point of view using the social network analysis (SNA) approach" (pg. 19; Balest, *et al*., 2015b), the methodology employed in the SNA approach used to classify the stakeholders into the categories is not detailed. Additionally, the report does not provide details of the final selection of stakeholders. Not providing details of stakeholder classification could indeed be due to privacy issues, what is provided in the report regarding selection of stakeholders is as follows:

> *"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….Stakeholders – identified through the*

> *stakeholder analysis and classified using the SNA approach – were invited to participate actively in the last step of the process (roundtables).”* (pg. 19; Balest, *et al.*, 2015b)

Thus, while the roundtable reports (Zangrando, *et* al., 2015) do state how many stakeholders were involved (30 from the Mis valley and 38 from the Maè valley) as well as the category that the selected stakeholders belonged to (e.g. local administration, environmental associations, sport/recreational associations, citizens, etc.), it is not mentioned how stakeholders have been classified. The selection process of stakeholders is thus not transparent and there remain some unanswered questions, such as: How many key stakeholders were invited? Were there more primary stakeholders than secondary stakeholders? Were the ‘experts’ who did the analysis for stakeholder selection local and have knowledge of the pilot regions? Clearly, stakeholder selection can be very influential in the outcomes of participatory event, and even the final Recharge.green report acknowledges “the exclusion of relevant stakeholders may compromise the process, delegitimizes the decisions taken and increase conflicts between interest groups” (pg. 19; Balest, *et al*., 2015b). However, the lack of clarification of how this process of selection was achieves, obscures possibly important decisions that could ultimately influence the outcomes of these stakeholder events.

In the first meeting, they were shown the results of the energy scenarios Recharge.green partners had generated using modeling and spatial mapping. These scenarios shown to the stakeholders were a “first hypothesis of use of water and wood resources, analyzed by the DSS in a scientific and objective way” (pg. 3, Zangrando, *et al*., 2015). The input obtained from the stakeholders following this was described as follows:

> *“Participants were then provided of [sic] some material, consisting of A3 format maps, and were asked to contribute, starting from their personal knowledge, adding or revising information”* (pg. 5; Zangrando, *et al*., 2015)

The second meeting, was “focused on ensuring a “synthesis of the valley”” (pg. 5; Zangrando, *et al.*, 2015) and involved collection of stakeholder feedback in the form of a questionnaire:

> *“In confirmation of the importance that the anthropological dimension assumes in the assessment of ecosystem services, participants were asked to rank in order of importance (1= extremely important and 7= least important) the values present in their valley, referring to their own experience, perceptions and preferences through a questionnaire”* (pg 5; Zangrando, *et al*., 2015)

The seven values they were asked to rank were: environmental value, economic value, touristic and recreational value, social value, emotional-sentimental value ("Family"), historical and cultural value, aesthetic and landscape value. The questionnaire results were then translated into a pie graph and bar chart (shown below, Figure 7). An explanation for how these graphs were obtained was described as follows:

> *"The results obtained by the questionnaires delivered to the stakeholders correspond to ordinal values, and not to cardinal numbers, in fact, the score expresses an order of preference/importance. In order to sort the ecosystem values of the two valleys, the correct method would refer to the values of mode and median. However, because of the available population of respondents is restricted, there could be matching values for different values or it could not be possible to achieve, for example, a value for each class. To overcome these problems, it was decided to calculate the percentage of people who have attributed a certain class to each value, pondering the classification on the number of people who have expressed these values"* (pg 9; Zangrando, *et al*., 2015)

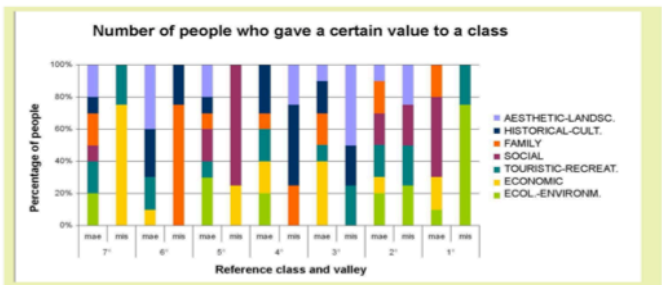

Figure 2: number of people (in percentage) who gave a certain value to a class. Every single element composing the histogram (the different colour represent a specific value) represents the % of people that gave a certain value to that class.

[4] Given a set of data, the **mode** is the value that appears most often. The **median** is the number that occupies the central position in an ordered set of data. The **mean** is the sum of a list of values divided by the number of values in the list.

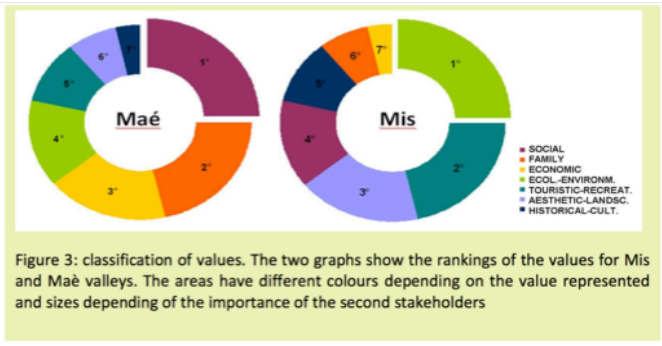

Figure 3: classification of values. The two graphs show the rankings of the values for Mis and Maè valleys. The areas have different colours depending on the value represented and sizes depending of the importance of the second stakeholders

Figure 7. Stakeholder survey results translated into bar and pie charts. (Taken from Zangrando, et al., 2015; pg. 9 & 10)

While the authors do state that percentages are being depicted in the graphs, and also provide their rationale for this decision, the statement referring to "pondering the

classification on the number of people who have expressed these values" either is a rather poor choice of words or a very vague explanation as to how the classification was performed in the end.

Looking at what is shown in the graphs in Figure 7, the bar graph (top) depicts how each of the seven values were ranked by the stakeholders and the percentage of them giving each value a specific ranking. Results from the two valleys are displayed separately in order that the differences in the preferences can be visualized. The pie charts in Figure 7 (bottom) supposedly summarize the results of the survey rankings – it shows that from the rankings, the Maè valley stakeholders have "social" as their most important value, whilst for the Mis valley stakeholders put "environmental" value as their top priority. The accompanying text to describe how the calculations were performed was as follows:

> *"The calculation sorted the values in descending order, starting with the most important ones: we considered which values were indicated by most of the respondents in the first three classes, then in the first two and then in the first class (excellence). Comparing these rankings with those resulting from the analysis of mode, median and average for each type of value, it was possible to obtain the final results for the valley. This method considers separately two terms having apparently the same value, and then compares them referring to other variables for determining the priority/weight.*" (pg. 10; Zangrando, *et al*., 2015)

This same figure was shown on pg. 83 of Balest, *et al.* (2015b) and was only described with the quote below, indicating that:

> *"The two graphs show the ranking 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*" (pg. 83, Balest, *et al.*, 2015b)

From the description provided by Zangrando and colleagues (2015), it is not exactly clear how the analysis of the ranking was done, particularly regarding the "other variables" that were used to determine priority and weight. Nevertheless, there is at least an attempt to describe the analytical aspect, which is more than can be said for what was reported in the final results (as shown in Balest, *et al*., 2015).

Following the participatory events held in the Mis and Maè valleys, the results obtained from the mapping exercises and questionnaires were combined to generate a new set of input data for the Decision Support System, which in turn was

then used to map the intrinsic value of the regions. The quote below describes how this was done:

> *"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."* (pg. 83; Balest, *et al.*, 2015b)

What is unclear from the description is how the questionnaire results were actually incorporated spatially. They mention that three values in particular (i.e. emotional-sentimental, historical-cultural, and social values) were used to produce a map, however there is no mention of how percentages of stakeholder preference is translated into a spatial map of the region. This is another example of black-boxing and also highlights a limitation when document analysis is the primary form of research.

What is evident in the valuation of intrinsic value is that there different types of data that need to be combined, requiring translations of the information during the valuation process. In the first round table, stakeholders are shown the optimal energy scenarios generated by the project partners using the decision support system. Here, a device has generated an outcome based on the data obtained (such as ecological data, costs, land variables). It should also be noted that these scenarios also incorporated the results from an experts interviews and questionnaires performed near the start of the project. During that same meeting, stakeholders were provided with some A3 maps in order to provide their own information based on their personal knowledge. So what we have in the first meeting is the combination of expert assessments for the Pilot sites with the input from the local inhabitants based on their personal experiences. Both required materials and devices to present their information: the Recharge.green partners had results of the DSS obtained through lots of data input and several different parameters to generate a result, and the stakeholders were given A3 blank maps and pens to provide new elements to be considered in the analysis. Given the differences between the two valleys in how they ranked the same seven values, it does highlight the importance of local stakeholder involvement for the valuation of a particular region.

Callon (1986a) wrote, "to translate is to displace…but to translate is also to express in one's own language what others say and want" (pg. 223). The practices involved in valuing intrinsic value at the Veneto Pilot site required the translation of stakeholder

thoughts and experiences – something initially intangible and hard to measure - into a format (i.e. language) that the Recharge.green partners are able to more tangibly work with (i.e. a module in the r.green DSS program). Ultimately, the results the intrinsic values were mapped spatially by generating new input data for an additional model in the scenarios – a 'recommended' scenario – in which areas were defined as excluded from the production of energy due to its intrinsic value. A summary of the translation involved in valuing intrinsic value in the Veneto Pilot site is shown in Figure 8.

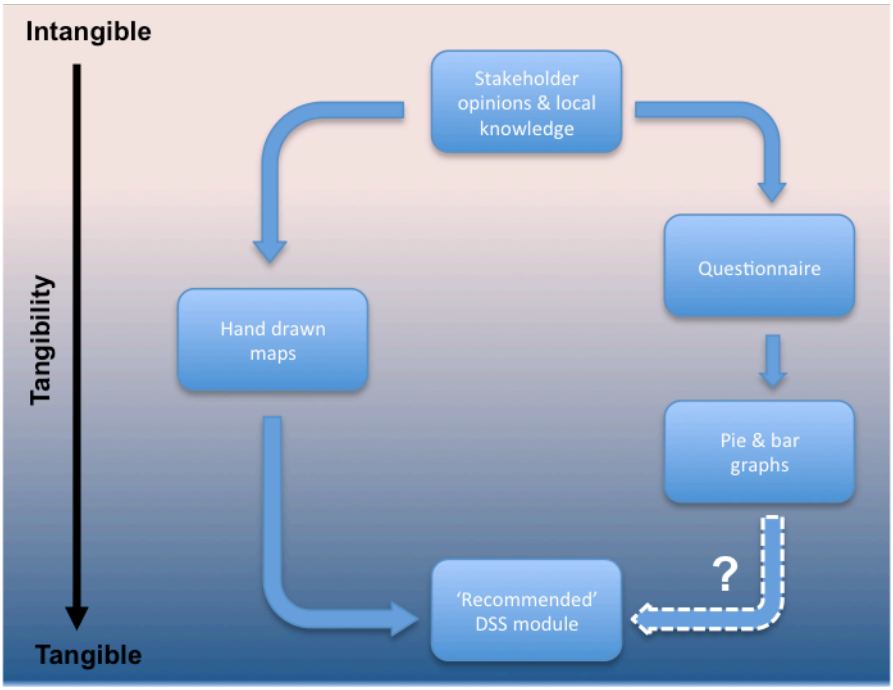

Figure 8. Translations involved in valuing intrinsic value during the roundtable events at the Veneto Pilot site. The white-dotted arrow indicates uncertainty in how questionnaire results were used to generate spatial map of 'intrinsic' value. (Author's construction based on document analysis)

The role of instruments and devices in measuring and mapping nature

From an ANT lens, while attention is paid to the processes of translation, it also considers the role that materials and instruments - that facilitate representation and communication and thus allows the transferring of information from one form to another. Using document analysis presented limitations regarding finding out explicit details regarding how information (and also in what form this information was) was transferring when measuring and mapping of ecosystem services. However, the r.green DSS was one device that was an integral part of the Recharge.green project for spatial mapping of ecosystem services and also played a role in the evaluation process.

Latour and Woolgar (1986) have argued that particular realities are constructed by their specific inscription devices and practices. The role of the DSS in the decision-making process can certainly be argued as having a large role in constructing particular realities of the project outcomes. Firstly, in terms of how ordering was evident in the development and implementation of the DSS, the data input required for generating scenarios required both mandatory and optional input data. This is a clear example of ordering as the mandatory data (examples include forest management and treatment, ordinary and forest road network and water network) has been given a higher ranking of importance in the scenario generation than the optional data (examples include soil data, lakes, protected areas and fire risk). Furthermore, with the optional data input, there is a choice available regarding whether to include certain information for the decision-making – this therefore makes certain values visible whilst others may remain invisible. While the reports do not detail which optional data is included in the various DSS modules, they do state "the more complete and accurate the list of provided variables, the more specific and precise are the results" (pg. 42, Balest, *et al*., 2015b). The choices made by Recharge.green partners involved in the DSS design and implementation therefore also can enforce a certain level of agency as they have the power to decide whether or not to use certain data or not. How the DSS designers dealt with problematic data is described in the final report as follows:

> *"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 meta-data* [the information that describes the data] *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" (pg. 58; Balest, et al., 2015b)*

From this excerpt it is stated that the input data for the DSS is adjusted and fine-tuned for the model – thus the DSS designer has the power to manipulate data to suit the purposes of the model. How this is done is another black box as there are no details as to how this is done. Furthermore, with the designers having the discretion to decide whether or not to trash certain data, there is clearly agency here as what data they choose to use or not (not to mention how they also adjust and re-tuned the data) will potentially influence the scenarios being generated.

Additionally, there is an added layer of ordering also evident in the sub-modules within the DSS. The five sub-modules (theoretical, legal, recommended, technical and

economic) are not independent of each other but rather create hierarchy for the information input (as shown in the schematic in Figure 9). Each subsequent sub-module after the theoretical layer thus adds further constraints to regions that are available for renewable energy sites. As depicted in Figure 9, while the theoretical sub-module considers 'resource availability and physical variables', the legal and/or "recommended" sub-modules adds the legal and planning constraints on top of the areas that are theoretically available – this is explained in the schematic with "Theo + L/R".

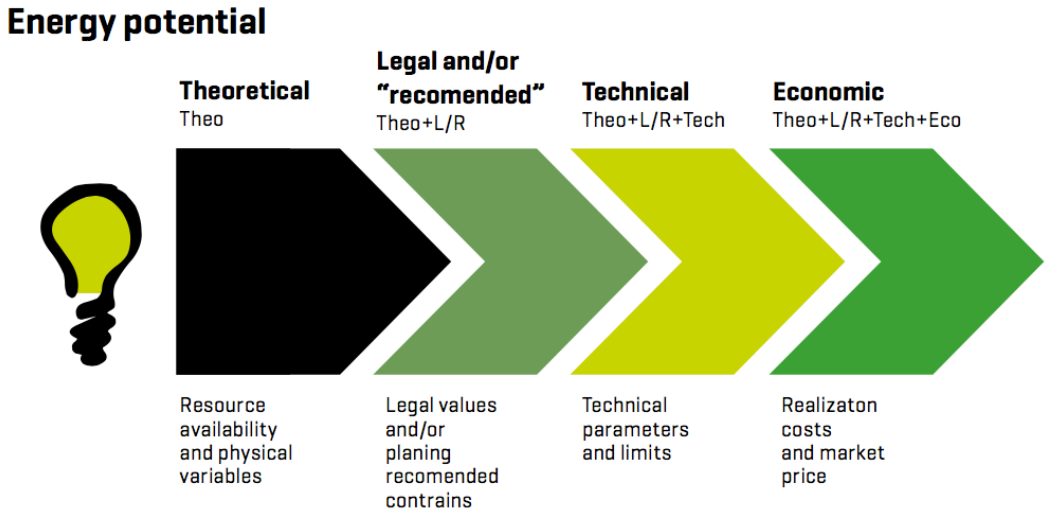

Figure 9. The sub-modules of r.green to assess energy potential. (Taken from pg. 42, Balest, et al., 2015b).

Using document analysis, we see evidence of ordering and ranking of input information as well as an ordering that was implemented within the DSS design (i.e. through the sub-modules). This has certainly provided some insight into the evaluation process that was used to assist in the decision-making regarding renewable energy siting as well as shed light onto the relations between different types of information used to evaluate the energy potential at the pilot sites. Comparing the mandatory and optional input data, it becomes evident that logistical data such as road networks (one of the mandatory inputs) has been given a higher importance than ecological data such as soil information (which is an optional input for the DSS).

At this point, it is interesting to contrast the formal Recharge.green reports about the DSS with what was described in the public relations material (i.e. the perpetual calendar). In the calendar, the DSS are said to be "needed for decision-makers and stakeholders to better understand complex system interactions so that they can make

balanced decisions". Described further in the calendar, the DSS is said to be a tool "that permits politicians and energy producers to make sensible decisions in economic and ecological terms in order to enable optimum land use." Based on the description of the DSS as stated in the calendar, it appears that this tool is indispensible to the decision process. This claim does seem to be supported by the formal reports as the DSS is described as being is an important tool that was developed as part of the project aims in order to spatially map ecosystem service values. However, what is particularly interesting from the comparison between what is written in the formal reports to that of the public relations material, is the description of what aspects the DSS places specific importance on for the decision making process. In the perpetual calendar, the two predominant factors singled out are the 'economic' and 'ecological' aspects. The importance of the economic factor is evident in the formal reports as this is the final constraint of the DSS (see Figure 9) and therefore, in a sense, it is the deciding factor for which sites can be considered for renewable energy siting options. Interpreting the schematic, one would assume that regardless of if a particular site is amenable to renewable energy production based on theoretical, legal and technical parameters, if it costs too much, the site be deemed unsuitable. However, what is far less visible in the formal reports (as opposed to what is claimed in the perpetual calendar) is how the ecological aspect even features within the DSS design. There are no parameters pertaining to biodiversity aspects such as animal and plant species, and even what little aspects of ecological data that is taken into consideration (e.g. such as soil data) is considered to only be optional input data. This highlights a discrepancy between the two types of documents in how information is portrayed. It makes a point of how documents communicate through their representations and language and have the power to specify desired connections (in the case of the calendar, to highlight the importance of biodiversity and ecology despite this not being so strongly confirmed in formal reports) as well as to make certain aspects visible over other aspects.

The role of the DSS in spatially mapping ecosystem services was seen as an important aspect in helping to visualize the impacts that renewable energy expansion can have on the different ecosystem services. However, one aspect of the mapping process that was not very detailed in the reports was the resolution of the spatial mapping of the different ecosystems. When the lead partner was queried about it, the reply was:

> *"They did try to map the ecosystem services but in the end it just turned out to be too complicated….so what they did was they used a sort of proxy….the high biodiversity areas and that*

were protected were excluded on a scale from ah, either totally excluded or partially excluded so to make the model easier" (Interview, 26th Jan 2017)

Thus, there does appear to be varying levels of resolution for the different ecosystem services, however without additional research resources (it may require interviews with those who were responsible for the mapping), it is difficult to comment precisely about the resolution of how each ecosystem was mapped. From the discussion with the lead partner, it appears that resolution for ecosystem mapping may have needed to be decreased in instances where there was insufficient data. No details were provided as to which datasets these refer to as he was not directly involved in the DSS design process. As such, further comment about this cannot be made regarding this issue using the information at hand. In questioning the lead partner about the mapping resolution, it is interesting that it does appear that biodiversity areas were taken into consideration as part of the DSS design process. This was not as evident when looking at the formal documents as there is no mention of biodiversity and how it is taken into account in the sub-modules that were used within the DSS. It is therefore possible that these aspects were made invisible during the process of simplifying the model.

In assessing how the r.green DSS was designed and implemented in the project, we can see evidence of the ways in which social preferences of its designers has the ability to influence the outcomes and functioning of the device itself. Examples of this include the use of mandatory and optional input data sets as well as the hierarchical ordering in the DSS sub-modules. These orderings and preferences that have been decided and set by the DSS designers can be said to enforce a certain trajectory of the outcomes that can be potentially produced. However, using an ANT approach, one could also argue that this delegation does not occur in one direction. In 'Technology is society made durable', Latour (1992) uses examples such as the large metal weight attached to hotel keys to show that technology also has ways in which to create certain effects and enforce a particular action on people. Applying ANT's heterogeneity of networks, an argument can be made that whilst the DSS may generate scenarios dependent on the orderings that were pre-set by the designers, it can also be said that the scenarios generated by the DSS have the power to dictate where renewable energy sites are built.

Returning here to Latour and Woolgar's (1986) argument that particular realities are constructed by their specific inscription devices and practices, certainly we can see how both the design of the DSS as well as how it was implemented could have played a role

in the realities that eventuated within the project. This argument can be extended further to and draw on Mol's (2002) discussion about ontological multiplicities. In designing the DSS, it can be said that it has been crafted into a specific arrangement and gathering in order to enact a particular reality, however, these arrangements could have been otherwise – had there been no optional input data or a different assignation of what was mandatory and optional, it is highly likely that different scenarios would have been generated by the DSS. Similarly, the ordering of the hierarchical sub-modules – had these been different too, again, the scenarios for which sites would be deemed amenable to renewable energy production would differ again.

In this analysis of the DSS design and implementation based mainly on document analysis, it is clear that there are certain aspects that cannot be answered using this approach, certain black boxes that cannot be opened. One aspect that cannot be commented on in more detail is regarding the decision processes made in real time during the development of the DSS. As the Recharge.green project was already completed once research on this thesis had begun, it was not possible to know which actors were specifically involved in making the decisions regarding what was going to be considered mandatory data versus optional data, how the sub-modules were ranked, why were these four selected – these questions are not answerable from finalized report documents. What this highlights is that during the process of design, decision-making processes that occur get black-boxed once a course of action has been chosen. One can no longer know for certain if a particular data set was set as 'optional input' due to being deemed less important or if because it was a logistical decision due to a lack of availability of accurate data sets. Indeed the issue of access to data was brought up by the lead partner in the interview:

> *"all this data that has been paid by tax payers money, is actually not available and some of it is downright, downright difficult to find and access. And sometimes they even want you to pay for it as well….and of course, um, the um, methodology used to create the data made, different across the area. And then it's not comparable and so on." (Interview with lead partner, Jan 26th, 2017)*

However, as to which data sets this is in reference to, is not specified and therefore it cannot be speculated in what ways this could have impacted on the decisions made during the DSS design. Also, using document analysis, what is presented is the finalized product. Unlike the ethnographic study by Woolgar and Latour (1979) where they were able to detail specific inscription devices and translations that occurred during the process of a laboratory experiment, this was not possible for this thesis with the

selected methodology. Indeed some of the questions posed here regarding how decisions were made for the DSS design could have perhaps been answered with additional interviews with those specifically involved in the DSS development, however this was outside the scope of this particular thesis research.

Discussion

Comparing the methodologies used to value different ecosystem services

In assessing how the different ESS were valued in the Recharge.green project, one must keep in mind that the partners chose to use an economic valuation framework. Within this specific framework, the steps involved in all the methodologies were ultimately directed towards finding an estimated monetary worth of each service. However, given the disparity between the four types of ecosystem services selected for detailed analysis, one must then be particularly attentive to what sort of steps were necessary in each of the valuation methodologies in order to gain a better understanding of how the valuation was made possible.

Summarizing the comparison of these different methods for valuing ecosystem services, it is apparent that each methodology employed very different approaches in arriving at a monetary value. Provisioning services used market price based approaches, regulating services employ a combination of function approaches and cost-based approaches, and the measurement of recreational services depends on revealed preferences (i.e. survey results) based on observations. In discussing this with the lead partner of Recharge.green, even he did acknowledge limitations with the methodologies used to measure ecosystem services within the project:

> "*I think it's clear that the ecosystem services approaches we have now with valuation, we can only get part of that service…or part aspects of it.*" (Recharge.green lead partner Interview, 26th Jan, 2017)

Furthermore, another important aspect to keep in mind regarding applying an economic approach is that the various ecosystem services are defined as being composed of different types of value (Balest, *et al.*, 2015b) – these are defined in the Recharge.green final handbook as follows:

- *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 used 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).* (pg.17; Balest, *et al*., 2015b)

With such a range of value types, clearly certain types of value will be more amenable to economic valuation compared to others. Thus, this is where being attentive to the translations and transformations during the valuation process becomes important as it can highlight the ways in which different ecosystem services are a) transformed from an ecosystem service into a monetary unit, and b) allows for comparisons to be made regarding the ways in which ecosystem services from different categories are made commensurable (as well as question to what extent they can be considered commensurable).

Of the four methodologies employed to value the four different ecosystem services, provisioning services required the least transformations of data as this ecosystem service consisted of products that already have an existing market price. However, there was the need to utilize the agricultural unit (i.e. Livestock Unit) when estimating the provisioning of grasslands by livestock. Thus, this was an instance where a theoretical reference unit was used to help in the estimation of the value of this 'ecosystem service' as purely using a market price for this was not feasible. Given that the Recharge.green reports did not provide much information regarding this reference unit, its use in the valuation did highlight that even when valuation methods for ecosystem services using market-price approaches, there can still be instances of black-boxing – such as was the case with using livestock numbers and coefficient in order to calculate a final price for grasslands.

The replacement cost method used to value the protection against natural hazards required a few transformations as the starting point was ecological data (i.e. forest management data) and the final outcome was an estimated price for an artificial substitute for this natural service. From the document analysis, there appeared to be three steps involved in the valuation process in order to translate forest management data into monetary value: 1) assessing forest management data in order to calculate a protection score for each forest, 2) selecting the artificial man-made substitute and 3) calculating the cost for the artificial substitute – and each step involved an element of black-boxing. Firstly, how the ecological and topographical forest data was used to calculate a protection score is not mentioned at all in the reports. Furthermore, there was no information provided for what type of substitutes were selected, nor any

information regarding how the protection score contributed to the selection of the artificial substitute. Lastly, there was no information at all regarding how the costs for the artificial substitutes was calculated. To find this information, it was necessary to delve into additional literature in order to find the formula used by the Recharge.green partners to calculate the replacement costs for natural hazards. This valuation methodology required some very distinct changes of data as ecological data had to be converted into a monetary price. Thus, in comparison to the general approach to valuing the provision services category, what is shown here is that the replacement cost method involves more processes in order to be converted into a monetary price, whilst at the same time, highlighting more black-boxing as part of the process.

While the replacement cost method required at least three translations in the valuation process, even more steps were involved when one looks at the methodology used for valuing recreational value in the Recharge.green project. The method used was known as the Benefit Transfer, more specifically the 'average value transfer' method was used to estimate the economic value of forest recreation activities. Investigating how this was done revealed it to be a seven-step process, however the important aspect to note here is that this methodology requires the use of non-local data – which is then applied to the specific site being valued. This methodology required several studies about different kinds of recreation to be collated and then a final single average value was proposed and subsequently applied to a given pilot site. Firstly, the issue of using non-local data to propose a monetary value for a specific site raises questions to how accurate to the given site this estimation can be considered given that no data from the actual site is used in the valuation process. Secondly, from the reports, the processes involved (i.e. the seven steps of the average transfer method) are not very detailed and thus how each transformation occurred is unable to be fully unpackaged by document analysis alone (unfortunately the additional interview did little to shed any further light on this either).

From the three economic valuation methods used in valuing ecosystem services, it is evident that the number of steps required to convert an ecosystem service into a monetary unit increases as we move from provision, to regulating to cultural categories. The reasoning behind providing an economic quantification of these services is that it permits cost-benefit analyses to occur under different scenarios (Busch, *et al*., 2012). However, in choosing to use an economic approach to assess these tradeoffs, it is also important to examine how easily are these ecosystem services quantified using

economic approaches. From the detailed analysis of the valuation methodologies - it is clear that there are numerous translations that are involved when converting an ecosystem service into a monetary value. Some services require more translation steps than others, but nevertheless, all methods of valuation analyzed in the Recharge.green project do utilize this. Thus if only part of the value of certain/all ecosystem services can be measured, one must then also question what implications this can have on decision-making processes for environmental issues. When there are different levels of confidence in valuation robustness – as is the case in the different methodologies analyzed – are the various services truly commensurable? How can valuation methodologies hope to take these factors into account knowing these limitations exist?

The final valuation method analyzed in the Recharge.green project was evaluation of intrinsic value. This was not an economic valuation method as the methodology did not involve translation of the ecosystem service into a monetary value. In contrast to the three other economic valuation methods analyzed where each ecosystem service was considered in isolation, valuation of intrinsic value was not assessed as a stand-alone service, but rather always in reaction to the results of the other valuation processes. Requiring stakeholders to complete a questionnaire and rank the importance of pre-selected values, the aim of this valuation was to ultimately incorporate stakeholder thoughts and experiences to spatially map regions to be excluded from renewable energy development.

Regardless of the unit of measure that is chosen to assess and quantify ecosystem services, what we are seeing here is a struggle to classify nature and biodiversity in a way that allows its different aspects to be compared and measured. If valuation is about measuring and making things comparable, one must also then consider what occurs when there is an element of incomparability. Bigger and Robertson (2017) point out that by focusing on comparison and measurement, what is often not fully addressed is the *in*comparability between different ecosystem services. How comparable are natural hazard protection compared to appreciating the beauty of a pristine landscape and hiking along a mountain path? They contend that "finding incompatibility between values in not an endpoint, but must lead onward to questions of how such incompatibilities are socially constituted through different measures" (pg. 69). It should thus be made a priority to understand, as well as contest, the issues that arise when there are apparent incompatibilities in regimes of value.

Differences in enactments of ecosystem service valuation when comparing formal documents and public relations material

As mentioned by Prior (2007), documents can be both "receptacles of content" (pg. 346) as well as functioning agents in their own right. Bearing in mind that they are situated and manufactured products made for a specific audience, specific to this thesis, it allows for a comparison to what aspects of the project were made visible in one form of documentation versus another.

One point that was strongly emphasized in the calendar that was not made so explicit in the reports was how biodiversity was being taken into consideration in the decision making process. Within the calendar, the word 'biodiversity' features very prominently, appearing on almost every month of the calendar and mentioned as being one of the key aspects that can be impacted when there is expansion of renewable energy. The emphasis on biodiversity is certainly not as prominent within the formal reports. When analyzing the specific methods for assessing the ecosystem methods, how biodiversity is actually taken into account is not visible at all – in stark contrast to how the calendar presents the assessment process. Within the formal documents, there are instances when 'ecological considerations' are mentioned. This occurred particularly when describing how the Decision Support System was developed and subsequently applied and used to assist in the decision-making. However, when one looks into the details for how the DSS is actually constructed (i.e. in the information input data and the hierarchical modules it has), how ecological considerations are actually incorporated into the process are barely visible at all – the ecological input data was optional, and of the four modules of the DSS, there are no explicit terms that refer to ecological considerations or biodiversity.

Additionally, the calendar often describes need to find a 'balance' between different conflicting factors. The term 'balance' appears often during the pages of the calendar, the sub-heading for the calendar states, "a balancing act" – suggesting that decisions between energy expansion and nature need to consider different factors. Even when explaining ecosystem services, the calendar states "values can be assigned to these services and contrasted with the values generated by producing renewable energy" – with this description, renewable energy is portrayed as having a negative environmental impact, and thus renewable energy expansion must be carefully considered and balanced with how it impacts on ecosystem services. While the term 'balance' does not feature so prominently within the formal reports, the term 'trade offs' is often used

(particularly when explaining the broad project aims) to imply the need to make decisions between conflicting factors.

With the emphasis of balance and considering biodiversity, the calendar seeks to depict the decision-making process as one that looks at the situation from a 'holistic' vantage point. Even the graphics used within the calendar always depict the four elements of people, renewable energy, natural landscapes and animals within the same image. This can be interpreted as a means for emphasizing the need to balance different factors as well. Despite this portrayal in the public relations material, when compared to the details of the methodologies employed to assess individual ecosystem services, this holistic idea quickly disappears. The economic valuation methods only consider each service in isolation, there is no evidence in the methodologies used that highlight or take into consideration the ways in which ecosystem service functions are interlinked and impact on each other.

With different audiences in mind for the two types of documents, there were clear differences in the way the information was presented. As Prior mentions, "different forms of text and visual image are associated with the different kinds of setting"(pg. 355, Prior, 2007). This was clearly evident in terms of language used to describe the project as well as the use of visual aids. However, what was also apparent was a stark difference between the ways in which the project aims and processes were proposed. The project partners clearly wanted to emphasize the importance of biodiversity and the calendar seem to suggest that this was very prominent within the project – however, when one looks at the details for how nature was actually valued within the project (i.e. in the detailed analysis of specific ecosystem services), this is clearly not as prominent as suggested in the public relations material.

Conclusion

Implications of using the ecosystem services approach to valuing nature

This thesis research sought to look at the ways in which nature is valued. Nature can be – and is – defined in many ways, thus understanding specific instances of how value is attributed to it, can provide some insight into how nature is conceptualized within a given context. It was decided that for this thesis, investigating the ways in which nature is valued would be done within the specific context of the Recharge.green project. This case study sought to facilitate decision-making processes regarding renewable energy production in the Alps and thus provided a setting in which conflicting aspects (e.g ecological, social, technical and logistical factors) would have to be compared, contrasted and ranked in order to facilitate decision-making. With the decision to employ an economic approach to environmental valuation (i.e. the ecosystem services approach), this presents a specific framing of nature and environmental issues. Thus this thesis research was particularly interested in understanding the practices involved within the valuation methods used to assess different ecosystem services in order to gain a better understanding of environmental valuation practices within the empirical context of the selected case study. In understanding the practices involved (not forgetting to also be attentive to the devices that were involving in facilitating these processes), one can then also look more broadly at the implications this can have on how nature is being enacted through these practices.

In assessing the broad aims of the project, while the project aims are presented in public relations materials as having a major focus on biodiversity, when looking at the finer details for how this was done based on the final reports, the decision-making process regarding renewable energy production ultimately involved assessing and comparing a list of nine Alpine-specific ecosystem services – none of which explicitly include biodiversity. From the document analysis, it was found that the Recharge.green partners adopted an ecosystem services approach – this is an economic method for environmental valuation and is more and more commonly being used to make the value of nature visible in economic terms. The very selection of the ecosystem approach already presents a very specific lens with which the Recharge.green partners used to make their assessments. Moreover, with a total of nine Alpine-specific ecosystem services selected for valuation, this presents a very select view of what aspects of nature are deemed important with regards to decisions involving renewable energy expansion in Alpine regions. What this highlights is the socially-constructed nature of valuation –

the Recharge.green partners made a choice regarding which environmental valuation approach to apply and decided for using an economic model. Furthermore, they also decided which ecosystem services they would make visible and be counted. What we can see is that how nature is valued, and what aspects of it are selected to be valued, is very much constructed for specific circumstances. Just as feminists have discussed the notion of situated knowledges (Haraway, 1988), valuation is also considered to be a situated activity (Dahler-Larsen, 2012) – and is contingent on who is doing the valuation, what aspects are chosen to be assessed, the method used to measure these selected values and also for what purpose the valuation is being done for. Thus from the choices made by the partners to adopt an economic framework for the valuation involved within the project, this therefore influenced the methods that were selected and employed to value, compare and rank the different ecosystem services (which then contributed to the decision-making processes down the line).

The methodologies for measuring the value of nature in the Recharge.green project works within the framework of the ecosystem services approach – a very specific way of viewing nature. In using monetary units as a means to compare the value of the different ecosystem services, vastly different ecosystem services needed to undergo a series of translations to allow them to be measurable by this unit of measure. While Callon and Muniesa (2005) were describing financial markets when they noted that this involved "a series of operations resulting in the calculability of the good" (pg. 1235) – the situation applies to this case study as well. The implications of commensuration when applied to valuing environment has been widely discussed and debated (Dempsey and Suarez, 2016; Kosoy and Cobera, 2010; Robertson, 2012; Fourcade, 2011). One argument by Gomez-Baggethun and Ruiz-Perez (2011) is that by using the homogeneity of monetary figures, it can mask some of the critical processes underlying these ecosystem services being values and result in certain aspects of an ecosystem service's value being lost in the translations needed to convert its value into a monetary unit. Certainly, from the valuation methods analyzed in the Recharge.green project it was evident that translations were necessary for each of the methods – some methods needing more translations than others - before a monetary unit could be achieved. One consequence of the need to translate ecosystem services into a monetary unit is that these practices result in the fore-grounding of specific elements of an ecosystem service (especially those that may be more amenable to economic valuation) whilst others remain in the background. In the specific example of how provisioning services was valued in the Recharge.green project, what was found was there was the need to

explicitly detail each product that was being valued, thus resulting in a clear fore-grounding of specific elements as only those listed were considered to be included in the economic valuation. Furthermore, looking at the project more broadly, one could also say that the selection of nine Alpine-specific ecosystem services to be valued, also only foregrounds these specific aspects to be taken into consideration to evaluate renewable energy siting options.

Role of valuation devices in decision-making

As noted above, as a result of applying an economic approach to valuation, a series of translations were required in the individual methods to value ecosystem services. Callon and Muniesa (2005) have discussed at length about the calculating devices and specific organizations that make calculated exchange possible and similarly, Robertson's (2012) analysis of ecosystem services has brought up that often the technologies of measurement developed by ecosystem scientists come to describe nature in terms of exchange values.

In being attentive to the devices that were used within the Recharge.green project, one critical aspect to the project involved the development of the DSS r.green as a way of spatializing the ecosystem service values as well as generating potential scenarios for renewable energy sites. The role of this device was to translate values into a visual format and thus was an integral instrument in the measuring and ordering values. Described in the public relations material as generating scenarios that provide "a holistic range of possibilities", this device is promised as being able to provide a rational basis for decision-making. However, upon detailed analysis of the design and implementation of this device within the project, there are a lot of contingent value choices that were involved. Firstly, there is evidence of a hierarchy of information input (i.e. having mandatory and optional data input) and the multi-tiered sub-modules. This particular ordering of information creates a certain set of relations between the different types of data being put in (or left out) and cannot be seen as being neutral. How the data was ordered and the relations that were created through the DSS design and implementation permits a degree of performativity regarding how the optimal scenarios are generated. Subsequently, the scenarios generated will also impact on the decision-making process – thus is can also be said that the relations and associations created within the DSS also contributed in constructing the realities that ensured. Callon and Muniesa (2005) have also discussed the diversity of configurations that are

possible when investigating the role of material devices in making things calculable. They raise the point that as these devices have the potential to produce a multitude of outcomes, it therefore highlights the potential for political dimensions to can factor into calculability.

The ordering and hierarchy of data can also be applied more broadly to the valuation methods (given that within this thesis they are also viewed as devices in their own right as they are a particular configuration of processes that can transform data into another form). The valuation practices used within the Recharge.green project similarly involve order and hierarchy and require choices and decisions to be made. Institutional arrangements such as the MA were instrumental in establishing firstly the definitions and classification of ecosystem services and secondly, the ways in which these services could be valued. As noted by Robertson (2012), "the world cannot be remade into a collection of ecosystem services without a group of committed thinkers dedicated to the problem of defining and debating new technologies for quantifying value" (pg. 390). What this highlights is that institutional arrangements and the development and implementation of devices for valuation, presents an entry point to discuss the power relations and the politics that underpin these valuation regimes. Within these valuations of ecosystem services there are political and performative dimensions at play and one must also be attentive to the legitimation practices that are occurring. This ties in with what has been raised by Blok *et al.,* (2014) in their analysis of multiscale assessments such as the MA and IPBES – that while they are meant (and often perceived) to be achieved by unbiased means, there is always an inherent connection of these assessments to the distribution of power. Given the deeply political and non-neutral status of such devices, this in turns makes the opening of black boxes when there are instances of transformation a crucial process in valuation in order to gain a better understanding of the performativities that are occurring.

Limitations with using document analysis

In assessing the valuation methods used within the Recharge.green project, the use of document analysis as the primary source of information did prove to be an obvious limitation particularly regarding the extent to which the black-boxes that were evident within the various valuation practices could be opened and scrutinized. The Recharge.green documents selected for analysis often lacked sufficient details and this therefore required additional readings in order to obtain the knowledge necessary to

understand how exactly the valuation processes were done. At times, even these additional readings did not provide the level of detail or explanation that was desirable. Thus, while the thesis sought to analyze the transformations involved to convert a specific ecosystem service into a monetary unit, a broad account of the methods and processes involved could be gleaned, however, the finer details of what was occurring during each step of the process were not possible to be obtained using document analysis.

Unlike Latour and Woolgar's (1986) detailed account of the literary inscriptions and transformations involved in scientific work in a laboratory from their ethnographic study, this level of detail was not possible here. While Latour and Woolgar were able to witness events occurring in the lab, they were therefore able to provide detail the types of inscription devices that were used, document how data was transferred and also specifying what forms the data was in at each state. As such, they were able to provide a rich account of the practices performed in a laboratory as well as all the types of instruments and devices that were involved in these processes. Given that this study was not an ethnography (an ethnography would have not been possible anyway as this project was already completed when it was selected to be used as a case study for this thesis research), it was not possible to witness the processes of decision-making that would have occurred throughout the various valuations. This also meant that it was not possible to provide specific details of all the devices and instruments that were used during the processes of valuation and when there were transformations and translations occurring during the application of these methods.

Despite interviewing the lead partner of the project, it was apparent that by not being directly involved in the valuation of ecosystem services, the details missing from the documents were also not able to be obtained through the interview process. Additional interviews with those in the project directly involved in either the valuation of the ecosystem services analyzed or the development of the DSS would be beneficial but were outside the scope of this masters thesis.

Enactments of nature within the Recharge.green project

The decision to employ the ecosystem services approach for environmental valuation also results in a specific representation and performativity of nature. In choosing to select nine Alpine-specific ecosystem services for valuation to facilitate the decision-

making process regarding renewable energy siting options, nature is reduced to being enacted through these nine ecosystem services. Thus, within the Recharge.green project, the value of nature can be found within the amount of timber produced in a region, the number of mushrooms foraged in a forest, in the price of a man-made structure that will hypothetically protect against natural hazards, through the use of surveys and questionnaires – just to name a few. What these vastly different enactments of nature highlight is that nature is not only seen in one way. It can be enacted differently depending on the sets of relations and the contexts. Just as Mol (2002) showed that there are a multiplicity of ways in which atherosclerosis is observed and discussed, so too can we see this multiplicity of how nature is viewed and valued through the application of the ecosystem services approach.

Within this project, the ecosystem – made up of a diverse range of interwoven functions - are compartmentalized into discrete units and valued individually. Robertson (2012) has commented on the ways in which economists and policymakers often seek to "reframe ecosystems as 'bundles of functions' or 'bundles of values'" (pg. 393). Thus in applying an economic valuation, nature is no longer viewed as an whole entity, but rather lines are drawn to demarcate boundaries to specify what should be included in the valuation of a specific ecosystem service and what should be excluded. In enacting nature as a series of discrete units, what we also see is the construction of abstract spaces and the definition of boundaries – a point also raised by Turnhout regarding ecological indicators (2009). This was particularly evident in the specificities required to itemize the components to be valued in the provisioning category. Similarly, in the methodology used to value recreational value – different types of recreational activities are 'bundled' into one over-arching category of recreation. This compartmentalization and bundling of ecosystem services result in what can therefore be described as 'individuation' in the commodification of nature (Robertson, 2012). In order to find the complete value of an ecosystem, it then becomes a matter of aggregating the value of various measurable services. One could then ask, has the correct boundaries been drawn to segregate individual valuable elements within a given ecosystem of a particular class or category, especially given that classification and the creation of standards are fundamentally a social act (Timmermans and Epstein, 2010)?

Another effect that results from using this economic form of valuation in which ecosystem services are made into discrete units is that it fails to make visible is how different ecosystem services impact on each other. There are complex linkages between

ecosystem functioning, biodiversity and human activities – however by valuing discrete units, these linkages and the value in them cannot be accounted for. Of the three economic valuation methods analyzed (i.e. provisioning services, protection of natural hazards and recreational value), these are all considered in isolation. Interestingly, it should be noted that only in the non-economic valuation methodology used for valuing intrinsic services did we see evidence of different ecosystem services considered together – intrinsic value was not measured in isolation but was in reaction to how the other ecosystem services were valued.

In asking how is nature being enacted, the other question would then be, what aspects of nature are not being enacted within these valuation methodologies? Kosoy and Corbera (2010) have argued that use of the ecosystem services approach masks ecological complexity and non-economic values of ecosystems. This is also clearly apparent within the Recharge.green project as the representation of ecological and biodiversity aspects are decidedly minimal within the project reports as well as within the methods of valuation analyzed. Despite the public relations material (i.e. the calendar) having the term 'biodiversity' heavily emphasized and it containing statements regarding the "right planning processes and tools" being able to "protect ecosystems and landscapes enough to safeguard biodiversity and human well-being", and others such as "expanding renewable energy needs to be balanced with biodiversity conservation and a functioning ecosystem" (Ciolli, *et al*., 2015), biodiversity and human well-being were not often visible in the valuation methodologies analyzed when analyzing the formal finalized documents.

How methods can produce/enact multiple realities

Through investigating the different methods used to value ecosystem services in this case study it is clear that while these methods with their specific practices can be viewed as techniques for describing a particular reality, at the same time, they are also involved in producing the reality that they understand (Law, 2004). Scientific investigations interfere in the world in one way and as Law has noted, "reality is both unknowable and generative" (pg. 7; Law, 2004). The methods used for valuing ecosystem services can thus be viewed as contributing to generating the reality of how nature is valued, as a result of its shaping by its historical, organizational and social context. There have been historically contingent acts of meaning–making that have played a role in mediating how people, governments and organizations relate to and

engage with nature. This includes how they perceive, control and manage their own effects – whether intended or unintended- on nature (Lachmund, 2013). Regarding the development of methods to value ecosystem services, these methods were developed after initial conservation initiatives failed to halt the rapid decline in biodiversity. As a means to make biodiversity and conservation needs more visible to policy-makers, international conservation communities, non-governmental organizations and state agencies came together and designed new regimes for international environmental policy to provide incentives for biodiversity protection. As a result, what has evolved in the last twenty years has been called neoliberal conservation, or "for-profit biodiversity conservation" - referring to the rising prominence of applying an economic logic to conservation efforts. The development of market-based instruments such as commercial ecotourism, payment for ecosystem services programs and forest carbon offset schemes have drastically transformed socio-ecological relations and understandings (Dempsey and Suarez, 2016; Robertson, 2012). Specifically with regards to the ecosystem services approach, nature was made to be measurable – and this is reflected in the methods that are used to value the various ecosystem services. In analyzing the methods used to value ecosystem services within the Recharge.green project, there is a similarity to Machlup's construction of the knowledge economy where he discusses steps of 'operationalizing' knowledge in order to make produce and distribute it (Godin, 2010). Here, nature is being operationalized and enacted as something that made up of discrete units, entities that can be monetized and where these different units (i.e. services) are made commensurable and thus exchangeable through the use of a market-based approach.

However, in narrowing down ecosystem services into discrete units, one must also be aware that this has resulted in serious technical difficulties – as is evidenced by the ongoing debates regarding their classification and methods for valuation (Boyd, and Banzhaf, 2007; Wallace, 2007) – not to mention as well the ethical implications in the way we perceive and relate to nature (e.g. being viewed as commodities that can be traded and exchanged, being of value only if it is of human benefit). Given that the initial impetus for developing economic approaches to environmental valuation was to make the value of nature more visible in economic and policy terms, one could say that as a result of the development of these economic methods and calculative devices (i.e. in the process of commodifying nature) these technical difficulties and causes for debates can be considered collateral realities, realities that have ensued not by design, but as a consequence of these framings and methods. Within the context of the Recharge.green

project, the public relations material puts great emphasize on the need to take biodiversity into account, however, in the analysis of the methods used to value the ecosystem services within the project, this emphasis is not evident or made visible. Can this be considered a collateral reality – an unintended consequence in striving to make the value of nature more visible in political realms? Or does this highlight the need to continue to develop environmental valuation approaches so that such nature can be made visible in other ways that are not anthropocentric or in monetary terms? Ultimately, the methods for valuing nature are a reflexive activity, they can be adapted in order to establish a new rule, to employ a different perspective from which to base valuations, in essence the settings for valuing nature should be conceived as being a 'forum', a public space, "the specific structuring of which is yet to be defined" (pg. 195; Callon, *et al*., 2002).

Analyzed documents

Balest, J., Curetti, G., Garegnani, G., Grilli, G., Gros, J., Pezzutto, S., Vettorato, D., Zambelli, P., Paletto, A., De Meo, I., Geitner, C., Hastik, R., Leduc, S., Bertin, S., Miotello, F., Zangrando, E., Pettenella, D., Portaccio, A., Petrinjak, A., Pisek, R., Polijanec, A., Kuenzer, N., Badura, M., Walzer, C. (2015a). *Renewable Energy and Ecosystem Services in the Alps. Status quo and trade-off between renewable energy expansion and ecosystem services valorization*. Recharge.green.

Balest, J., Berchtold-Domig, M., Bertin, S., Ciolli, M., Curetti, G., D'Alonzo, V., Garegnani, G., Geitner, C., Geri, F., Grilli, G., Gros, J., Haimerl, G., Hastik, R., Kralj, T., Kraxner, F., Kuenzer, N., Leduc, S., Miotello, F., Paletto, A., Petrinkjak, A., Piske, R., Poljanec, A., Portaccio, A., Sacchelli, S., Serrano Leon, H., Simoncic, T., Svadlenak-Gomez, K., Vettorato, D., Vrscaj, B., Zambelli, P., Zangrando, E., Walzer, C. (2015b). *Sustainable Renewable Energy Planning in the Alps. A handbook for experts & decision makers*. Recharge.green.

Ciolli, M., Garegnani, G., Hastik, R., Kraxner, F., Kuenzer, N., Miotello, F., Paletto, A., Svadienak-Gomez, K., Ulrich-Schneider, A., Walzer, C. (2015). *Energy & nature in the Alps: a balancing act.* Recharge.green [perpetual calendar].

Kraxner, F., Leduc, S., Serrano Leon, H., Garegnani, G., Grilli, G., Gros, J., Sacchelli, S., Zambelli, P., Ciolli, M., Geri, F. (2015), *Modeling and visualization of optimal locations for renewable energy production in the Alpine Space with a special focus on selected pilot sites*. Recharge Green WP5 Report. Recharge.green.

Zangrando, E., Bertin, S., Miotello, F., Portaccio, A. (2015). Report about round tables for the pilot areas Mis and Maè Valley, Balancing Alpine Energy and Nature, Recharge.green.

References

Akrich, M. (1992). The de-scription of technical object: shaping technology/building society. In W. Bijker and J. Law (eds.) *Studies in Sociotechnical Change.* Cambridge: MIT Press, pg. 205-224.

Altvater, E. (1993). *The future of the market: an essay on the regulation of money and nature after the collapse of 'actually existing socialism'.* Verso, New York.

Asdal, K. (2014). Performing environmental change: the politics of social science methods. *Environment and Planning A*. 46:2055-2064.

Asdal, K. (2008). Enacting things through numbers: Taking nature into accounting, *Geoforum*, 39, pg 123-132.

Ashwood, L., Harden, N., Bell, M. M., Bland, W. (2014) Linked and Situated: Grounded Knowledge. *Rural Sociology* 79(4): 427-452.

Azqueta, D. and Sotelsek, D. (2007). Valuing nature: From environmental impacts to natural capital. *Ecological Economics*. 63:22-30.

Bakker, K. (2005). Neoliberalizig nature? Market environmentalism in water supply in England and Wales. *Annals of the Association of American Geographers*. 95:542-565.

Balest, J., Curetti, G., Garegnani, G., Grilli, G., Gros, J., D'Alonzo, V., Paletto, A., Ciolli, M., Geri, F., Geitner, C., Hastik, R., Leduc, S., Bertin, S., Miotello, F., Zangrando, E., Pettenella, D., Portaccio, A., Petrinjak, A., Pisek, R., Poljanec, A., Kralj, T., Vrščaj, B. (2015c). *Recharge.green project Activities in Pilot Areas – Testing and Implementation*. Recharge.green.

Baxter, P. and Jack, S. (2008), Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers, *The Qualitative Report*, 13(4); 544-559.

Beck, S. Forsyth, T., Kohler, P. M., Lahsen, M. and Mahony, M. (2017). The Making of Global Environmental Science and Politics. In U. Felt, R. Fouché, C. A. Miller and L. Smith-Doerr, (Eds.), *The Handbook of Science and Technology Studies* (4th Edition). pg. 1059-1086. Cambridge MA: The MIT Press.

Bigger, P. and Robertson, M. (2017). Value is Simple. Valuation is Complex. *Captalism Nature Socialism.* 28(1): 68-77.

Boltanski, L. and Thévenot, L. (2006). *On Justification: Economies of Worth.* Princeton, N. J.: Princeton University Press.

Bowker, G. C. and Star, S. L. (1999). Sorting Things out: Classification and Its Consequences.Cambridge,MA: MIT Press.

Boyd, J. and Banzhaf, S. (2007). What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics*. 63(2-3):616-626.

Brunsson, N. and Jacobsson, B. (Eds.) (2000). *A World of Standards*. Oxford: Ocford University Press.

Burrows, R. (2012). Living with the h-index? Metric assemblages in the contemporary academy. *The Sociological Review*, 60(2): 355-372.

Busch, M., La Notte, A., Laporte, V., Erhard, M. (2012). Potentials of quantitative and qualitative approaches to assessing ecosystem services. *Ecological Indicators*, 21:89-103.

Caliskan, K. and Callon, M. (2009). Economization, part 1: shifting attention from the economy towards processes of economization. *Economy and Society.* 38(3): 369-398.

Caliskan, K. and Callon, M. (2010). Economization, part 2: a research programme for the study of markets. *Economy and Society*. 39(1):1-32.

Callon, M. (1986a). Some elements of a sociology of translation: domestication of the scallops and the fisherman of St Brieuc Bay. In J. Law (Ed.), *Power, Action and Belief. A New Sociology of Knowledge?* (pg. 196-233). London: Routeledge & Kegan Paul.

Callon, M. (1986b). The Sociology of an Actor-Network: The Case of the Electric Vehicle. In: M. Callon, J. Law, A. Rip (Ed.), *Mapping the Dynamics of Science and Technology*. (pg. 19-34). Klewer Academic Publishers: London.

Callon, M. (1998). The Embeddedness of Economic Markets in Economics. In M. Callon (ed.) *The Laws of the Markets*. Oxford: Blackwell. Pg. 1-57.

Callon, M. (2007). What does it mean to say that economics is performative? In D.A. MacKenzie, F. Muniesa, L. Siu (Eds.) *Do economists make markets? On the performativity of economics.* Princeton: Princeton University Press.

Callon, M., Méadel, C., Rabeharisoa, V. (2002). The economy of qualities. *Economy and Society.* 31(2): 194-217.

Callon, M. Millo, Y. and Muniesa, F. (2007). *Market devices.* Malden, MA: Blackwell.

Callon, M. and Muniesa, F. (2005). Economic Markets as Calculative Collective Devices. *Organization Studies*. 26(8):1229-1250.

Charmaz, K. (2006a). Coding in Grounded Theory Practice. In *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*. London/New Delhi/Thousand Oaks:Sage.

Charmaz, K. (2006b). Memo-writing. In *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysisis*. Pg. 72-85. London/New Delhi, Thousand Oaks: Sage.

Cooper, M. H. (2015). Measure for measure? Commensuration, commodification, and metrology in emissions markets and beyond. *Environment and Planning A*. 47(9): 1787-1804.

Cotoi, C. (2011). Neoliberalism: a Foucauldian Perspective. *International Review of Social Research*. 1(2): 109-124.

Cressman, D. (2009). A Brief Overview of Actor-Network Theory: Punctualization, Heterogeneous Engineering and Translation. ATC Lab/Centre for Policy Research on Science & Technology (CPROST), School of Communication, Simon Fraser University [online], Retrieved from: http://blogs.sfu.ca/departments/cprost/wp-content/uploads/2012/08/0901.pdf

Dahler-Larsen, P. (2012). Introduction, The Evaluation Wave: From Mystery to Analysis. In *The Evaluation Society* (pg. 1-32). Stanford, CA: Stanford University Press.

Dalsgaard, S. (2016). Carbon Valuation: Alternatives, Alternations and Lateral Measures? *Valuation Studies.* 4(1): 67-91.

Dalsgaard, C. (2013). The commensurability of carbon. Making value and money of climate change. *Journal of Ethnogaphic Theory*, 3(1): 80-98.

Dempsey, J. and Suarez, D. C. (2016). Arrested Development? The Promises and Paradoxes of 'Selling Nature to Save It'. *Annals of the American Association of Geographers*, 106(3): 653-671.

Department for Environment, Food and Rural Affairs (DEFRA) (2011), http://adlib.everysite.co.uk/adlib/defra/content.aspx?id=000IL3890W.198AWLDOHJ69F3

Department for Environment, Food and Rural Affairs (DEFRA) (2007). *An Introductory guide to valuing ecosystem services.* London: Defra Publications.

Doel, R. (2003). Constituting the Postwar Earth Sciences: The Military's Influence on the Environmental Sciences in the USA after 1945. *Social Studies of Science.* 33(5): 635-666.

Ehrenstain, V. and Muniesa, F. (2013). The Conditional Sink Counterfactual Display in the Valuation of a Carbon Offsetting Reforestation Project. *Valuation Studies,* 1(2): 161-188.

Espeland, W. N. and Stevens, M. L. (1998). Commensuration as a Social Process. *Annul Review of Sociology* 24: 313-343.

European Union (2013). http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Livestock_unit_(LSU)

Foucault, M. (1991). Governmentality. In G. Burchell, C. Gordon & P. Miller (Eds.) *The Foucault effect: Studies in governmentality,* Chicago: The University of Chicago Press.

Fourcade, M. (2011). Cents and Sensibility: Economic Valuation and the Nature of "Nature". *American Journal of Sociology*. 116(6): 1721-1777.

Fourcade-Gourinchas, M. (2001). Politics, institutional structures, and the rise of economics: A comparative study*, Theory and Society*, 30(3): 397-447.

Godin, B. (2010). The Knowledge Economy: Fritz Machlup's Construction of a Synthetic Concept. In R. Viale & H. Etzkowitz (Eds.), *The Capitalization of Knowledge. A Triple Helix of University-Industry-Government*. Pg. 261-285. Edward Elgar Publishing.

Gómez-Baggethun, E. and Ruiz-Pérez, M. (2011). Economic valuation and the commodification of ecosystem services. *Progress in Physical Geography*. 35(5):613-628.

Grilli, G., Paletto, A., Garegnani, G., Biscaini, S., Sacchelli, S., Geri, F., Ciolli, M., Curetti, G., Vettorato, D. (2015). ESS Evaluation and Mapping, Recharge.green.

Grilli, G., Paletto, A., De Meo, I. (2014) Economic Valuation of Forest Recreation in an Alpine Valley. *Baltic Forestry*. 20(1): 167-175.

Gubrium, J. F. and Holstein, J. A. (2003). From the Individual Interview to the Interview Society. In J. F. Gubrium and J. A. Holstein (Eds.), *Postmodern Interviewing.* Pg. 21-49. Thousand Oaks: Sage.

Haraway, D. (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies,* 14(3): 575-599.

Helgesson, C. F. and Muniesa, F. (2013). For What It's Worth: An Introduction to Valuation Studies, *Valuation Studies*, 1(1): 1-10

Irvin, R. and Stansbury, J. (2004). Citizen Participation in Environmental Decision-Making: Is It Worth the Effort? *Public Administration Review.* 64(1): 55-65.

Jasanoff, S. (2001). Image and Imagination: The Formation of Global Environmental Consciousness. In C. A. Miller & P. N. Edwards (Eds.), *Changing the Atmosphere: Expert Knowledge and Environmental Governance*. Pg. 309-337. Cambridge, MA: MIT Press.

Jasanoff, S. and Martello, M. L. (Eds.) (2004). *Earthly Politics, Local and Global in Environmental Governance*. Cambridge, MA and London: The MIT Press.

Kosoy, N. and Corbera, E. (2010). Payments for ecosystem services as commodity fetishism. *Ecological Economics*. 6:1228-1236.

Kremen, C. (2005) Managing ecosystem services: What do we need to know about their ecology? *Ecological Letters*. 8(5):468-479.

Kvale, S (2007.) Doing Interviews, SAGE Publications: London. Edited by U. Flick.

Lachmund, J. (2013). *Greening Berlin. The Co-Production of Science, Politics, and Urban Nature*. Cambridge, MA: The MIT Press.

Lachmund, J. (2004). Knowing the Urban Wasteland: Ecological Expertise as Local Process. In Jasanoff, S. & Martello, M. L. (2004). *Earthly Politics: Local and Global in Environmental Governance*. (S. Jasanoff & M. L. Martello, Eds.). Cambridge, MA, and London: The MIT Press.

Lamont, M. (2012). Sociology of Valuation and Evaluation. *The Annual Review of Sociology*. 38: 201-21.

Latour, B. (2013). Biography of an Investigation: On a Book about Modes of Existence. In *Archives de philosophie* (coordinated by B. Karsenti), translated by Cathy Porter.

Latour, B. (2005). *Reassembling the Social: An Introduction to Actor-network-theory*. Oxford: Oxford University Press.

Latour, B. (2004). *Politics of Nature. How to Bring the Sciences into Democracy*. London: Harvard University Press.

Latour, B. (1983). Give me a laboratory and I will raise the world. In K. Knorr-Cetina and M. Mulkay (Eds.). *Science Observed.* Pg. 141-170. London and Beverley Hills: Sage.

Latour, B. and Woolgar, S. (1979). *Laboratory Life: The Social Construction of Scientific Facts.* Beverley Hiils, CA: Sage Publishing.

Law, J. (2011). Collateral realities. Version of 29th Dec 2009, available at http://www.heterogeneities.net/publications/Law2009CollateralRealities.pdf .

Law, J. (2009a). Actor network theory and material semiotics. *The new Blackwell companion to social theory*. 3: 141-158

Law, J. (2009b). Seeing Like a Survey. *Cultural Sociology*. 3(2): 239-256.

Law, J. (2004). After Method, Mess in social science research. Routeledge, Madison NY.

Law, J. (1992). Notes on the theory of the actor-network: Ordering, strategy, and heterogeneity. *Systems Practice*. 5(4): 379-393

Law, J. and Urry, J. (2004). Enacting the social. *Economy and Society*, 33(3), pg. 390-410.

Lövbrand, E. and Stripple, J. (2011). Making Climate Change Governable: Accounting for Carbon as Sinks, Credits and Personal Budgets. *Critical Policy Studies.* 5(2): 187-200.

Lupton, D. (1999). Introduction & Theorizing Risk & Risk Culture. In *Risk (Key Ideas)*. Pg. 1-57. New York: Routeledge

Maes, J. Egoh, B., Wilemen, L., Liquete, C., Vihervaara, P., Schägner, J.P., Grizzetti, B., Drakou, E.G., La Notte, A., Zulian, G., Bouraoui, F., Paracchini, M.L., Braat, L., Bidoglio, G. (2012).Mapping ecosystem services for policy support and decision making in the European Union. *Ecosystem Services*, 1(1):31-39.

MacKenzie, D. (2009). Making things the same: gases, emission rights and the politics of carbon markets. *Accounting, Organizations and Society*. 34: 440-455.

Michael, M. (2017). *Actor-Network Theory. Trials, Trails and Translations.* LA:SAGE.

Miles, M.B. and Huberman, A. M. (1994). *Qualitative data analysis: An expanded source book (*2nd ed.). Thousand Oaks, CA: Sage.

Millennium Ecosystem Assessment (2003). *Ecosystems and Human Well-Being, A Framework for Assessment*. Island Press. (accessed from: http://www.millenniumassessment.org/documents/document.300.aspx.pdf)

Miller, C., and Erickson, P. H. (2006). The politics of bridging scales and epistemologies: Science and democracy in global environmental governance. In W. Reid, F. Berkes, T. Wilbanks, D. Capistrano (Eds.), *Bridging scales and knowledge systems: Concepts and applications in ecosystem assessment,* pg. 297-314. Washington, DC: Island Press.

Mol, A. (2014). A reader's guide to the "ontological turn" Part 4. (http://somatosphere.net/2014/03/a-readers-guide-to-the-ontological-turn-part-4.html)

Mol, A. (2002). *The body multiple: Ontology in medical practice.* Durham, NC, and London, UK: Duke University Press.

Mol, A. (1999). Ontological politics: a word and some questions. In J. Law and J. Hassard (Eds.), *Actor-Network Theory and After,* pg. 74-89. Oxford and Keele: Blackwell and the Sociological Review.

Moor, L. and Lury, C. (2011). Making and Measuring Value. *Journal of Cultural Economy*, 4(4), 439-454.

Moser, I. (2008). Making Alzheimer's disease matter. Enacting, interfering and doing politics of nature. *Geoforum*, 39, pg. 98-110.

Müller, R. (2014) Racing for What? Anticipation and Acceleration in the Work and Career Practices of Academic Life Science Postdocs. *Forum: Qualitative Social Research*, 15(3):

Muniesa, F., Millo, F., Callon, M. (2007). An introduction to market devices. *The Sociological Review*. 55(2): 1-12.

Notaro, S., and Paletto, A. (2012). The Economic Valuation of Natural Hazards in Mountain Forests: An Approach Based on the Replacement Cost Method. *Journal of Forest Economics,* 18 (4):318–328.

OECD (1996), The Knowledge-based Economy. http://www.oecd.org/sti/sci-tech/1913021.pdf

Paletto, A., Geitner, C., Grilli, G., Hastik, R., Pastorella, F., and Rodriguez Garcia, L. (2015) Mapping the value of ecosystem services: A case study from the Austrian Alps. *Ann. For. Res.* 58(1):157-175.

Peters, M. A. (2008). Foucault, biopolitics and the birth of neoliberalism. *Critical Studies in Education*. 48(2): 165-178

Prior, L. (2007). Documents. In C. Seale, G. Gobo, J. F. Gubrium & D. Silverman (Eds.), *Qualitative Research Practice*, pg. 345-360. London: Sage.

Recharge.green. (2015). Pilot region Regione Veneto (Poster). Downloaded from http://www.recharge-green.eu/downloads/

Rhodes, J. (2009). Using Actor-Network Theory to Trance an Ice (Telecenter) Implementation Trajectory in an African Women's Micro-Enterprise Development Organization. *Information Technologies and International Development*. 5(3): 1-20.

Robertson, M. (2012). Measurement and alienation: making a world of ecosystem services. *Transations of the Institute of British Geographers*. 37:386-401.

Robertson, M. (2006). The nature that capital can see: science, state and market in the commodification of ecosystem services. *Environment and Planning D: Society and Space*. 24:367-387.

Rosenberger, R. S. and Loomis, J. B. (2001) Benefit transfer of outdoor recreation use values: A technical document supporting the Forest Service Strategic Plan (2000 Revision). United States Department of Agriculture, General Technical Report RMRS-GTR-72.

Salter, C., Burri, R. V., Dumit, J. (2017). Art, Design, and Performance. In In U. Felt, R. Fouché, C. A. Miller and L. Smith-Doerr, (Eds.), *The Handbook of Science and Technology Studies* (4th Edition). pg. 139-167. Cambridge MA: The MIT Press.

Shackley S. and Wynne, B. (1996). Representing Uncertainty in Global Climate Change Science and Policy: Boundary-Ordering Devices and Authority. *Science, Technology, & Human Values*, 21(3): 275-302.

Shackley, S. and Wynne, B. (1995). Global climate change: The mutual construction of an emergent science-policy domain. *Science and Public Policy*. 22:218-230.

Shankar, K., Hakken, D. and Østerlund, C. (2017). Rethinking Documents. In U. Felt, R. Fouché, C. A. Miller and L. Smith-Doerr, (Eds.), *The Handbook of Science and Technology Studies* (4th Edition). pg. 59-85. Cambridge MA: The MIT Press.

Shore, C. and Wright, S. (2000). Coercive accountability: the rise of audit culture in higher education. In M. Strathern (Ed.) *Audit Cultures: Anthropological Studies in Accountability, Ethics and the Academy*, (pg. 58-69). Routeledge.

Sismondo, S. (2010). Actor Network Theory. In *An Introduction to Science and Technology Studies* (2nd edition). UK: Wiley Blackwell.

Szerszynski, B. (1999). Risk and Trust: The Performative Dimension. *Environmental Values*. 8: 239-252.

Thévenot, L. (2000). Organized complexity: conventions of coordination and the composition of economic arrangements. *European Journal of Social Theory.* 4(4): 405-425.

Timmermans, S., & Epstein, S. (2010). A world of standards but not a standard world: Toward a sociology of standards and standardization. *Annual Review of Sociology*, *36*, 69-89.

Turnhout, E.(2009). The effectiveness of boundary objects: the case of ecological indicators. *Science and Public Policy.* 36(5): 403-412.

Verran, H. (2013). Numbers Performing Nature in Quantitative Valuing. *NatureCulture,* 23-37.

Wallace, K. J. (2007). Classification of ecosystem services: problems and solutions. *Biological Conservation*. 139(3-4):235-246.

Whatmore, S. and Landström, C. (2011). Flood apprentices: an exercise in making things public. *Economy and Society.* 40, 582-610.

Wynne, B. (1996). May the Sheep Safely Graze? A Reflexive View of the Expert-Lay Knowledge Divide. In S. Lash, B. Szerszynski and B. Wynne (Eds.), *Risk, Environment and Modernity: Towards a New Ecology.* Pg. 281-304. London: Sage

Abstracts

English version

Decision-making processes involving environmental issues often require assessing several conflicting factors. Apart from the ecological and conservation considerations, there is the need to adhere to international and regional policies and treaties, technical and logistical aspects, whilst also taking into account the views and opinions of local communities that may be affected. The ways in which these differing aspects are classified and ranked – and in this sense, valued – will impact on how environmental decisions are made. Since the 1960s there have been concerted efforts to assign value to environmental assets and the use of economic valuation for environmental assessment is increasingly being used as a means to make the value of nature and biodiversity visible in political realms. One environmental assessment framework that has gained importance on a global scale is the ecosystem services approach. This is an economic valuation approach in which ecosystems are divided into categories and valued in terms of ecosystem services – defined as benefits people obtain from the environment. However, valuing the environment through these economic and anthropocentric perspectives has raised debates regarding how to apply economic logic to environmental valuation as well as the implications regarding how the environment and issues pertaining to it are conceptualized and addressed. Given that valuation and the methods that measure and assign value are entirely socially constructed, understanding the methods (and the practices within them) for environmental valuation can shed light on the performativities involved as well as highlighting how nature is being enacted as a result. This thesis will investigate the methods and practices involved for valuing ecosystem services in the context of the empirical case study of the Recharge.green project, whose main goal was to facilitate decision-making processes regarding renewable energy expansion in the Alps.

German version

Entscheidungsprozesse die Umweltfragen betreffen beinhalten oft die Bewertung mehrerer widersprüchlicher Faktoren. Neben den rein ökologischen und konservatorischen Überlegungen müssen internationale und regionale Richtlinien und Abkommen beachtet und die technischen und logistischen Aspekte in Betracht gezogen werden. Darüber hinaus müssen aber auch die Ansichten und Meinungen der betroffenen lokalen Bevölkerung berücksichtigt werden. Die Art und Weise wie diese unterschiedlichen Aspekte eingeordnet und klassifiziert und - in diesem Sinne bewertet - werden hat Einfluss darauf, wie Umweltentscheidungen getroffen werden. Seit den 1960er-Jahren gibt es gezielte Bemühungen Umweltgüter zu bewerten und es werden zunehmend ökonomische Wertesysteme für solche Umweltbewertungen verwendet um den Wert von Natur und Biodiversität im politischen Diskurs sichtbar zu machen.

Ein Umweltbewertungs-Modell das auf globaler Ebene an Bedeutung gewonnen hat ist der sogenannte Ansatz der Ökosystemleistungen. Dies ist ein ökonomischer Bewertungsansatz bei dem Ökosysteme in Kategorien eingeteilt und in Bezug auf ihre Ökosystemleistungen (definiert als Nutzen, den die Menschen aus der Umwelt erhalten) bewertet werden. Allerdings hat die Bewertung der Umwelt anhand dieser ökonomischen und anthropozentrischen Perspektiven die Debatte angeheizt, ob und wie ökonomische Logik sich überhaupt auf Umweltbewertung übertragen lässt und ebenso wie die Umweltauswirkungen und die dazugehörenden Themen konzeptualisiert und adressiert werden. Angesichts der Tatsache, dass Bewertung per se und die Methoden Wert zu messen und zuzuordnen soziale Konstrukte sind, kann das Verstehen der Umweltbewertungs-Methoden (und der Praktiken innerhalb dieser) Einblick in die beteiligten Performativitäten bringen und beleuchten wie dadurch über Natur verfügt wird.

Die vorliegende Arbeit will die Methoden und Praktiken zur Bewertung von Ökosystemleistungen anhand der empirischen Fallstudie des Projekts „Recharge.green“, dessen Hauptziel es war die Entscheidungsfindungsprozesse zur erneuerbaren Energieerweiterung in den Alpen zu erleichtern, untersuchen.