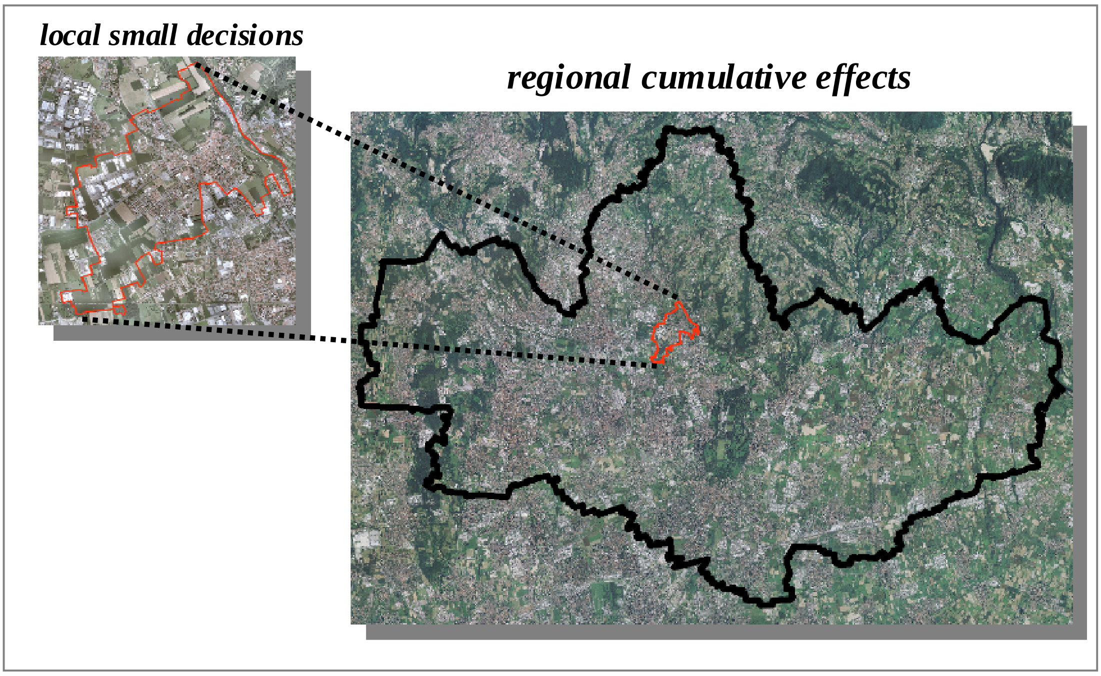
Doctoral School in Environmental Engineering

Improving the consideration of cumulative effects in Strategic Environmental Assessment of spatial plans

A case study in the peri-urban region of Milan

Chiara Bragagnolo



UNIVERSITÀ DEGLI STUDI DI TRENTO
Dipartimento di Ingegneria Civile e Ambientale

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Doctoral thesis in **Environmental Engineering, XXXIII cycle**

Faculty of Engineering, **University of Trento**

Academic year **2009/2010**

Supervisors: **Dr. Davide Geneletti, University of Trento**

Prof. Thomas B. Fischer, University of Liverpool

University of Trento

Trento, Italy

2011

fabbricando case… ospedali… casermoni… e monasteri…
fabbricando case… ci si sente più veloci e più leggeri…
fabbricando scuole… dai un tuo contributo personale all'istruzione…
fabbricando scuole… sub-appalti e corruzione bustarelle da un milione…
fabbricando case… popolari biservizi secondo il piano regolatore…
fabbricando case… ci si sente vuoti dentro il cuore…
ci si sente vuoti dentro il cuore…
ma dopo vai dal confessore e ti fai esorcizzare…
spendi per opere assistenziali…
per sciagure nazionali…
e ti guadagni l'aldilà…
e puoi morire in odore di santità…

[Rino Gaetano, 1978]

Acknowledgements

I would just start these acknowledgements with a sentence pronounced by an unknown speaker at a conference I have participated in, who said that "*the world of research cannot make you rich, rather it allows you to meet special people*". During these three years people on my way were many and really special.

First of all, I would like to thank my supervisor Dr. Davide Geneletti for supporting my research and offering me the opportunity to work together. Thank you, Davide, for always arriving in time and redirecting me when I was going towards black holes! Thank you for giving me the opportunity to put into practice what I was learning through the theory…without those inputs this work would never be a PhD thesis. And last, but not least, thank you for accepting my forthrightness and my ups and downs.

I would also give my greatest thanks to Prof. Thomas Fischer for supervising this work from afar, providing his critical suggestions. Thank you, Thomas, for giving me the opportunity to visit your department and dedicating your precious time during the darkest time of this work…I could never forget your support!

I would like to thank all experts who participated in the survey for their willingness and kindness: James Allan, Alessandro Bonifazi, Maristella Caramaschi, Lourdes Cooper, Pasquale De Toro, Peter Duinker, Mark Fessey, Paola Gazzola, Ainhoa González, Marie Hanusch, Clare Harmer, Jan Looijen, Giuseppe Magro, Anastassios Perdicoulis, Marco Pompilio, Chiara Rosnati, Roel Slootweg, Riki Therivel, Marja van Eck, Gustavo Vicente. And an extra thanks to Bram Noble who additionally provided his recommendations during the earlier stage of this research.

I would wish to extend my gratitude to the 'SEA group' of the *Italian Environmental Assessment Association* and in particular to: Marco Pompilio for his 'fit for the process' SEA perspective; and Carlo Rega for his support and his '*de-structuration theory*'.

Thanks to Marco Felisa for illuminating me about the case study and to all who have shared with me the good, the bad and the fuzzy of Italian SEA practice during this three years.

My sincerest thanks to Mauro Taufer for helping me to carry out part of the results of this work.

I would also like to specially thank Gianfranco '*giangi*' Franz because without the 'MAPAUS-experience', I would never start this challenging 'trip'.

To my wonderful parents for their unconditional love and support. Un primo grazie per la vostra gioia ed allegria. Un secondo grazie per avermi fatto crescere libera. E un terzo grazie per avermi insegnato a credere che ‘un altro mondo è possibile’.

To my housemate, colleague and, not least, best friend Roberta for sharing this three years of life. Because without you Trento would be even more ‘*out of history*’.

To the time spent at the Trento university, I would like to thank: the ‘Lungadige neighbour-colleagues’ Corrado, Daniele, Francesco e Marco; Mauricio (gracias por los almuerzos latinos), Cristina (for the gossips), Elena (por entender de verdad que es la mexicanidad), Carlo (l’emerito Professore), Michela, Alessandro, Marika, Rocco, Emanuela, Chiara, Simonetta, Alessandra.

I am grateful to all the ‘buena onda’ people that I met in Trento. Primero que nada, gracias a mi *pinche* amigo Ernesto por nuestras *charlas moteñas* sobre todo y nada. Obrigada a galera dos capoeristas, vocês são muito especiais pra mim....Enrico *corpo fechado*, Lucia, Super, Velvet, Pippo, Barriga, Paolinho, Gallo, Alice, Shana, Clodoaldo&Lia, Osan, the ‘Porno Fratellis’, Clarinha&Marco, Ciccio, Mago&Cristina, Mister D., Maruskinha, etc. And Paolo&Anna (i maledetti).

A special thanks to my ‘*little guru*’ Matteo for his deep wisdom and to my *accomplice* Hans for being on my same wavelength during our long friendship.

To those supporting me from afar. I would like to thank particularly: Zara (la storica), Diletta (la querida), Vesna (la weona), Enrica (pour ton pied-à-terre en Bruxelles).

Y finalmente, gracias México, por re-darme la fuerza de enfrentar estos desafios de la vida!

Adesso si apre un altro capitolo!

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Summary

Most of the significant changes on the environment have resulted from individually minor but collectively significant human actions and decisions. This kind of consequences has been defined Cumulative Effects (CE) and their systematic consideration can be attributed to the scientific basis and institutional context of Environmental Assessment (EA) theory and practice. In particular, addressing CE in EA has been accepted to be more particularly important at strategic level, giving a great emphasis to higher tier assessment, namely Strategic Environmental Assessment (SEA), as the most appropriate level to effectively consider CE due to its broad scale and its focus on influencing future development (Sadler and Verheem, 1996; Cooper and Sheate, 2002; Fischer, 2002; Thérivel and Ross, 2007).

Within the European context, Strategic Environmental Assessment (SEA) Directive, concerning '*the integration of environmental considerations into plans and programmes*', explicitly solicit CE to be considered (*Annex I*) and spatial or land use plans are among the most important planning instruments required to be linked up with SEA by this Directive. Generally speaking, spatial plans aim to manage the present and the future use of land, resources and services to allow for sustainable and efficient pattern and future development, mainly acting at regional and local level. Therefore, the SEA of spatial plans can be defined as a decision support process aiming to address the potential environmental effects that can result from implementing the proposed plan, paying particular attention to anticipate cumulative and large-scale effects.

However, in spite of recognition amongst the scientific, regulatory and practitioner communities of the importance to adopt a strategic approach to appropriately deal with CE, it is worth noting that it seemed to be seldom the case as the treatment of CE results particularly disregarded in current SEA practice, suggesting that there is a gap between the theoretical emphasis given to SEA and SEA practice with respect to the consideration of CE.

Additionally, referring to the spatial planning context, the challenge to capture those individually minor consequences on the environment relies on its hierarchical tiered system as local spatial plans often contribute to small insignificant changes, mainly not subjected to EIA, that could significantly affect regional environment. And this could cumulatively cause significant environmental changes at regional scale which are seldom considered by local level decisions since not significantly relevant at that scale (e.g. land take, air quality, biodiversity loss, etc.). In particular, these scale-lag consequences has been stated mostly noteworthy for highly urbanised regions, where environmental or ecological thresholds (e.g. air quality

standards, land take, CO_2 emissions, etc.) tend to be more easily exceeded due to narrow, small and, apparently, insignificant land use changes (Antrop, 2004; MEA, 2005; EEA, 2006).

In the light of this, this dissertation aimed to propose and apply a methodological approach to improve the consideration of cumulative effects in SEA of spatial plans, by focusing on the Italian spatial planning system and urban regions.

This overall goal was reached by pursuing the following intermediate objectives:

1. to understand how SEA for spatial planning works in practice;
2. to explore how CE are currently treated in SEA of spatial plans;
3. to develop a methodological approach to improve the consideration of cumulative effects in SEA of spatial plans;
4. to apply the proposed approach to a case study, by empirically testing its applicability and discussing its limitations.

The first assumed that proposing a methodological approach to support SEA in treating CE required the achievement of a good knowledge on SEA and planning processes. To meet it a double-perspective was adopted, by moving forward from theoretical basis to empirical observations. Findings suggested a number of systemic and methodological constrains affecting SEA practice. Among the most important, the inadequate role of scoping in appropriately addressing relevant issues and in supporting the overall SEA process and methodology; as well as a scarce consideration and assessment of future alternatives and an unsatisfactory definition of monitoring plans.

The second investigated whether and how cumulative effects are currently considered by SEA practice in different international contexts, with particular reference to spatial plans at local and regional level. To meet it, both an international expert survey and a systematic review of SEA reports were carried out. The results suggested that: CE were poorly and not thoroughly considered by international SEA practice, highlighting general and contextual barriers (e.g. legal requirements, availability of guidance, etc.). They further highlighted a lack of methodological approaches to: support the scoping of CE; orient the assessment towards the 'future'; and assess CE through a more evidence-based perspective, being the most frequent consideration of CE a qualitative description based on expert opinions. Conclusions mainly regarded the need to: better scope CE issues (Valued Ecosystem Components (VEC), '*other foreseeable future actions*', etc.); better handle the scale-lag effects (spatial crowding and time lag); better explore planning alternatives and future conditions; and improve the systematic treatment of uncertainty.

Basing on findings and shortcomings emerged from theoretical and empirical outcomes, a methodological proposal for improving the consideration of CE in SEA of spatial plans was developed in order to meet the third objective. By focusing on regional spatial plans, it consisted of four key tasks: the selection of VEC; the identification of relevant PPPs (other projects, plans, programmes and policies) contributing to cumulative changes on identified VEC; the definition of spatial planning alternatives and future conditions; and the assessment of CE on VEC through a core set of indicators.

Therefore, in order to achieve the last objective of the research its applicability was tested in a case study in the peri-urban region of Milan. The study area represents one of the most urbanised and industrialised part of Italy, with significant urban pressures on existing protected areas and remaining rural patches, which are playing an important role in maintaining the regional ecological network and provide for several important environmental services. Firstly, regional green infrastructure was selected as VEC; then, three relevant '*other foreseeable future actions*' were identified (i.e. highway transportation corridor, protected areas conservation plans, and rural policies). Subsequently, two main planning alternatives and future land use scenarios were developed and made spatially explicit, starting from a couple of regional land use maps. Then, the regional cumulative effects on VEC (e.g. habitat fragmentation, surface runoff, etc.) were assessed against a range of future conditions through a core set of indicators, mainly quantitative and spatially explicit, simulating relevant environmental processes, such as hydrological cycle, local surface temperature, ecological connectivity. They were all selected and computed starting from land cover data, allowing the combined effects to be quantified and land use scenarios to be compared. The results mainly showed that the method provided an applicable means to, firstly, transfer policies and decisions into maps, and then, predict their combined effects on selected VEC. Moreover, it can be straightforwardly included in SEA of regional spatial plans in order to support more evidence-based and sustainable decision-making, and thereby, applied to other case studies, by appropriately tailoring the selection of indicators on relevant VECs. In addition, future developments of the proposed approach were suggested. Among the most important were: a better exploration of future conditions, including, for instance, those actions and decisions whose spatial explicitness is not directly detectable, but whose contribution to CE on VEC could be significant; and a systematic treatment of the uncertainty characterising assumptions and predictions.

Finally, being the proposed approach specifically tailored for the SEA of regional spatial plans, it would be particularly interesting to test its feasibility and effectiveness in a real-life spatial planning process, providing, at least, an indication of whether or not the developed method could have any discernable impact on the management of CE and, subsequently, on the environmental quality of the region in which the spatial plan would be applied.

Chapter 1

1 Scope and outline of the thesis

1.1 Introduction

Most of the significant changes on the environment have resulted from the combination of minor effects of multiple actions, rather than from the direct effect of an individual action or decision. This kind of consequences has been defined Cumulative Effects (CE) and their systematic consideration can be attributed to the scientific basis and institutional context of Environmental Assessment (EA) theory and practice. In facts, addressing CE through EA procedures has been required over the world since the inception of Environmental Impact Assessment (EIA) regulation. However, it has been largely agreed that project-level EIA generally failed in addressing CE, due to narrow scope of analysis (single project, site effects), reactive support to decision-making and limited responsibilities of projects' proponents to mitigate those individually minor effects (Duinker and Greig, 2006; Gunn, 2009). Then, a great emphasis has been given to higher tier assessment, namely Strategic Environmental Assessment (SEA), as the most appropriate level to effectively 're-consider' CE due to its broad scale and its focus on influencing future development (Sadler and Verheem, 1996; Noble, 2000; Cooper and Sheate, 2002; Canter and Ross, 2010).

Within the European context, spatial or land use plans are among the most important planning instruments required to be linked up with SEA by the SEA EU-Directive, concerning '*the integration of environmental considerations into plans and programmes*'. Generally speaking, spatial plans aim to manage the present and the future use of land, resources and services to allow for sustainable and efficient pattern and future development, mainly acting at regional and local level. Therefore, the SEA of spatial plans can be seen as a decision support process mutually interacting with the planning process, by identifying and addressing the potential environmental effects that can result from implementing the proposed plan, paying particular attention to anticipate cumulative and large-scale effects. Then, according with the EU procedure, the outcomes of SEA process need to be summarised into an SEA report which usually forms part of the spatial planning documents.

However, being the consideration of CE mandatory required by the SEA Directive (see *Annex I*), it is worth noting that it should be a prior issue to address within SEA of spatial plan. On the contrary, this seemed to be seldom the case as the treatment of CE results particularly disregarded in current SEA practice, suggesting that there is a gap between the theoretical emphasis given to SEA and SEA practice with respect to the consideration of CE.

In particular, two major factors generally constraint the proactive consideration of CE in SEA: the greater inter-institutional efforts required in order to face on broad scale and future significant consequences arising from a set of inter-tier actions, mostly dealing with contextual aspects (institutional arrangements, legal frameworks, etc.); and a methodological lack to appropriately deal with combined effects at strategic level (Gunn and Noble, 2009; Canter and Ross, 2010), further exacerbated by the scarce availability of technical support characterising several contexts.

With particular reference to spatial planning, the challenge to capture individually minor consequences relies on its hierarchical tiered system as local spatial plans often contribute to small insignificant changes, mainly not subjected to EIA, that could significantly affect regional environment. In particular, local spatial decisions often concern small changes in urban and natural patterns due to the direct role of local spatial plans in: converting natural or agricultural land into urban land, promoting urban renewal, providing for services and, thereby, increasing the demand of transport, housing, employment, protecting nature conservation areas, open spaces, etc. And this could cumulatively cause significant environmental changes at regional scale which are seldom considered by local level decisions since not significantly relevant at that scale (e.g. land take, air quality, biodiversity loss, etc.). Moreover, these scale-lag consequences has been stated mostly noteworthy for urban regions, or regions with high level of urbanisation and/or industrialisation, where environmental or ecological thresholds (e.g. air quality standards, land take, CO_2 emissions, etc.) tend to be more easily exceeded due to narrow, small and, apparently, insignificant land use changes (Antrop, 2004; MEA, 2005; EEA, 2006). With particular reference to Europe, its urban future has been stated a matter of great concern as more than a quarter of land is currently covered by urban land uses and urbanisation is no longer tied to population growth (EEA, 2006). As a result, the various demands for land in and around cities are becoming increasingly acute and, by 2020, approximately 80% of Europeans will be living in urban areas, peaking at over 90% in several European regions. Consequently, being the urban sprawl considered one of the most ignored European challenge, a great emphasis has been given to land use planning policies at both local and regional level in order to define and share sustainable urban and environmental planning strategies (EEA, 2006; Gibelli and Salzano, 2007). However, the management of individually minor land use decisions and, then, their likely cumulative consequences on the environment, is still considered a tricky goal to achieve due to both methodological and contextual factors. Consequently, SEA may play a key role in supporting spatial plans to anticipate negative cumulative consequences and mainstream positive cumulative benefits, by focusing on those resources that are particularly valued for the community and vital to the healthy functioning of the environment.

In the light of these considerations, this dissertation advances a methodological proposal to improve the treatment of cumulative effects in SEA of spatial plans, by focusing on: urban regions and Italian spatial planning system.

1.2 Research objectives

The purpose of this research is to improve the consideration of cumulative effects in SEA of spatial plans, by proposing a methodological approach and applying it to an Italian urban region.

The specific objectives of the research are:

- **O1.** to understand how SEA for spatial planning works in practice. The objective assumes that proposing a methodological approach to support SEA in treating CE requires the achievement of a good knowledge on SEA and planning processes;
- **O2.** to explore how CE are currently treated in SEA of spatial plans, with the double purpose of ascertaining the main research hypothesis (i.e. gap between SEA theory and practice in respect of the treatment of CE) and identifying conceptual, procedural and methodological key issues, including the investigation of methods applied;
- **O3.** to develop a methodological approach to improve the consideration of cumulative effects in SEA of spatial plans, focusing on shortcomings emerged from theoretical and empirical outcomes;
- **O4.** to apply the proposed approach to a case study, by empirically testing its applicability and discussing its limitations.

1.3 Structure of the thesis

The thesis is structured in three main sections. Chapters 1, 2, 3 and 4 constitute the theoretical and methodological basis of the research; as well as the input to frame the framework proposed in Chapters 6 and 7 in order to meet the main research aim. Chapter 5 is a linking section, proposing preliminary findings and remarks coming from the previous section and advancing important shortcomings for the advancement of the next part.

Figure 1.1 shows the structure of the thesis which is following in depth described.

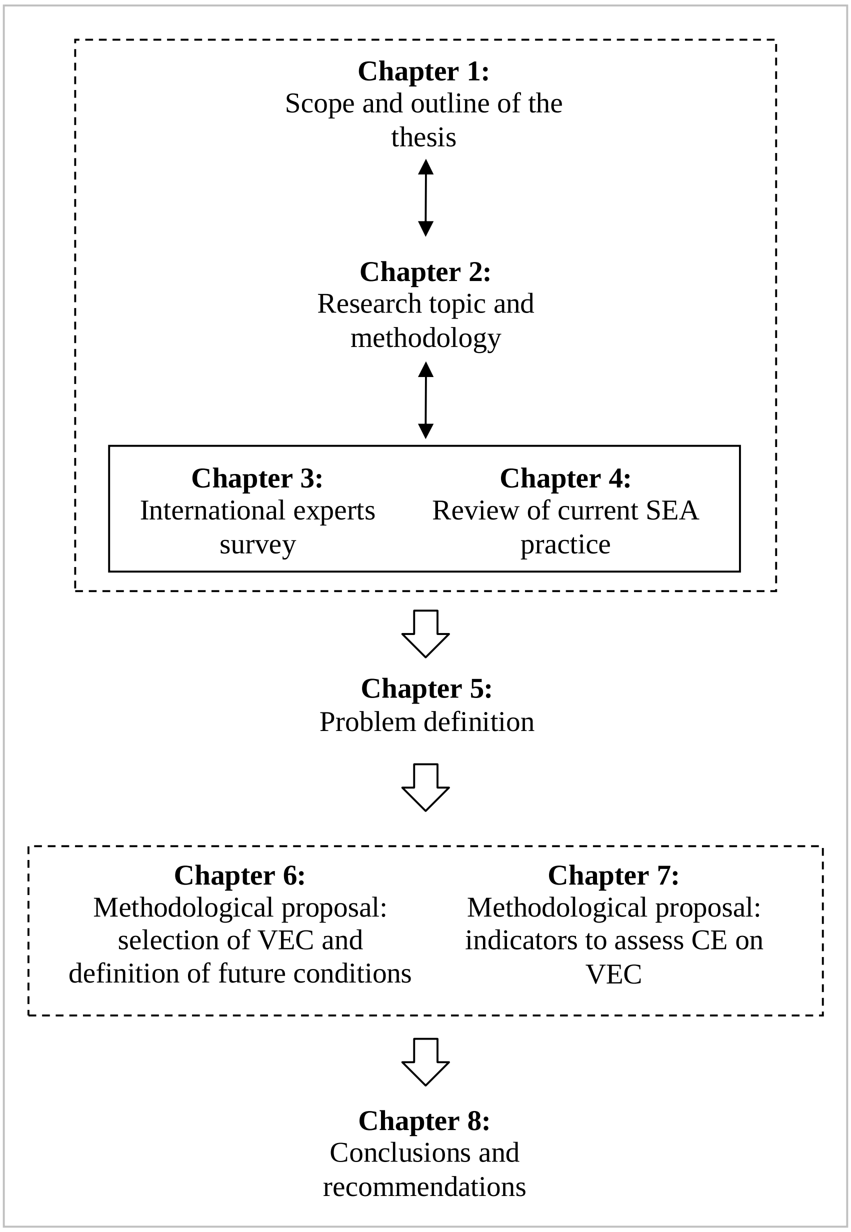

Figure 1.1: Structure of the thesis

Chapter 2 introduces the topic of the research, focusing on three key concepts, namely Strategic Environmental Assessment (SEA), cumulative effects (CE) and spatial planning. It generally aims at framing the research focus, by reviewing the literature and establishing the interactions among these three key elements. It further provides a description of the research methodology, by illustrating its approach, as well as how the research activities have been structured in order to meet the specific objectives previously listed. **Chapter 3** and **Chapter 4** respectively present the results of: an international expert survey and a systematic review of twenty SEA reports of Italian and English local and regional spatial plans, aiming to explore to what extent and how CE are considered and assessed in current SEA practice, uncovering conceptual, procedural and methodological key issues. **Chapter 5** is a linking section within this dissertation, being a crucial input to, on the one side, define the research problem and, on the other, frame the methodological approach. As a result, it, firstly, summarises the findings of previously conducted activities, including lessons learned from two real-life SEA processes; and subsequently, it introduces the specific context in respect of the methodological approach has been developed: urban regions and Italian spatial planning system. Then, it provides an introduction to the case study selected to empirically test the proposed approach.

Chapter 6 and **Chapter 7** propose a methodological approach to improve the consideration of cumulative effects in SEA of spatial plans, by introducing a general framework and testing its applicability in a case study selected within the peri-urban region of Milan. Its boundaries fit to the new administrative Province of Monza and Brianza, covering a surface of 405 Km^2.

In particular, the proposed framework focuses on SEA preliminary steps (i.e. CE scoping; definition of CE future conditions; and prediction of CE), consisting of four key tasks. It generally bases on Valued Ecosystem Components (VEC), being the selection of those vital resources at the heart of the conceptual development of the framework. Additionally, it adopts a spatially explicit approach, being the spatial evidence at the methodological core of the framework. Accordingly, Chapter 6 introduces the general framework and applies three preliminary steps (selection of VEC; identification of other relevant projects, plans, programmes; definition of spatial planning alternatives and future conditions); while Chapter 7 proposes the fourth step, by applying a core set of indicators to assess CE on VEC.

Then, **Chapter 8** summarises the main research findings; advances conclusions; and offers some recommendations for further research.

Chapter 2

2 Research topic and research methodology

2.1 Introduction

This chapter aims at introducing the topic of the research, focusing on three key concepts, namely Strategic Environmental Assessment (SEA), cumulative effects (CE) and spatial planning. It also aims at framing the research focus, by reviewing the literature and establishing the interactions among these three key elements (see Figure 2.1). The structure of the chapter is as follows. Section 2.2 introduces a general overview of SEA. Section 2.3 analyses the concept of CE and their treatment within the environmental assessment domain, discussing the important issue of scale. Section 2.4 explains the rationale of treating CE in SEA of spatial plans, focusing on the opportunity to early approach CE through SEA and to adopt a spatially explicit approach in order to improve the effectiveness of SEA in addressing CE within the spatial planning processes. Finally, Section 2.5 describes the overall research methodology, by illustrating the research approach and portraying how the research activities have been structured in order to meet the specific objectives.

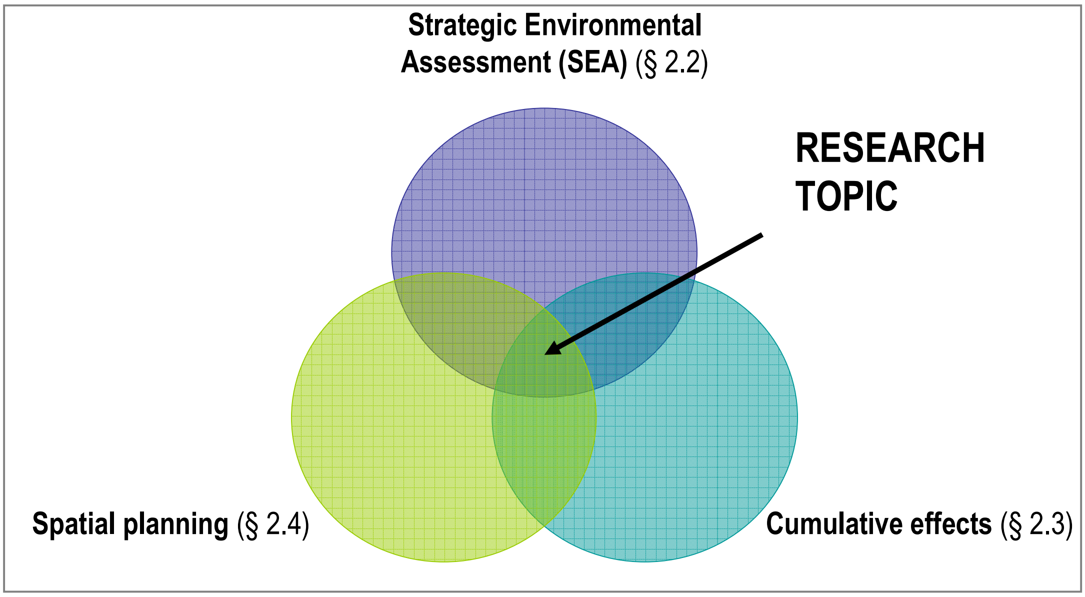

Figure 2.1: Research topic

2.2 Introduction to SEA

2.2.1 Origin and purposes

The National Environmental Policy Act (NEPA, 1969) of the United States is generally acknowledged as the original legislative impetus for systematically integrating the "environment" within the decision-making procedures. Following NEPA, other countries started to establish environmental assessment requirements, such as: Canada, Australia, West Germany, and France (Dalal-Clayton and Sadler, 2005; Fischer, 2007). However, during the 1980's, a distinction started to be made within the environmental assessment domain, between project and higher tiers of decision-making (Fischer, 2007). And with particular reference to the European Union (EU), this distinction was formalised through the introduction of Environmental Impact Assessment (EIA) in 1985, based on Directive 85/337/EEC, covering projects only.

However, due to a growing awareness that environmental consequences also needed to be considered above the project-level and addressed before practical actions, Strategic Environmental Assessment (SEA) was introduced in the second half of the 1980s, covering policies, plans and programmes (PPPs) (Wood and Djeddour, 1991). Consequently, SEA practice has received considerable impetus from a number of international organisations, such as the World Bank, the United Nations Development Programme (UNDP) and the Organisation for Economic Co-operation and Development (OECD) (Fischer, 2007). The same purpose to integrate environmental considerations with development drove the Brundtland Commission through the 1992 Earth Summit, Agenda 21 (UNCED, 1992a) and the Rio Declaration (UNCED, 1992b), providing further impetus for national governments to enforce the incorporation of the "environment" into all levels of decision-making. Moreover, the Rio Declaration stated the role of environmental assessment as a means to enforce this institutional challenge (UNCED, 1992b, Principle 17). Accordingly, the United Nations Economic Commission for Europe (UNECE) recommended the extension of EIA principle to PPPs.

Many countries now have some type of SEA system: regulations requiring SEA, guidance recommending SEA (or various SEA procedures and techniques), and/or experience in carrying out SEAs. Therefore, SEA procedures are internationally characterised as formal or informal approaches to the environmental assessment of PPs and, in certain cases, policies. Moreover, in some instances (i.e. Canada, Hong Kong, US, South Africa, etc.) SEA occurs under other labels (e.g. regional planning, etc.) or, in some cases, under the guise of EIA legislated systems. Consequently, it is currently difficult to give an exact account of formal SEA systems globally due to terminological differences. Not all the systems explicitly use the term SEA. Furthermore, the international SEA literature tends to focus on certain systems only (Fischer, 2007).

Currently, the SEA European Directive 42/2001/EC *on the assessment of the effects of certain plans and programmes on the environment* (SEA Directive, European Commission, 2001) may be probably recognised as the best-known SEA legal framework establishing a minimum common framework for spatial and other sectoral plans and programmes (Dalal-Clayton and Sadler, 2005), leaving each member states to a flexible implementation. In particular, the Directive advocates the application of a systematic, pro-active, EIA-based and participative process that must be prepared with a view to avoiding unnecessary duplication in tiered assessment practice (Thérivel, 2004; Fischer, 2007).

Definitions of SEA have been provided by numerous academics (Sadler and Verheem, 1996; Thérivel and Partidário, 1996; Brown and Thérivel, 2000; Partidário, 2000; Fischer, 2003; Stoeglehner, 2004). In general, SEA may be defined as a decision-making support instrument for predicting and evaluating the likely environmental effects of implementing a proposed PPPs (Sadler and Verheem, 1996), and thereby, aiming at supporting the design of PPPs, by "greening" their decisions and anticipating their negative consequences. As a result, the implementation of SEA has been conceived as a post-modern transition of decision support paradigm from substantive (rational choice) to procedural rationality (rational choosing)[1], due to the recognition that in practice decision- and policy-making processes do not follow a rational procedure owing to subjective norms, values and interests of different systems and actors involved (Kørnøv and Thissen, 2000).

Consequently, the purposes of SEA can be resumed as following (Fischer, 2007):

1. SEA should support the systematic consideration of environmental and other sustainability aspects during the overall decision-making process;
2. SEA should add an evidence-base to decision-making process, thus ensuring scientific rigour through the application of a range of assessment methods and techniques;
3. SEA should support more effective and efficient decision-making, by facilitating consultation between authorities, enhancing public involvement and improving governance.

[1] According to Simon (1976), substantive decision refers to approaches that attempt to provide knowledge-based expertise to address particular decisions and it is particularly useful when what need to be done and why are known, but it needs help in deciding how it should be done. Consequently, substantive decision support tools may help to decide how an objective should be achieved, hence the value of a knowledge base. At the opposite, a procedural decision support tool should support decision makers in addressing the why and what questions, rather than just helping them to think about how an objective should be achieved. As in higher decision tiers (policies, plans and programmes), procedural rationality may help the use of reasoning in order to think about future developments and consequences in a structured and proactive way.

Therefore, the perceived opportunities from SEA have been mostly argued as stemming from its proactive and strategic nature as well as from its capacity to achieve a more integrated and sustainable sound of development during decision-making, allowing to facilitate:

- the earlier consideration of environmental consequences;
- the examination of a wider range of potential alternatives;
- the generation of standard mitigation measures; and
- the opportunity to address a wide range of effects (Thérivel *et al.*, 1992; Sadler and Verheem, 1996; Eggemberger and Partidário, 2000; Fischer, 2003; Thérivel, 2004; Jones *et al.*, 2005).

Additionally, SEA has been widely acknowledged as an important addition to project EIA due to the opportunity to adequately and proactively consider cumulative impacts of more that one project (see § 2.3.2).

However, several systemic and methodological constrains have been recognised in international literature affecting SEA performance (Thérivel and Partidário, 1996; Partidário, 2000; Fischer, 2003; Jones *et al.*, 2005; Fischer and Gazzola, 2006; Runhaar and Drissen, 2007; Stoeglehner *et al.*, 2009). On the one hand, the position of SEA into the political arena submits its effectiveness to political interests and attitudes, varying among different decision-making contexts. And these have been considered the most threatening factor for SEA to be effective as well as the longer to overthrow. On the other hand, the often wide geographical scale, the extended time horizons, and the broad range of alternatives, as well as higher level of uncertainty inherent in assessing strategic decisions can complicate the development of methodological approaches for enabling tiering of assessments between different levels of decision-making. This can be further constrained by the availability of information, data, time and resources (Thérivel, 2004).

2.2.2 The SEA process

SEA is a process that requires connection and accordance with the decision-making process into a linked up, continuous and integrated decision flow (Fischer, 2007) in a timely fashion (Dalkmann *et al.*, 2004; Gunn, 2009). According to Verheem and Tonk (2000), a number of different SEA procedures exist, varying in their openness, scope, intensity and duration, such as policy SEAs, sectoral SEAs, sustainability-based SEAs, regional SEAs, issue-based SEAs, and EIA-based SEAs. These often vary according to the circumstances under which they are applied. Even though flexible SEA approaches have been recognised to be essential to allow the process to be tailored for that particular context and situation, a number of particular SEA stages can be recognised from practice both in case of a non-EIA- or EIA-based approach is adopted. This includes scoping, definition of SEA objectives, identification of alternatives, prediction and evaluation of effects, follow-up and monitoring; consultation and participation and preparation of a report (Sadler and Verheem, 1996; Thérivel and Partidário, 1996; Brown and Thérivel, 2000; Jones *et al.*, 2005). Scoping generally details the environmental state of the context, by selecting through an evidence-based analysis those relevant environmental aspects, describing the institutional framework and proposing a range of environmental and sustainable objectives and criteria. Scoping further includes a methodological proposal for the overall assessment. Then, the definition of plausible alternative developments allows to explore how objectives can be achieved in an environmentally resilient way as well as predict their likely consequences, by comparing and assessing their environmental performance. Subsequently, specific objectives and measures to avoid, reduce or compensate negative adverse effects could be envisaged in order to optimise environmental and social benefits. This is supposed to influence the underlying plan and programme making process, with a view to improving it from an environmental perspective, as well as to contribute to more transparent, robust and sustainable decisions. Then, monitoring helps to evaluate the effectiveness of decisions taken, highlighting unexpected or negative environmental outcomes of planning actions which might require appropriate remedial actions, as well as to test the validity of the assumptions and predictions previously made and, thereby, it may enable to tackle uncertainty better. Finally, consultation is supposed to ensure a participation of multiple agencies and knowledge, assuring a better cohesion and a more integrated approach, whilst participation is supposed to ensure more transparent processes as well as more democratic and equal decisions.

At the heart of SEA process is the preparation of an Environmental Report (ER) which is expected to: provide as detailed a picture as possible of the environmental consequences related to the implementation of a plan or programme on relevant environmental aspects; portray the relationship with other policies, plans and programmes; explain how SEA was considered in decision-making and provide adequate information on the choice of a certain alternative (Fischer, 2007; Geneletti *et al.*, 2007). According to the SEA Directive, CE must be taken into account and reported on within the ER (*Annex 1*, note 1). However, the methodological approach for treating CE at strategic level is still largely unclear and further research is required to tackle this (see § 2.3 and 2.4).

2.2.3 Overview of methods

Over the last few decades, impact assessment practice moved from point source analysis to a more strategic approach, responding to the complexity of combined effects caused by human activities on natural resources, services and human well-being searching to avoid them; and coping with uncertainty related to the effects of strategic actions.

Some authors have argued that new methodologies and procedural requirements are required for SEA, in order for it to be able to provide a suitable framework to bring different methods, tools and techniques together in a more conscious, structured, and comprehensive way, moving towards more holistic analysis (Thérivel, 2004; João, 2007; Sheate *et al.*, 2008; Morris and Thérivel, 2009). Even where existing techniques include an emphasis on the environment, SEA provides an opportunity to broaden it from a biophysical emphasis in some instances, or a social emphasis in others (see § 4.4). And this is particularly appropriate for the formulation of strategic-level actions, where environmental costs at one tier of decision-making can be offset with benefits at other tiers.

Despite environmental assessment methods and techniques being numerous, only a very limited range of them has been used in practice (Thérivel and Partidário, 1996; Thérivel, 2004; Fischer, 2002). And these mostly include expert judgements, matrices, multi-criteria analysis, mapping and overlays using GIS, and modelling (Thérivel *et al.*, 1992; Fischer, 2002; Thérivel, 2004; González, 2008). Moreover, they have been often classified by: purpose in case of descriptive, analytical or involvement and communicative (Fischer, 2007); components in case of environmental or socio-economic issues (Morris and Thérivel, 2009); tier of decision-making and scale of analysis (Thérivel and Partidário, 1996; João, 2007); approach adopted in case of qualitative, quantitative or semi-quantitative (Baldizzone, 2006); and SEA stages (Cooper, 2004; ODPM, 2005).

For instance, impact matrices and forecasting/simulation techniques have been suggested as more suitable for the impact assessment stages (ODPM, 2005). Referring to the issue under concern, network analysis has been found particularly helpful to identify cumulative impacts (Thérivel and Ross, 2007; Perdicoùlis and Piper, 2007; Cooper, 2010). While MCA[2] and optimisation techniques[3] have been considered particularly powerful in comparing and

2 MCA is a decision support technique by which a set of solutions of a structured and known decision problem is ranked based on a set of evaluation criteria and attributes or objectives. MCA allows to provide indications on the performance of alternatives and then to compare them.

3 Optimisation is a normative approach to identify the best solution for a given decision problem (Wilson *et al.*, 1981; Thomas and Huggett, 1980). An optimisation method seeks to find the best (maximum or minimum) solution to a well-defined management problem. Optimisation techniques help to support well structured problems where objectives are clear and, comparing with MCA, allow to generate an optimal solution from a much larger or

assessing different alternatives in case of structured problems (Malczewski, 1999). Overlay mapping, whether weighted or not, has been shown to be very functional for supporting suitability analysis in order to obtain maps indicating different values or properties such as sensitive or vulnerable area for a specific purpose through the merge of different spatial themes such as topographical issues, relevant environmental aspects, etc. (Marull *et al.*, 2007). And this has been demonstrated as having the opportunity to improve consultation, active participation and consensus building as well as the overall SEA process, with particular reference to spatial planning (González, 2008). However, lack of knowledge, information, and data as well as time, availability of resources may contribute to limit the application of sophisticated techniques as well as to hinder in gaining acceptability and trust for the outputs.

Additionally, the environmental assessment at strategic levels requires to cope with considerable degree of uncertainty[4]. Thereby, incorporating systematic analysis/discussion on uncertainty into environmental assessment procedures has been advanced in order to:

- address and relate the role of uncertainties in the context of policy advice;
- not necessarily reduce them but assess their potential consequences;
- avoid susceptibility associated with their ignoring; and
- facilitate the design of effective strategies for communicating uncertainty (Van der Sluijs *et al.*, 2004).

Nonetheless, uncertainty seems to be a challenging aspect to address in practice and its tackling in environmental assessment procedure seems to require further investigation (see § 2.2.3).

possibly infinite set of alternatives, where the set of alternatives to choose from is implicitly created by the optimisation procedure itself.

4 Two principal types of uncertainty further complicate assessment of future environmental changes: the first arises from an incomplete understanding of the interactions and dynamics within environment hence of the current situation; the second depends on the indeterminacy of all future developments and could be distinguish among ignorance, surprise and volition (Raskin *et al.*, 2002; MEA, 2005). Ignorance refers to limits in scientific knowledge in the understanding of possible future dynamics and it is similar to the first type; surprise is due to the inherent unpredictability of complex systems that can exhibit emergent phenomena and structural shifts; volition represents the institutional and societal uncertainty and is introduced when the future is subjected to human choices.

2.3 The concept of cumulative effects

2.3.1 A challenging concept to define

The possibility of environmental cumulative effects (CE) arising based on certain actions has been discussed in literature since before the inception of environmental assessment (EA) practices. Various authors observed that significant environmental changes may result not from the direct effects of a particular action, but from the combination of individually minor effects of multiple actions over the time. This has been referred to as the "*destruction by insignificant increments*" (Gamble, 1979) and the "*tyranny of small decisions*" (Odum, 1982). However, although these consequences on the environment have been notable for centuries, their systematically recognition can be attributed to the scientific basis and institutional context of EA theory and practice.

The US National Environmental Policy Act (NEPA, 1969) is generally acknowledged as the original legislative impetus for cumulative effects assessment through Environmental Impact Assessment (EIA). These days, the process of systematically analysing and assessing cumulative environmental changes or Cumulative Effects Assessment (Spaling, 1994; Smit and Spaling, 1995) is mandatory required by many countries around the world.

The concept of CE has been firstly defined by the US Council on Environmental Quality (CEQ, 1978)[5] and later detailed by other scholars (Canter, 1999; Ross, 1998; Sadler and Verheem, 1996; Cooper, 2004), highlighting two substantive issues:

1. the causal-effects relationship between the combination of activities (sources) and impacts on the receptor or resources of concern (also called Valued Ecosystem Components or VEC[6]);
2. the accumulation of individually minor effect of multiple actions over space and time.

To develop a clear picture of CE, numerous conceptual frameworks have been elaborated and appropriate terminology regarding CE has been promulgated (Canter and Kamath, 1995). Among others, the concept of *Valued Ecosystem Components* (VEC)[7] is commonly referred to in the CE literature, as it has been considered the main focus of CEA. Other conceptual

[5] The impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions […] Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

[6] Any part of the environment that is considered important by the proponent, public, scientists or government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concern (Hegmann *et al.*,1999).

[7] Hegmann *et al.* (1999) suggested that VECs need not to be necessarily biophysical in nature, rather they may encompass aspects with a social or economical values such as recreational areas, local communities, sensitive categories of people, etc.

developments contributing to the notion of cumulative environmental changes have been further identified in the literature (Smit and Spaling, 1995). However, they generally followed a causal model consisting of: sources (or stressors); pathways of accumulation (e.g. additive, synergistic, etc.); and receptors (or VECs) (Figure 2.2).

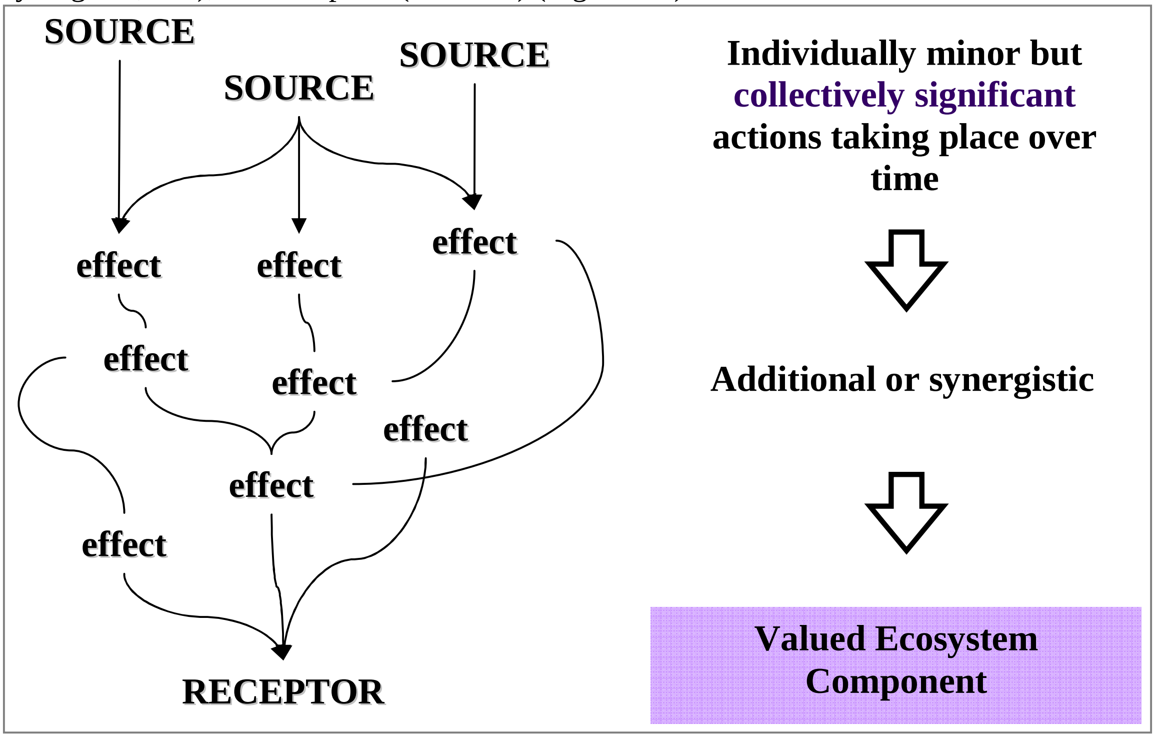

Figure 2.2: Cumulative effects: conceptual framework

As a result, this conceptual basis has been applied in order to:

- set substantive principles (Contant and Wiggins, 1991; Spaling, 1994);
- frame practical EA guidance (CEARC and NRC, 1986; Sadler and Verheem, 1996; CEQ, 1997; Hyder, 1999; MacDonald, 2000; Cooper, 2004); and
- establish criteria to review whether and how EA practices deal with CE (Burris and Canter, 1997; Baxter *et al.*, 2001; Piper, 2001a; Cooper and Sheate, 2002).

However, it has been noted that no internationally accepted definition of CE currently exists, leaving the basic concept deceptively simple (MacDonald, 2000; Cooper and Sheate, 2002; Wärnbäck *et al.*, 2009). One of the main problems arising from this conceptual lack has been considered to set the assessment boundaries in CEA practices (Piper, 2001a; Piper, 2001b; Duinker and Greig, 2006; Noble, 2008). Furthermore, the choice of what human activities to consider in CEA practice is difficult: existing guidance typically refer to past, present and likely future plans and projects (CEQ, 1997; Hegmann *et al.*, 1999; Hyder Consulting, 1999), even though underlying trends not related to specific plans or projects may often be much more significant, particularly at more strategic level (Thérivel and Ross, 2007). Additionally, although the adoption of a VEC-centred approach has been often recognised the key in order to better scope, assess and manage CE both at project and strategic level (Duinker and Greig, 2006; Thérivel and Ross, 2007; Noble, 2008; Canter and Ross, 2010), the choice of VEC is tricky in practice, since: on the one hand, CE may affect multiple receptors in a synergistic way; and on the other, there may be various factors influencing their relevance (specific contextual values, scale, etc.).

2.3.2 Project-based vs. strategic based assessment

By recognising that determining the cumulative environmental consequences of an action requires delineating the complex causal-effect relationships between multiple actions and resources, ecosystems, and human communities under concern (CEQ, 1997), it has been agreed that the assessment of CE should go beyond the evaluation of site-specific and direct project impacts (Sadler and Verheem, 1996; Cooper and Sheate, 2002; Piper, 2002; Duinker and Greig, 2006; Thérivel and Ross, 2007), moving forward the EA legal frameworks from the traditional Environmental Impact Assessment (EIA) to Cumulative Effects (or Impacts) Assessment (CEA/CIA)[8] and Strategic Environmental Assessment (SEA).

Despite approaches for addressing particular types of cumulative problems varying, e.g. with different tiers of assessment; two distinctive, but interconnected, perspectives have generally been recognised in the CEA theory literature: the project-based and the strategic-based (Spaling and Smit, 1993; Dubé, 2003; Cooper and Sheate, 2004). While the first mainly refers to the traditional procedure of EIA, or, to some extent, to CEA, using principles of research design and scientific analysis to support the information-generating and the integration of environmental considerations in project approval procedures; the second usually refers to a more strategic and proactive approach to EA, with particular reference to SEA, or regional CEA[9], utilising planning principles and procedures to support the avoidance and management

[8] CEA or CIA is an *ad hoc* project-based procedure implemented in North America (respectively Canada and US) during the Nineties to systematically assess the cumulative effects of single or cluster of projects. Contrasting the regulatory approach of the US, where CIA was implemented through various federal acts, Canada emphasised on institutional responses to CEA that was gradually put into action during the eighties through a series of research reports and “pilot” project-EIAs followed by various environmental assessment panels. Subsequently CEA became mandatory for all EIAs required under the Canadian Environmental Assessment Act of 1995.

[9] Within the EU, the strategic approach to the treatment of CE was formalised by the SEA Directive (42/2001/EC) which is known as the best “framework law that establishes a minimum common procedure for certain official plans and programmes” (Dalal-Clayton and Sadler, 2005). At the opposite, within the Canadian context, despite SEA is kept a voluntary procedure without legislative basis, interest for assessing CE through regional-SEA is strongly growing and several regional-SEA frameworks to integrate regional CE assessment and management through planning processes have been developed both from academic and institutional side (AXYS Environmental Consulting Limited, 2000; Gunn, 2009).

of CE at higher tier of decision-making. However, this distinction is not exclusive to CEA, but rather it seems to be at the basis of the evolution of high tier EA such as SEA, requiring a better and more effective integration with decision-making processes than project-level EIA.

Therefore, despite project-EIA contributing to:

- the advancement of theoretical understanding of CE;
- the promotion of the development of various analytical methods and approaches for predicting and assessing cumulative environmental changes; and
- the integration of the environmental considerations in project approval procedures.

It has been accepted that it currently fails to adequately analyse and manage CE (Duinker and Greig, 2006; Gunn, 2009). On the one hand, limited temporal and spatial dimensions generally narrow impact analysis to consideration of single project, simple causal-effects relationships, first-order impacts and immediate individual site effects; disregarding complex causalities, spatial and temporal crowding and nibbling effects, and changes induced by higher level of decision-making, which are frequently the driving forces behind individual projects (Spaling and Smit, 1993). On the other hand, traditional project-level EIA has been conceived by many as reactive, unfocused and divorced from the surrounding policy and environmental context (Creasy, 2002; Duinker and Greig, 2006, Gunn, 2009). As a result, it has become commonly accepted that strategic-based EA can improve the consideration of CE, by considering multiple levels of decision-making tiers, higher-order impacts, interacting processes and time lags (Fischer, 2002; Cooper and Sheate, 2004; Thérivel and Ross, 2007).

By resuming the major reasons for addressing cumulative effects at strategic level, Cooper and Sheate (2004) pointed out to four main aspects:

1. cumulative effects can occur at different scales (sub-regional, regional, national and transboundary), hence project-level CEA does not effectively address the concern of gradual environmental degradation from a range of activities and multiple stresses, and the interaction of multiple projects, programme and policy decisions;
2. strategic planning authorities are in a better position than the project's proponent to address cumulative effects because of its availability of information and resources;
3. cumulative effects mitigation requires a broader approach than project-based assessment and monitoring and the necessity for multiple agency involvement;
4. the strategic approach to CEA can be more proactive in identifying and minimising the potential for cumulative effects as these effects can be addressed earlier in the planning process.

Additionally, recommendations to adopt a strategic-based approach to better address CE through EA have been largely arisen, in both, the European and North American literature, from the systematic review of EIA practices (EIA statements and CEA documents).

Consequently, the call for a broader analytical approach as well as a more strategic planning perspective is one of the most stressing recommendation for adequately treating CE (Baxter *et al.*, 2001; Piper, 2001a; Cooper and Sheate, 2002; Duinker and Greig, 2006).
However, in spite of recognition amongst the scientific, regulatory and practitioner communities of the importance to adopt a strategic approach to appropriately deal with CE, the advancement of CEA beyond the individual project, both conceptually and methodologically, seems to be slow to evolve (Cooper, 2003; Gunn, 2009; Canter and Ross, 2010). In addition, although different methods have been developed over the years and several manuals with practical guidance to support the assessment of CE in EA practice were published in the US, Canada and the EU (CEQ, 1997; Hegmann *et al.*, 1999; Hyder Consulting, 1999), most of the guidance has been tailored to project-level CEA and fitted for North American procedures, further presenting a number of limitations (Fuller and Sadler, 1999).
Consequently, although not mutually exclusive, each tier of assessment asks for conceptually different questions, playing a different role in decision-making and delivering different levels of detail of assessment results. According to Gunn (2009), much work has been done to define both, SEA and CEA as individual processes, but very little has been done to develop a strong conceptual and methodological foundation to support their integration, recognising that further investigation on this subject is needed.

2.3.3 Does scale matter?[10]

The role of scale is generally considered a challenging issue in the EA literature. João (2002) showed how results of EIAs can be affected by changes of scale, in term of detail and spatial extent, such as in determining impact significance and in measuring environmental parameters, concluding that scale choice can have important repercussions for the accuracy of an EIA study. Based on this assumption, a special issue of the Journal EIA Review (Issue n.27, 2007) was entirely dedicated on Data and Scale Issued for SEA, facing on the role of scale in EA from a strategic perspective. Accordingly, João (2007) confirmed how scale (both, temporal and spatial) fundamentally shape the SEA process, affecting the problem addressed, the objectives identified, the options found, and the impacts evaluated. And although this generally applies to EA, when it deals with CEA, the choice of spatial and temporal boundaries becomes more difficult (CEQ, 1997; Burris and Canter, 1997; Cooper and Sheate, 2002; João, 2007).
The US CEQ handbook (1997) argued that if spatial boundaries are defined too broadly, the analysis of CE becomes unwieldy; whilst, if they are defined too narrowly, significant CE

[10] This section's title reminds to the title of article "*Cumulative effects assessment: Does scale matter?*", Thérivel, R. and Ross, W., 2007, Environmental Impact Assessment Review 27: 365-385.

issues may be missed. Additionally, Ross (1998) cautioned that the larger the area covered by a CEA, the less likely a particular effect is to be identified as being significant, because more other sources of effect get captured in the analysis. Similarly, the greater the temporal extent covered by a CEA, the less likely short-term effects are to be identified and captured. And this could imply that effects can be "lost" and that single project's effects are likely to be less significant in a regional-level than a project-level assessment (Thérivel and Ross, 2007). However, even though smaller stressors seem less significant over a large area, the cumulative effect on VEC may be not less significant. Thereby, setting the assessment boundaries based on VEC can be particularly important for adequately treat CE, considering that the inadequate definition of spatial and temporal boundaries has been recognised as one of the most important deficiency in EIA and CEA practices (Piper, 2001b; Cooper and Sheate, 2002).

Additionally, determining SEA boundaries is not easy (Ortolano and Shepherds, 1995), being strategic-level decisions, not only based on long-term actions over a large geographic area, but further substantially linked to different administrative levels of decision-making.

By reviewing how CEA practice considers scale issues[11], Thérivel and Ross (2007) recently moved backwards through the CEA process, from effect management to scoping, concluding that scale matters in:

- ✓ the ability to manage CE, because the management of CE strongly depends on if decision makers have the clout to impose management measures and if they are willing to do it;
- ✓ the appropriateness of scale for predictions, because limited choice of scale, with particular reference to time, and the avoidance of important issues due to the excess of level of detail needed by many prediction methodologies, could lead to preclude significant CE that needed to be considered by decision makers in order to be avoided;
- ✓ the understanding of the policy and environmental context, because limited investigation of past trends and scarce application of a VEC-based approach, could lead to an inadequate consideration of CE;
- ✓ the relevance of scoping, because the lack of appropriate methodologies in order to capture scale-dependant or relative CE could lead to miss, underestimate or overestimate CE at that specific level of analysis and management.

Referring to strategic level CEA, adopting a multi-scaled approach has been suggested among scholars, in which regional and strategic analyses are to inform the scope of downscale assessment, avoiding to overlook localised and point sources problems (Duinker and Greig,

[11] The article refers to scale as identified in João (2007), assuming it as having two key meanings, applicable to both spatial and temporal issues. The first meaning is the *extent* of the assessment (e.g. size of area, time period) and the second the level or amount of *detail* (map scales, rate of sampling).

2006; Thérivel and Ross, 2007; Noble, 2008). Furthermore, a better linkage between different tiers of EA have been advocated in order to cope with regional CE and the opportunity for strategic-level CEA to "*set the rules*" for lower tier EA, such as establishing maximum acceptable levels of change or regional management frameworks, has also been recognised by various scholars (Thérivel and Ross, 2007; Gunn, 2009). Nevertheless, in practice this appears to be rarely the case since significant CE at broader scale are often neglected at lower tier decisions (see also § 5.6). And this seems to be particularly relevant in the context of spatial planning as is subsequently argued.

2.4 Cumulative effects in SEA of spatial plans

2.4.1 A rationale for the inclusion of CE

CE has been deemed to be most effectively treated through SEA due to its substantive nature (systematic, proactive and participative approach to the assessment) (Sadler and Verheem, 1996; Fischer, 2002; Canter and Ross, 2010). However, even though the need to assess CE is clearly remarked in the EU SEA-Directive (Dir 42/2001, *Annex 1*), it seems that little has changed regarding CE since the implementation of the Directive in practice (see § 5.4). On the one side, the effectiveness of SEA practices in addressing CE still remains scarcely investigated (Thérivel and Ross, 2007; Wärnbäck and Hilding-Rydevik, 2009). And on the other side, the limitations of EA to adequately treat CE are still based on the assumption that the project-based environmental assessment has failed (Baxter *et al.*, 2001; Duinker and Greig, 2006), leaving the topic disregarded and unsatisfactorily considered in SEA common practices.
Spatial or land use plans[12] are one of the most important planning processes requiring to be integrated with SEA by the EU-Directive and various national legislations.
In particular, spatial planning may be defined as the decision-making process of managing the present and the future use of land as well as its resources in order to:

- coordinate different socioeconomic sectors and determine the amount and location of their development;
- prevent environmental problems, protect natural environment and maintain environmental functions and services, by ensuring that interests at stake are taken into account; and

[12] One of the earliest definitions of spatial planning comes from the European Regional/Spatial Planning Charter (often called the Torremolinos Charter), adopted in 1983 by the European Conference of Ministers responsible for Regional Planning (CEMAT): "*Regional/spatial planning gives geographical expression to the economic, social, cultural and ecological policies of society. It is at the same time a scientific discipline, an administrative technique and a policy developed as an interdisciplinary and comprehensive approach directed towards a balanced regional development and the physical organisation of space according to an overall strategy.*"

- ensure that the development and use of land is in general "public interest" (Jones *et al.*, 2005).

Consequently, it can be argued that spatial plans have to commonly face on various decision complexities (e.g. multi-objective decision problems and conflicting interests of stakeholders; changing of global situation and accelerating globalisation; and uncertainty surrounding decisions), including the chaotic domains of environmental decisions (French and Geldermann, 2005).

In particular, the need to better consider cumulative effects in spatial planning seems to mainly rely on:

1. the tiered system and the strategic nature spatial plans deal with; and
2. the kind of actions under spatial plans' agenda.

2.4.1.1 The tiered spatial planning system

In principle, there exists a tiered and hierarchical approach to spatial planning systems among countries. This is normally portrayed as starting with the formulation of a policy at the upper level followed by plans, programmes and projects (Figure 2.3). And this also applies to SEA.

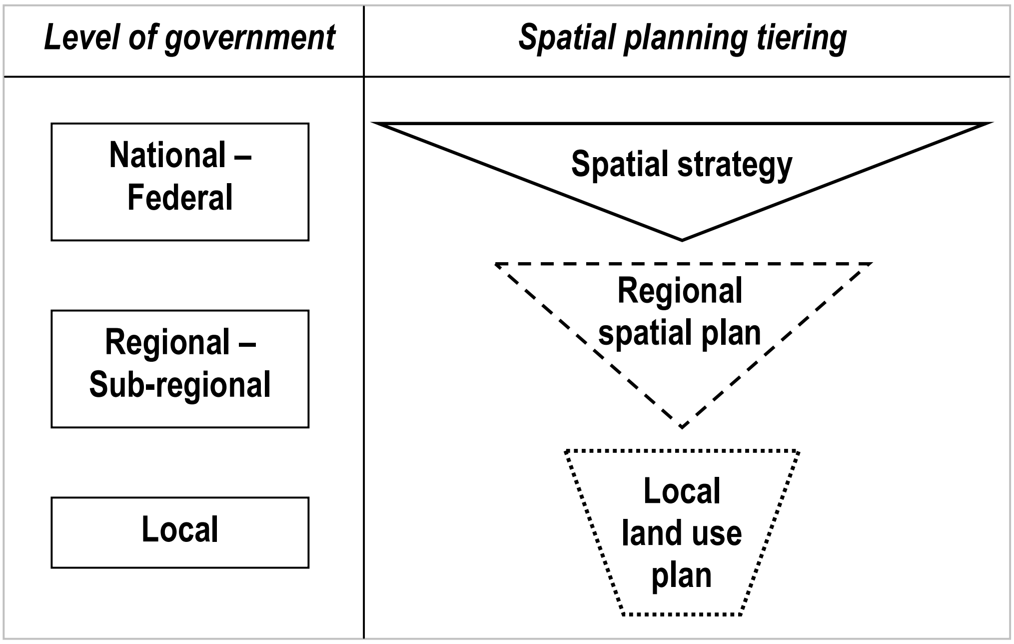

Figure 2.3: Spatial planning tiered system

In reality, however, this model oversimplifies the inter-tiered relationships since spatial planning bounded to a specific geographical and administrative context has to mutually dealt with different spatial tiers (European and international land use policies, national spatial strategies, regional planning, provincial and urban planning) as well as sectors and projects (transportation, energy, etc.).

Additionally, even though linking spatial planning with SEA has been considered a crucial condition for sound development, and an important opportunity to ensure a mainstream consideration of environmental concerns and their earlier integration with social and economic issues within the plan (Eggemberger and Partidário, 2000; Fischer, 2003; Thérivel, 2004); in practice, the effectiveness of SEA process and the quality of its outcomes may vary according to the circumstances under which SEA is applied, including contextual and methodological elements (Jones *et al.*, 2005; Fischer and Gazzola, 2006).

2.4.1.2 Actions under spatial plans' agenda

Evidence that environmental changes associated with urban development have been significantly increasing during the last century and are expected to continue through the next several decades has been largely demonstrated in the literature (Antrop, 2004; Alberti and Marzluff, 2004; MEA, 2005). However, the regional cumulative effects of urban land use changes are seldom considered in local level spatial planning decisions (see § 5.6). Consequently, understanding the implications of land use changes has been recognised a fundamental part of planning for sustainable development (MEA, 2005).

In fact, activities under spatial plans' agenda often include developments that, despite being individually insignificant in terms of the likely environmental consequences and, hence, not subjected to project EIA; they might accumulate over time and space causing gradual and multi-scale changes, which may negatively interact with natural resources, environmental processes and human well-being. For example, the cumulative effects of landtake by small housing, retail and road developments can lead to a gradual loss of open spaces, fragmentation of habitats, increasing of water runoff, increasing of greenhouse gases emission and decreasing of air quality which combined could lead to a significant erosion of environmental quality over the time. And plans' lifespan as well as their spatial boundaries are often inadequate to cover that scale-gap (spatial crowding and time delay) by which the effects become significant. Therefore, managing those proposed human activities, even though their effects are individually insignificant, could result more challenging than avoid impacts from human activities commonly considered hazardous or dangerous such as waste treatment plants, energy production plants, etc.

As a result, treating CE through SEA of spatial plans does not merely mean to sum up the effects of planned activities within their geographical administrative boundaries; rather, it requires:

- on the one hand, to ensure an adequate scoping of interrelationships between multiple activities/tiers and their likely consequences on relevant VECs, including the linkages among these effects over time; and
- on the other hand, to delineate inter-tier management frameworks in order to cope with CE across different levels of planning and tiers of decisions.

Accordingly, SEA provides an opportunity for ‘reconsidering’ CE among different systematic tiers of planning, by supporting higher level spatial plans to set the terms of reference for the downstream tier, and consequently addressing lower level spatial planning decisions. However, according to Gunn and Noble (2009), this seems to require a better focus upon resource-based standards, thresholds or maximum acceptable level of change, allowing broader level strategies (regional visions, strategic initiatives, etc.) to be translated into local operational measures.

2.4.2 Addressing CE through different SEA stages

Despite the consideration of CE should be an integral part of the overall SEA process (Cooper, 2004), it is worth to note that for SEA to be effective in addressing CE, there is a need to treat those during the first SEA stages, with particular reference to scoping and definition of planning strategies (objectives, options, alternatives), since predicting, monitoring and managing CE mostly depend on how scoping (spatial and temporal scale, complexity of effects, relevance and importance of environmental issues and processes, etc.) and the definition of planning strategies are adequately addressed. According with the assumption of Thérivel and Ross (2007), it is impossible to get good management without good prediction; good prediction without a good understanding of the background context; or a good context description without good scoping. Nonetheless, this sounds effective only in case of an adaptive process of feedbacks and learning through monitoring planning and SEA outcomes (predictions, successful of mitigations, uncertainty, etc.) is in place.

2.4.2.1 Scoping of CE

Extending the scoping stage is not a new task in the CEA literature (CEQ, 1997; Hegmann *et al.*, 1999; Baxter *et al.*, 2001; Cooper, 2004). Scoping has been often discussed as a key procedural step for addressing CE through EA due to:

- the importance to consider CE from a range of activities and multiple stresses;
- the need to set appropriate temporal and spatial boundaries and to early consider explicit ecological and social values required for selecting sensitive and important VECs;

- and the opportunity to analyse positions, interests and interrelationships of actors involved in both planning and SEA processes (Kørnøv and Thissen, 2000; Baxter *et al.*, 2001; Thérivel and Ross, 2007).

Nevertheless, findings that current CEA scoping is done poorly in practice and that there is a lack of appropriate methodologies to scope CE have been accepted in literature (Canter and Kamath, 1995; Baxter *et al.*, 2001; Thérivel and Ross, 2007). Consequently, a number of methodological approaches to scoping have been developed for project-level CEA (Canter and Kamath, 1995; Baxter *et al.*, 2001). Nevertheless, strategic-level scoping may require the consideration of many interrelationships among different tiers of decision-making and their effects, which need to go beyond the biophysical research and the traditional rational approach to EA in order to be understood (Kørnøv and Thissen, 2000; Partidário, 2000; Fischer, 2003; Gunn, 2009). Therefore, benefits from extending scoping at strategic-level CEA have been further relied on the importance of addressing appropriate issues and alternatives throughout different tiers and sectors of decision-making, helping to identify environmental conditions and strategic objectives and to set assumptions for a broader future-oriented approach (Duinker and Greig, 2006; Gunn, 2009).

2.4.2.2 Definition of future planning alternatives

Supporting a better understanding of what alternatives may be suitably addressed in a specific decision-making context is considered one of the main challenges of applying strategic-level EA (Partidário, 2000; Kørnøv and Thissen, 2000; Fischer, 2007). Therefore, it has been largely argued how strategic-level EA provides the opportunity for considering a wide ranging nature of options, giving proper consideration to different ways of achieving certain aims, presenting a comparison of the likely environmental consequences of each option, and supporting the choice of the preferred one (Noble, 2000; Partidário, 2000; Jones *et al.*, 2005).

Referring to spatial planning, although intrinsically spatial in nature, options may be substantially different in scale and level of detail, according to the tier of plan. Generally speaking, the higher the planning tier the larger the geographic area and the more strategic the plan actions and policies. On the opposite side, the lower the planning tier the more definite the land uses and the more punctual the actions are likely to be (e.g. allocation).

In particular, the definition of reasonable planning alternatives for the treatment of strategic level CE seems to be even more challenging, especially if inter-tier CE are considered, due to the addition of '*other foreseeable actions*' dealing with different level of detail which may require different amount of information as well as different methodological approaches in order to be defined and assessed.

Additionally, an earlier analysis of alternatives on during the process should allow plan strategies that are less likely to cause significant contributions to CE to be better predicted, as well as social conflicts on use of resources (land, water, etc.) to be avoided. Nonetheless, the development of reasonable planning strategies not only depend on whether SEA is applied at each during the planning process, but also on the willingness and openness of a particular decision-making context to think about alternative options before decisions are already taken, or, in other terms, on to what extent options are democratically and transparently developed. In fact, appropriate consideration of alternatives has been recognised as one of the most critical and weak feature in EA practices: by citing the results of an EU report about the application and effectiveness of EIA in different Member States, Vanderhaegen and Muro (2005) noted that the development of alternatives is a weak feature in many of European environmental assessment processes. In addition, the consideration of appropriate alternatives has been considered as one of the most critical SEA issues since in current SEA practices alternatives are arguably generated to fulfil the minimum regulatory requirements of SEA Directive rather than to consider a number of plausible ways for achieving the strategic goals (González, 2008; Rega, 2008).

2.4.2.3 Prediction of CE

Generally speaking, strategic-level predictions require to cope with considerable degree of uncertainty[13] (Partidário and Fischer, 2004; Fischer, 2007), relying on: the specific preferences of stakeholders resulting from decision-making processes; the assumptions made for predictions; as well as the assessment methods and tools applied. According to most authors (including e.g. Morris and Thérivel, 2009), prediction of effects is not an exact science, and therefore it needs to be aware of the level of uncertainty which can considerably increase at higher planning levels because scales are broader, issues generally larger and assumptions which alternatives are based on potentially untrue. Moreover, in case of CE, uncertainty can also arise due to: the variation in natural systems and their interactions, the lack of information and knowledge regarding cause-effect relationships or the inability of predictive models to accurately represent complex systems (see § 2.3). Among others, adaptive management based on feedbacks of monitoring has been considered a crucial tool both to evaluate to what extent CE are thoroughly predicted and CE management measures (i.e. mitigations, compensations, enhancements) successfully implemented (Cooper and Sheate, 2004; Duinker and Greig, 2006; Noble and Gunn, 2009). Nevertheless, due to the involvement of multiple agencies/authorities it requires, an effective management of CE could be more difficult to achieved.

[13] See note 4.

Accordingly, SEA provides an opportunity for early addressing CE during the planning process, by better scoping VEC and '*other foreseeable planning actions*' and simulating what if the combined effects of planning alternatives are likely under different management frameworks and future conditions which may be greatly uncertain (see § 6.3-6.5).

2.4.3 Opportunities of adopting a spatially explicit approach[14]

The use of appropriate tools on SEA depends on both, technical and procedural aspects, such as: the tier of plan (strategic, project, etc.); the stage of SEA (scoping, impact prediction, mitigation measures proposal, follow-up); technical expertise, data and time availability, and their credibility among others (see § 2.2).

Although various approaches and techniques may be used in assessing CE, given the intrinsic spatial nature as well as the importance of the management of space for spatial planning, it has been shown how spatial evidence and spatially explicit approaches can significantly benefit plan-making and their SEA (Antunes *et al.*, 2001; Vanderhaegen and Muro, 2005; Geneletti *et al.*, 2007; González, 2008).

In general, spatial data and spatially explicit techniques allow to simultaneously consider different scale (spatial and temporal dimensions, level of detail) as well as environmental and planning issues. And this is particularly relevant for land use planning since the potential significance and magnitude of an impact largely depend on the spatial distribution of proposed actions, receptors and their sensibility over time.

Therefore, the opportunities to adopt a spatially explicit approach rely on the potential improvement of:

- ✓ the quality of scoping and prediction of CE in SEA, supporting the visualisation of future land uses and planning options, displaying trends of relevant environmental processes over the time and quantifying the combined effects of urban land use change at regional scale;
- ✓ the inter-tier management of CE in spatial planning, by spatially simulating small future developments which together may contribute to regional environmental consequences and, thereby, improving the coordination between different spatial planning levels and decision-making tiers.

Nevertheless, the benefits to adopt a spatially explicit approach not only rely on the presentation of spatial baseline data in a map, but it may also contribute to the transparency of decisions, by enhancing the understanding and the perception of the distribution of

[14] This thesis refers to spatially explicit approach as the integration of spatial analysis (e.g. overlay mapping, etc.) and techniques (e.g. GIS, etc.) into a broader SEA methodology.

environmental issues and effects within a geographical context, and by facilitating more effective communication, consultation and participation assuring a deeper consideration of CE during the preparation and adoption of plans. Therefore, SEA provides the opportunity to bring together different methods, tools and techniques in a more conscious, structured, and comprehensive way, improving the prediction of cumulative effects and consequently their management earlier on during the planning process.

2.5 Research methodology

2.5.1 Research aim and objectives

This dissertation starts from the hypothesis that there is a gap between SEA theory and practice in treating cumulative effects. In fact, while the substantive nature of SEA has been broadly emphasised in literature as a proactive means to treat cumulative effects, SEA practice seems to remain far from achieving this intention. In the light of this, the main purpose of this research is to propose and apply a methodological approach to improve the consideration of cumulative effects in SEA of spatial plans. Accordingly, in order to advance the proposal, the achievement of a good knowledge on spatial planning and SEA theory and practice is considered the key (Figure 2.4).

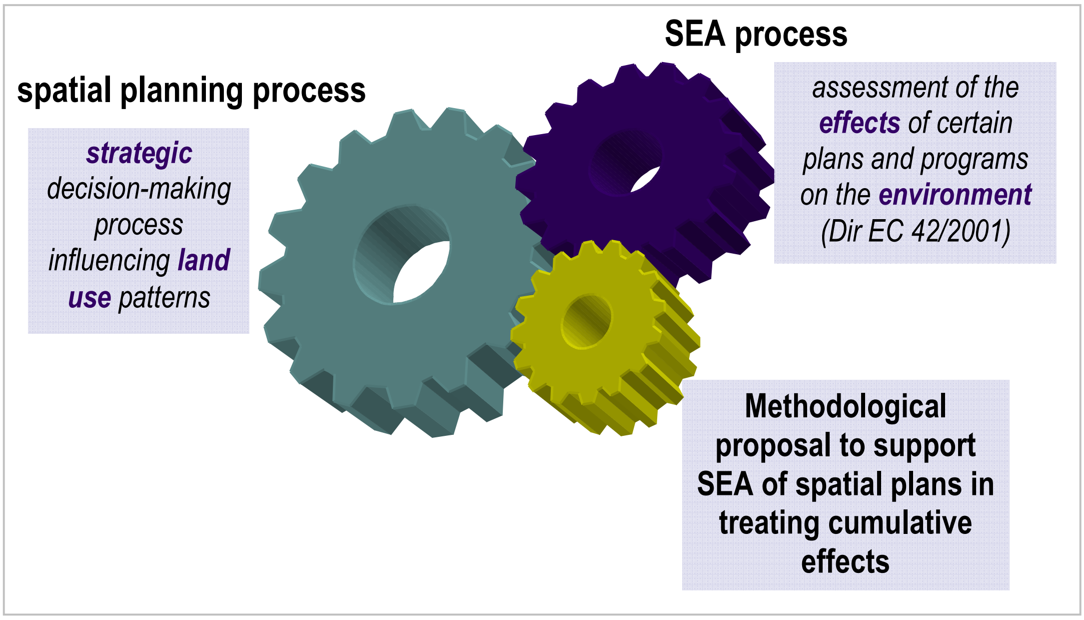

Figure 2.4: Integration of the methodological proposal in SEA of spatial plans

In particular, the specific objectives of the research are:

O1. to understand how SEA for spatial planning works in practice. The objective assumes that proposing a methodological approach to support SEA in treating CE requires the achievement of a good knowledge on SEA and planning processes;

O2. to explore how CE are currently treated in SEA of spatial plans, with the double purpose of ascertaining the main research hypothesis and identifying conceptual, procedural and methodological key issues, including the investigation of methods applied;

O3. to develop a methodological approach to improve the consideration of cumulative effects in SEA of spatial plans, focusing on shortcomings emerging from theoretical and empirical outcomes;

O4. to apply the proposed approach to a case study, by empirically testing its applicability and discussing its limitations.

Additionally, it is worthy noting that the methodological approach does not aim to provide a comprehensive guidance to treat CE in SEA of spatial plans, rather it suggests and discusses a basic framework that can improve the consideration of cumulative effects in SEA of spatial plans.

2.5.2 Research approach and activities

According to the main hypothesis, this research adopts a double-perspective, moving forward from theoretical basis to empirical observations. Consequently, several research activities are organised and programmed over the research period in order to meet the research objectives. Table 2.1 summarises them according with each specific objective.

Table 2.1: Research objectives and activities

Objective 1	**Objective 2**	**Objective 3**	**Objective 4**
Literature review	Literature review	Literature review	Critical review of documents (spatial plans, environmental reports, etc.)
SEA real life case study	International expert survey	International expert survey	
International expert survey	SEA reports’ review	SEA reports’ review	SEA real life case study
		SEA real life case study	

Firstly, an in-depth literature review is conducted during the overall research period in order to:

1. frame the research topic, by focusing on three key concepts, namely strategic environmental assessment (SEA), cumulative effects (CE) and spatial planning and establishing the interactions among these three key elements (**O1, O2**);
2. support the theoretical framework, by identifying key issues for the treatment of strategic level CE (**O2**), highlighting conceptual, procedural and methodological shortcomings (**O2, O3**); and
3. further refine the research objectives.

It mostly focuses on: theoretical developments, practices and empirical findings published in the international journal literature; as well as government guidance and handbooks such as SEA and CEA guidelines, etc.

Secondly, two real-life SEA processes (Italian local spatial plans) are followed according to the SEA EU-Directive, national and regional regulations in order to:

1. better understand the integration between SEA and spatial planning processes, and thereby, support to frame the research topic (**O1**);
2. select, develop and test a methodological SEA approach, mainly based on indicators (quantitative and spatially explicit) in order to support the decision-making process to integrate environmental considerations during different planning stages (**O3, O4**).

Thirdly, an international expert survey and a systematic review of SEA reports are conducted in order to:

1. contribute to fill in the literature gap on the treatment of CE in SEA current practice (**O1, O2**);
2. support the theoretical background, by in-depth investigating conceptual, procedural and methodological key issues for the treatment of strategic level CE (**O2; O3**).

In particular, the international expert survey explores both inputs and outputs of SEA processes (Chapter 3), otherwise namely quality and effectiveness of SEA[15], by including a range of questions on the overall satisfaction of SEA of spatial plans, assuming that advancing the methodological basis of strategic approach to CE further requires a good understanding of SEA practice in terms of outputs (**O1**). At the opposite, this does not apply to the review of SEA reports (Chapter 4) which only explores SEA process in terms of inputs, with particular reference to SEA methodologies.
Among others, particular attention is paid to those SEA methodologies in which spatially explicit approaches are integrated in[16], considering the relevance of 'space' and 'spatial thinking' for spatial planning (see § 2.4.3). Consequently, both activities (survey and review) investigate the application of those specific techniques to scope, predict and assess likely effects, including CE, in current SEA practice as well as their potential role in supporting SEA of spatial plans with special regard to several SEA stages (i.e. scoping, definition of alternatives and prediction of effects) and aspects (**O3**).

[15] A distinction between inputs and outputs of SEA processes has been proposed in literature in order to evaluate SEA practice (Thissen, 2000; Jones *et al.*, 2005), respectively referring to quality (i.e. institutional arrangements and SEA methodologies) and effectiveness of SEA (i.e. achievement of identified goals).
[16] See note 14.

Furthermore, considering that future decisions and assessments are inextricably linked to uncertain issues (see § 2.2) and this has been agreed as particularly the case of combined sources and effects (see § 2.3), a direct investigation on uncertainty is conducted through both the survey and the review, in order to explore whether and how current SEA practice are actually dealing with this crucial aspect.
Finally, while the survey involves a sample of international experts, by covering international spatial planning contexts; the SEA reports' review only focuses on SEA of Italian and English spatial plans, basing on the following criteria:

1. outcomes of survey, as experts involve in the survey majorly represent these two planning systems (7 from UK and 6 from Italy in a sample of 21);
2. preference to look at the EU context, where SEA national legal frameworks are in place (i.e. Italy and UK);
3. outcomes of literature review: Italian and English planning contexts have been often deemed as opposite in terms of contextual decision-making and methodological EA aspects.

Fourthly, according to the findings and shortcomings of the above activities (see § 5.2 – 5.4), a methodological approach aiming at improving the treatment of CE in SEA of spatial plans is firstly framed (§ 6.1) and, then, applied to a case study (Chapter 6 and 7) located in a highly urbanised region in north-eastern Italy: the Province of Monza and Brianza.
In particular, although the proposed approach cannot be applied to a real-life SEA process, mainly due to time constraints (the extent of the research period cannot cover an overall planning process), the case study is selected within the same Italian administrative region where the two real-life SEA processes are followed (Region of Lombardia), assuming that the good understanding of that environmental and policy context allows:

- the approach to be more soundly and 'fit for the purpose';
- a better discussion of its applicability and limitations to be advanced.

Chapter 3

3 International experts survey

3.1 Introduction

This chapter aims at presenting the results of a questionnaire survey on whether (*level of consideration*) and how (*by means of which approaches and methods*) CE are considered and assessed in current SEA practice. In particular, following the purpose of this research, the questionnaire focused on: the procedure adopted by the EU legal framework (EU SEA-Directive); and SEA of spatial plans, regarding local and regional level. Consequently, a direct reference to the environmental report documents (ER) has been made, being its preparation at the heart of SEA process (Fischer, 2007), at least within the EU context.

The structure of the chapter is as follows. Section 3.2 describes the survey methodology. Section 3.3 illustrates the results, focusing on: the consideration of CE in current SEA practice (§ 3.3.1); the state of art of SEA of spatial plans (§ 3.3.2); the treatment of uncertainty (§ 3.3.3); and the application of spatially explicit approach (§ 3.3.4). Subsequently, section 3.4 discusses results with respect to three key aspects: the treatment of CE at strategic level (§ 3.4.1); the role of scoping (§ 3.4.2); and approaches and methods (§ 3.4.3). Finally, preliminary conclusions are presented in section 3.5.

3.2 Questionnaire survey methodology

In order to carry out the survey, a questionnaire on current SEA practices as well as on the treatment of CE in SEA of spatial plans (both consideration and methods) was prepared in July 2009 and conducted between August and October 2009. Forty international EA academic experts and practitioners were selected based on their experience on SEA, CEA and environmental assessment methods. They were identified using both literature references and lists of participants of the two special thematic meetings of the *International Association for Impact Assessment* (IAIA) on SEA (Prague, 2005) and Cumulative Effects Assessment and Management (Calgary, 2008). Other criteria for identifying them included the context they came from: EU and Canada, representing two opposite approaches to the treatment of CE at strategic level[1] (see § 2.3).

Then, the experts were twice contacted and invited to participate to the survey. 21 of them accepted to be involved. They were predominantly from EU (19) and the other two were based in Canada (2). EU member state included: UK (7), Italy (6), The Netherlands (3), Irish/Spain (1), Germany (1) and Portugal (1).

The questionnaire was firstly sent by e-mail, then a flexible approach was adopted allowing experts to agree with the most convenient way to be involved. The majority of them preferred to fill in the questionnaire on their own and to be later contacted for adding their comments, others chose to be interviewed by phone and one preferred to have a general chat on the topic instead than strictly follow the survey.

The questionnaire included 3 main sections (see Appendix 1):

a. **investigation of current SEA practice**, aiming at exploring whether SEA stages are conducted to a satisfactory standard[2] (Thissen, 2000; Jones *et al.*, 2005); how often CE are treated (Cooper and Sheate, 2004; Thérivel and Ross, 2007; Gunn, 2009; Canter and Ross, 2010); which environmental issues are mostly addressed (Thérivel, 2004; Kørnøv, 2009); and how often uncertainty is discussed (Pischke and Cashmore, 2006; Canter and Atkinson, 2010);
b. **application of techniques**, intending to understand which methods and techniques are mostly used, with particular reference to: CE scope and prediction (Thérivel and Ross, 2007; Perdicoùlis and Piper, 2008; Cooper, 2010), definition of planning alternatives (González, 2008; Collingwood Environment Planning *et al.*, 2005) and treatment of uncertainty (Duinker and Greig, 2006);
c. **suggestions** on the potential role of spatial techniques in order to improve different SEA stages and critical issues (e.g. CE, uncertainty, etc.) (Thérivel, 2004; González, 2008).

Generally, questions based both on contents of SEA documents expert reviewed and on his/her own opinion on the topic. Therefore, the direct experience of experts on SEA processes (*how many SEA processes have you been involved in?*) and SEA documents (*how many Strategic*

[1] Contrasting the regulatory approach of the EU, where the systematic assessment of CE has been mandatory required by SEA Directives; in Canada, despite a long tradition of project-level CEA, SEA is kept a voluntary procedure without legislative basis and interests for assessing CE through regional "pilot" SEA is strongly growing (Noble, 2008; Gunn, 2009).

[2] This thesis refers to the satisfaction of SEA practice in terms of both inputs and outputs of SEA processes, avoiding to distinguish between quality and effectiveness of SEA practice as proposed in Thissen (2000) and Jones *et al*. (2005). Consequently, satisfaction refers to both inputs and outputs of SEA processes, including, on the one side, institutional arrangements and SEA methodologies; and on the other side, the achievement of identified goals.

Environmental Reports have you read?) were further explored, showing the majority of interviewees (60%) read more than 30 environmental reports and half of them were directly involved in 10 to 30 SEA processes (see Figure 3.1).

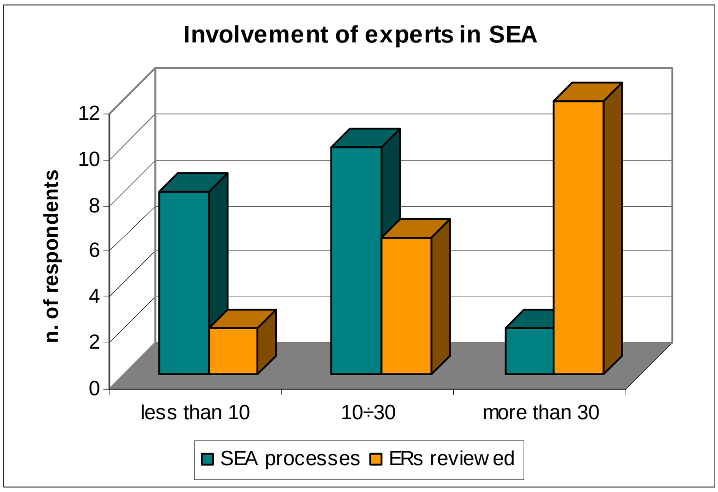

Figure 3.1: The involvement of international experts in SEA

3.3 Results

3.3.1 Consideration of CE in current SEA practice

The consideration of CE in SEA practices was firstly investigated, by asking how often they were treated; and secondly, by in-depth reviewing comments of respondents. Although class frequencies (occasionally, frequently, etc.) were not *a priori* defined, most of respondents considered CE as an issue occasionally considered (see Figure 3.2).

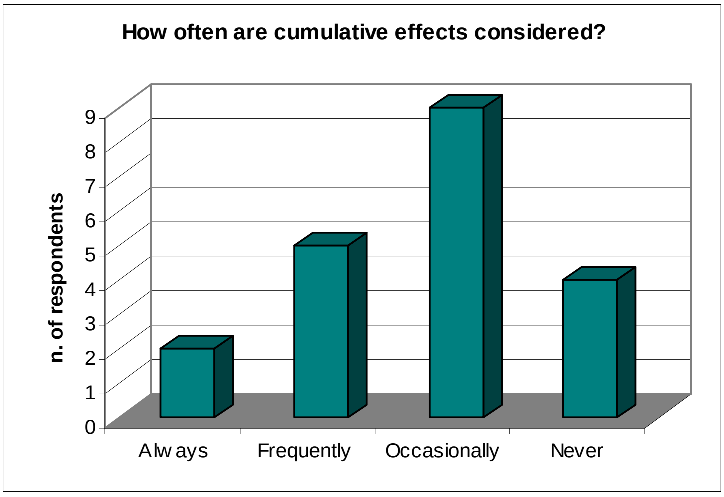

Figure 3.2: Consideration of CE

In fact, additional comments generally agreed that considering CE does not mean accurately treating and assessing them. Several experts observed that "*CE are frequently considered, but not in enough details*"; "*CE are occasionally considered, but never treated*"; "*considering CE is not necessarily the same as assessing them*" and "*cumulative effects are commonly seen as the sum of impacts, instead than a complex interaction of effects*".

A number of constraints to appropriately consider CE were further pointed out such as the complexity to scope and assess synergistic effects that in practice are completely disregarded; the definition of scale (spatial, temporal and level of detail) of the analysis as well as the identification of those other tiers of decision-making cumulatively contributing to the effect; the uncertainty associated with strategic-level CE; the availability of data and time.

Two broad approaches were recognised having been adopted in assessing CE in SEA practice: objective-led and baseline-led. And this was highlighted to be not distinguished from the overall SEA methodology. Furthermore, the most frequent consideration of CE was a qualitative description based on expert opinions which were often who followed the SEA process and wrote the ER. Moreover, a matrix-based approach to predict CE was frequently found either in case of objective-led or baseline-led approach. Additionally, a consistent application of spatial techniques, mainly based on a straightforward use of GIS, was found since they allowed the identification of "*cumulative areas of impact*" (i.e. impact on natural sites or noise from different sources) through overlay and weighted overlay maps. And this was mentioned as mainly the case of local spatial plans (site allocation plans, local master plans, etc.). Furthermore, casual-effect networks was cited by an expert to be coupled with GIS for predict and assess CE at local level. Whilst modelling was stated to be used to assess CE on biodiversity at landscape scale in a pilot regional SEA.

3.3.2 SEA practice: state of art

The general satisfaction of each SEA stages in current spatial planning practice was investigated (see note 2). SEA stages followed the EIA-based approach adopted by the EU SEA-Directive and they were clustered in four main parts, according with the Table 3.1.

Table 3.1: SEA stages

Scoping	*Context scoping*	**Consultation and participation**
	Definition of SEA objectives	
	Definition of alternatives	
Assessment	*Prediction of effects*	
	Mitigation/compensation measures	
Monitoring/Follow up		

Figure 3.3 summarises general results.

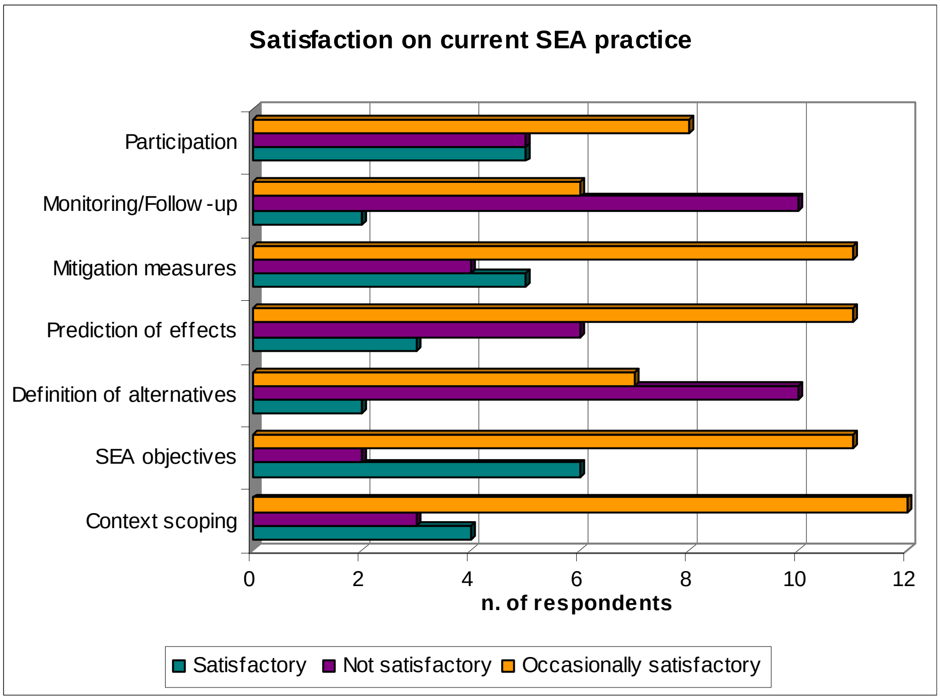

Figure 3.3: General satisfaction on SEA practice

3.3.2.1 Scoping

Context scoping

The scoping was the stage with the major agreement among interviewees since the 65% of them considered it occasionally satisfactory addressed. The main reason it did not result well done was that it manly failed to appropriately address the context, including the definition of scale[3], the selection of relevant environmental issues and sensitive receptors, the setting of the baseline, the identification of significance criteria, etc. As stated by an expert: "*despite reports are generally voluminous, most of the information included is generally useless for the assessment scope*".

With particular reference to CE, it was found that current practice is paying very little attention on scale, since spatial and temporal dimension are frequently disregarded, ignoring to scope spatial crowding effects and future trends, being the baseline assessments mostly treated as "*here and now*". As stated by an expert: "*I would argue that the current baseline condition is the result of cumulative change and any contribution of a project, plan or programme to that change is inevitably a cumulative effect*".

Definition of SEA objectives

This stage has been stated as always formally addressed. Nonetheless, SEA objectives were generally commented as:

- ✓ not fitted for the context and consequently: "*too generic*", "*not specific*", "*not realistic*", "*not ambitious*", "*too broad*";
- ✓ not completely useful for assessing plans' objectives.

In facts, whilst it was generally agreed that they should support the definition of plans' objectives and the assessment of their sustainability; this was not perceived as always the case: SEA objectives often resulted "*not congruent with the ones really pursued by the plan*" and "*not useful for the assessment*".

Definition of alternatives

This stage was considered one of the most inadequately addressed through SEA practices, regardless CE. In particular, it was agreed that current SEA practice generally failed to proactively deal with alternatives since, when considered, they were perceived as reactive and, in most of the cases, mainly generated to comply with the legal requirement. As noted by several interviewees: "*in many cases, the 'do nothing' is the main alternative compared with a worst case*" and "*they take the form of variants or amendments to the 'mainstream' option*".

[3] This chapter refers to scale as identified in João (2007), assuming it as having two key meanings, applicable to both spatial and temporal issues. The first meaning is the *extent* of the assessment (e.g. size of area, time period) and the second the level or amount of *detail* (map scales, rate of sampling).

Furthermore, the types of alternatives mentioned ranged from "*spatial allocation*", "*dimensioning*", "*functional*", "*scenario-based*", to "*topic-based*" and "*objective-based*", mostly varying with the level of spatial plans. As a result, a 'scale' matter emerged since "*level of detail of alternatives within the plan was not the same and the SEA process played little role in determining a preferred option as it was not possible to provide a comparable appraisal of them*".

Finally, techniques mostly applied to support the definition of planning alternatives in current practices were workshops, expert opinions and scenario analysis.

3.3.2.2 Assessment

<u>*Prediction of effects*</u>

Agreement about current SEA practices always include some kind of predictions was found. Nonetheless, this stage was mainly commented as occasionally satisfactory as well as one of the most difficult to address through SEA. Two broad existing approaches to prediction were found: qualitative and quantitative[4]; and the first was mentioned as the most applied in current practice.

Methods and techniques mostly found to predict effects were:

- matrices and checklists; and
- combination of techniques, with particular reference to GIS, multicriteria, causal-effects and scenario analysis.

In particular, the use of scenario analysis was commented being specifically applied in order to support SEA of spatial plan at regional level; while causal-effects analysis to support SEA of spatial plan at local level. Moreover, the application of modelling was mentioned to be usefully applied to predict risk of flooding and biodiversity loss at regional scale. Finally, it was reconfirmed that no particular methods or techniques were applied in order to predict CE (see § 3.3.1).

<u>*Proposition of mitigation or compensation measures*</u>

This stage was chiefly considered occasionally satisfactory addressed. Firstly, it was generally recognised that, although proposed within the SEA report, compensation and mitigation measures were not often included in the final plan and the role of SEA in supporting the integration of these measures was generally perceived weak. In facts, it was observed that "*it is not always known whether these are carried out*"; "*spatial plans aim to include them, but is still arguable whether they are the results of SEA process*"; "*…at least at local level*

[4] Although not exactly synonymous, they were often associated with the appraisal or objective-led and assessment or baseline-led approaches since a baseline assessment is often based on quantitative or semi-quantitative criteria.

compensation measures do not arise from the SEA process" and "*when proposed, they are barely considered by planners or local administrations personnel*". Secondly, there was agreement, at least regarding local spatial plans, about measures proposed were not adequate to the specific EA tier since their level of detail was often more appropriate to project than to strategic level (i.e. suggestions on building construction methods or materials, plantation indexes, etc.).

3.3.2.3 Monitoring and follow-up

This stage was considered one of the most poorly performed in current SEA practices, although it was recognised that it might be difficult to evaluate its enforcement as so far in many countries few SEA processes came up to final approval. However, a scarce role of SEA in adequately defining and planning monitoring plans was pointed out. Additionally, monitoring plans were often limited to a list of indicators which often appeared to be not completely suitable for monitoring neither plans' actions nor the 'goodness' of the predictions of likely effects.

Furthermore, the scarce implementation of monitoring was generally perceived as a consequence of it is not strictly mandatory, at least in most of EU countries, as well as of institutional responsibilities and arrangements to effectively put into force monitoring plans are not *a priori* identified (e.g. "*monitoring is often very poor and follow-up is not normative required*", "*there is no monitoring system implemented in Italy, even for the oldest and virtuous SEA process*").

3.3.2.4 Consultation and participation

This stage was considered by the majority of interviewees occasionally satisfactory addressed. And the main concern was generally its effectiveness. However, the results were different among countries. In fact, several interviewees made the point that, at least for some national regulations, the results of consultation and/or participation processes are not meant to be included within the SEA reports. Finally, a distinction was pointed out between consultation and participation.

3.3.3 Uncertainty

Agreement was found about uncertainty is commonly disregarded in current SEA practice: none of the interviewees answered uncertainty was always addressed and only three of them stated frequently (Figure 3.4).

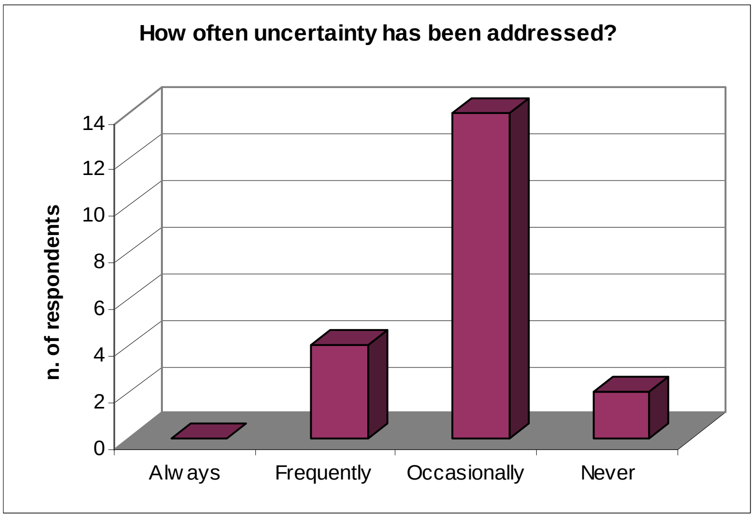

Figure 3.4: Consideration of uncertainty

Concerning the prediction of effects, uncertainty was found being mainly cited and justified as a general lack of data and methods, as well as a knowledge-gap regarding some complex environmental problems, including CE. Whilst regarding assumptions in which future planning decisions and, thereby, predictions stood on, uncertainty was rarely discussed.

Referring to how uncertainty was tackled, there was a great agreement about qualitative expert opinion was the way mostly found. And whilst several interviewees additionally specified that experts were simply who wrote the report, others stated that opinions were often based on the results of consultation with environmental agencies or other experts involved in the process. Furthermore, other techniques such as scenario and sensitivity analysis were mentioned being suitably applied to support a better consideration of this aspect.

3.3.4 Spatially explicit approach

Spatially explicit contents (e.g. maps, etc.) were always found/applied by experts in SEA reports as a consequence of the spatial nature of spatial plans. And this particularly applied to several SEA stages (i.e. context scoping and prediction of effects) (Figure 3.5).

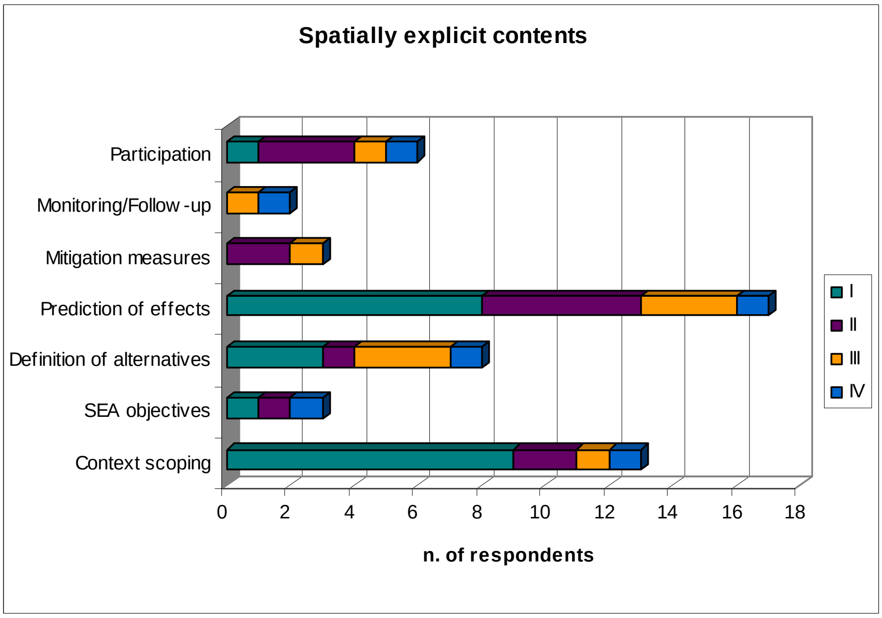

Figure 3.5: Spatially explicit contents (*ranking priority in roman characters*)

Moreover, several experts added that the use of spatial techniques was mostly applied to:

- present thematic issues (nature, soil, infrastructures, protected areas, hindrance contours) during scoping and consultation; and
- define spatial allocation options and spatially resolve their effects (i.e. loss of open spaces, risk of flooding, etc.), mostly at local level (e.g. site allocation plans, local master plans).

Furthermore, it was commented that these methods and tools were generally applied in a straightforward way mainly due to time constrains. As a practitioner noted "*GIS and spatial tools are often perceived as very complicated and time-consuming techniques and politicians ask for quick responses*". However, spatially explicit aggregated indexes such as environmental sensitivity and vulnerability composed by different environmental parameters were further found and commented as a suitable approach to spatially 'sum-up' environmental effects as well as spatial conflicts.

Finally, there was agreement among interviewees that spatial analysis may improve the overall SEA process, with particular reference to the opportunity to:

- better understand environmental issues and phenomena;
- help to integrate planning and environmental issues and to treat CE;
- support the visualisation and assessment of alternatives, by identifying areas of influence of certain biophysical effects (e.g. sensitive areas), affected ecosystems, and "spatial conflicts"; and

- support better and transparent consultation and participation processes.

It was further opined that spatial techniques may improve the consideration of temporal dimension. And this was underscored of particular importance for the treatment of strategic level CE through the comparison of alternatives ‘in time’.

The advantages of applying spatial techniques were further recognised due to the opportunity to spatially resolve the effects stemming from the enforcement of mitigation and compensation measures. Whereas different opinions were found regarding the monitoring stage, since only part of the experts perceived those tools suitable and helpful for this purpose.

At the opposite, it was commented that spatial analysis required spatial data and technical skills which may do not always available. Additionally, it was cautioned that the application of spatial techniques may be an additional source of bias, leading to bring along new uncertainty instead than uncover it. Finally, the digital divide was mentioned to be a limitation to the use of certain kind of techniques with particular reference to local public authorities.

3.4 Discussion

The results of questionnaire allowed general considerations to be illustrated with respect to: the treatment of CE in international SEA practice; and the overall SEA process. Moreover, several contextual trends emerged from the analysis due to the different planning systems in which SEA was applied.

The following discussion focuses on:

1. the treatment of CE at strategic level;
2. the role of scoping; and
3. approaches and methods.

3.4.1 The treatment of CE at strategic level

The added value to treat CE at strategic level seemed not to be fully perceived in common SEA practice since disagreement was found among experts. On the one side, the role of SEA in order to better cope with CE was broadly strengthened, stating the adoption of a more proactive approach as the benefit of assessing CE in a more strategic context as “*it is only in examining alternative possibilities that we can truly understand the magnitude of cumulative effects*”. On the other side, it emerged how in practice the consideration of CE is still mostly related to a narrow and EIA-based approach, assessing impacts and not their likely risk to occur; and giving poor consideration to different ways of avoiding certain negative CE before decisions have been taken. As commented by several interviewees: “*CE does not determine the strategic nature of the assessment*” and “*for CE to be adequately addressed, it is enough that* *the information about assumptions and environmental and spatial context is well discussed and detailed*".

Furthermore, despite the definition of planning alternatives (objectives, options and measures) and the prediction of their likely effects were considered crucial for SEA to be 'strategically effective' (i.e. "*it should facilitate decisions by alerting for risks and opportunities of strategic options*"), predicting strategic level effects arising from future decisions was perceived difficult to perform in a reliable way through SEA, "*considering the uncertainty implicated, the data available and the actors involved*". And this particularly applied to the prediction of CE due to: on the one hand, there may be "*not enough of an understanding of the issues or processes involved in some aspect of the assessment or in the underlying theory required to adequately predict effects*"; and, on the other hand, the predictions may be based on assumptions which "*may not hold true for every case*".

In particular, the treatment of strategic level CE seemed to be constrained by three main barriers:

1. the complexity to deal with tiered decisions;
2. a lack of future-oriented approaches; and
3. contextual issues.

The first referred to the recognition that there exists a "*strategic gradient*" of decisions, being the strategic nature of objectives, alternatives and management measures (e.g. mitigations, compensations) different, not only among different tiers of decision-making, but even within the same spatial plan (see also § 2.4). In fact, despite in theory a tiered system of spatial planning decisions was recognised, specifying that the higher the tier of decision-making, the more strategic the option, the more difficult to define it and the less certain the prediction of their effects; in practice, SEA seemed to play a little role in supporting to define them as well as to provide a comparable appraisal of their combined effects due to "*spatial planning actions*" often range from allocation issues to strategic visions whose combined effects could be tricky to predict whether or not other PPPs contributing to the effects are taken into account[5].

Secondly, although several ways to look at strategic level CE and to develop alternative management strategies were suggested by respondents, proposing for instance the distinction between different topics or main objectives of the plan (e.g. environmental issues, transport concerns, etc.), a lack of "*consensual way to do it*" generally emerged, highlighting a lack of future-oriented approaches and confirming the limited role of SEA in supporting to take future

[5] A broad distinction can be made among intra-tier CE arising from different component of the plan and inter-tier CE arising from the plan in combination with other foreseeable future actions.

decisions. Furthermore, the need to include assumptions based on reasonable management responses to CE were suggested as the key of strategic level assessment, although in practice this was noted as seldom the case as, on the one side, "*it is difficult to propose effective mitigation/compensation measures when the effects to be mitigated are not really identified and assessed*"; and, on the other side, the uncertainty related to their implementation may not ensure management measures to be such effective in avoiding or minimising negative as well as enhancing positive CE.

Additionally, despite developing future decisions was recognised as "*never an easy task*" in SEA practice, the choice of whether and how defining them was further perceived as a matter of institutional arrangements, willingness of decision-makers and time which may be different among spatial planning contexts. With respect to UK, for instance, it was specified that "*definition of alternatives is the role of the plan-maker, rather than the SEA practitioner*". Nonetheless, an effective role of SEA was perceived in order to support to communicate options since "*the requirement to undertake SEA has driven forward the appropriate consideration of options, which has led to much more transparent plan-making*", even though "*often alternatives (if developed) are suggested for the sake of it and not as real potential alternative options*". Referring to the Italian context, it was generally commented how: "*coping with alternatives is not commonly considered in planning practice*"; or "*the definition of alternatives, when complied, is done in a very generic terms since decisions are not driven by environmental concerns*".

In fact, willingness and openness characterising different planning systems, timing, legal requirements and definition of clear objectives and responsibilities were argued as main constrains to adopt a proactive and strategic approach in current SEA practice. And this consequently applied to the treatment of CE at strategic level.

Referring to the Italian context for instance, a lack of higher tier sustainability strategy as term of reference to set SEA objectives was pinpointed, noticing the requirement of higher spatial strategies in order to adequately share responsibilities and goals for the management of combined effects. Furthermore, even though significant efforts were done by several Italian administrative Regions (i.e. definition of general SEA objectives through regional legislation, etc.), an upstream problem emerged from comments due to cultural planning attitudes as "*decision makers generally tend to avoid to make planning goals evident*", even though "*SEA led to a wider recognition of the need to clearly state planning goals and purposes*".

Finally, major contextual differences were pointed out with respect to SEA consultation and participation processes whose importance with respect to CE seemed to mainly rely on their management, needing a broader effort in terms of institutional responsibilities at multi-levels of decision-making.

English experts, for instance, stated that due to regulatory requirement under UK planning and SEA system, plan-makers have the responsibility to ensure that there is adequate consultation on the plan and this was perceived as adequately supported by SEA. Nevertheless, they further added that in practice engaging the public was often difficult; as well as including the values of different statutory bodies since "*they simply do not have the time to meaningfully participate and therefore their input is often of little value*".

Italian experts underscored how, despite consultation on the plan is a common practice, it generally tended to occur late during planning processes, limiting its effectiveness. Furthermore, a scarce involvement of environmental authorities on during the SEA processes was underlined as a consequence of a poor coordination among different institutions and agencies; and the 'bureaucratic application' of SEA in that country. Finally, a scarce attitude to public participation in decision-making processes was pinpointed as plan-makers are inclined to 'deliberatively' confuse it with consultation to achieve public consensus (e.g. "*participation is often more formal than substantial*"; "*public participation is a leg-pulling*" and "*participation has been rarely required by public, which in this country seems not to believe that it could effectively impact decisions*"), further avoiding relevant issues to be considered ("*cumulative effects are one of the reasons why public administrators tend to avoid participatory processes*", "*despite the public 'ignorance' on complex environmental issues, they perceive better than consultants what cumulative means in terms of quality of life*").

However, public participation was argued as commonly reactive and ineffective even with respect to other planning contexts (i.e. Ireland, Spain, Portugal, etc.), where it seemed to be often carried out to comply with legal requirements and legitimate decisions already taken.

3.4.2 Role of scoping

Despite the general role of scoping was confirmed crucial for SEA to be successful, both in terms of effectiveness and quality (see note 2), in practice it was generally perceived as often 'reduced' to an analytical description of the surrounding environment, not being context specific as it should, and consequently not leading to: scope out those issues that are not relevant for that particular situation; as well as focus on those significantly relevant.

Consequently, there was agreement that poor scoping usually reflected unsatisfactory SEA process and contents (issues addressed, scale, assessment methodology, monitoring plans, etc.), emphasising the importance of this stage for the successful of the overall assessment process as: "*it is the lack of clear focus on the scope, purpose and objectives of the SEA that in turns* *affects the satisfactory implementation of the following stages*"; and "*scoping could be deemed as the most important SEA stage due to it follows the planning process when strategies are going to be defined*".

Furthermore, despite in theory, if an SEA does focus on one issue, this should be because the scoping process highlighted (through a review of available evidence) that this issue should be a focus given the particular planning context and likely significant effects. Practically, other reasons were recognised driving this choice including: assessment approaches, scale, the tier of plan, specific legal requirements, data availability, time and background of practitioners. Among others, several experts underlined how: "*the integrated approach used by Sustainable Appraisal for spatial planning in UK plays a role in what is looked at*"; "*because of global climate change, climatic factor are taken into account at local and county scale mostly in terms of flooding*"; and "*extensive European and national legislations on natural issues and biodiversity call for great attention on these issues*".

However, although this generally applied to SEA, when dealing with CE, the role of scoping was stated even more crucial. Firstly, in spite of seldom the case, scoping was deemed the key stage in order to identify significant and important issues, namely valued ecosystem components within CE literature (see § 2.3). Secondly, scoping was commented essential in order to give proper consideration to scale due to CE analysis and management often require, one the one hand, to enlarge physical boundaries in order to capture crowding effects; and on the other, to extend decision-making boundaries in order to identify those planning actions and tiers likely contributing to CE over time and space. Moreover, this aspect was further commented of particular concern with respect to effective management of CE, requiring follow-up to go beyond the single plan's boundary in order to ensure a more flexible and adaptive management of combined consequences.

Finally, a lack of appropriate methodologies to scope CE at strategic level was broadly perceived. In facts, in spite of several approaches were cited having been occasionally adopted to scope CE (i.e. thematic approach, holistic approach, etc.), a systematic CE scoping seemed to be rarely the case in common SEA practice, likely affecting an appropriate consideration of combined effects during the overall SEA process.

3.4.3 Approaches and methods

A great emphasis was generally given by respondents to the baseline-led and quantitative approach for the treatment of CE, commenting them as more effective to assess cumulative consequences on the environment: "*a solid baseline assessment is essential to identifying, assessing, and managing potential cumulative effects*"; "*from the measure is easier to know* *what the effect is*”; and “*likely environmental effects may be better defined through quantitative predictions*”. Nonetheless, the availability and reliability of data, accuracy, credibility, uncertainty, time and resources were commonly cautioned as barriers to satisfactory predict the effects in practice, particularly at strategic level. As stated by several interviewees: “*[…] quantitative approach depends on data availability and reliability both on environmental and planning issues*”; “*qualitative approach often relies on lack of data, oversimplifying the assessment*”; “*data reliability and time are often barriers for a quantitative approach*”; and “*carrying out a reliable assessment in a quantitative way is usually perceived by decision makers as time-consuming and not at all as a benefit or trade-off of a shorter planning process*”.

Moreover, the approach by which CE were considered and assessed in SEA of spatial plans was commented as relying on different planning systems and availability of supporting tools, providing conceptual and methodological frameworks (e.g. guidelines, handbooks, etc.). Regarding UK for instance, the integrated Sustainability Appraisal approach used for land use planning was noted playing a role with respect to “*what is looked at*” as CE usually encompass socioeconomic issues (i.e. deprivation, loss of identity, etc.), and they are typically considered as combined consequences of “*preferred spatial policies and options*” (i.e. intra-tier CE).

With respect to spatial analysis and spatial techniques, they were suggested as more suitable to those SEA stages requiring a better understanding of environmental phenomena and a better communication of them, having been spatial techniques “*a fast and effective means of communication with planners and stakeholders*” during particular SEA stages (i.e. scoping, consultation and participation, definition of alternatives and prediction of effects); as well as a synthetic means to represent complex issues and cumulative changes (i.e. deprivation, environmental sensitivity, spatial conflicts, etc.). Nevertheless, it was argued that the integration of this kind of techniques in a broader assessment methodology further depended on: the decision-making system, the scale of analysis, the nature of issues, data availability and time. Moreover, there was some caution expressed about spatial analysis only represent the ‘spatial piece’ of the plan which could not be fully expressed in a spatially explicit way (i.e. strategic objectives, monitoring results, etc.).

Finally, with respect to the role of methods within the SEA process, it was reminded that “*methods have to improve the process and to be able to cope with it in a time-fashion way*”, providing a support during important ‘decision windows’ in a ‘fit for the process’ way (“*sometimes processes take a break of months and then they suddenly reopen and conclude in a very few time. These ‘decision windows’ cannot wait for the perfect method*”).

3.5 Conclusions

The results of the survey highlighted both contextual and methodological aspects with respect to the overall SEA process and the treatment of CE.

With respect to the overall SEA process, the most unsatisfactory standards referred to:

- an inadequate role of scoping in appropriately addressing relevant issues and in supporting the overall SEA methodology and process;
- a scarce consideration and assessment of future alternatives; and
- a lacking definition of monitoring plans.

And among others, a number of contextual barriers constraining their satisfaction emerged such as: national legal frameworks (e.g. consultation's outcomes not required to be reported, monitoring not strictly mandatory in several countries, etc.); availability of guidance (e.g. SEA handbooks, topic guidelines); and socio-political attitudes (e.g. reactive assessment and decision-making, scarce public participation, bureaucratic application of SEA which precludes monitoring phases, etc.), suggesting that more attention should be paid to the context in which SEA is applied in terms of both environmental and policy aspects.

With respect to the treatment of CE, a lack of a "*thought-over methodology*" for scoping emerged as a barrier for strategic CE to be satisfactory addressed, suggesting that more consideration should be given during scoping to scale, inter-tier issues, scale-lag-effects, etc.

Secondly, a scarce attitude in orienting the assessment towards the future and in tackling uncertainty was found, highlighting a restricted awareness on the added value to treat CE at strategic level. Additionally, both a methodological lack, concerning how to technically deal with 'future'; and a series of contextual barriers (e.g. data availability, time, definition of responsibilities, credibility of decision-makers, etc.) emerged, suggesting the need to further investigate on this topic.

Thirdly, the main risk with respect to the assessment of CE was perceived the greater uncertainty characterising both assumptions and predictions, suggesting to base future assumptions on management and adaptive measures in order to better tackle uncertainty and cope with CE.

Finally, the main opportunities to adopt a spatially explicit approach were mostly suggested in order to support: a better understanding of environmental issues and effects; the definition of spatial options; the identification of areas of influence of decisions and 'spatial conflicts'; a better and transparent consultation and participation processes. Among the disadvantages were: the scarce support to map aspects with limited spatial explicitness (i.e. strategic objectives, monitoring results, etc.); data availability and reliability, and time.

Chapter 4

4 SEA of spatial plans: current practice review

4.1 Introduction

This chapter aims to explore to what extent cumulative effects are currently consider by SEA practice in two different spatial planning systems (UK and Italy), by systematically reviewing about twenty SEA reports of Italian and English local and regional spatial plans. In particular, the review mainly focused on conceptual and methodological issues (CE and strategic aspects, assessment approaches, methods, etc.), being the general information on SEA process (e.g. effectiveness, etc.) scarcely noticeable from the SEA documents.

The structure of the chapter is as follows. Section 4.2 introduces to the Italian and English spatial planning systems. Section 4.3 describes the review framework and the sample set. Section 4.4 illustrates the results, focusing on: the consideration of CE and key strategic aspects in SEA reports (§ 4.4.1); the treatment of CE during SEA process (§ 4.4.2); approaches and methods applied for the analysis of CE and strategic aspects (§ 4.4.3). Section 4.5 discusses the results of SEA reports' review. Finally, preliminary conclusions are presented in section 4.6.

4.2 Italian and English spatial planning systems

The Italian spatial planning is based on a tiered system, including national acts, regional and provincial spatial coordination plans, and general policy and land use plans at municipal level (Gazzola *et al.*, 2004; Geneletti *et al.*, 2007). However, spatial planning and environmental assessment is the responsibility of the regional level, therefore, each region has its own regulation and SEA is currently applied at regional, provincial and municipal levels (Figure 4.1).

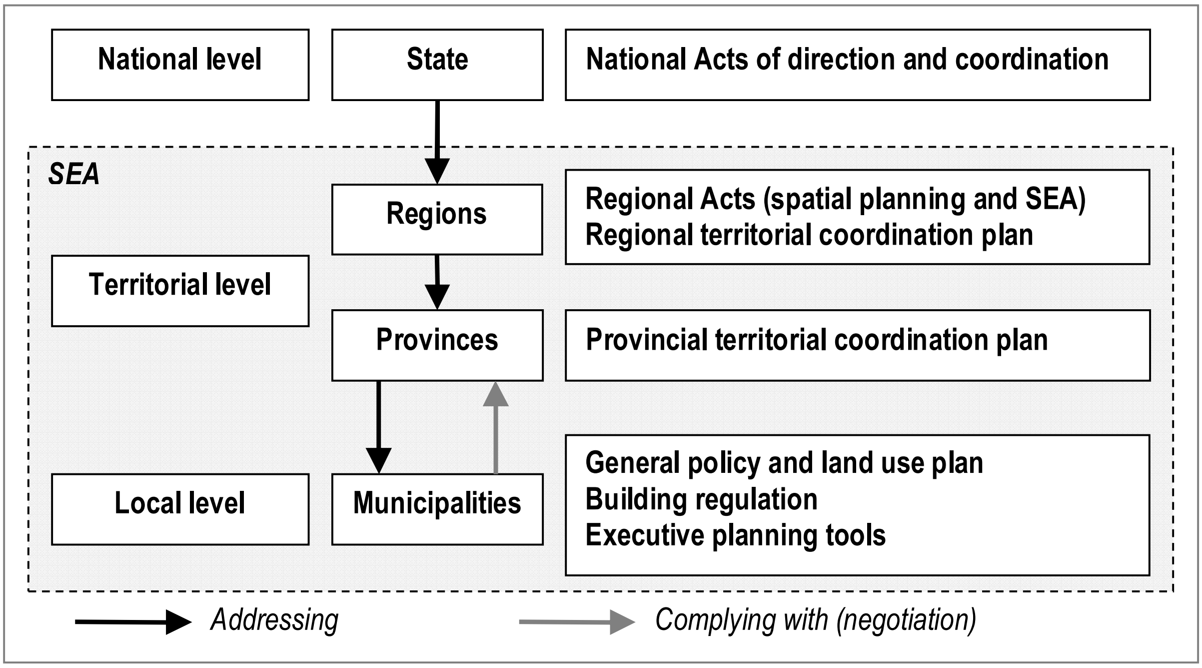

Figure 4.1: Italian spatial planning tiered system. *Modified from Gazzola, 2006*

In fact, although the implementation of SEA Directive at national level occurred extremely late (D.lgs. 152/2006 and D.lgs. 4/2008), SEA emerged during an institutional reform which involved spatial planning system, and provisions to perform SEA have been introduced before by several regional governments (Geneletti *et al.*, 2007). Therefore, it can be argued that a great variability of SEA experiences is currently characterising the Italian spatial planning context, moving from pioneer studies to usual practices, at least for those regions that earlier implemented the Directive (e.g. Emilia Romagna, Lombardia).

The review focused on SEA reports of:

1. spatial coordination plan at provincial level, hereafter referred to as the regional spatial plan, and;
2. municipal spatial plan, hereafter referred to as the local spatial plan.

The first sets up general strategies for spatial development and for the use of natural resources as well as regulations on soil management and natural hazard prevention. While the second defines a more detailed local spatial planning framework by integrating higher regional strategies and regulating new developments and services. In particular, local spatial plan encompasses different documents (General policy and land use plan, Building regulations, Executive planning tools) which may or not wholly subjected to SEA according with the particular regional regulation.

With respect to the English context, the Planning and Compulsory Purchase Act 2004 incorporated the requirements of the SEA Directive into the procedure of Sustainability Appraisal (SA) which under UK legislation must be prepared for regional and local development plans, by assessing whether proposed plans and policies meet sustainable development objectives, including socioeconomic aspects. Consequently, SA is actually applied at regional and local levels. In particular, the Regional Spatial Strategies is the statutory development plans for the regions of England, providing a regional level planning framework. And the Local Development Framework (LDF) which made up of a portfolio of local development documents (LDDs) is required to have regard to the Regional Spatial Strategy. Additionally, the Core Strategy represents the key strategic document for local spatial plan and all other policy documents produced as part of Local Development Framework (Supplementary Planning Documents, Area Action Plans) (Figure 4.2). Furthermore, it should also draw on other strategies that have implications for the development and use of land (e.g. Local Transport Plan, Waste plan, etc.). This review focused on SA/SEA reports of Regional Spatial Strategies and Core Strategy.

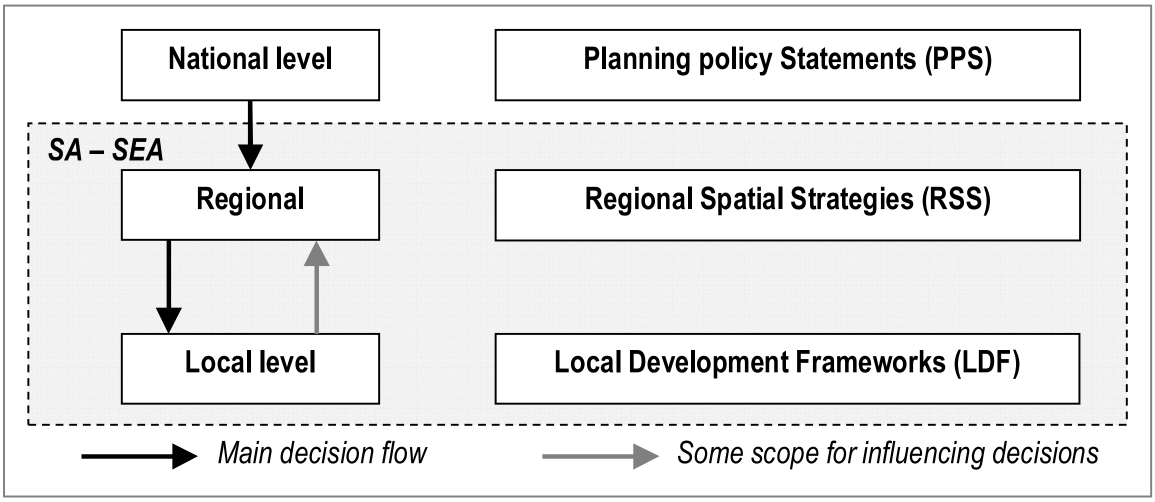

Figure 4.2: English spatial planning tiered system. *Modified from Fischer, 2007*

4.3 The review framework and the sample set

In order to explore to what extent CE are considered and predicted in current SEA practice, a framework was firstly developed and, therefore, applied to systematically review SEA/SA reports. It needed to be as flexible as possible, considering that SEA process vary according to the planning system, stage and procedure (Noble, 2000; Verheem and Tonk, 2000; Fry *et al.*, 2002; Jones *et al.*, 2005). Furthermore, it mainly focused on conceptual and methodological issues with respect to the treatment of strategic level CE emerging from both the theoretical background (see Chapter 2) and the results of expert survey (see § 3.3 and 3.4), encompassing general and specific aspects (e.g. CE and strategic contents, assessment approaches, methods, etc.). In particular, general issues mostly referred to those aspects deemed crucial regardless the treatment of CE, such as: the definition of planning alternatives and uncertainty characterising assumptions and predictions.

The framework includes three sections (see Appendix 2):

1. the exploration of to what extent CE and key strategic aspects are considered (Cooper and Sheate, 2004; Cooper, 2008; Gunn, 2009; Canter and Ross, 2010);
2. the investigation of when CE are identified and predicted during SEA process (Cooper, 2004; Thérivel and Ross, 2007);
3. the examination of approaches and methods applied to treat CE and key strategic aspects (Thérivel, 2004; Cooper, 2004; ODPM, 2005).

The sample set consisted of twenty SEA documents selected based on the suggestions of Italian and English experts involved in the survey previously carried out (see question 16 in Appendix 1). English SEA reports[1] included: Sustainability Appraisal Reports of Regional Spatial Strategies (2); Sustainability Appraisal Reports of Core Strategies (6); Scoping Reports (2). Italian SEA reports consisted of: SEA Environmental Reports of Provincial Spatial Coordination Plan (5); SEA Environmental Reports of Local Spatial Plan (5). Appendix 2 included the detailed list of SEA documents consulted, providing information on the spatial plan and SEA document, date of publication, and assigning an ID code to each document in order to facilitate next discussion.

[1] A range of sustainability appraisal tasks in parallel to the Core Strategy are commonly carried out. The findings of appraisal are contained in a series of SA documents (i.e. 'Issues and Options' SA report, 'Preferred Options' SA report, Final SA report).

4.4 Results

The results of the review are presented according to the three sections of the framework previously portrayed.

4.4.1 The consideration of CE and key strategic aspects in SEA reports

4.4.1.1 Definition and consideration of CE

An explicit definition of cumulative effects was found in five SEA reports (25%), while the rest of documents consulted (75%) did not provide a clear explanation or classification of them (Figure 4.3).

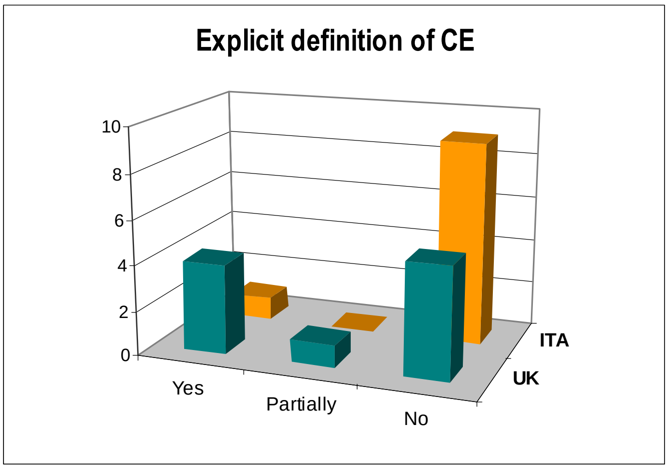

Figure 4.3: Definition of CE in SEA reports

Referring to UK, the definitions of CE varied from general descriptions such as those provided in guidelines (e.g. U.S. handbook, OPDM, etc.) to classifications more tailored for spatial planning[2].

Regarding Italian SEA reports, an explicit mention to CE was only once found, although numerous statements having reference to them were uncovered in SEA reports such as: "*combined effects*" of different planning objectives (e.g. achieving land use efficiency, protecting natural resources, meeting the development requirements such as housing, accessibility, etc.); and "*interaction of effects*" of different human activities within the same area such as small developments induced by transportation infrastructures or other projects and

[2] CE were identified as "*impacts that result from incremental changes caused by other past, present or reasonably foreseeable actions together with the South East Plan*"; "*effect that results from all of the policies of the DPD acting in combination upon a common receptor*"; and "*two insignificant impact combine to form a significant impact* […] *several policies can work together to achieve what may be more accurate to call a 'collective impact' both positive (synergistic) and negative (cumulative)*".

spatial plans which together could cumulatively affect open spaces and biodiversity (ITA6; ITA7; ITA10) or cumulatively contribute to an overall deterioration of air quality (ITA1; ITA2) and landscape character (ITA1; ITA3); as well as synergistic effects on population and human health due to the interaction of natural and anthropogenic risks (ITA1; ITA8; ITA10). A brief example is following reported:

> *"The area included between Coriano and Ravegnana is among the most important industrial sites of the region. However, due to the high industrial and road density and the planned new developments (highway, industrial and commercial sites, waste incinerator) an increasing of mobility demand and atmospheric pollution is expected to occur as combined effects of those sources of pressure on air quality, population and human health."*[3]

Therefore, two kinds of CE were identified within the sample:

1. the combined effects on relevant issues/objectives arising from the different components of the spatial plan (*intra-tier CE*);
2. the combined effects on relevant issues/objectives of the plan together with other PPPs (*inter-tier CE*).

And the first was the main frequently discovered, since other projects, plans or programmes (PPPs)[4] contributing to minimise, maximise or neutralise effects of spatial plan were only identified in four SA/SEA reports (20%) of the total sample (Figure 4.4).

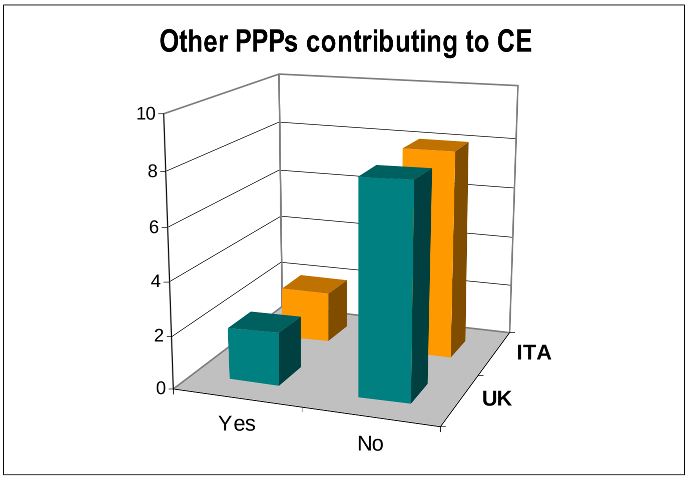

Figure 4.4: Consideration of other PPPs contributing to CE in SEA reports

Furthermore, explicit recommendations, mitigations and compensations to address CE were only found in three SEA reports of regional spatial plans (UK1, ITA3, ITA4) (Figure 4.5).

[3] This is an extract of ITA1 (pg. 30). Original Italian version has been personally translated.
[4] Referring to current and reasonable foreseeable future actions in CEA literature.

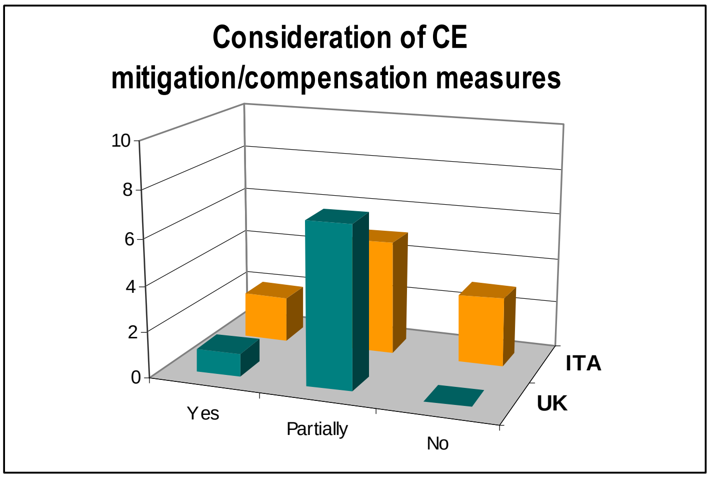

Figure 4.5: Consideration of CE management measures in SEA reports

In particular, they mainly concerned the proposal of regional policies, objectives and targets such as: including policies to maximise the use of previous development land in order to face on loss of greenfield and land take[5]; protecting existing woodland and supporting the creation of new green spaces throughout technical support in order to prevent biodiversity loss and adapt to climate change[6]; establishing of clear CO_2 reduction target for the region during the lifetime of the Plan in order to offset climate change[7]. Mitigations further included more detailed targets or frameworks for addressing local spatial plans such as encouraging sub-regions to adopt strategies that promote concentrated rather than disposed development[8] or promoting the allocation of parking areas in public transport accessible zones in order to prevent cumulative increasing of road traffic[9]; prevent new housing/development in flood plain areas or implementing of sustainable drainage systems (SUDS) for all new development to avoid incremental flooding risk[10]. However, the expected effects of their implementation was only partially predicted or discussed (ITA6, UK7) and none of reports included predictions based on assumptions on the implementation of proposed management measures.

Finally, a general disregarding of CE in monitoring plans were found. Moreover, none of the SEA reports proposed remedial actions to be undertaken if adverse CE would occur.

[5] Found in ITA1, ITA2, ITA3, ITA4.
[6] Found in UK2, ITA2, ITA4.
[7] Found in UK1.
[8] Found in UK1, ITA2, ITA3, ITA4.
[9] Found in ITA1, ITA3.
[10] Found in UK1, UK2, ITA3.

4.4.1.2 Identification of planning alternatives

A description of how reasonable alternatives were identified considering objectives and scope of the plan was not provided in SA/SEA reports consulted since an outline of the reasons for selecting them was lacking. Furthermore, they were generally those developed in the plan preparation and the process leading up to their definition was rarely reported.

In general, reasonable alternatives, both at local and regional level, mostly concerned the situation without Plan, with Plan and with several proposed changes, which for instance corresponded to policies set out in the adopted plan (i.e. UK2).

Moreover, with respect to Italian SEA reports, alternatives were completely disregarded in five cases (50% of Italian sample): three were SEA of reviews of spatial plans; a report stated it as a consequence of SEA was an *in itere* process, while the other did not provide any motivation (Figure 4.6).

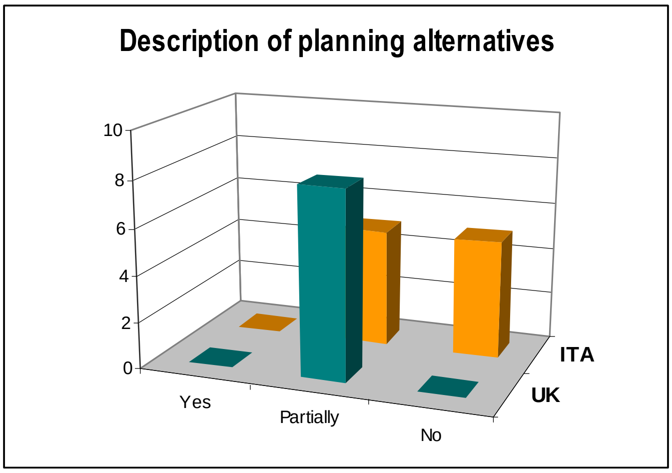

Figure 4.6: Consideration of planning alternatives in SEA reports

4.4.1.3 Uncertainty

Information on uncertainty was generally provided by thirteen SA/SEA reports reviewed (65%). In general, the mostly mentioned sources of uncertainty included: external factors influencing regional and local conditions (e.g. lifestyle and personal choice, economy, other policies, etc.)[11]; the way in which a policy will be implemented[12]; and speculation due to incomplete/missing baseline data, lack of available research[13], etc.

Among others, uncertain effects relied on: borough-wide issues (e.g. climate change, air quality)[14]; long term effects (unemployment, air quality, protected areas, etc.)[15]; indirect

[11] Found in UK1, UK2, UK3, UK7, ITA3, ITA6, ITA7, ITA8.
[12] Found in UK1, UK2, UK4, UK7, ITA3, ITA6, ITA7, ITA8, ITA9.
[13] Found in UK2, UK7, UK10, ITA6.
[14] Found in UK4, UK7, UK8, UK10, ITA3, ITA4.

consequences (e.g. enhancing green infrastructures may contribute to encouraging cycling and walking and then improve heath)[16]; combined effects (increasing of air pollution due to loss of open spaces and increased traffic)[17]; spatial distribution of impacts (e.g. noise)[18], etc.

Finally, uncertainty characterising spatial options or planning alternatives mostly relied on assumptions made to define suitable location[19], implementation of mitigations[20], future changes on transport patterns and land use changes[21]. While in case of future growth scenarios, uncertainty mainly referred to exogenous factors (i.e. people's future behaviour, climate change, economy, etc.)[22].

4.4.2 The treatment of CE during SEA process

The identification of likely CE generally occurred during the prediction of effects or appraisal of preferred options. In none of the reports consulted the issue was addressed before (i.e. scoping).

In particular, twelve SEA reports (60%) analysed CE during the stage in which the likely significant effects of spatial plan were predicted, while the comparison of likely CE between future planning alternatives, such as the 'do nothing' and the implementation of spatial plan was partially found in: ITA2 (aggregated effect of planning policies); ITA5 (incremental effects of alternative set of planning policies); ITA6 (combined effects of noise, air pollution and electromagnetic radiation on population); and ITA7 (combined effects of plan together with other PPPs).

Referring to UK SA/SEA reports, the consideration of CE usually occurred during the appraisal of preferred options stage as any consideration of CE was absent before (i.e. scoping and '*Issues and Options*' SA/SEA documents; see UK6, UK8, UK9).

4.4.3 Approaches and methods

4.4.3.1 Identification and prediction of CE

The identification of CE did not integrate any additional analysis to the overall SEA approach, being generally focused on those aspects recognised as relevant through the SEA scoping such as thematic issues (e.g. housing, community, etc.), environmental issues (e.g. land, water,

[15] Found in UK3, UK4, UK7, ITA4.
[16] Found in UK3, UK4, UK7, ITA6, ITA3, ITA4, ITA7.
[17] Found in UK4, UK7, UK,10, ITA3, ITA7.
[18] Found in UK1, UK4, UK7, ITA4, ITA6.
[19] Found in UK7, UK8.
[20] Found in UK2, UK3, UK4, UK8, ITA4, ITA6.
[21] Found in UK2, UK7, UK8.
[22] Found in UK1, UK2, ITA6.

biodiversity, etc.), policies and strategies (e.g. housing, service and facilities, economy, etc.), or sub-areas (e.g. sectors of municipalities, sub-regions, etc.).

Nevertheless, a systematic scoping of potential CE was separately found in UK1 which set out a matrix-based analysis of potential cumulative impacts, by identifying: potential CE (e.g. lack of affordable housing; increased emissions from transport; loss of rural and urban character; increased flood risk; increased social exclusion; loss of Greenfield Land; loss of biodiversity); causes (e.g. exogenous factors; ways of implementation of policies; etc.); limits and thresholds (e.g. flooding areas; climate change scenarios; Income Deprived Households, etc.); influence of RSS; receptors (e.g. residents of the region, coastal zone, water, biodiversity, tourism, etc.); relevant PPS; and potential mitigations. And a brief extract is following reported (Figure 4.7).

Cumulative/synergistic effects	**Cumulative Effect**	**Causes**	**Limits, thresholds, current status etc**	**Influence of RSS**	**Affected receptors**	**Relevant plans and programmes**	**Potential mitigation**
The use of PDL, if maximised, will help to reduce the overall demand on undeveloped/Greenfield sites. However, due to large number of factors affecting the use of PDL, not least the location of such areas, pressures on Greenfield sites are still likely to be strong. This demand will be strongest where there is low availability and low	Loss of Greenfield Land	The impacts of development in the region depend on the extent to which development can be accommodated in away that maximises the use of PDL whilst minimising the use of green fields sites	The amount of derelict and vacant land in urban areas increased by 600ha to 4,520 in 2003. This represents 2.2% of the region's developed land. The South East has the third most extensive areas of derelict and vacant land of any English region. 600ha of land was covered by derelict buildings in 2003.	The policies within the RSS aim to encourage the use of PDL to satisfy regional housing and development needs. It is, however, the role of local authorities to assign specific areas for development. The ability of local authorities to	Residents, businesses, agricultural/green belt land. Biodiversity	RSS, RES, Regional Housing Strategy.	Policies to maximise the use of PDL should be included in the Plan. Detailed mapping/assessment of PDL including identification of constraints/solutions should be carried out to guide the
demand for PDL. The overall effect of the RSS should be a reduction in available PDL. A focus on use of PDL will also require the 'green infrastructure needs of development to be taken into account. This should incorporate existing areas of PDL o high biodiversity value to prevent erosion of urban biodiversity.			The proportion of homes built on PDL has increased from 55% in 1998-99, 68% in 2001-02 and 71% in 2002-03 (compared to a target of 60% by 2008). The proportion of housing completions in urban areas has increased from 53% in 1998-99 to 60% in 2002-03, although there are wide intra-regional variations from 43% in Buckinghamshire to 80% in Berkshire. 72% of land with planning permission for housing in 2003 was PDL. Housing density rates average at 34.2 homes/hectare across the region, compared to a target of 30% and a rate of 27.6 in 1997-98.	focus on the use of PDL will depend on the characteristics of the stock of PDL in their area. Key characteristics will include: • The size of panels (ie, infill or larger areas) • The distribution of panels • Target end/user/buyer • Existing adjacent land uses • Accessibility • Degree of contamination • Current planning designations • Cost of development.			implementation of LDFs. Plan policies and sub-regional strategies should favour intensification rather than dispersed development this should be carried through into LDFs. Use of Greenfield Land should be minimised as should the use of high quality agricultural land.

Figure 4.7: Systematic scoping of CE adopted in UK1

Referring to the prediction of CE, a systematic approach emerged from English SA/SEA reports. Moreover, a range of terms of reference were explicit cited to have been followed by seven SEA reports in order to assess CE.

In particular, English SA/SEA appraisal adopted an objective-led approach, by qualitatively evaluating each plan's policy on SA objectives and, therefore, by combining the results of each policy into a summary matrix, assuming there may be CE which occur as a result of the combined implementation of plan's policies (Figure 4.8).

SA objectives / **Plan's objectives/policies**	Housing	Poverty and social exclusion	Air quality	Previously developed land	Energy efficiency	High employment	Sustainable tourism	Etc…
1								
2								
3								
4								
5								
Etc…								
Cumulative effects								

Figure 4.8: Systematic assessment of CE of plan's policies on SA objectives adopted in English SA/SEA reports

And this summary matrix was often followed by extra comments such as:

> *"Preferred Policy 6 (Town Centres expansion) is expected to develop PDLs. Also, Preferred Policy 1 (Managing Growth) directs development to regeneration areas (Haringey Heartlands, Tottenham Hale, Seven Sisters and Wood Green Metropolitan Centre) which are likely to have PDLs. This policy would strong contribute to this SA Objective* [to encourage the use of previously developed land]*."* or

> *"Preferred Policy 4 (Movement) could have a positive cumulative impact on air quality in the long term by reducing car dependency. Also, Preferred Policy 1 (Managing Growth) and Preferred Policy 6 (Town Centres) directs growth to regeneration areas and town centres which should reduce travel and indirectly contribute to this SA objective* [to protect and improve air quality]*."* Source: UK4

The same approach was found in English SA/SEA of local spatial plans in order to predict CE of site-specific proposals or strategic sites on relevant environmental issues, assuming there may be combined effects as result of the overall realisation of plan's development sites as showed in Figure 4.9.

	Landgate	Stubshaw Cross	The Bell	North Leigh	South of Hindley	East of Atherton	Garrett Hall	Firs Lane	Cumulative / synergistic Impacts
Biodiversity (designated habitats)	✗	0	0	0	✗✗	✗	0	✗✗	✗
Biodiversity (species)	?	?	?	?	?	?	?	?	?
Air quality a) Impact	✗✗	✗✗✗	✗	✗✗✗	✗✗✗	✗	✗✗	✗	✗✗✗
Air quality b) With infrastructure secured	0 / ✓	✓	✓	0	✓	0 / ✗	0	0 / ✓	✓
Soil & minerals a) % brownfield	✗✗	✗	✗✗✗	✗	✗✗	✗✗?	✗✗	✓✓	✗✗✗
Soil & minerals b) Agricultural land	✗	✗	✗	0	0	0	✗	0	✗
Water a) Flood risk	0	0	0	0	0	0	✗	✗✗	0 / ✗
Water b) water supply	0	0	?	?	0	0	✗	?	0
Water c) Waste water& drainage	0	✗✗✗	?	✗✗✗	0	0 / ✗	0	0	✗
Landscape (Character assessment)	0	0	✗✗	✓	✓	✗	✗✗	0	0
Buildings (Impact on heritage)	0?	0	0	0	0	0 / X	0	0	0
Community Safety	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
N.Quality a) Amenity impacts	0 / ✗	0 / ✗	0 / ✗	0	0 / X	0 / X	0 / X	0	0 / X
N.Quality b) Environmental gain	0 / ✗	0	✗	✓✓	✓✓	✓	0	✓	✓

Figure 4.9: Systematic assessment of CE of site-specific proposals on relevant issues adopted in UK3

Referring to Italian SEA reports, a systematic approach to assess CE was only found in ITA7: providing a definition of CE (‘*impacts of planning actions affecting the same component/receptor*’); identifying those direct and indirect planning actions which together with local spatial plan could likely affect the same component (e.g. population, local economy, landscape); and qualitatively predicting likely positive and negative CE through a coaxial matrix (e.g. positive synergistic effect on landscape due to new building regulations and urban renewal; incremental increasing of traffic due to new ski areas and housing for winter tourism, etc.).

With respect to the others Italian SEA reports, the approach adopted to predict *pseudo-CE*[23] varied from qualitative description (ITA1) to semi-quantitative matrix-based assessment (ITA3, ITA4, ITA5, ITA7), quantitative aggregated index (ITA2, ITA8), map overlay and spatial multicriteria analysis (ITA6, ITA9, ITA10). In particular, the objective-led approach was usually adopted to assess the synergies between plans’ objectives and higher level spatial and sectoral policies (EU sustainability principles, regional policies, etc.). While a baseline-led approach mostly characterised the prediction of effects on relevant environmental or planning issues (e.g. air quality, settlement density, accessibility to green areas, flooding risk, etc.).

Figure 4.10 showed an example of a spatially explicit aggregated index (called *combined impact of urban land use change*[24]), based on a zoning multicriteria analysis, ‘combining’ different thematic parameters (e.g. hydrogeological risk, accessibility, protected areas, etc.) and assigning a score to support the allocation of different land uses.

[23] The definition refers to Italian SEA reports since CE were only explicitly mentioned in ITA7, otherwise personally interpreted.
[24] Personally translated from Italian version.

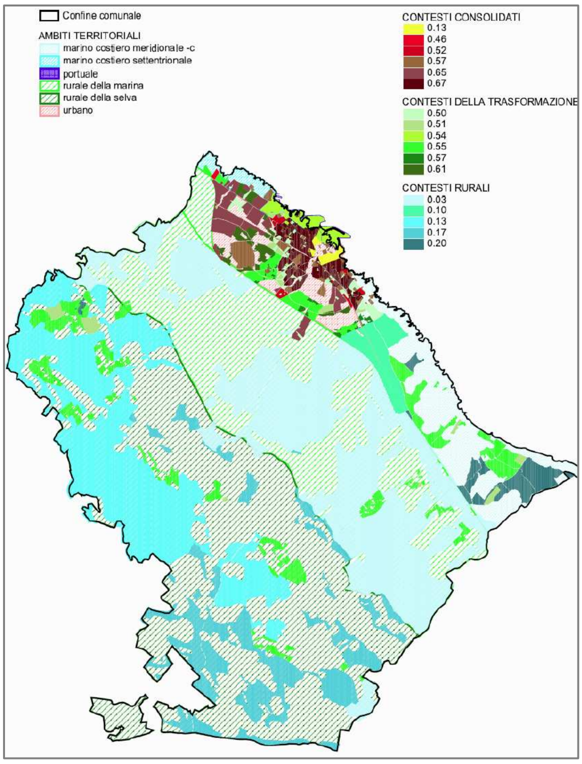

Figure 4.10: Index of *Combined impact of urban land use change* found in ITA10

Additionally, Figure 4.11 shows a spatially explicit aggregated index (called *urban quality index*) applied in ITA6, combining the effects of noise, air pollution and electromagnetic radiation in order to compare the baseline situation with the future implementation of local spatial plan.

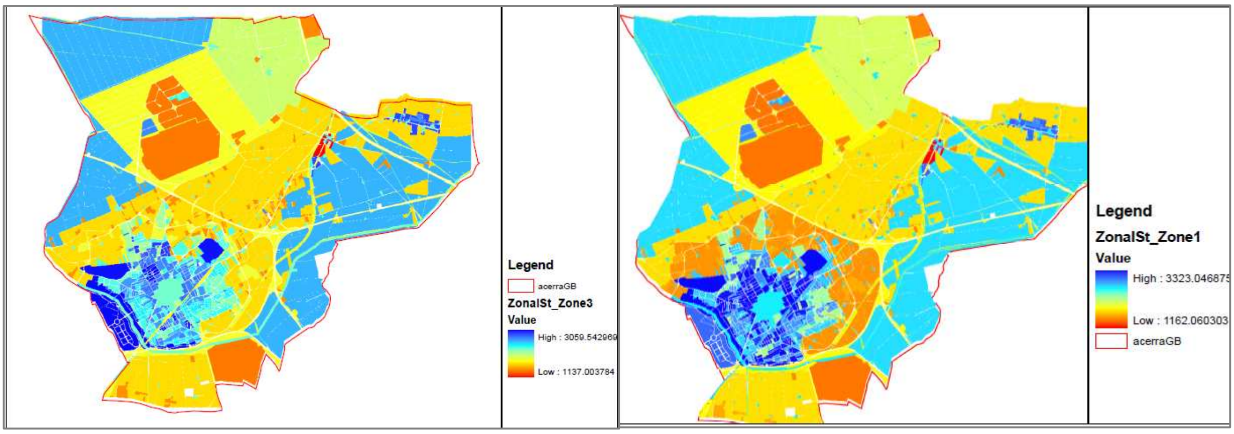

Figure 4.11: *Urban quality index* found in ITA 6 (on the left: baseline condition; on the right: implementation of spatial plan)

Finally, the methods and techniques applied to predict CE were not different from those generally used in common SEA practice, varying from matrices, quantitative indicators and aggregated indices, spatial analysis (map overlay, etc.) and MCA. Furthermore, qualitative analysis and semi-quantitative assessments was mostly found in regional SEA reports; while map overlay mainly characterised local SEA reports.

4.4.3.2 Definition of planning alternatives

The planning alternatives were generally identified and developed during the plan preparation and, thereby, taken from the plan. Thereby, the 'do nothing' alternative was generally set as the baseline condition in order to compare likely effects between different future planning options.

Both English SA/SEA reports of RSSs (UK1, UK2) considered what if the situation was: without Plan, with Plan and with several proposed changes, under different growth scenarios which mainly assumed future level and distribution of housing and employment provision based on existing plans as well as national and regional predictions, including temporal targets (e.g. number of new housing, etc.).

English SA/SEA reports of Core Strategies usually referred to two levels of detail of planning alternatives: those related to the allocation of future developments (i.e. *spatial options*) and those referring to policies (i.e. *policy options*), characterising different ways to achieve plan's objectives. The first was found in four reports (UK3, UK4, UK5, UK10), while the second was always present.

In case of Italian SEA reports, regional alternatives mainly concerned: 'do nothing' and different levels of implementation of spatial plan in terms of objectives (protection of natural sites, prevention of natural and industrial risk, controlling sprawl and regulating local developments, etc.) and/or spatial developments (road infrastructures, industrial sites, etc.). Whilst local alternatives mostly regarded: 'do nothing' and spatial future developments proposed by the plan based on their allocation. Therefore, suitability analysis was often found as a means to map and visualise the most suitable allocation for particular land use purposes (settlements, industrial sites, public services, etc.).

Additionally, three SEA reports (ITA2; ITA6, ITA7) explored the implementation of spatial plans under different future conditions, by assuming what if exogenous factors (e.g. population growth, public transportation demand and provision, accessibility to public services, realisation of relevant projects, etc.) were changed under a business as usual future condition. And in two cases (ITA2, ITA6), transportation models were applied in order to computed and spatially represent future scenarios, assuming different provision and/or demand of transportation.

4.4.3.3 Uncertainty

An explicit reasoning upon uncertainty in policy appraisal was found in UK1, suggesting the uncertainty associated with the assessment as the key in assessing impact significance, and proposing two strategic dimensions of uncertainty: the magnitude of impact the policy will have (*what magnitude of impact will the policy have?*) and the likeliness of implementation of policy (*how certain is the policy to be implemented?*).

However, although sources of uncertainty and/or uncertain effects were often cited (e.g. uncertain impacts on air quality dependant upon successful implementation of infrastructure[25] or long-term future consequences on protected sites is considered highly uncertain as a result of complex influences and pressures, including climate change and active management of sites[26]), uncertainty was systematically treated only in UK7, by adopting a score-based approach which, firstly, defined a scale of uncertainty levels and, then, assessed the probability that the effects will occur as appraised, should plan's policies be implemented.

The results of the review are following summarised. Appendix 2 further provides a more detailed synthesis of results.

General consideration of CE in SEA	▪ Poor definition and vague scoping of CE ▪ Inadequate comparison of CE of planning alternatives ▪ Vague predictions of CE ▪ Disregarding of CE in monitoring plans
Key strategic aspects	▪ Scarce consideration of other PPPs and exogenous drivers ▪ Poor consideration of reasonable planning alternatives ▪ Inadequate consideration of ways to compensate/mitigate CE ▪ Lack of information on uncertainty
Approaches and methods	▪ Lack of structured approaches to identify CE issues ▪ Predictions of CE only qualitative ▪ Lack of future-oriented approaches

[25] Extracted from UK3 (pg. 41).
[26] Extracted from UK7 (pg. 30).

4.5 Discussion

The following discussion focus on: the role of scoping, the treatment of CE at strategic level, and the approaches and methods discovered in SEA reports.

4.5.1 The role of scoping

The scoping of CE was generally vague. None of the reports consulted explicitly identified relevant issues referring to potential CE, rather they mainly predicted CE for each issue listed in the SEA Directive or, alternatively, for all of those issues or objectives emerging from the baseline condition, by 'summing up' single effects. And this consequently influenced: the selection of '*other foreseeable future actions*', the range of effects investigated, the mitigation and enhancement measures recommended, and the overall assessment approach.

Concerning UK SA/SEA practice, despite a separate analysis of potential cumulative impacts was found in UK1 (see Figure 4.7), it seemed to be not usefully applied in order to: appraise preferred spatial strategy, regional and sub-regional policy framework; predict likely impacts of the RSS plus other PPPs; and support the identification of *ad hoc* recommendations. In fact, most of its contents seemed to remain separately treated from the final report (e.g. cross reference, etc.). Moreover, its updating was optionally postponed to the monitoring phase, leading to be probably neglected in practice.

Referring to Italian SEA practice, an upstream problem was generally found due to the lack of appropriate conceptual and methodological frameworks supporting CE assessment and management. However, in contexts characterising by such as scarce technical support (e.g. guidelines, best-practices handbooks, etc.) (see Diamantini and Geneletti, 2004), a flexible approach with respect to the treatment of CE could be developed during scoping stage, varying with relevant VEC, scale (spatial extent, level of detail of plan, etc.), environmental context and planning system.

Finally, '*spatial crowding*' effects or effects which may become significant at higher scale (e.g. increment of traffic at regional level due to a new local commercial area; cumulative impact on regional water balance due to housing growth; land take due to small developments, etc.) were often disregarded, as well as both spatial and management boundaries of CE analysis never expanded in order to capture them. Consequently, although this may rely on time constraints and indirect responsibilities of planning authorities in managing broader scale issues (water regulation, flooding risk, etc.), it could be further a consequence of the failure of scoping in focusing on relevant VECs and, thereby, in expanding the analysis only for those key issues.

In particular, a better scope of CE could be in support of SEA, not only by focusing on relevant key receptors, but by further detailing the analysis on combined threats and opportunities of other tiers of decision-making (e.g. coordination of sectoral policies, planning tools, etc.) which together with the proposed spatial plan could contribute to the CE management.

4.5.2 The treatment of CE at strategic level

The review suggested that the exploration of different way to deal with CE was not well done due to the assessment of CE was only partially undertaken when considering options or alternatives. Additionally, the way in which other '*foreseeable future actions*' (PPPs and exogenous factors) could cumulatively affect a receptor were seldom identified; as well as their combined effects vaguely predicted.

In particular, the treatment of strategic level CE seemed to be threatened by the complexity to deal with tiered decisions; and by a lack of future-oriented approaches supporting the adoption of a management-oriented perspective.

Firstly, a large variability in levels of detail of planning components was found both in Italian and English SA/SEA reports, ranging from planning principles, broad strategic objectives and spatial development options to site-specific proposals, which in case of local spatial plans were characterised by a more detailed spatial reference (i.e. allocation). And although this relied on the systematic decision tiers characterising spatial plans, it seemed to further influence the level of detail of CE predicted which ranged from:

a. the combination of effects of planning objectives on sustainable objectives or issues, assuming that all planning policies were implemented together (*intra-tier CE*);
b. the combined effects of strategic developments on particular issues or areas, assuming spatial planning developments to be fully implemented (*intra-tier CE*)[27]:
c. and the combined effects of spatial plan and other '*foreseeable future actions*', including other PPPs and/or exogenous factors, assuming that there may be other tiers of decision-making and/or external factors interacting together with spatial plan (*inter-tier CE*):

However, the predictions of CE generally based upon the assumptions that: firstly, all policies and objectives were fully implemented which may be not always the case; and, secondly, they were strictly implemented across all development proposals and/or planning applications which may not always occur, considering that the application of strategic objectives requires an appropriate level of flexibility due to site-specific conditions or executive planning regulations

[27] The distinction between *a* and *b* was particularly marked in UK SA/SEA reports of Core Strategy (UK4, UK5, UK10) since the prediction of CE was separately treated for different levels of detail of planning components (core strategy objectives, spatial options, preferred policy options).

which can vary with physic and planning context. In fact, even though the likeliness of implementation of planned actions (policies, strategies, proposals, compensations, etc.) was among the most cited source of uncertainty (see § 4.4.1.3), planning alternatives considered mainly referred to: '*do nothing*' and full implementation of plan through policies and spatial options (with minimum variations).

Secondly, a lack of proactive approaches to CE management was perceived since:

- the combined consequences of reasonable planning alternatives were frequently compared after preferred options were selected; and
- options were seldom based on assumptions on the likely implementation of management measures, despite negative CE (e.g. habitat fragmentation, flood risk, etc.) were often predicted as a consequence of the failure of plan in addressing and ensuring appropriate mitigation/compensation and enhancement measures (e.g. habitat restoration, sustainable water drainages, etc.).

Consequently, it seemed that introducing assumptions on the likeliness of implementation of those measures could improve the prediction and the management of CE as well as the treatment of uncertainty characterising them. Among others, measures could encompass those generally found in SEA reports both at local (i.e. integration of compensation targets in building regulations)[28] and regional level (i.e. identification of those planning tools which could contribute in facing on negative or enhancing positive cumulative consequences)[29].

Additionally, the exploration of what if the situation changed under future exogenous conditions was rarely considered, even though external factors were among the most cited source of uncertainty (see § 4.4.1.3). As a result, predicting likely effects under exogenous conditions (people's future behaviour, population growth, etc.) seemed to be particularly important in order to support reasonably foreseeable management actions to be identified. Nonetheless, different assumptions on such complex issues (e.g. energy sources, economic dynamics, climate change, etc.) could lead to huge uncertainty which may affect predictions, and hence, a great consensus may be required within the planning arena in order to deal with future and avoid cumulative conflicts.

In particular, a future-based approach standing on management measures could be of benefit to SEA, by supporting to set assumptions on future conditions (e.g. implementation of planning policies and regulations; exogenous driving forces) and improving the overall planning process in managing combined effects.

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[28] Quantitative targets for new developments in order to both control flooding risk which may cumulative increase with soil sealing and loss of permeable areas; and promote renewable energy and energy efficiency (e.g. 10 m^2 of solar collectors for developments with more that 100 m^2 of surface, energy efficiency standards, etc.). See ITA3, ITA4, ITA6, ITA8, ITA9, ITA10.

[29] Local Transportation Plan, EMAS, Building regulations, Land reclamation Programmes, etc. (ITA3, ITA4)

4.5.3 Approaches and methods

A structured approach to address CE in SEA practice only emerged from English SA/SEA reports since English government guidance on SA/SEA (ODPM, 2005) sets out key procedural points in the assessment of secondary, cumulative and synergistic effects.
However, it seemed that:

- firstly, it failed to address CE in a proactive way since CE were never considered before preferred options were selected, and
- secondly, it led to a 'win-lose' analysis of CE arising from the 'sum up' of sustainability issues, due to economic benefits could neutralise negative environmental or social consequences, and, thereby, resulting as a positive, or, at least, a neutral CE against SA objectives, leading important consequences to be disregarded (see Figure 4.12).

	SA Objectives																								
	Social objectives									Environmental objectives											Economic objectives				
Core Strategy Objective	1 Housing	2 Flooding	3 Health & Well being	4 Poverty & Social exclusion	5 Educational achievement	6 Safe community	7 Vibrant community	8 Accessibility	9 Leisure & culture	10 Efficient use of land	11 Air quality	12 Reduce climate change	13 Protect biodiversity	14 Environment & landscape	15 Historic environment	16 Sustainable travel	17 Efficient use of resources	18 Reduce waste	19 Protect water environment	20 Energy efficiency	21 High employment	22 Thriving economy	23 Commercial floorspace	24 Diverse employment	25 Sustainable tourism
1	-	++	++	+	O	+	+	+	O	O	++	++	+	+	+/-	+	++	++	++	++	O	+/-	O	O	++
2	-	-	+	+	O	+	++	++	++	-	++	++	+/-	+	O	++	O	+	+	O	O	+	+	+	++
3	++	-	O	O	O	O	O	O	O	+/-	O	-	--	--	-	O	O	O	-	O	+	++	-	+	O
4	+/-	-	+	O	O	+	++	+	+	+/-	O	O	-	+	+/-	O	O	O	O	O	O	+/-	O	O	+
5	+	-	+	O	O	O	O	++	O	++	O	+	-	+	-	++	+	O	-	O	O	+/-	+	O	+
6	++	O	+	+	O	O	++	O	O	O	O	O	O	O	O	O	O	O	O	O	+	+	O	+	O
7	+	O	++	+	O	+	+	++	+	O	++	++	O	O	O	++	O	O	O	O	+	+	O	O	+
8	+	O		+	O	O	+	++	+	O	+	+/-	O	O	O	++	O	O	O	O	+	+	O	O	+
9	+	-	++	+	O	+	O	O	++	O	O	-	+/-	+/-	+	+	O	O	+/-	O	O	+	O	O	++
10	O	-	O	+	+	O	+	+	O	-	-	-	-	-	+/-	O	O	O	-	O	++	++	++	++	O
11	O	O	+	++	++	O	+	O	O	O	-	-	-	-	+/-	O	O	O	-	O	++	++	+	+	+
12	+	O	+	+	O	+	++	+	O	+	+/-	+/-	-	-	+/-	+	O	O	-	O	+	++	+	+	+
13	-	+	++	+	O	O	+	+/-	+	+	+/-	+/-	+	++	+	+	O	O	+	O	-	+/-	O	-	+/-
14	-	+	+	+	O	O	+	-	O	+	+	+	++	+	O	O	O	O	+	O	-	-	O	O	+
15	-	+	+	O	O	+	O	O	+	O	+/-	-	+	O	++	O	-	O	O	O	+/-	+/-	O	+/-	+
16	+	+	++	+	O	++	++	+	+	O	O	O	O	O	O	O	O	O	O	O	O	++	O	+	+
17	-	+	++	+	O	+	+	O	O	O	++	+	+	+	O	O	+	O	++	O	O	-	O	O	+
Cumulative performance	+/-	+/-	++	+	+	+	++	+	+	+/-	+/-	+/-	-	-	+/-	++	+	+	+/-	+	+	+/-	+	+/-	+

Figure 4.12: Systematic assessment of CE of Core Strategy objectives on relevant issues adopted in UK5

Accordingly, by summing up the effects for each SA objective, the overall Core strategy often resulted performing in negative way in case of environmental consequences (e.g. biodiversity and landscape; see Figure 4.12) due to the substantive nature of spatial plans, aiming to protect environment and 'accommodate growth'. Thereby, a positive cumulative performance of plan against SA objectives resulted as often the case and suggestions to minimise this trade-off were generally disregarded. Moreover, by simply 'summing up' the effects, several consequences may be accounted for twice or more, since there may be more than one policy cumulatively or synergistically contributing to the same effect and this was only cautioned in UK7.

Finally, due to qualitative appraisal, predictions could be affected by a greater subjectivity and uncertainty which highly dependent upon professional judgement, requiring a great consensus of stakeholders and public. And this seemed to be more adaptable to flexible and "deliberative" planning contexts such as the English case, even though a more evidence-based approach focusing on environmental limits has been recently advocated for better treating CE also in UK SA/SEA practice (Thérivel *et al.*, 2009).

On the other side, Italian SEA practice showed a lack of conceptual and methodological approaches to treat CE, since they were seldom identified or assessed in a structured way. However, among the wide variability of methods found in Italian SEA reports, aggregated and spatially aggregated indices (e.g. dashboard index, maps, etc.) composing by a core set of semi-quantitative indicators seemed to be particularly useful in predicting and mapping combined effects on a specific issue/area (e.g. mobility, risk, neighbourhood, etc.) or, in general, on the environment. And this seemed to chiefly rely on the zoning-based perspective of local Italian land use plans, whose SEA mostly concerns the assessment of future land use changes.

However, a better treatment of strategic level CE seemed to be required at broader level due to the direct role of regional spatial plans in addressing future small local developments which together may have a significant effects. In particular, spatially explicit approaches should help to better manage CE since the spatial simulation of small future local developments could improve the coordination between regional and local spatial plans and the integration between spatial and sectoral policies, by supporting to identify likely spatial distribution of enhancement measures (e.g. small renewable energy sources, ecological restoration of open spaces, etc.) which in common SEA practice resulted particularly disregarded.

4.6 Conclusions

The results of the review firstly confirmed a lack of a systematic CE scoping, considering that the identification of CE issues was generally vague both at local and regional level. And this allowed previous research findings (literature review and international expert survey) to be ascertained. Furthermore, it suggested that more attention should be paid by scoping on the selection of relevant VEC and of those other tiers of decisions and external factors contributing together with spatial plan to CE on VEC (*inter-tier CE*), confirming a general lack of structured approach to do it.

Secondly, a scarce proactive approach in considering CE mostly emerged both from Italian and English SEA reports. On the one hand, the poor consideration of '*other foreseeable future actions*' likely contributing to CE, together with a limited exploration of spatial planning alternatives, suggested that more efforts are actually required in SEA practice in order to orient the assessment of CE towards the future. And this seemed to rely on both contextual and methodological aspects. In fact, even though guidance supporting the assessment of CE there exists, such as the case of UK, a failure in early addressing CE was perceived because they were never predicted before preferred options were defined (see Cooper, 2008).

On the other hand, an inadequate consideration of reasonable ways to manage CE appeared due to none of the reports addressed an earlier exploration of likely management measures to cope with CE, including assumptions on the envisagement of compensation and mitigation measures. And this was particularly the case of likely positive CE arising, for instance, from small enhancements, which were completely neglected by current SEA practice, despite the opportunity of spatial plans to deal with individually minor effects at narrow scale. Accordingly, a better consideration of management of CE seemed to be required in SEA practice in order to cope with CE and better tackle uncertainty characterising the assumptions on which predictions based on, being the way in which a policy will be implemented among the most cited source of it.

Thirdly, the qualitative and objective-led approach generally adopted in order to analyse and predict CE, particularly structured in English SEA practice, seemed to often lead to: disregard relevant environmental consequences arising from minor sources due to a scarce evidence-base perspective, threatening significant thresholds to be identified; as well as focus the assessment away from relevant valued environmental components. And this seemed to confirm the need of a more evidence-based analysis in order to adequately deal with CE (Thérivel *et al.*, 2009). In particular, spatially explicit approaches such as those found in local Italian spatial plans seemed to be of benefit to the treatment of CE, by adding baseline and spatial evidence to the simulation of future small developments and of their likely crowding consequences at broader scale. And, referring to the Italian context, this seemed to further support a better coordination between regional and local spatial plans in which the management of those particular kind of CE (i.e. crowding effects arising from small minor decisions) based on.

Chapter 5

5 Problem definition

5.1 Introduction

This chapter aims at:

1. defining the research problem; and
2. illustrating the rationale behind the selection of a particular physical, structural and socio-economic context (i.e. urban regions), by introducing the case study in which the methodological approach will be tested.

The main findings of the international expert survey and the SEA reports' review are separately summarised in section 5.2 and 5.3. While section 5.4 presents the major overarching considerations coming from both the theoretical framework and the previous research activities. Section 5.5 shows the results of two real-life SEA case studies followed during the research period, by pinpointing the most important lessons learned, being a crucial input to define the research problem and frame the methodological approach. Finally, section 5.6 introduces the description of the case study region, by discussing the rationale for its selection.

5.2 Main findings of the international expert survey

The international expert survey allowed general and contextual trends in current SEA practice to be highlighted with respect to: the overall SEA process; and the treatment of CE. Figure 5.1 summarises the main findings of this activity, which are afterward briefly argued.

General trends in current SEA practice	▪ Scoping not well done ▪ Unsatisfactory consideration of alternatives and monitoring plans ▪ Poor consideration of CE ▪ Disregarding of uncertainty
Contextual trends in current SEA practice	▪ Different SEA legal requirements and planning systems ▪ Availability of guidance (for general SEA, for treating CE) ▪ Different socio-political attitudes
Approaches and methods	▪ No particular methods used for treating CE in SEA practice ▪ Opportunities and threats of spatially explicit approach ▪ Lack of future-oriented approaches ▪ Lack of baseline-led approaches and scoping methodologies for strategic level CE

Figure 5.1: Main findings of the international expert survey

Firstly, an inadequate role of scoping in appropriately addressing relevant issues (including CE) and affecting the overall SEA process, was among the most frequent outcomes of the survey's results. Furthermore, the consideration and assessment of future alternatives and the definition of monitoring plans were generally agreed as the most unsatisfactory SEA stages. Among others, a number of contextual barriers constraining their satisfaction emerged such as: national legal frameworks (e.g. reporting of consultation's outcomes not required, monitoring not strictly mandatory in several countries, etc.) and/or socio-political attitudes (e.g. reactive assessment, scarce public participation, bureaucratic application of SEA which precludes monitoring phases, etc.).

Secondly, even though the availability of guidance for the treatment of CE was argued as an advantage in supporting their consideration in common SEA practice, a general agreement about CE were poorly and not thoroughly considered by international experts was confirmed since not enough attention seemed to be paid to combined effects such as synergistic, scale-lag effects (spatial crowding, time lag), etc.; as well as to '*other foreseeable future actions*' which together with the spatial plan could contribute to those effects. On the one side, the results showed that: the most frequent consideration of CE was a qualitative description based on expert opinions; and no particular methods or techniques were applied to scope and assess CE. On the other side, a large consensus was found about the lack of appropriate methodologies to scope CE at strategic level.

Thirdly, a restricted awareness on the added value to treat CE at strategic level was perceived due to the scarce role played by SEA in supporting to define and assess future decisions and in uncovering uncertainty characterising predictions and assumptions. And this was commented as a consequence of both a methodological lack, concerning how to technically deal with 'future'; and a series of contextual barriers (e.g. data availability, time, definition of responsibilities, credibility of decision-makers, etc.).

Finally, spatial analysis and spatially explicit methods were commented as having usually been part of SEA process (above all in scoping and prediction of effects) due to the relevance of the 'space' for spatial plans. And the main opportunities to integrate a spatially explicit approach in SEA mostly referred to:

- a better understanding of environmental issues, phenomena and effects;
- an useful support to define and assess spatial options, by identifying areas of influence and "*spatial conflicts*"; and
- a means to achieve better and transparent consultation and participation processes.

However, it was generally reminded that: the spatial analysis can only deal with the '*spatial part*' of the plan due to the limited spatial explicitness of several actions (i.e. strategic objectives, monitoring results, etc.); and its integration into a broader SEA methodology may rely on various aspects (e.g. decision-making context, scale, planning tier, issues, data availability, time, etc.).

5.3 Main findings of the SEA reports' review

The review of SEA reports showed whether and how CE are currently considered, by only focusing on Italian and English SEA of local and regional spatial plans. In particular, several key aspects for treating CE at strategic level emerged. Figure 5.2 summarises the main findings of this activity, which are afterward briefly argued.

General consideration of CE in SEA	▪ Poor definition and vague scoping of CE ▪ Inadequate comparison of CE of planning alternatives ▪ Vague predictions of CE ▪ Disregarding of CE in monitoring plans
Key strategic aspects	▪ Scarce consideration of other PPPs and exogenous drivers ▪ Poor consideration of reasonable planning alternatives ▪ Inadequate consideration of ways to compensate/mitigate CE ▪ Lack of information on uncertainty
Approaches and methods	▪ Lack of structured approaches to identify CE issues ▪ Predictions of CE only qualitative ▪ Lack of future-oriented approaches

Figure 5.2: Main findings of the SEA reports' review

Firstly, the definition of CE was generally poor, particularly in Italian SEA reports, where an explicit mention of CE was only once found, although statements having reference to "*combined effects*" were recurrent (e.g. spatial plans which together could cumulatively affect open spaces and biodiversity, etc.). Furthermore, the identification of CE was generally vague and never addressed in both Italian and English scoping reports, leading to an overarching disregarding of key issues (VEC, other PPPs, management measures, etc.); and an inappropriate focus on those "*minor actions*" which collectively could significantly contribute to cumulative problems or benefits (scale-lag effects). In fact, none of the reports consulted explicitly identified relevant issues referring to potential CE on VEC, rather they mainly predicted CE for each issue listed in the SEA Directive or, alternatively, for all of those issues or objectives emerging from the baseline condition, by 'summing up' single effects. And this subsequently influenced: the selection of '*other foreseeable future actions*', the range of effects investigated, the envisagement of mitigation and enhancement measures, and the overall assessment approach which never based on a resource or VEC.

In particular, two kinds of CE were recognised within the sample:

1. the combined effects on relevant issues/objectives arising from the different components of the spatial plan (*intra-tier CE*);
2. the combined effects on relevant issues/objectives of the plan together with other decisions or PPPs (*inter-tier CE*).

And the first was the most frequent, since other PPPs which together with spatial plan could likely contribute to CE were seldom identified; as well as their combined effects vaguely predicted.

Secondly, the combined consequences of reasonable planning alternatives were rarely predicted in SEA reports, suggesting a general lack of structured approaches to explore alternative ways to cope with CE. In particular, none of the reports reviewed addressed an earlier exploration of a range of likely management measures to cope with CE (i.e. mitigations, compensations, enhancements, etc.), envisaging a better consideration of them in order to improve also the treatment of uncertainty, being the way in which a policy will be implemented and the effectiveness of mitigations/compensations among the most cited source of it.

Thirdly, although the English government guidance on SA/SEA (ODPM, 2005) sets out key procedural points in the assessment of secondary, cumulative and synergistic effects, it seemed that: firstly, it failed to address CE in a proactive way, and, secondly, by assessing them through an objective-led and integrated approach, several environmental consequences could be: missed due to a scarce evidence-base perspective (lack of environmental limits, targets, etc.); or not adequately offset due to the SA integrated approach (see § 4.5).

At the opposite, the Italian SEA practice showed a lack of conceptual and methodological approaches to treat CE, since they were never explicitly considered. Nonetheless, aggregated indices and spatially explicit analysis seemed to be particularly useful to predict combined effects on particular issues/areas (e.g. mobility, risk, neighbourhood, etc.). However, a better treatment of strategic level CE seemed to be required at broader level due to the direct role of Italian regional spatial plans in: sharing regional future strategies on environment and development issues; coordinating different sectoral policies; addressing future small local developments which together may have a significant effects; and setting regional frameworks for the future management of CE (see § 5.6).

5.4 Overarching considerations

A lack of methodological approaches to treat CE at strategic level was confirmed through the theoretical background (Chapter 2) and the outcomes of both survey (Chapter 3) and SEA reports' review (Chapter 4). In particular, major highlights are following summarised.

Firstly, the poor quality of CE scoping suggested that a better scope could support SEA to both adopt a resource-based approach, by focusing on key receptors or VECs, and improve the analysis of combined negative threats and positive opportunities of other tiers of decision-making with the proposed spatial plan (e.g. coordination of sectoral policies, planning tools, etc.). And this seemed to be particularly relevant in order to adequately deal with individually minor effects at narrow scale, but collectively significant at broader level, having the tiered spatial planning system the opportunity to coordinate different levels and sectors of decision-making, by translating strategic purposes into operational mandates.

Secondly, the scarce exploration of future alternatives and the vagueness of the prediction of their effects envisaged that a future-based approach could be of benefit to SEA in treating strategic CE and managing the uncertainty characterising future decisions and complex effects. And this could further improve the exploration of different ways to manage CE under future conditions, by setting assumptions on the implementation of planning policies and regulations. Thirdly, the qualitative approach adopted in order to assess CE in current SEA practice which often led to disregard relevant environmental consequences and focus the assessment away from relevant valued environmental components, suggested the need of a more evidence-based analysis. Moreover, spatially explicit approach could further be of benefit to the treatment of CE, by: adding baseline and spatial evidence to the simulation of future small developments and of their likely crowding consequences; and supporting to address the spatial distribution of management measures. And referring to the Italian context, this could further facilitate a better coordination between regional and local spatial plans in which the management of crowding effects arising from small minor decisions based on.

5.5 SEA of local spatial plans: a review of two real-life processes

Two SEA processes of local spatial plans have been followed during the research period. The case studies referred to two small municipalities located within the Region of Lombardia[1]: the first one, Comune of Ponteranica, is located within the province of Bergamo, covering an area of 8,5 Km^2 with a population of about 6.750; while the second one, Comune of Albiate, is located in the North-east part of the Province of Milan, covering an area of 3 Km^2 with a population of about 6.000. (Figure 5.3)

[1] The Region of Lombardia can be consider one of the pioneer within the Italian context in respect of SEA experiences due to a series of SEA pilot case studies such as the SEA of Spatial coordination plan of the Province of Milan (Colombo *et al.*, 2008); and the involvement of the Region in the *Enplan project* which helped an earlier introduction of SEA procedure in its normative and planning frameworks. The *Enplan project* was conducted within the *EU-Interreg IIIB Medocc programme* and coordinated by the Region of Lombardia. It aimed at supporting the implementation of SEA Directive involving several Italian and Spanish regions. It provided a procedural SEA guideline based on a series of pilot case studies, including SEA of spatial plans, which can be still considered one of the few technical supporting document for Italian SEA practice.

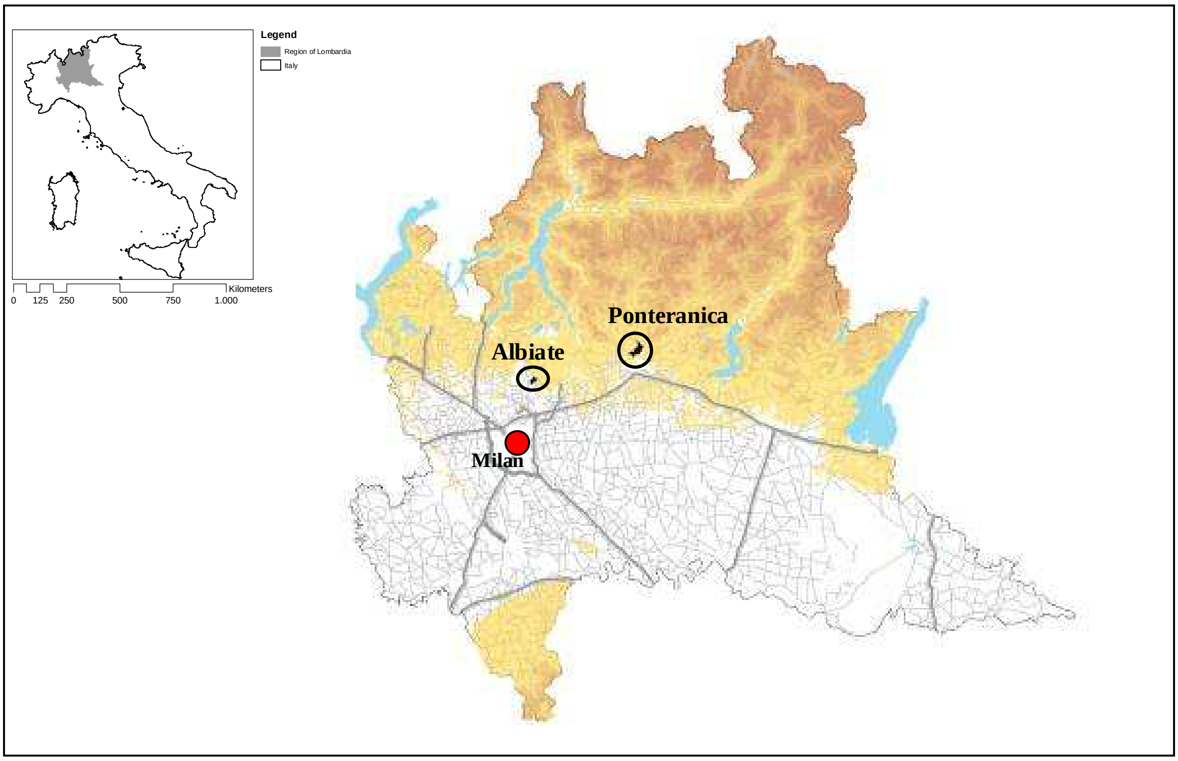


Figure 5.3: Municipalities of Albiate and Ponteranica – Region of Lombardia

In particular, although the local contexts were different in terms of natural, environmental and socioeconomic aspects, local spatial plans aimed to some common purposes such as increasing the quality of public spaces and services (open spaces, public transport, local services, etc.) and demanding for suitable areas to be transformed. Consequently, a flexible methodological approach was adopted and integrated within the regional SEA standard procedure for local spatial plans[2], based on the following steps. Firstly, the assessment methodology was defined during scoping stage. It started from a baseline-led scoping of local and sub-regional context (field work, and data processing supported by GIS), allowing environmental strengths and weaknesses to be identified and discussed during the ongoing consultations with environmental and planning authorities, and stakeholders (NGOs, etc.). Then, relevant planning and environmental issues (soil, accessibility to public services; ecological network; human health)

[2] SEA Directive was implemented by the Region through its territorial planning reform (L.R. 12/2005) and followed by an SEA guideline, standardising the SEA procedure at different planning tiers (regional, provincial and municipal). Thereby, in order to comply with the new regional planning regulation, local spatial plans need to be updated and integrated with SEA procedure. Moreover, the new regional planning system reformed the traditional structure of local plan based on zoning, by splitting it into three parts: strategic, operative and normative. According with the regional planning regulation, only the strategic part of the local spatial plan (*Documento di Piano*) is subjected to SEA.

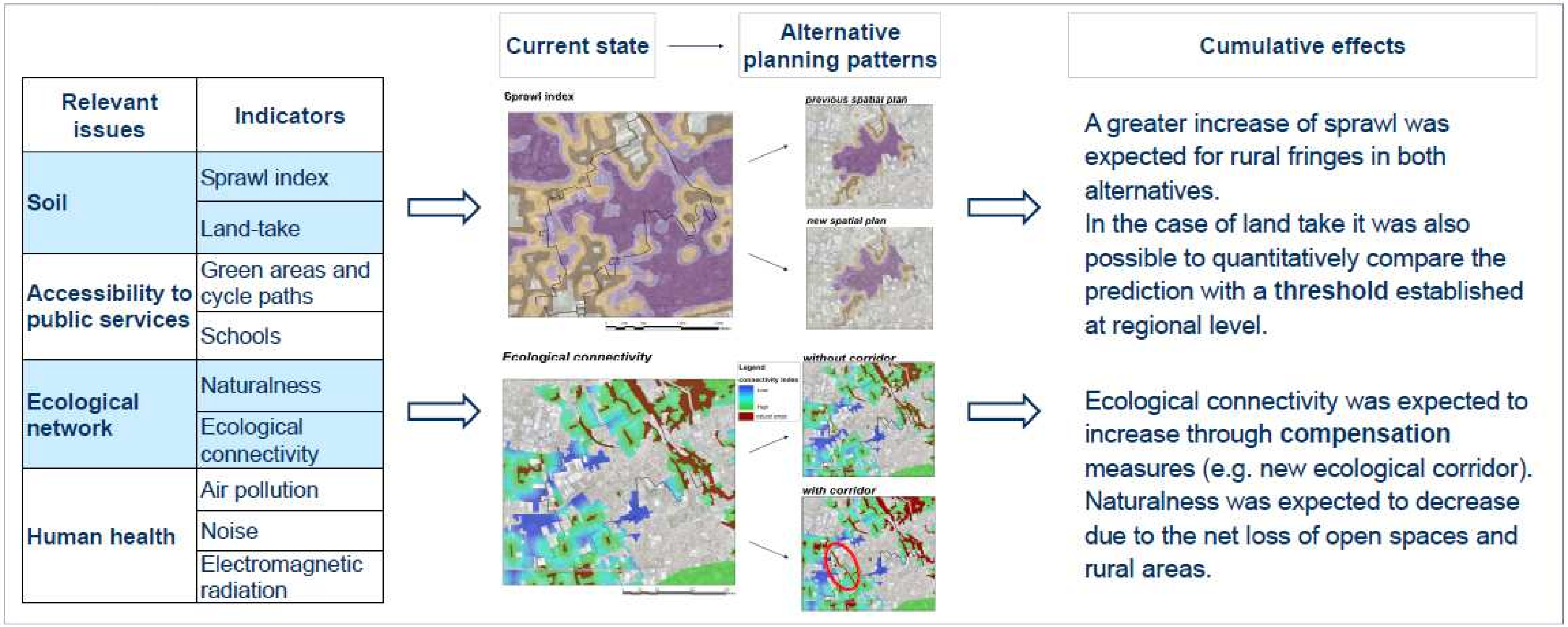
were selected and a core set of indicators (quantitative and spatially-explicit) was defined and integrated with qualitative information, supporting:

1. the definition of general planning strategies and specific actions (local mobility, cycle paths, building regulations, etc.);
2. the comparison of likely CE of alternative planning patterns ('do nothing', overall implementation of previous plan, new plan);
3. the assessment of likely effects on relevant environmental issues due to site-specific proposals (e.g. housing allocations, etc.).

Thematic maps further supported to set assumptions on future developments (e.g. population growth, etc.), by helping the definition of alternative planning patterns which mainly referred to allocation of green areas, public services and new housing. Moreover, the envisagement of several measures to prevent and reduce significant adverse effects was provided, including suggestions to lower assessment tiers (e.g. EIA). Finally, a list of indicators was proposed to SEA follow-up concerning the monitoring of the effects predicted and the effectiveness of the proposed planning strategies and measures.

Furthermore, depending on the particular political context, SEA timing as well as the openness of the two processes were different. While the first SEA process started from the preliminary planning phase, allowing environmental concerns to be better integrated into local spatial plan on during its elaboration, the second played a minor role since it started when most of decisions were already been taken.

However, Figure 5.4 briefly shows the results of the comparison of CE of alternative planning patterns for the local case study located in the peri-urban region of Milan.



The results showed how the overall implementation of the new spatial plans was likely to contribute to a better accessibility to public services, cycle paths and green areas. Nevertheless, it was expected to have negative cumulative effects on land take and ecological connectivity. While in the case of land take it was possible to quantitatively compare the prediction with a threshold established at higher level, ecological connectivity was expected to not decrease only in case of new plan will enforce compensation measures (enhancements). Cumulative negative effects were also cautioned for human health as an indirect consequence of increasing of pattern of disturbance (i.e. traffic, industrial sites, etc.) as well as a synergistic effect between different impacts (noise, air pollution, etc.). Nevertheless, it was avoided to quantitatively predict CE on human health due to the complexity of pathway of the effect, data unavailability, time constrain and uncertainty.

Figure 5.4: Results of an SEA followed at local spatial plan

5.6 Introduction to the case study region

By considering the previous outcomes as well as the lessons learned from the couple of case studies followed at local scale, a particular physical, structural and socio-economic context has been selected in order to applied the proposed framework (Chapter 6 and 7). In particular, it focuses on urban and peri-urban regions, where environmental thresholds (e.g. air quality standards, land take, CO_2 emissions, etc.) tend to be more easily exceeded due to narrow, small and, apparently, insignificant land use changes (Antrop, 2004; MEA, 2005; EEA, 2006). In fact, this does not significantly apply to other geographical contexts such as mountain basins or low-populated regions.

5.6.1 The biophysical context

The case study focuses on a flat peri-urban region located in the central-northern part of Italy (Region of Lombardia) (Figure 5.5).

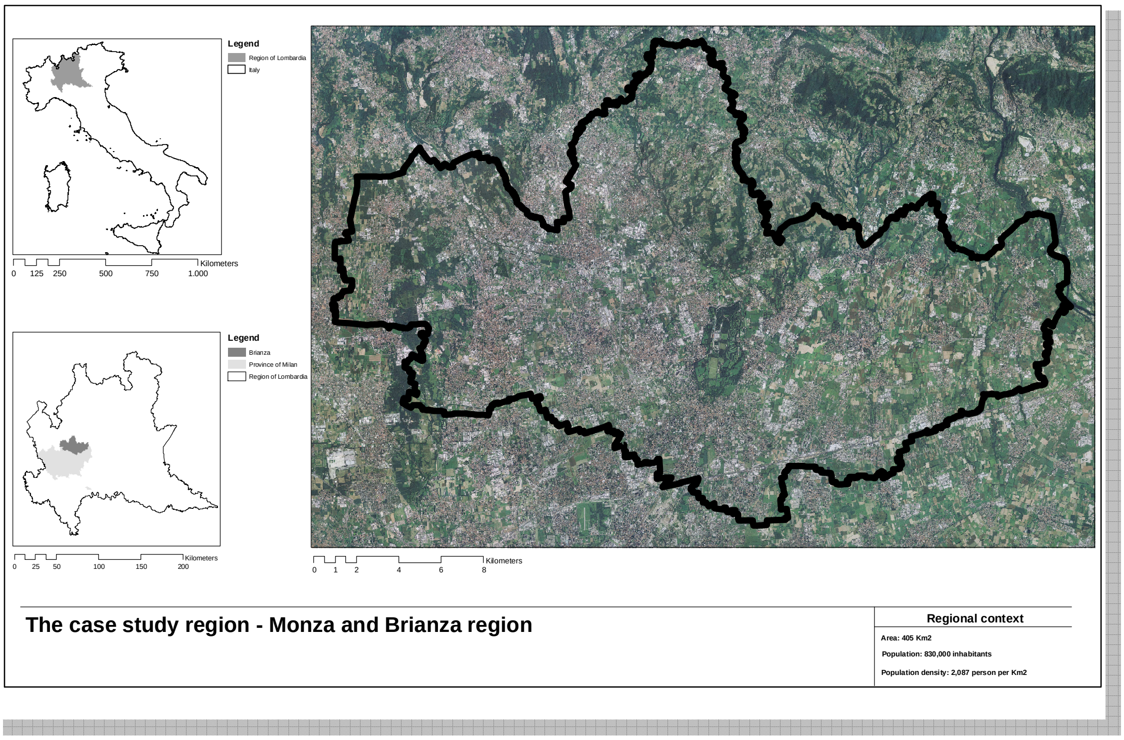


Figure 5.5: The case study region

It forms part of the 'central European urban region', otherwise known as *European Blue Banana*[3], reproducing the same structural patterns (e.g. high urbanisation, large industrial

[3] The *Blue Banana* (also known as the *Hot Banana*, *European Megalopolis* or *European Backbone*) is a discontinuous corridor of urbanisation in Western Europe, with a population of around 110 million. It stretches

concentration, dense traffic networks, dense population, well-developed physical and telecommunications infrastructure) and socio-economic features (European highest per capita incomes and lowest unemployment rates, strong development of services such as business, banking and public administration, large supply of cultural and educational facilities) (Hospers, 2002).

Since the nineties this European urban region has started to experience an incessant process of sprawling suburbanisation, generating a new urban form, fuelled by globalised economics and facilitated by new infrastructure (De Geyter, 2002; Gibelli e Salzano, 2007).

In particular, this 'type of growth' has been recognised particularly at risk in terms of:

- urban development, since the sprawling phenomenon is likely bound to not stop in the forthcoming future, increasing in an incremental or cumulative way. Furthermore, the phenomenon has been recognised particularly tricky to foresee as no longer tied to population growth, but rather driven by a variety of other powerful factors such as: individual housing preference, price of land, increased mobility, means of transportation, commercial investment decisions, and coherence and effectiveness of land use policies at all levels (EEA, 2006);
- major environmental impacts that are evident in increased energy, land and soil consumption, threatening both the natural and rural environments, raising GHG emissions that cause climate change, and elevated air and noise pollution levels which often exceed the agreed human safety limits (EEA, 2006). And most of them have been recognised as caused by minor local land use changes;
- social divide, by generating greater segregation of residential development according to income, leading to inner cities with poor neighborhoods and suburban outskirts and peripheral areas with middle and upper lifestyle;
- encouragement of private transport and inhibition of public transport solutions and mass transportation systems which consequently increase travel related energy consumption (EEA, 2006).

Therefore, this pattern of urbanisation inextricably lead to a greater consumption of numerous natural resources. And under particular concern is the consumption of land and soil which are mostly non-renewable since urban land use change tends to be permanent or reversible at very high costs (EEA, 2006). Moreover, a large pressure is on natural and protected areas (reduction of ecosystem services, noise and air pollution, habitat fragmentation, biodiversity loss), rural

approximately from North West England in the north to Milan in the south. It covers one of the world's highest concentrations of people, money and industry (Hospers, 2002) and it has been often identified as the area that traditionally has shown the greatest development potential in Europe's geo-economy (RECLUS, 1989; Delamaide, 1994).

environments and open spaces as the growth of European cities in recent years has primarily occurred on former agricultural land. In fact, farmers can secure substantial financial benefits for the sale of farmland for new development, consequently reducing the quality of land in peri-urban areas and rural fringes. Finally, urban areas and their hinterlands are becoming increasingly vulnerable to geo-problems from major (e.g. earthquakes, floods, land subsidence, landslides) to minor hazards (e.g. local swelling or shrinking of clays in foundations) which could be further worsen due to expected climate change.

During the last decades, similar to the European urban core, the peri-urban region of Milan has experienced an incessant process of urban sprawl, evidencing a clear trend of encroachment of rural areas which does not occur with the same intensity in case of natural areas due to a more restricted regime of protection. And this implied a persistent increase of built-up areas and soil sealing which consequently caused major environmental problems (air pollution, noise, biodiversity loss, habitat fragmentation, health and flood risks, etc.). Furthermore, despite the limitation of land consumption has become a prominent issue of regional environmental reports (Provincia di Milano, 2005; Provincia di Milano, 2007; ONCS, 2009) and one of the most frequent recommendation of regional spatial plans (PTCP, 2003; PTCP, 2008); seeking to steer urbanisation has not been converted in effective planning tools (Gibelli and Salzano, 2007).

However, despite the problem of restricting the sprawling expansion of built-up areas within the peri-urban case study region could be perceived a consequence of:

- the Italian fragmented spatial planning system made up of a huge number of municipalities[4] whose local spatial plans could together contribute to regional significant cumulative changes on environment;
- reactive planning attitudes and corrupted political habits (e.g. historical and cultural late integration of environmental aspects in planning; traditional planning attitudes, etc.).

It could be argued that the these kind of urban processes further distinguishes different European contexts (Germany, UK, Benelux, etc.) as typically, European cities flow imperceptibly across municipal boundaries and this process is at different stages of development in different countries, but it occurs everywhere (EEA, 2006). Furthermore, the blame for land use management is often fragmented between different administrations and frequently exacerbated by the political tensions of neighbouring administrations, leading to incoherent and uncoordinated land use management and causing regional significant effects on the environment. However, although planners at the locals level have prime responsibility for the management of present and future use of land, the strategies and instruments to address

[4] Italian local municipalities are about 8,100. Case study region accounts for 55 *Comuni* (municipalities).

urban development and, thereby, to cope with its likely regional cumulative changes on environment, strongly depend on the interconnectedness between local, regional and national conditions (EEA, 2006) since the solution to one problem at one scale (local housing provision) is often the case of another at different scale (regional biodiversity loss).

5.6.2 The Regional spatial planning system

The Italian spatial planning tiered system is based on national acts, regional and provincial spatial coordination plans, and general policy and land use plans at municipal level (Gazzola *et al.*, 2004; Geneletti *et al.*, 2007). However, spatial planning and environmental assessment is the responsibility of the regional level, therefore, each region has its own regulation (Gazzola *et al.*, 2004). The planning system of the Region of Lombardia is currently based on the Regional Spatial Planning Act n. 12/2005 (*Legge per il governo del Territorio*), establishing the minimum role of plan's tiers and implementing the EU-SEA Directive. Thereby, in order to comply with the new regional planning regulation, local spatial plans need to be updated and integrated with SEA procedure.

However, according with the Italian spatial planning system, a crucial role in managing cumulative consequences on the environment arising from small developments together with '*other decisions*' seemed to be played by the provincial spatial coordination plan (*Piano Territorioale di Coordinamento Provinciale*), hereafter referred to as the regional spatial plan. It aims at setting up general strategies for regional spatial development and for the use of natural resources as well as regulations on soil management and natural hazard prevention.

Moreover, it intermediates between regional and local administrative levels, aiming at:

1. addressing local spatial plans, by ascertaining their compatibility with higher spatial strategies and establishing inter-institutional accords (Figure 5.6);
2. coordinating spatial and sectoral programmes and policies, by integrating sectoral strategies (e.g. waste management, protected areas, etc.) and establishing inter-sectoral accords.

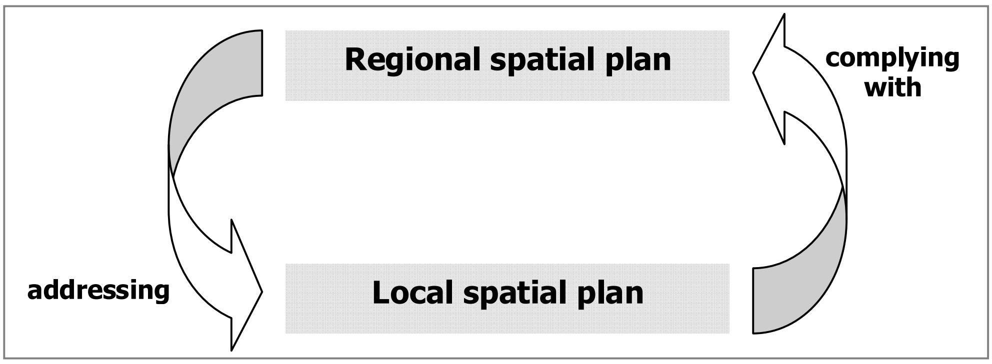


Figure 5.6: Mutual coordination between regional and local spatial plans

Consequently, a great coordination between local and regional spatial decisions as well as a better integration with sectoral policies have been often advocated in order to deal with scale-lag and crowiding effects both negative and positive, giving a great emphasis on the regional planning level (INU, 2008; INU, 2009; Pompilio, 2009) as the administrative decision-making level mostly appropriate for the management of this kind of consequences on the environment. Additionally, the Italian planning academic debate has often focused on the need to consider urbanisation processes at 'comprehensive' level (Gibelli and Salzano, 2007), avoiding to leave the management of '*space*' at the mercy of fragmented decisions and local interests with short term perspective and scarceness of resources.

Accordingly, it seemed that the regional spatial plan is the most appropriate level of decision-making in order to manage the cumulative consequences of small local decisions due to the broader scale it deals with and the clout in addressing local level decisions and coordinating '*other sectoral policies*'. As a result, the case study area fit to the administrative boundaries of the new province of Monza and Brianza.

Chapter 6

6 Methodological proposal: selection of VEC and definition of future conditions

6.1 Introduction

This chapter aims at proposing and applying a methodological approach to improve the consideration of CE in SEA of spatial plans. The general framework is based on the findings of literature review and the analysis of the shortcomings in current SEA practice presented in the previous chapters.

In particular, it refers to the SEA of regional plans, being the role of this planning level crucial within the Italian spatial planning system in order to:

1. provide a strategic framework for regions;
2. address local level small decisions and, thereby, their cumulative consequences on the environment; and
3. coordinate spatial and sectoral programmes and policies.

Accordingly, the proposed framework consists of four key tasks:

1. the selection of Valued Ecosystem Component (VEC);
2. the identification of relevant PPPs (other projects, plans, programmes and policies) contributing to cumulative changes on identified VEC;
3. the definition of spatial planning alternatives and future conditions;
4. the assessment of CE on VEC through a core set of indicators.

This chapter introduces preliminary steps (1 to 3) respectively in Sections 6.3, 6.4 and 6.5, while the assessment of CE (step 4) is presented in Chapter 7. Section 6.2 introduces the study area and Section 6.6 describes the land use cover scenarios. Then, Section 6.7 discusses the land use cover type approach adopted with a focus on uncertainty.

Firstly, the identification of VEC and the selection of those relevant PPPs which together with regional spatial plan can contribute to CE, could be addressed during CE scoping, basing on baseline information and/or consultation with environmental agencies, local stakeholders, etc. Furthermore, other relevant PPPs could be selected based on: their role in likely contributing to

cumulative negative and positive consequences on VEC; as well as their management capacity in facing on those consequences (planning tools, financial supports, etc.).
Secondly, the proposed approach assumes the effects of different combinations of PPPs on VEC as cumulative, suggesting that the definition of reasonable planning alternatives and future conditions should look at those selected PPPs (otherwise termed "*other foreseeable actions*"), by exploring what if the effect will be according to different level of implementation of both spatial plans and relevant PPPs. Consequently, likely CE could be predicted as the consequence of alternative combinations of future actions, allowing CE to be proactively addressed. In order to do it, the proposed framework suggests to adopt a baseline-led approach, by quantifying and comparing CE of different planning alternatives through indicators. Nonetheless, the prediction of large-scale issues and future time frames may involve both policy and scientific uncertainties (§ 2.2.3). On the one hand, the simulation of environmental processes may have a high level of uncertainty due to complex dynamics, data gaps and exogenous factors. On the other hand, the effectiveness of management measures and the collaborative efforts required in order to face on CE could be highly uncertain. Therefore, a systematic discussion on uncertainty's sources is further advanced.

In particular, the framework starts from the point that spatial plans at local and regional levels seek to guide land use changes through a wide range of interventions that either constrain certain developments (e.g. restrictive policies in flood risk zones, protecting nature conservation areas, etc.) or promote them (e.g. designation of new areas for residential and commercial development, implementing ecological networks, etc.). And this implies that various configurations of land use patterns lead to alternative outcomes in terms of amount and interspersion of built and natural land cover that have different effects on ecological processes at regional scale (landscape dynamics, hydrological cycle, energy flow, biogeochemical and atmospheric cycles, etc.).
Consequently, a spatially explicit approach is proposed as the methodological core of the framework (Figure 6.1), aiming to:

- establish the spatial extent and the areas of influence of selected relevant PPPs (e.g. road corridors, protected areas, etc.);
- make future conditions (planning alternatives and future scenarios) spatially explicit, by adopting a land cover type approach (see also Nuissl et al., 2009; Pauleit and Duhme, 2000); and
- quantify and spatially simulate likely regional CE on VEC, by selecting and computing a range of indicators in order to compare planning alternatives under different future conditions.

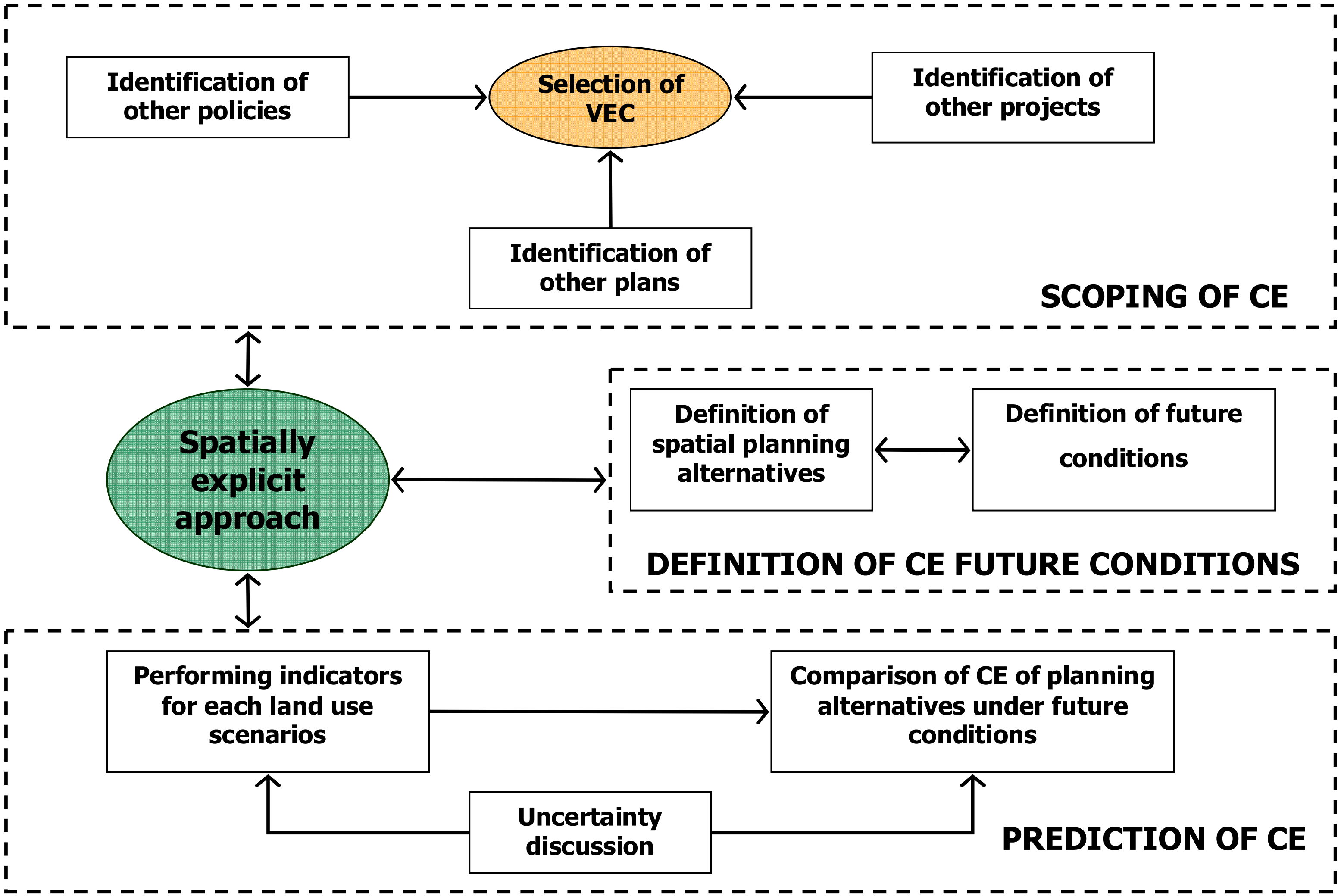


Figure 6.1: The general framework

6.2 Study area

6.2.1 Biophysical context

The case study focuses on the peri-urban region located in the central-northern part of Italy (Region of Lombardia), 30 Km north of Milan. The topography is mainly flat with a limited hilly area on the north corner (maximum elevation: 300 m) (Figure 6.2). The climate is classified as humid continental warm with cold wet winters (minimum temperature: -10°C/-12°C) and hot sultry summers (maximum temperature: +35°C in hilly part and +40°C in flat part).

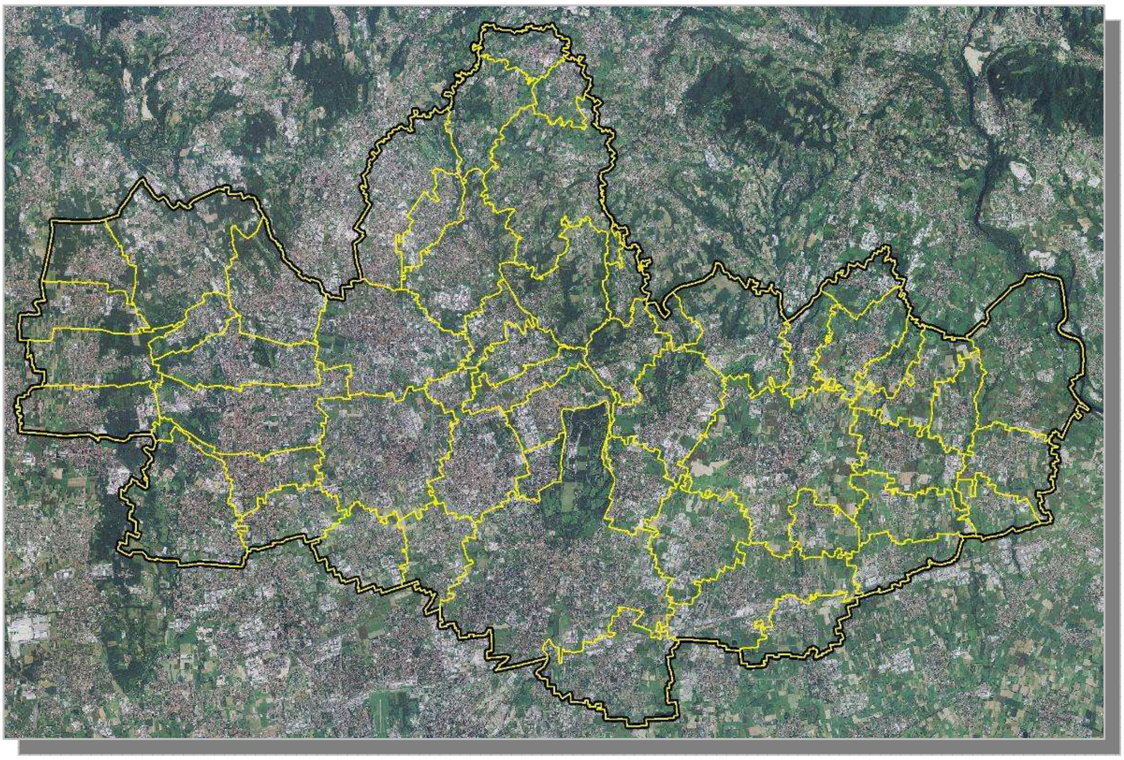


Figure 6.2: Case study region (*local administrative boundaries in yellow*)

The region covers 55 municipalities which form part of the new provincial authority of Monza and Brianza (405 Km^2). With a total population of 830,000; a population density of 2,087 person per Km^2 and an enterprise density of 76 enterprises per 1,000 inhabitants, it represents one of the most urbanised, dense and industrialised area of Italy and Europe.

However, different patterns of development can be recognised within the region. The central part is respectively characterised by: scattered small towns interfacing with semi-natural areas included in the Lambro river Valley regional park in the north sector; and continuous urban fabric densely populated with limited open spaces (semi-natural and rural areas, urban green areas) in the south sector. The western part is similar to the central-northern sector with the presence of residual forest and low density settlements. While the eastern part represents the rural core of the region with an extensive presence of homogeneous arable lands and a more polycentric urban system.

6.2.2 The Provincial Spatial Coordination Plan

Within the Italian spatial planning tiered system, the *Provincial Spatial Coordination Plan* (*Piano Provinciale di Coordinamento Territoriale*) (previously termed regional spatial plan) represents an important planning instrument with respect to the 'translation' of spatial strategies into operational terms and mandates, being the Province an intermediate institutional authority between regional and local administrative level, aiming to:

1. coordinate spatial and sectoral programmes and policies, by integrating sectoral strategies (e.g. waste management, landscape planning, natural hazard prevention, etc.) and establishing inter-sectoral accords;
2. address local spatial plans, by ascertaining the compatibility with higher spatial strategies and establishing inter-institutional accords.

In particular, the *Provincial Spatial Coordination Plan* generally provides:

- a large-scale description of the socio-economic and environmental context;
- indications on land capability and land allocation at broad scale;
- the basic framework for mobility and infrastructures;
- the comprehensive scheme for landscape and ecological network;
- regulations concerning water and soil management, as well as natural hazard prevention.

And this further applies to the *Provincial Spatial Coordination Plan* of Milan (PTCP, 2003) which constitutes the regional spatial planning framework for the study area.

However, the Province of Milan has been recently split into two new provincial authorities, including the new Province of Monza and Brianza whose boundaries limit the study area. Therefore, a new regional spatial plan is going to be prepared for the new region and, according with the regional spatial planning act (L.R.12/2005), it will include the integration of SEA process and documents.

6.3 Selection of VEC

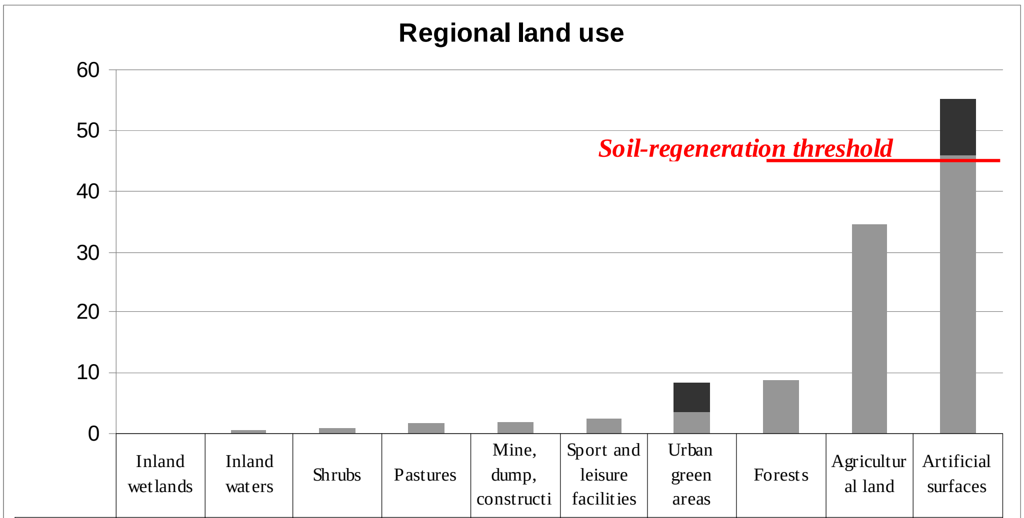
Considering the emerging regional features (see also § 5.6), the selection of VEC started from the analysis of two main spatial patterns of land cover: urban and natural.

During the last decades the region has experienced an incessant process of sprawling suburbanisation, further intensified by the depopulation of the core city of Milan and the role played by the agricultural park surrounding the south crown of the metropolis in containing land consumption. Therefore, an unprecedented conversion of agricultural land into urban areas has been accounted during last 15 years (ONCS, 2009), evidencing a clear trend of encroachment of rural areas which does not occur with the same intensity in case of natural areas due to a more restricted regime of protection. And this implied an incremental augment of built-up areas and soil sealing within the region, negatively influencing local climate, water balance, biota, as well as an increase of pollution, health and flood risks. Additionally, despite the limitation of land consumption has become a prominent issue of regional environmental reports (Provincia di Milano, 2005; Provincia di Milano, 2007; ONCS, 2009) and one of the most frequent recommendation of regional spatial plans (PTCP, 2003; PTCP, 2008); seeking to steer urbanisation has not been converted in effective planning tools (Gibelli and Salzano, 2007).

Accordingly, urban land uses are actually covering the 47,3% of the total region, peaking at over 80% in several municipalities. Moreover, according to local spatial plans, urbanisation is expected to increase more than other 10% during the next 15/20 years (ONCS, 2009)[1], broadly exceeding the *soil-regeneration threshold* (equal to 45%) established at regional level (PTCP, 2003; PTCP, 2008)[2] (Figure 6.3).

[1] The expected local transformations refer to those land plots planned to be converted by local spatial plans. In particular, according to the Italian spatial planning system, although these ongoing transformations have been approved by local authorities, their specific land use (i.e. housing, retail, etc.) will be later defined through executive planning tools (e.g. '*piani attuativi*', '*piani di recupero*', etc.). Therefore, they are only zoned with respect to that planning tool required in order to make approved land use changes executive ('*modalità attuative*'). Consequently, a broad distinction is hereinafter made only between expected urban green areas and future urban expansions which were generally considered as residential artificial surfaces (alternatively continuous and discontinuous urban fabric).

[2] Due to land consumption has been deemed one of the most relevant regional planning concern, a *soil-regeneration threshold* has been established by the regional spatial plan of Milan as the maximum acceptable regional land take assuring the renewability of soil functions (food production, landscape character and naturalness) based on a 'multicriteria' perspective (agronomy, rural economy, water availability, naturalness, landscape values, etc.).



	Inland wetlands	Inland waters	Shrubs	Pastures	Mine, dump, constructi	Sport and leisure facilities	Urban green areas	Forests	Agricultural land	Artificial surfaces
Expected							4,79			9,18
Current	0,03	0,52	0,86	1,69	1,96	2,43	3,53	8,76	34,37	45,85

Figure 6.3: Regional land use cover – baseline condition and expected transformations

However, despite this high level of urbanisation, protected areas cover the 17,5% of the region, including Natura 2000 sites; regional and local natural parks. Furthermore, the region is mostly characterised by low-density urban patterns, rural-urban fringes and scattered semi-natural areas not including into the natural protected networks which are still playing an important role for the regional ecology (e.g. ecological connectivity, regulating of water balance, etc.). Consequently, the **regional green infrastructure**, including existing greenspaces (from tiny city parks to residual woodland landscapes, river corridors and rural patches) and their distribution, was selected as the most important ***valued ecosystem component* (*VEC*)** due to its limited amount (PTCP, 2003; Toccolini *et al.*, 2006), as well as the multiple functions it is still supplying (Regione Lombardia, 2002; Pileri, 2007).

Moreover, the demand for increasing the amount of open spaces, greenways, and cycle paths for recreational purposes has been frequently showed resulting from citizens, civic organisations and public in order to off-set those environmental problems that typically characterise these urban contexts such as poor air quality, noise, traffic congestion, etc. (Swanwick, 2009). And this further applies to the case study region (Provincia di Milano, 2006; Provincia di Monza e Brianza, 2010).

6.4 Identification of relevant PPPs

With respect to the selected VEC (*Regional green infrastructure*), other decisions were identified as playing an active role in contributing to change regional green infrastructure together with the regional spatial plan in terms of both built environment and natural patterns (Figure 6.4).

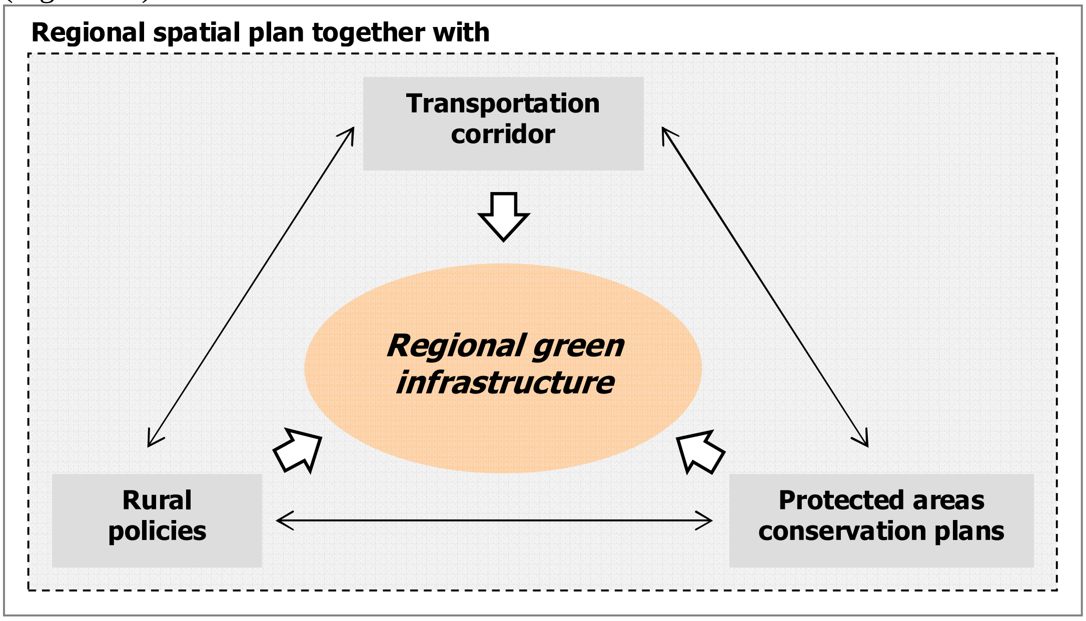


Figure 6.4: Relevant PPPs contributing to cumulative changes on VEC

Firstly, a major planned transportation corridor crossing the overall case study region, also called "*Pedemontana*" highway (Figure 6.5a), was selected due to its intrusion with the VEC in terms of:

- land consumption, habitat fragmentation and degradation, since it will take up part of the regional ecological network;
- and likely mitigation and compensation measures, since the overall project plans to stem mitigation and compensation measures such as forestation (about 73 ha), restoration and enhancement of urban green parks and abandoned green areas, as well as to design a green buffer zone (about 100 ha).

Secondly, conservation plans of regional and local protected areas (Natura 2000 sites; Regional and Natural Parks; PLIS[3]) were selected due to their relevant role in preserving biodiversity

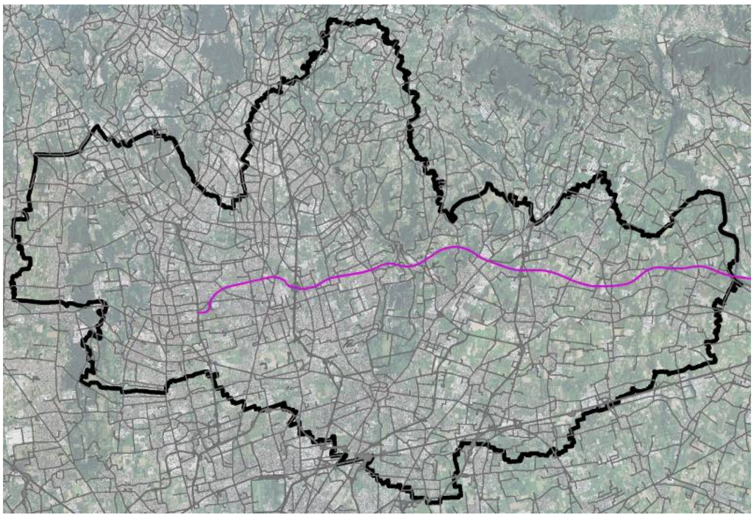
[3] PLIS is the acronym of *Parco Locale di Interesse Sovracomunale* which refers to local parks under particular concern for the surrounding inter-municipal area. They usually include rural and semi-natural patches which are not under restricted management.

and ecological functions (Gambino, 1994; Senes and Toccolini, 1998). Figure 6.5b shows the protected areas' network.

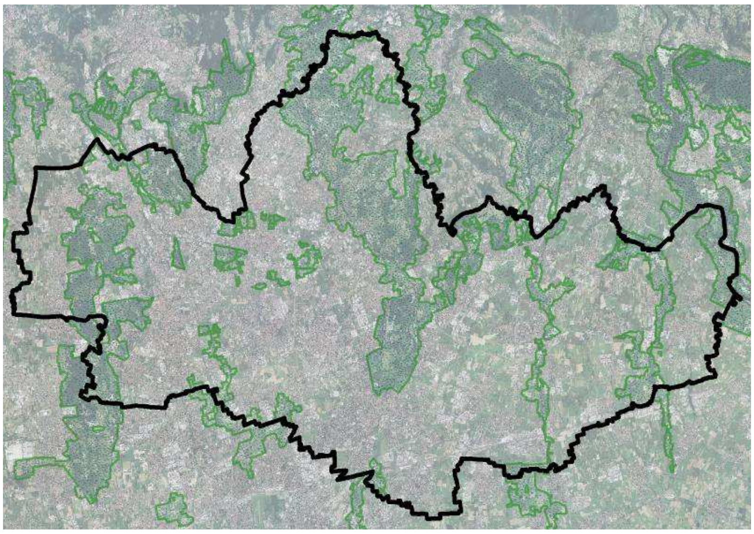
However, establishing of large scale ecological networks such as Natura 2000 was recognised not enough to preserve important environmental services and save up their functions within the case study region (Gibelli, 2003; Provincia di Milano, 2006), enforcing the role of regional decision-making level in addressing, designing and enhancing ecological networks and corridors, including non protected zones. Furthermore, a great urban pressure is expected on rural areas and fringes over the region as: on the one hand, agriculture is not securing large financial benefits; and on the other, rural patches are characterised by poor ecological value as a consequence of intensive use of rural land, involving the loss of traditional agroforestry network (hedgerows, irrigation channels, etc.) and high fertilisation standards which negatively affected landscape and water quality, increasing flooding risk and biodiversity loss. Consequently, a calling for a major integration between rural policies and spatial planning was often advocated through academic studies and planning documents as a means to face on land consumption within the case study region (PTCP, 2003; Pileri, 2007).

Accordingly, the actions of several regional rural policies, such as those proposed by: the Regional Rural Development Programme (PSR, 2007) and the Regional Operational Programme (POR, 2007) referring to the European Cohesion Policy (2007-2013); and other plans (e.g. Sustainability Regional Plan), were selected due to their active role in shaping the regional green infrastructure through spatial investments (e.g. rural heritage, urban-rural issues, agricultural landscapes, etc.) and the creation of more general funds and subsidies, in order to preserve structures and functions of agricultural landscapes and green areas. Figure 6.5c shows the regional rural network, called "*Dorsale Verde Nord*", identified at regional level with the purpose to enhance urban-rural linkages through a better integration of spatial and rural policies as a means to: face on urban sprawl (PTCP, 2003; Pileri, 2007) and maintain regional ecological network (PTCP, 2003; PTCP, 2008)[4].

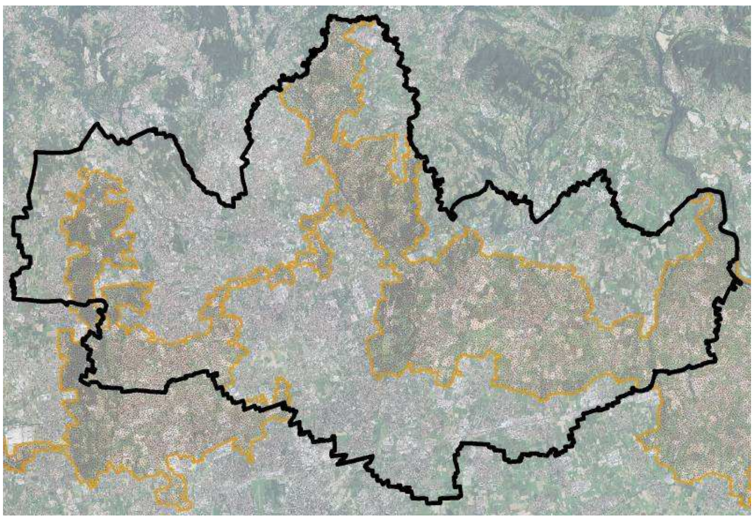
[4] The rural network does not refer to a planning restricted area, rather it has been suggested as a spatial scheme in which several measures could be implemented (enhancements, compensations, etc.).



a) New highway (*in pink*) and road and rail networks



b) Protected areas network



c) Regional rural network '*Dorsale Verde*'

Figure 6.5: Area of influence of PPPs

6.5 Definition of spatial planning alternatives and scenario conditions

6.5.1 Development of reasonable spatial planning alternatives

The development of reasonable spatial planning alternatives started from the point that there exists a mutual interaction between regional and local spatial plans, considering the opportunity of regional spatial plan to address and provide indications for local decisions and, *vice versa*, the scope of local plans for influencing regional decisions (i.e. inter-institutional negotiation for approval of regional spatial plan). Referring to the Italian planning context, this mutual interaction was stated varying, among others, with respect to different issues (INU, 2009), suggesting:

1. a stronger role of regional spatial plans in addressing local level decisions regarding mobility and environmental issues (protected areas, biodiversity, main transportation corridors, etc.); and
2. a weaker role of regional spatial plans in orienting settlement and housing aspects (allocation, dimensioning, etc.) which are traditionally driven by local land use plans;

due to the normative lack of a clear definition and distinction of institutional mandates in terms of settlement development and a stronger influence of local authorities and local interests on urban aspects (i.e. housing, building, etc.) (Figure 6.6).

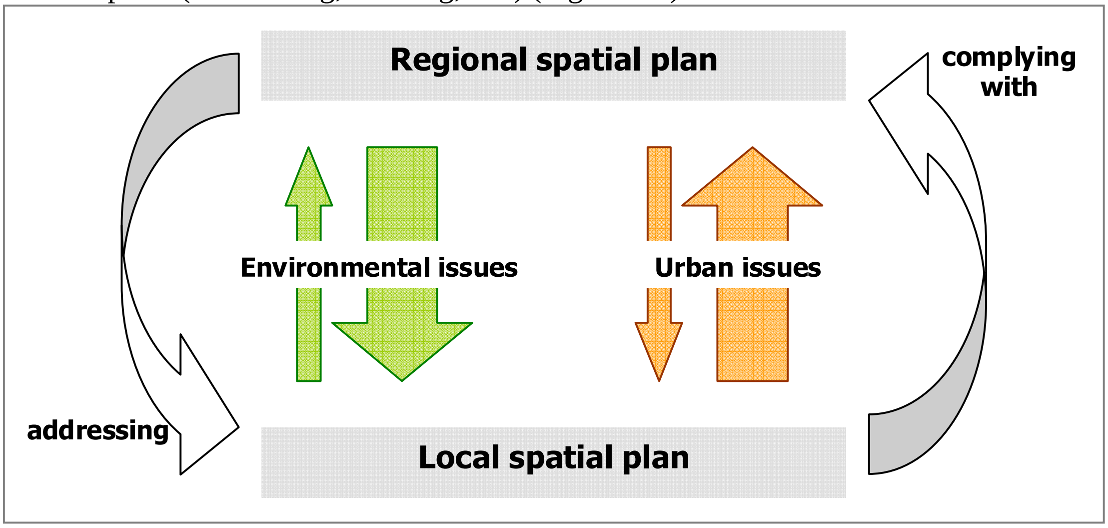


Figure 6.6: Mutual interaction between regional and local spatial plans

Accordingly, the proposed method assumed two alternative cases of spatial development as reasonably foreseeable (*planning alternatives*) standing on different level of coordination among local and regional spatial plans with respect to future urban development and conservation/creation of urban green areas.

Therefore, two spatial planning alternatives were generated and made spatially explicit, starting from a couple of land use cover maps:

1. the land cover map (DUSAF, 2007; scale 1:10,000), representing the existing land cover information data base, generated from the detection of aerial images covering the region of *Lombardia*;
2. the digital map of *Mosaic of municipal urban plans* (MISURC, 2008; scale 1:10,000) which represents the spatial composition of approved local land use plans for the overall region, basing on local land use zoning.

However, in order to come to spatially explicit alternatives, two preliminary steps were required. Firstly, the land cover map needed to be corrected, by incorporating important linear elements such as road and river corridors which were not included in the original map due to their smaller dimension with respect to minimum detectable element (minimum size of polygons: 1,600m; minimum linear dimension: 20m). Then, the corrected map was set as baseline condition. Secondly, the approved local land use changes were selected and extracted from the digital map of *Mosaic of municipal urban plans*, being the land plots zoned as '*modalità attuativa*' (see note 1) expected to be definitively transformed. In particular, the underlined assumption was that urban transformations, with particular regard to the conversion of private land from non-urban (i.e. natural, rural, etc.) to urban uses (i.e. residential, industrial, commercial, etc.), did not recede once they were approved by local land use plans, mostly due to the increase of land value[5].

Consequently, the pattern made up of the overall expected transformations extracted from the MISURC map was, firstly, merged with the baseline condition obtained by the correction of the regional land cover map; and secondly, reclassified. The reclassification was done by adopting a land use cover type approach. And this implied that, the expected land use cover (hereafter LUC) was reclassified based on LUC features of two broad LUC types (i.e. artificial surfaces and urban green areas)[6] of the regional land cover map. Table 6.1 and Table 6.2 provide a detailed description of them, in order to better underline the assumptions following made.

[5] The underlined assumption is that urban transformations directly imply the increase of land value. Therefore, if the approved transformation had to be canceled, the local authority should pay land owners. And this has been often argued as not reasonable with respect to the Italian planning context (Salzano, 2007), even though in accordance with the national urban law.

[6] See note 1.

Table 6.1: Artificial surface – LUC

Types of artificial surface	Land use cover features	Land use cover pattern
Dense residential urban fabric	It mainly covers historic and modern town centres made up of high and dense buildings. It has more that 80% of built-up surface.	
Medium-dense residential urban fabric	It mainly covers a residential semi-detached areas with small or no gardens and yards. It has more that 80% of built-up surface.	
Discontinuous residential urban fabric	It mainly covers a residential detached areas with front and back gardens and small number of trees. It has a built-up surface from 50 to 80%.	
Nucleated residential urban fabric	It mainly covers clusters of residential detached areas with large front and back gardens, and significant numbers of trees. It has a built-up surface from 30 to 50%	
Sparse residential urban fabric	It covers sparse residential areas mainly located in rural and semi-natural contexts. It has a built-up surface from 10 to 30%	

Table 6.2: Urban green areas – LUC

Types of urban green areas	Land use cover features	Land use cover pattern
Parks and gardens – poor conditions	Grass cover less than 50% and generally no trees.	
Parks and gardens – fair conditions	Grass cover from 50 to 75% and tree cover from 25 to 50%.	
Parks and gardens – good conditions	Grass cover larger than 75% and tree cover larger than 50%.	

In particular, despite both planning alternatives referred to the same distribution of expected transformations within the case study region (i.e. the overall expected transformations approved by local land use plans), the LUC type approach allowed different 'internal pattern' to be supposed under the two planning alternatives with respect to artificial surfaces and urban green areas, by generating two cases of development:

- *Case a* assumed a development mainly driven by local spatial planning level with the overall implementation of local spatial plans (Figure 6.7);
- *Case b* assumed a development mainly driven by regional spatial planning level with a major polycentric perspective. Consequently, a number of poles[7] have been identified based on: population growth; hosing demand and stock; and accessibility to public transport according to the regional spatial plan (PTCP, 2008) (Figure 6.8).

[7] Pole municipalities have been selected according to expected growth in population or housing demand (housing demand corrected for the housing stock) for the next 15 years (*Average+1Standard Deviation*). And this allowed 16 municipalities to be selected. Moreover, two additional municipalities were included based on their accessibility to public transport, despite they did not meet the previous criteria.

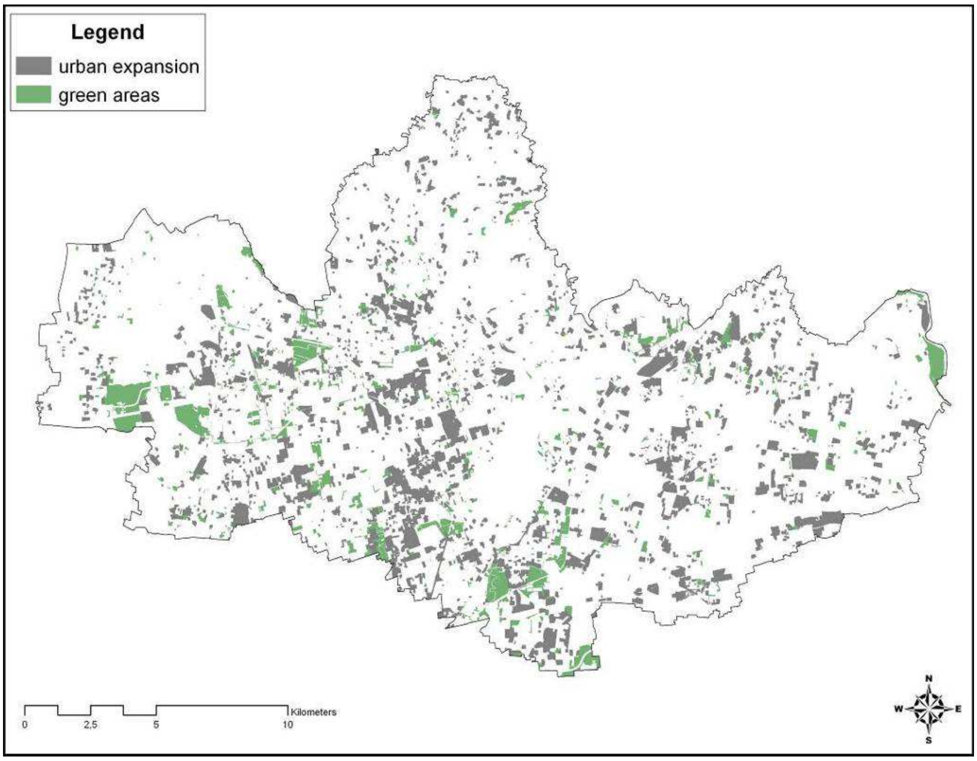


Figure 6.7: Spatial planning alternative – case *a*

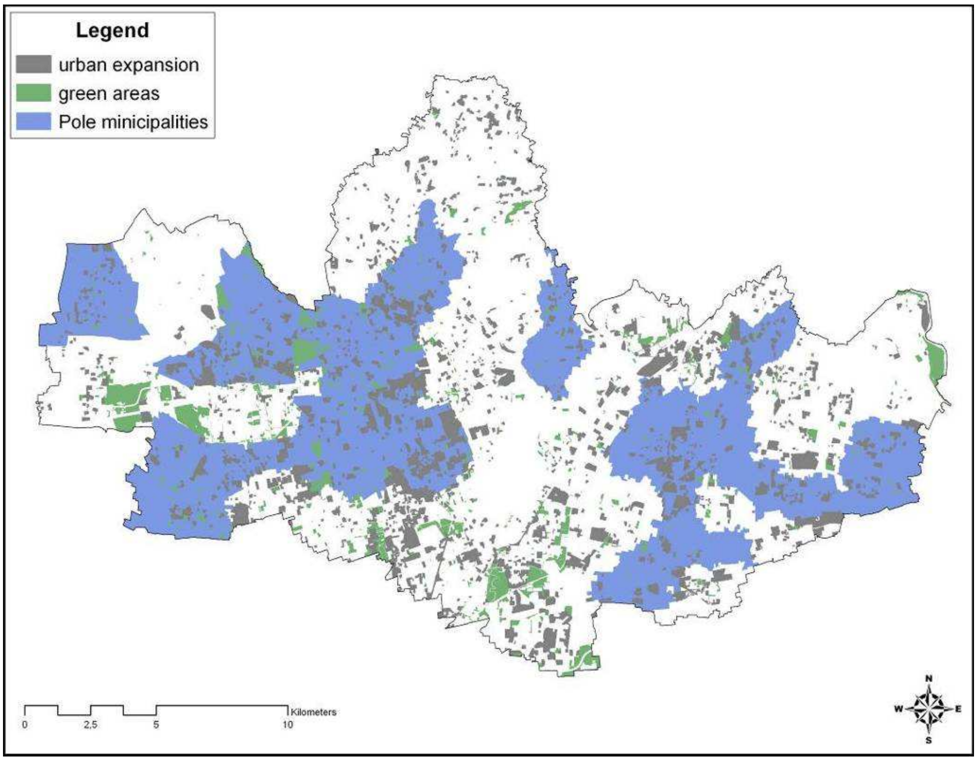


Figure 6.8: Spatial planning alternative – case *b*

Referring to expected urban growth, a different percentage of built-up surface ranging from 10 to 80% was supposed, and thereby a different LUC class of artificial surface was assigned, based on their location with respect to the baseline condition (*baseline land use cover*).

In particular, whilst alternative *a* and the sector included in pole municipalities under case *b* supposed an intensification of artificial surfaces sprawled through the overall region, including an increase of built-up areas within the existing residential pattern (e.g. from discontinuous to medium-dense residential urban fabric), a minor increase was assumed outside pole municipalities under case *b* due to a stronger role of regional spatial plan in addressing a more polycentric urban development. Table 6.3 shows the assumptions made for case *a* and for the sector included in pole municipalities under case *b*. While Table 6.4 illustrates the case *b* with respect to the portion outside the pole municipalities.

Table 6.3: Expected urban land use cover changes – Artificial surfaces (I)

Case a **Case b – within pole municipalities** *Baseline land use cover*	→ *Expected land use cover*
Discontinuous residential urban fabric	Medium-dense residential urban fabric
Nucleated residential urban fabric	Discontinuous residential urban fabric
Sparse residential urban fabric	Nucleated residential urban fabric
Construction sites Abandoned and degraded sites Gardens and parks Non-agricultural vegetated areas	Discontinuous residential urban fabric
Arable land Permanent crops Pastures	Discontinuous residential urban fabric
Forests	*if within a distance of 200m from urban fabric*: Discontinuous residential urban fabric *if within a distance of 400m from urban fabric*: Nucleated residential urban fabric *otherwise*: Sparse residential urban fabric
Shrubs	Discontinuous residential urban fabric

Table 6.4: Expected urban land use changes – Artificial surfaces (II)

Case b – out of pole municipalities *Baseline land use cover*	→ *Expected land use cover*
Construction sites Abandoned and degraded sites Gardens and parks Non-agricultural vegetated areas	Discontinuous residential urban fabric

Arable land Pastures	*if <1 ha surface*: Discontinuous residential urban fabric *if >1 ha surface*: Nucleated residential urban fabric
Permanent crops	Discontinuous residential urban fabric
Forests	*if within a distance of 200m from urban fabric*: Discontinuous residential urban fabric *if within a distance of 400m from urban fabric*: Nucleated residential urban fabric *otherwise*: Sparse residential urban fabric
Shrubs	Discontinuous residential urban fabric

Finally, the natural condition of expected urban green areas were assigned based on the previously LUC (*baseline land use cover*) in both alternatives (*a* and *b*), assuming, at least, the conservation of their natural condition. Table 6.5 details LUC changes assumed for alternative *a* and *b*, by only showing LUC transitions from no previously developed lands to urban green areas.

Table 6.5: Expected urban land use cover changes – urban green areas

Case a and b	
Baseline land use cover - - - - - - - - - -►	*Expected land use cover*
Mine and construction sites	Gardens and parks – poor conditions
Arable land	Gardens and parks – poor conditions
Permanent crops	Gardens and parks – fair conditions
Permanent pastures Shrubs in abandoned agricultural land	Gardens and parks – fair conditions
Permanent pastures with significant presence of trees and shrubs Broad-leaved forest	Gardens and parks – good conditions

Figure 6.9 summarises the overall procedure followed in order to make planning alternatives spatially explicit.

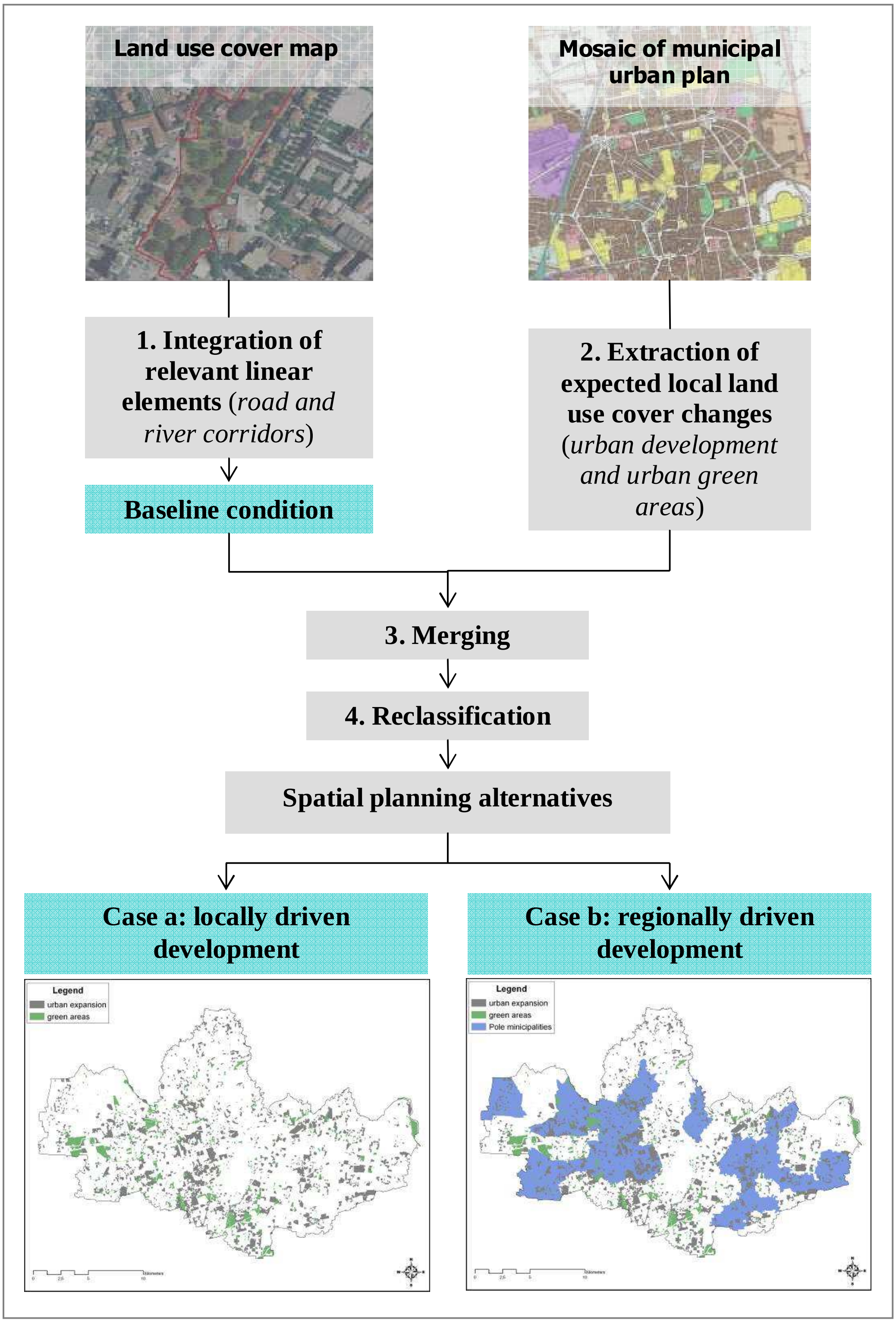


Figure 6.9: Generation of spatial planning alternatives

6.5.2 Definition of scenario conditions

Starting from land cover data, a core set of future scenarios[8] was developed, assuming different level of integration and implementation between PPPs previously selected and spatial plans at local and regional level (case *a* and *b*). Accordingly, the ways in which the three PPPs previously selected (i.e. highway corridor, protected areas plans and rural policies) will be implemented were considered those external conditions under which the two spatial planning alternatives were simulated and compared.

The underlined assumptions on external conditions included:

1. whether or not the highway corridor will be realised; and
2. an opposite role (strong vs. weak) of both conservation plans of protected areas and rural policies.

Therefore, a range of future LUC scenarios was generated, by simulating the implementation of planning alternatives (case *a* and *b* described in § 6.4.1) with respect to different combinations of external conditions. Figure 6.10 shows all the possible scenarios resulting from the combinations of spatial planning alternatives and scenario conditions.

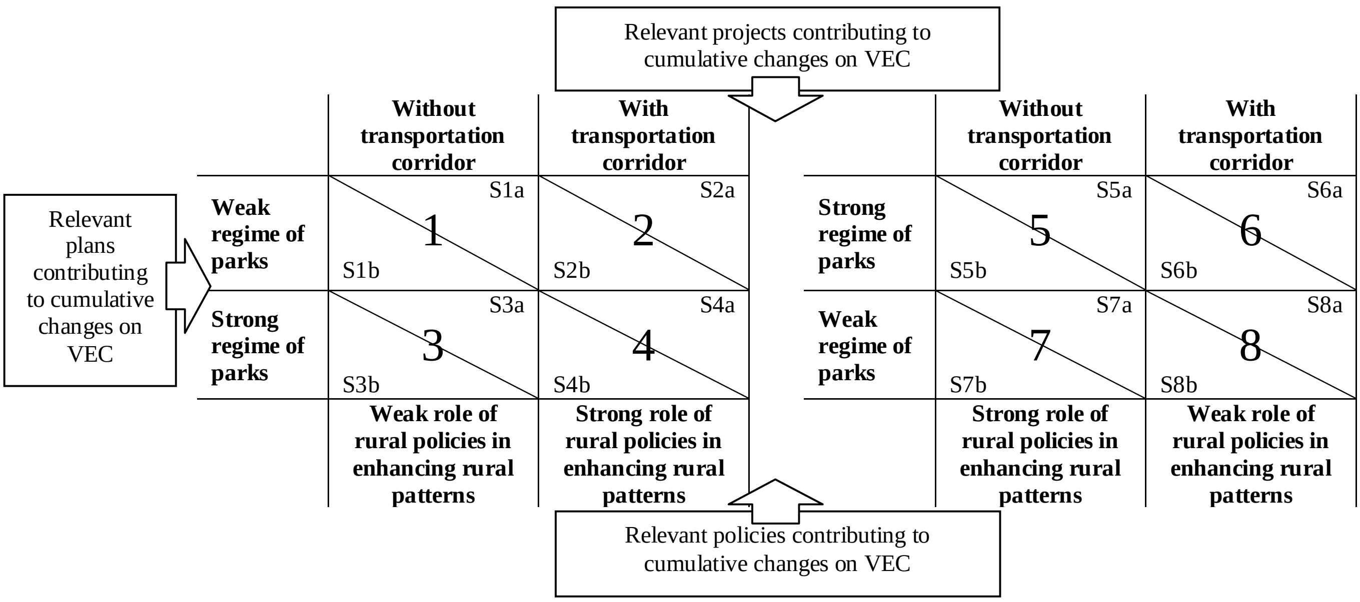


Figure 6.10: Possible scenarios

[8] The term scenario is here referred to as a range of possible futures which assume different future regimes of implementation and integration of PPPs.

Scenarios S1a and S1b respectively correspond to planning alternatives *a* and *b* under the future conditions of: no realisation of highway corridor and weak role of conservation plans of protected areas and rural policies.
Scenarios S3a and S3b respectively correspond to planning alternatives *a* and *b* under the future conditions of: no realisation of highway corridor, strong role of conservation plans of protected areas and weak role of rural policies.
Scenarios S4a and S4b respectively correspond to planning alternatives *a* and *b* under the future conditions of: the realisation of highway corridor, strong role of conservation plans of protected areas and strong role of rural policies.
Scenarios S5a and S5b respectively correspond to planning alternatives *a* and *b* under the future conditions of: no realisation of highway corridor, and the strong role of conservation plans of protected areas and rural policies.
Scenarios S6a and S6b respectively correspond to planning alternatives *a* and *b* under the future conditions of: the realisation of highway corridor, strong role of conservation plans of protected areas and weak role of rural policies.
Scenarios S8a and S8b respectively correspond to planning alternatives *a* and *b* under the future conditions of: the realisation of highway corridor and weak role of conservation plans of protected areas and rural policies.
In particular, despite a set of 16 scenarios could be generated from the different combinations of external conditions, only 12 were considered plausibly implementable with respect to the case study region[9]. And thereby, they were made spatially explicit, by extending the same LUC type approach previously adopted (see § 6.5.1) to other relevant LUC types which were supposed to change according to the external future conditions assumed (role of PPPs).
Table 6.6, Table 6.7 and Table 6.8 detail LUC features for relevant land types used to generate LUC scenarios.

[9] Due to the limited rationale on the implementation of combination 2 and 7, only 12 development scenarios have been considered, and, thereby, spatially resolved, by changing land use classes under alternative assumptions.

Table 6.6: Arable land – land use cover

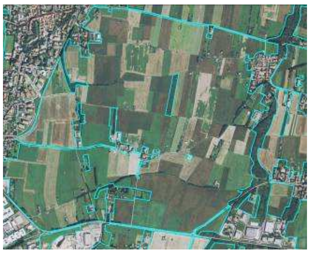
Types of arable lands	Land use cover features	Land use cover pattern
Homogeneous arable land	Arable land (monoculture or temporary fallow lands)	
Arable land with significant presence of trees	Arable land with presence of permanent crops (e.g. vineyards, fruit trees and berry plantations, etc.) and agro-forestry elements (hedges, etc.)	

Table 6.7: Permanent pastures – land use cover

Types of permanent pastures	Land use cover features	Land use cover pattern
Permanent pastures	Dense grass cover of floral composition harvested mechanically mainly for grazing and not under a rotation system.	
Permanent pastures with significant presence of trees and shrubs	Permanent pastures (see previous description) with significant presence of tree and shrub species	

Table 6.8: Shrubs – land use cover

Types of shrubs	Land use cover features	Land use cover pattern
Shrubs in abandoned agricultural land	Bushy or herbaceous vegetation mainly located in abandoned agricultural land with scattered trees	
Shrubs with significant presence of natural vegetation	Bushy or herbaceous vegetation with significant presence of tree and shrub species, representing either woodland degradation or forest regeneration/ recolonisation	

Consequently, starting from LUC type features, a sequence of LUC assumptions was firstly made with respect to future external conditions; and then, a number of LUC change rules was defined for each combination in order to generate LUC scenarios under which both planning alternatives (*a* and *b*) could be implemented.

Firstly, the realisation of road corridor assumed a green buffer zone (25m) as a minimum mitigation measure (combinations 4, 6 and 8). Furthermore, if combined with a strong regime of protected areas conservation plans (combination 6) and rural policies (combination 4), additional measures based on enhancement of greenspaces and rural patches from least-degraded to most-natural were assumed, respectively in protected and rural areas.

Secondly, when the regime of protected areas conservation plans in both containing urbanisation and enforcing green infrastructures was expected to be strong (combinations 3, 4, 5 and 6), different levels of changes of artificial LUC (from 10 to 80%) were assumed both in case *a* and *b*, as well as different enhancements of green infrastructures within protected areas' network (see Figure 6.5b).

Thirdly, if the role of rural policies was expected to be strong (combinations 4 and 5), a major enforcement of policy actions was assumed acting within the regional rural network (see Figure 6.5c).

Next tables detail the set of LUC change rules established for generating scenarios 5a and 5b. The corresponding tables are reported in Appendix 3 for each combination.

Table 6.9: Expected urban land use cover changes – Artificial surfaces (I)

Case a **Case b – within pole municipalities** *Baseline land use cover*	----------→ *Expected land use cover*
Construction sites Abandoned and degraded sites Gardens and parks Non-agricultural vegetated areas	Nucleated residential urban fabric
Arable land Permanent crops Pastures	Nucleated residential urban fabric
Forests Riparian vegetation	*within a distance of 200m from urban fabric*: Nucleated residential urban fabric *otherwise*: Sparse residential urban fabric
Recent forest Shrubs	Nucleated residential urban fabric

Table 6.10: Expected urban land use cover changes – Artificial surfaces (II)

Case b – out of pole municipalities *Baseline land use cover*	----------→ *Expected land use cover*
Construction sites Abandoned and degraded sites Gardens and parks Non-agricultural vegetated areas	Sparse residential urban fabric
Arable land Permanent crops Pastures	Sparse residential urban fabric
Forests Riparian vegetation Recent forest Shrubs	Sparse residential urban fabric

Table 6.11: Expected urban land use cover changes – Urban green areas

Case a and b *Baseline land use cover*	----------→ *Expected land use cover*
Mines Construction sites Abandoned and degraded sites	Gardens and parks – fair conditions
Gardens and parks Non-agricultural vegetated areas	*if <3ha surface:* Gardens and parks – fair conditions *if >3ha surface:* Gardens and parks – good conditions
Arable land Permanent crops	*if <3ha surface:* Gardens and parks – fair conditions

Permanent pastures Permanent pastures with significant presence of trees and shrubs Shrubs in abandoned agricultural land	*if >3ha surface:* Gardens and parks – good conditions
Forests Riparian vegetation Shrubs with significant presence of natural vegetation	Gardens and parks – good conditions

Table 6.12: Additional land use cover changes in protected areas

Case a and b	
Baseline land use cover ---------→	*Expected land use cover*
Abandoned and degraded sites Non-agricultural vegetated areas	*<3ha:* Gardens and parks – poor conditions *>3ha:* Permanent pastures
Homogeneous arable land	Arable land with significant presence of trees
Permanent pastures	Permanent pastures with significant presence of trees and shrubs
Shrubs in abandoned agricultural land	Shrubs with significant presence of natural vegetation

Table 6.13: Additional land use cover changes in rural network

Case a and b	
Baseline land use cover ---------→	*Expected land use cover*
Gardens and parks – poor and fair conditions	*if within flooding areas or with high permeability:* Gardens and parks – good conditions *otherwise*: Gardens and parks – fair conditions
Abandoned and degraded sites Non-agricultural vegetated areas	*<3ha:* Gardens and parks – poor conditions *>3ha:* Permanent pastures
Homogeneous arable land	Arable land with significant presence of trees
Permanent pastures	Permanent pastures with significant presence of trees and shrubs
Shrubs in abandoned agricultural land	Shrubs with significant presence of natural vegetation

Table 6.14: Additional land use cover changes

Case a and b	
Baseline land use cover ---------→	*Expected land use cover*
Gardens and parks – poor and fair conditions	*if within flooding areas or with high permeability:* Gardens and parks – good conditions *otherwise*: Gardens and parks – fair conditions

Abandoned and degraded sites Non-agricultural vegetated areas	*if within flooding areas or with high permeability:* Permanent pastures *otherwise*: as baseline land use cover
Homogeneous arable land	*if within flooding areas or with high permeability:* Arable land with significant presence of trees *otherwise*: as baseline land use cover
Permanent pastures	*if within flooding areas or with high permeability:* Permanent pastures with significant presence of trees and shrubs *otherwise*: as baseline land use cover
Shrubs in abandoned agricultural land	*if within flooding areas or with high permeability:* Shrubs with significant presence of natural vegetation *otherwise*: as baseline land use cover

6.6 Results

The 12 LUC scenarios developed are following described. Table 6.15 reports the LUC classes used to illustrate results. They base on the same legend (ID code and LUC classes) of the regional land cover map, excepting for *ID 0*, corresponding to the highway buffer zone assumed if highway corridor is realised (combinations 4, 6 and 8).

Table 6.15: Land use cover classes

ID	Land use class	Broad land use category
111	Continuous urban fabric	Urban fabric
112	Discontinuous urban fabric	
121	Industrial, commercial and service units	Industrial, commercial and transport units
1221	Road networks and associated land	
1222	Rail networks and associated land	
13	Mine, dump and construction sites	Mine, dump and construction sites
1411	Gardens and parks	Artificial, non-agricultural vegetated areas
1412	Abandoned green areas	
142	Sport and leisure facilities	
2112	Arable land with significant presence of trees	Agricultural areas
2111	Homogeneous arable land	
2113 2114 2115	Other arable land	
22	Permanent crops	
2311	Permanent pastures	
2312	Permanent pastures with significant presence of trees and shrubs	
31	Forests	Natural and semi-natural
3241	Shrubs with significant presence of natural vegetation	
3242	Shrubs in abandoned agricultural land	
41	Inland wetlands	
51	Inland waters	Water bodies
0	Green buffer zones – highway	Added land use class

Table 6.16 shows the land use cover for each land use scenario in terms of percentage of surface with respect to the regional surface. It further includes the baseline conditions. Additional information on each scenario is included in Appendix 3.

Table 6.16: Land use cover under land use scenarios (*percentage*)

ID	Baseline	S1a	S1b	S3a	S3b	S4a	S4b	S5a	S5b	S6a	S6b	S8a	S8b
111	3,31	4,87	3,89	4,82	3,87	3,31	3,31	3,31	3,31	4,82	3,87	4,87	3,89
112	24,80	27,80	28,73	27,85	28,75	29,23	29,24	29,31	29,32	27,78	28,67	27,73	28,65
121	13,56	14,00	13,98	14,00	13,98	13,94	13,96	13,96	13,98	13,98	13,97	13,98	13,97
1221	3,86	3,86	3,86	3,86	3,86	4,17	4,17	3,86	3,86	4,17	4,17	4,17	4,17
1222	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32	0,32
13	1,96	1,30	1,31	1,28	1,28	1,11	1,11	1,16	1,16	1,23	1,23	1,25	1,25
1411	3,25	6,44	6,45	6,46	6,47	6,58	6,57	6,61	6,60	6,44	6,45	6,42	6,43
1412	0,28	0,21	0,21	0,19	0,19	0,14	0,14	0,14	0,14	0,18	0,18	0,20	0,20
142	2,43	2,43	2,43	2,43	2,43	2,43	2,43	2,43	2,43	2,43	2,43	2,43	2,43
2112	0,27	0,22	0,22	9,42	9,44	20,00	19,99	20,17	20,16	9,33	9,34	0,22	0,22
2111	32,17	27,10	27,14	17,90	17,92	6,99	6,98	7,21	7,20	17,60	17,63	26,71	26,75
2113 2114 2115	1,60	1,36	1,36	1,36	1,36	1,35	1,35	1,37	1,36	1,34	1,35	1,34	1,35
22	0,33	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19	0,19
2311	1,60	1,15	1,16	0,65	0,65	0,49	0,49	0,47	0,47	0,66	0,66	1,15	1,16
2312	0,09	0,07	0,07	0,60	0,60	0,82	0,82	0,83	0,83	0,61	0,61	0,10	0,10
31	8,76	7,53	7,54	7,53	7,54	7,49	7,49	7,54	7,54	7,48	7,49	7,48	7,49
3241	0,29	0,20	0,20	0,38	0,38	0,50	0,50	0,50	0,50	0,38	0,38	0,20	0,20
3242	0,57	0,40	0,40	0,22	0,22	0,10	0,10	0,10	0,10	0,20	0,20	0,38	0,38
41	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
51	0,52	0,52	0,52	0,52	0,52	0,52	0,52	0,52	0,52	0,52	0,52	0,52	0,52
0	0,00	0,00	0,00	0,00	0,00	0,31	0,31	0,00	0,00	0,31	0,31	0,31	0,31

Next figure provides an example of LUC change under different scenarios.

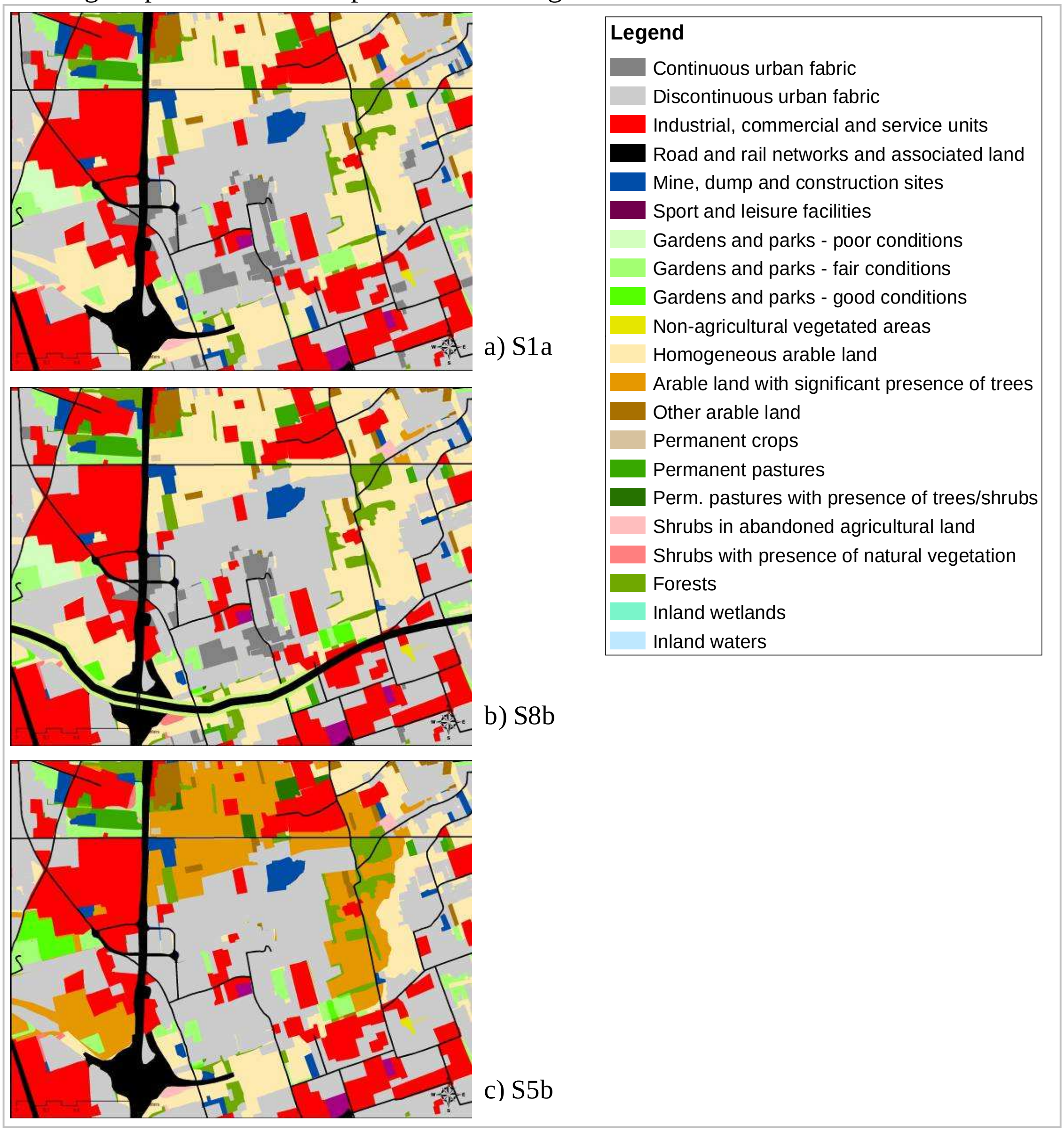


Figure 6.11: Land use cover changes under scenarios 1a, 8b and 5b

6.7 Discussion

The following discussion mainly focuses on the land use cover type approach adopted in order to generate LUC scenarios and the uncertainty characterising assumptions made.

6.7.1 Land use cover type approach

This approach allowed reasonable LUC scenarios to be generated, assuming that land uses could change under different future conditions and decisions. Accordingly, by starting from a couple of available and free-downloadable land use cover maps, it provided a straightforward procedure based on LUC change rules which were established according to LUC features. Nevertheless, considering that changes in land use are amongst the most controversial consequences of human actions (Meyer and Turner, 2007), as well as factors influencing the urbanisation process could be non linear, interdependent and agent-based, the approach may be perceived as oversimplify complex LUC dynamics. However, despite the great interest in recent literature in developing land use change models focusing on simulating socioeconomic, physical and agent-based processes that drive spatial and temporal dynamics of change (see Verburg *et al.*, 2004), their application were deemed out of the aim of this thesis, being the purpose of the method to be time-fashionably applicable into SEA common practice.
Therefore, the assumptions made to generate spatial planning alternatives based on a business as usual future condition supposing the current trend of urban growth to persist, at least over the next 15/20. However, although this may lead to disregard important drivers affecting the distribution of LUC patterns (e.g. peoples' lifestyle, transportation policies and behaviours, etc.), it seemed to be reasonably foreseeable in respect of the Italian spatial planning system, as local land use transformations seemed to never recede once they are approved (see note 5). Additionally, due to the level of detail of the digital map of *Mosaic of municipal urban plans* used to extract expected LUC transformations, important urban LUC changes, and, thereby, decisions were unavoidably neglected such as urban renewal policies, new industrial sites, sport and leisure facilities, etc. And this consequently influenced the selection of those LUC types (i.e. artificial surfaces and urban green areas) in which the spatial representation of planning alternatives based on. However, the generation of alternatives from land use cover maps was inevitably affected by a time conflict because of the time-gap between LUC changes and available spatial information. In addition, the proposed LUC type approach may be further improved, by encompassing, for instance, the generation of other planning alternatives based on additional or alternative assumptions on urban growth, being those proposed mostly

generated in order to test the applicability of the approach, rather than provide a comprehensive range of reasonably foreseeable options.

Furthermore, the assumptions on LUC changes made to simulate future conditions mostly referred to the implementation of those PPPs previously selected with respect to VEC and regional context (see Appendix 3). However, it is worth to note that the previously selected PPPs referred to their 'relative' role in influencing VEC, even though they could interact with other issues (e.g. transportation corridor may affect air quality or contribute to urban sprawl, etc.). In addition, there may be other policies (reforestation, carbon reduction policies, etc.) or other external conditions (e.g. climate change) influencing VEC; as well as, there may be conflicts between selected PPPs since they could not be implemented simultaneously or their implementation could reveal a 'spatial overlap'. Moreover, the assumptions and, thereby, the LUC change rules standing on LUC types, were defined assuming that a greater coordination among spatial and sectoral decisions could allow VEC (e.g. open and green spaces, ecological networks, recreation, etc.) to be better managed through different measures (e.g. ecological restoration, etc.). Accordingly, the enhancements of ecological condition of greenspaces and rural patches from least-degraded to most-natural condition were supposed acting within important sectors of the region (i.e. protected areas, regional rural network, river banks, etc.) as a measure to: improve the ecological quality of VEC; compensate urban growth; and provide other important environmental services. Nonetheless, the ecological conditions of LUC types was assumed basing on LUC features, even though they may not always match to. However, it was deemed enough appropriate as the scale of analysis did not allow natural and rural patches to be tested through, for instance, ecological field surveys. Furthermore, major findings that landscape patterns and structures mutually influences landscape functions are at the basis of landscape ecology (Forman, 1986).

6.7.2 Uncertainty

The assumptions made in order to define spatial planning alternatives and LUC scenarios involved a high level of uncertainty.

On the one side, the definition of spatial planning alternatives assumed an overall implementation of approved local transformations which, firstly, may do not simultaneously occur, and secondly, they inevitably rely on site-specific conditions and executive planning regulations. In addition, even though defined according with the regional spatial plan, the selection of "*pole municipalities*" in which alternatives based on (see note 7), may lead to disregard local conflicts due to restrictive urban development was supposed for municipalities out of poles.

On the other side, the effectiveness of the implementation of management measures (e.g. enhancement of greenspaces, improvement of rural areas, etc.) and the collaborative inter-institutional efforts on which future scenarios based on, seemed to be highly uncertain since:

- there may be a number of technical and non-technical factors constraining the realisation of those measures (e.g. scarce financial and technical support, limited plan's or policy's timeframe, local and political conflicts, lack of monitoring responsibilities, etc.); and
- they may be not successfully achieved due to institutional barriers (shared blames, etc.) and lack of shared regional strategies on VEC.

As a result, the role of follow-up seems crucial to gain insight into the reliability of the assumptions made, suggesting the opportunity to improve the proposed framework, by extending it towards the ex-post assessment in order to better cope with uncertain consequences arising from the volition of decision-makers.

Chapter 7

7 Methodological proposal: indicators to assess CE on VEC

7.1 Introduction

Following the general framework introduced in § 6.1, this chapter deals with the fourth step, namely the assessment of CE on VEC. In particular, it proposes a core set of indicators, mainly quantitative and spatially explicit, in order to predict combined effects on the selected VEC (see § 6.3).

Accordingly, section 7.2 firstly introduces and describes the proposed indicators. Then, the results are presented in sections 7.3, including: the estimation of the expected land take (§ 7.3.1); the expected changes of indicators under alternative future conditions (§ 7.3.2 – 7.3.5); and an overview of the performance of different scenarios (§ 7.3.6). Subsequently, the results are discussed in Section 7.4, by underscoring emerging relevant considerations (§ 7.4.1 and 7.4.2) with a focus on uncertainty's sources (§ 7.4.3). Finally, Section 7.5 summarises the overall application of the proposed approach.

7.2 Description

The selection of indicators started from the point that regional green infrastructure (selected VEC) plays a role in regulating important processes such as hydrological cycle and local climate as well as in preserving biodiversity (see also Pauleit *et al.*, 2005). In fact, with particular reference to urban regions, it has been showed how environmental thresholds (e.g. air quality standards, ecological limits, etc.) tend to be more easily exceeded as a consequence of small minor actions (Antrop, 2004; MEA, 2005; EEA, 2006). Furthermore, urbanisation generally led to a decline of vegetated areas, and thereby, a reduction of evapotranspiration rates due to a negative interplay with land and vegetation cover contributing to increase surface runoff (Haase and Nuissl, 2007) and alter local climate (Barbera *et al.*, 1991; Taha, 1997).

Firstly, the major effects of urbanisation on hydrological processes are caused by the replacement of vegetated areas by more impermeable structures (i.e. roads and buildings), leading to less: evapotranspiration; interception of rainfall by plants; and water infiltration. As a result, surface runoff increases both in terms of volume and speed. Thus, more of the rain is diverted to drains, storm sewers and streams, reducing the time between the rainfall event and its appearance in streams; and increasing the risk of both riverine flooding, as well as flooding from combined sewer overflows, where the capacity of the drains is overwhelmed by the runoff (Whitford *et al.*, 2001; Gisotti, 2007).

Secondly, urbanisation also alters energy exchanges due to heat produced by building and cars directly warms up the environment. Moreover, the loss of vegetated areas directly contribute to lower energy loss from evapotranspiration, changing the energy exchange processes (Oke, 1987; Tso *et al.*, 1991). And this has been agreed as particularly adverse during the summer months, making life uncomfortable for the inhabitants, particularly on hot days; and increasing the need for air conditioning (Whitford *et al.*, 2001; Gisotti, 2007).

Thirdly, urbanisation has been considered among the primary cause of natural areas fragmentation, altering both structure and function of habitats (Forman and Godron, 1986; Turner *et al.*, 2001; Farina, 2005); and consequently, contributing to biodiversity loss and reduction of ecological resilience (Holling, 1973), particularly at landscape scale.

Therefore, a core set of indicators were selected in order to quantify and map those effects: surface runoff, surface emissivity, evapotranspiration, and ecological connectivity (Figure 7.1).

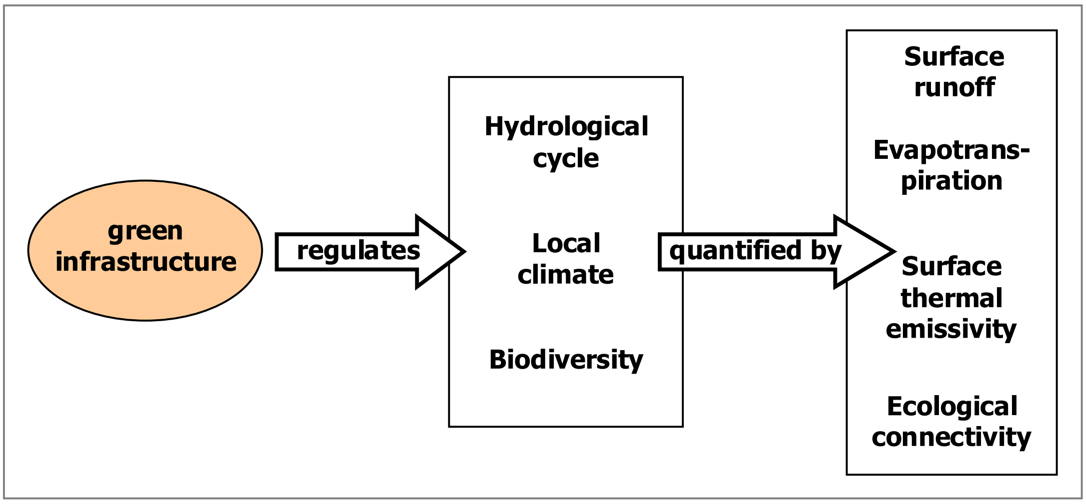


Figure 7.1: Selection of indicators

The data required to map these indicators were all available and freely downloadable on the web, mainly including regional land use cover maps, soil types, climate data, and a satellite image.

7.2.1 Surface runoff

A surface runoff indicator was selected to determine the approximate amount of direct runoff from a particular rainfall event. Although there exists many models for estimating it (e.g. Watershed Science Centre, 2000), most of them tend to be complex computer-based, requiring large amount of data (Mansell, 2003). Therefore, according to the purpose of this thesis, the Soil Conservation Service approach was adopted (SCS, 1972) as it is based on theoretical foundations and empirical studies, providing a straightforward method for quantifying surface runoff with few input requirements (Whitford *et al.*, 2001) (see Box 1). In order to compute it, a rainfall event of 24 hours duration was fixed due to: firstly, 24 hour duration spans most of the applications of the SCS approach (NRCS, 1986); and secondly, a daily rainfall of 80 mm corresponded to the alarming threshold for hydraulic risk with respect to the case study region (DGR n. 7/21205, 2005).

BOX 1: computation of surface runoff indicator

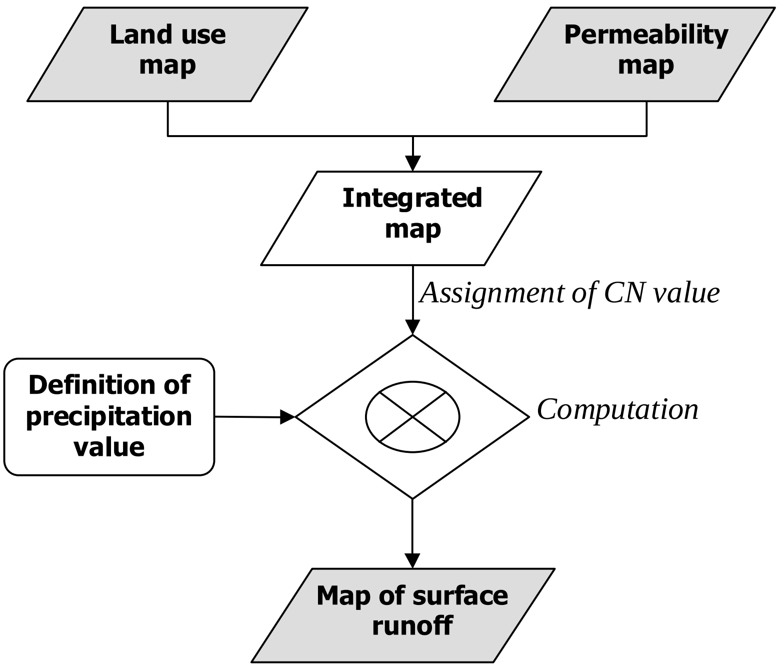
According with SCS (1972), the computed equation for calculating surface runoff for a given rainfall event is:

$$P_e = \frac{(P - 0.2S)^2}{P + 0.8S} \quad (7.1)$$

where P is the precipitation [*mm*], and S is the maximum potential retention of the catchment, given by the expression:

$$S = \frac{2540}{CN} - 25.4 \quad (7.2)$$

where CN is a dimensionless curve number of the particular type of watershed experimentally determined. It ranges between 0 and 100 depending on the amount of pervious surface, and thereby, on land cover type, and hydrologic soil conditions[1].



[1] For impervious and water surfaces CN=100, while for pervious surfaces CN<100. However, runoff is affected by the soil moisture before a precipitation event, or the *antecedent moisture condition* (AMC). A curve number may also be termed AMC II or CN_{II}, or average soil moisture. The other moisture conditions are dry, AMC I or CN_I, and moist, AMC III or CN_{III} (USDA, 1986). This application adopted CN_{II} for normal antecedent moisture condition (AMC).

7.2.2 Surface emissivity

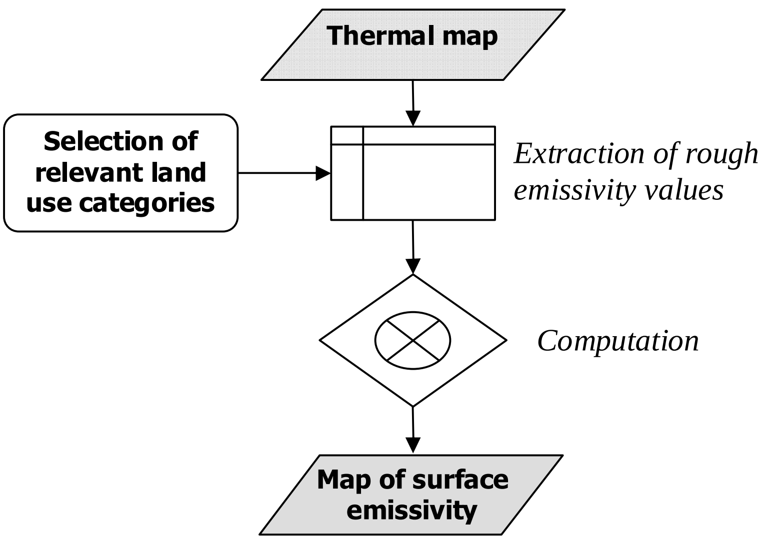
One of the most important parameter for the urban climate research is the *Land Surface Temperature* (LST), which modulates the air temperature of the lower layer of urban atmosphere (Voogt and Oke, 1998; Gisotti, 2007). However, the relationship between the total amount of energy emitted by a surface and air temperature is not linear, being latent or horizontal heat fluxes also important for the energy exchange balance. Therefore, despite many approaches are available in order to model LST, they often base on complex algorithms and equations, requiring intensive amount of data. At the opposite, according to the purpose of this thesis, an indicator of land surface thermal emission was chosen starting from the approach proposed in Schwarz *et al.* (2010) which analysed thermal data for the Leipzing Region (Germany). Following the same procedure, a freely available remote sensing satellite image obtained from Landsat 7 ETM+ (band 6.1, spatial resolution 60x60) covering the case study area was firstly downloaded (acquisition date: 21 June 2001; acquisition time: approximately 10:00am), and secondly used to extrapolate case study specific emissivity values for all regional land use classes (see Box 2).

BOX 2: computation of surface emissivity index

Emissivity values were obtained for each regional land cover category (see Appendix 4), based on the following equation:

$$emissivity\_index[i] = \left(\frac{emissivity[i]}{emissivity[GardensAndParks\_good]} * 100 \right) - 100 \qquad (7.3)$$

where: the numerator is the emissivity value for the land use type [i]; and the denominator is the emissivity of the reference land use class (emissivity value of gardens and parks in good conditions). Both are expressed in $\left[\frac{W}{m^2 * ster * \mu m} \right]$.



7.2.3 Evapotranspiration

To determine evapotranspiration, both empirical (e.g. eddy-correlation, Bowen ratio) and estimating (e.g. hydrological equations, water balance) methods are available. According to the regional climate conditions (see § 6.2.1), this thesis proposes the use of the *f*-value for evapotranspiration potential of land use classes as indicator following the method described in Schwarz *et al.* (2010) which approximates potential evapotranspiration of a land use class for emitting latent heat in Leipzing region (Germany), basing on empirical estimations, soil types and regional climate data. A set of evapotranspiration values were obtained for several regional land cover categories based on average age of trees and available water capacity of soils (AWC). Therefore, different combinations of these classes were used in order to assign evapotraspiration values to the overall land use categories (see Box 3).

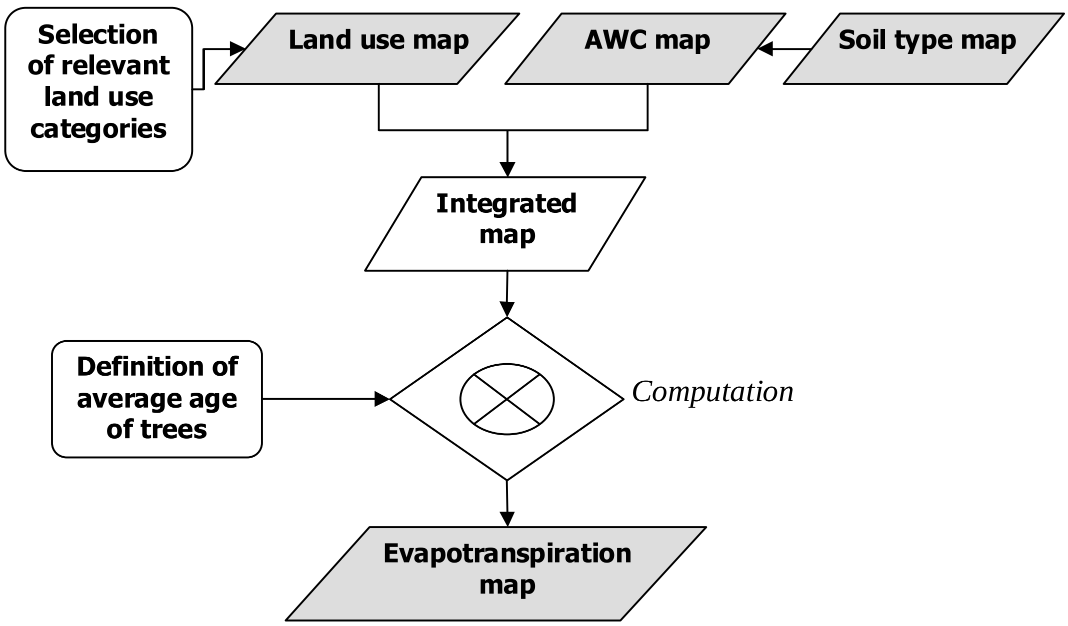
BOX 3: computation of evapotranspiration indicator

The f-value for land uses bases on the following equation:

$$f[i] = \frac{\max\_evapotranspiration[i]}{ET_0} \tag{7.4}$$

where: the numerator is the maximum evapotranspiration for the land use type [i]; and the denominator is the reference evapotranspiration of grass, 12 cm high, depending on local climate. Both are expressed in [*mm*].

The f-value for water surfaces was fixed at 1.05 as suggested in Allen *et al.* (1998).



7.2.4 Ecological connectivity

Many spatial landscape metrics have been proposed and tested in order to describe structural and functional changes on ecosystems (Handley, 1988; Forman, 1995; McGarigal and Marks, 1995; Löfvenhaft *et al*., 2002; Geneletti, 2004; Marull and Mallarach, 2005), showing them as suitable set of measures to evaluate 'configuration and pattern effects'.

According to the purpose of this thesis, two indicators commonly employed in landscape ecology (Gustafson, 1998; Geneletti, 2008) were firstly selected in order to predict changes on VEC structure, and therefore, computed with FRAGSTATS (McGarigal and Marks, 1995): the *Landscape Shape Index* (LSI) and the *Mean Shape Index* (MSI) (see Box 4).

BOX 4: computation of ecological connectivity indexes

LSI is a shape index expressing the overall compactness level of patches within a region, according to the formula:

$$LSI = \frac{E}{\min E} \tag{7.5}$$

Where: E = total length of edge in landscape; and min E = minimum total length of edge in landscape. Accordingly, LSI=1 when the landscape consists of a single square (or almost square) patch, whereas LSI increases without limit as landscape shape becomes more irregular and/or as the length of edge within the landscape increases (McGarigal and Marks, 1995).

MSI is a shape index expressing the average compactness level of patches within a region, according to the formula:

$$MSI = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} \frac{p_{ij}}{\min p_{ij}}}{N} \tag{7.6}$$

Where: pij is the perimeter of patch ij in terms of number of cell surfaces; min pij is the minimum perimeter of patch ij in terms of number of cell surfaces; and N is the total number of patches.

7.3 Results

The spatially explicit indicators previously introduced were computed for each land use scenario in order to compare their different performance and, thereby, to predict their cumulative effects on VEC. In particular, section 7.3.1 showed a rough means to assess CE, by estimating and comparing the likely land take for each planning alternatives under future conditions, whilst the following sections present to what extent spatial planning alternatives (e.g. increase of artificial surfaces, etc.) affect the role of VEC under different future conditions (e.g. enhancement of ecological conditions of green infrastructure, etc.), referring to the control of surface runoff, the local climate regulation and the preservation of the regional ecological connectivity. Therefore, the results are discussed focusing on expected cumulative changes in terms of surface runoff, surface emissivity, evapotranspiration and ecological connectivity.

7.3.1 Land use cover changes and expected land take

According with the assumptions made (see § 6.5), spatial planning alternatives showed different distribution of urban and natural patterns under future scenarios. Changes in urban patterns mostly resulted between different spatial planning alternatives (case *a* and *b*); whilst changes on natural patterns were mainly driven by external conditions, particularly under strong role of protected areas conservation plans and rural policies.

Figure 7.2 shows the overall land use cover change for relevant broad LUC categories under different scenarios. Appendix 4 includes a table summarising values of changes in terms of percentage.

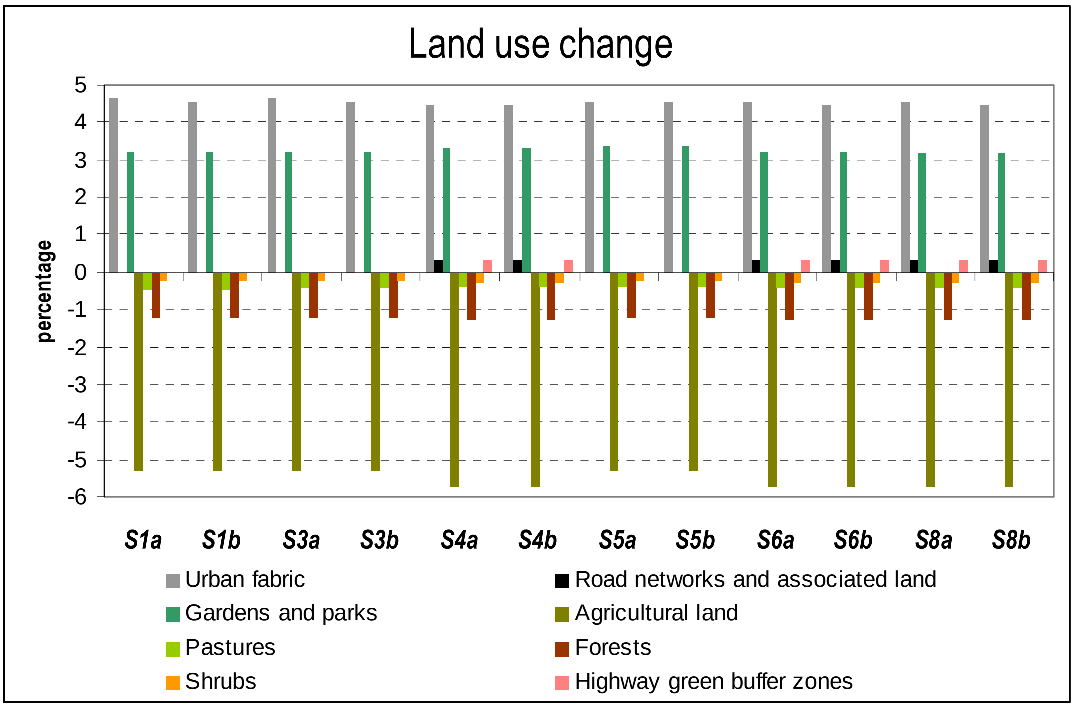


Figure 7.2: Land use cover changes under different scenarios

In particular, LUC changes are mostly expected for two broad land use categories: artificial surfaces and agricultural areas. The first is expected to increase ranging from 4,6% (S1a) to 4,4% (S4a, S4b); while the second is expected to decrease of about 5,5% in all scenarios, confirming the foreseen trend of encroachment of rural areas predicted for the region (see § 6.3). Furthermore, a net decrease of forests (about 1,3%) is expected under all land use scenarios, covering the 14,6% of the regional woodland.

Additionally, although the overall land take showed minor changes between different scenarios, artificial surfaces are expected to increase more if urban development is locally driven (case *a*), exceeding the 4,5%. Furthermore, by comparing the amount of urban fabric under different scenarios, different internal patterns emerged, due to major changes are expected with respect to discontinuous and continuous urban fabric under different future conditions (Figure 7.3).

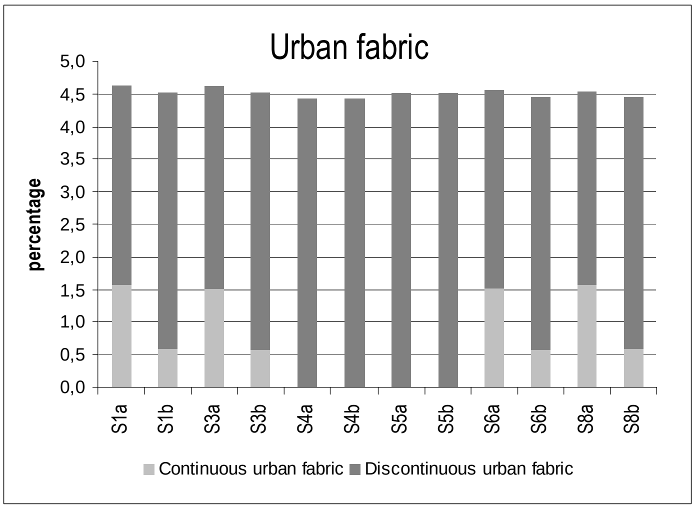


Figure 7.3: Urban fabric land cover under different scenarios

Moreover, an intensification of continuous urban pattern is expected for scenarios S1a, S3a, S6a and S8a. At the opposite, it is expected to not increase for both spatial planning alternatives under combination 4 and 5, maintaining almost the same percentage of the baseline condition (Figure 7.4) and, consequently, confirming the role of rural policies in preserving rural fringes and patches within the urbanised areas.

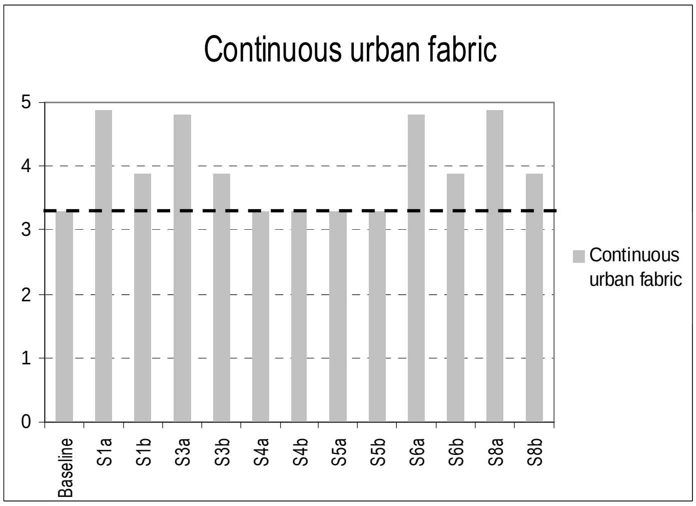


Figure 7.4: Continuous urban fabric land cover under different scenarios

As a result, major changes in urban patterns, at least for the next 15/20 years, resulted under combinations 1, 3, 6 and 8, anticipating that:

1. spatial plans, even though regionally driven (case *b*), could be not enough in avoiding soil regeneration threshold to be exceeded;

2. a strong role of protected area conservation plans could be not enough effective in containing urban developments;
3. then, under weak role of rural policies, the current trend of encroachment of rural areas caused by urban developments is likely to continue over the case study region.

Referring to urban green areas, a total increase is expected in all scenarios (about 3,2%) which slightly rose in 4 and 5 combinations (+3,3%). However, their natural condition, ranging from good to poor, is expected to largely change under different future combinations due to the enhancements planned in case of strong integration among protected areas conservation plans, rural policies and spatial plans. Figure 7.5 shows the expected transformations on green urban areas under different future conditions.

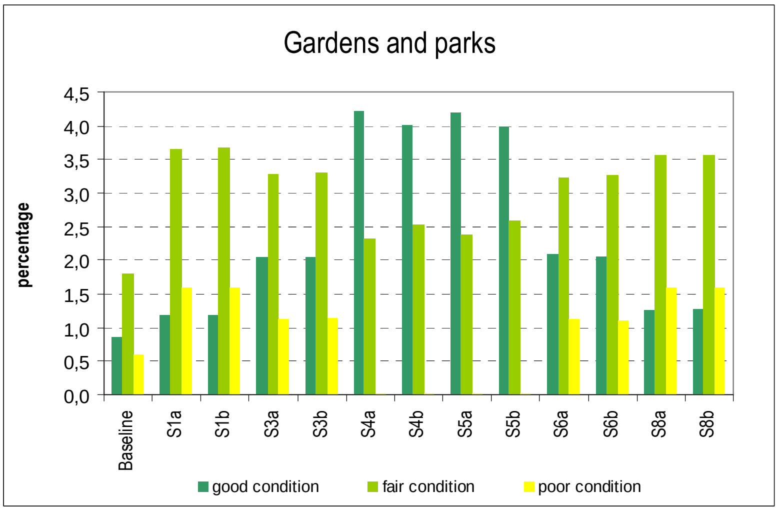


Figure 7.5: Gardens and parks (natural conditions) under different scenarios

Moreover, different combinations of agricultural and semi-natural patterns resulted for both spatial planning alternatives (*a* and *b*) under different future conditions. In particular, despite the expected net decrease of rural areas, the likely conversion of arable land from homogeneous to rural land with significant presence of trees (Figure 7.6), respectively inside (+9%) and outside protected areas (+20%), resulted under combinations 3, 4, 5 and 6, due to a strong regime of protected area conservation plans and rural policies in mainstreaming ecological enhancements within protected sites and regional rural network.

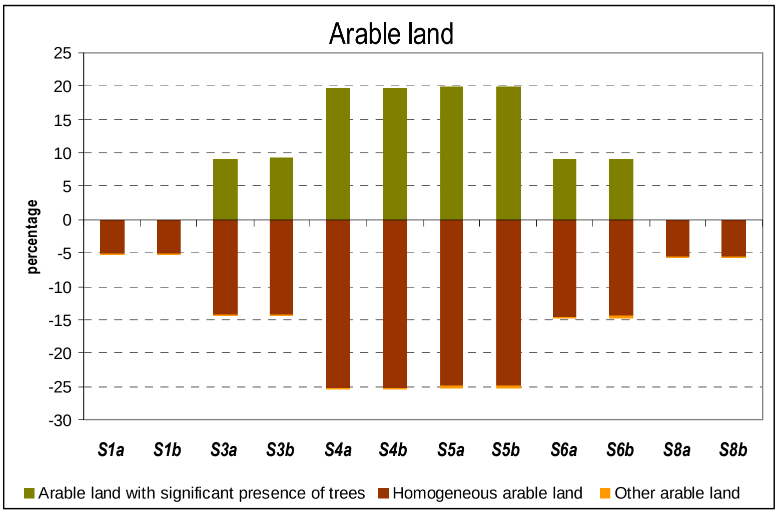


Figure 7.6: Arable land under different scenarios

And, in spite of their limited amount, this was further the case of other natural LUCs such as pastures and shrubs, whose enhancements are expected under scenarios 3, 4, 5, and 6, due to the enforcement of protected area conservation plans and rural policies in converting, and thereby, improving, their natural condition. Figure 7.7 shows the total amount of those LUC classes among different scenarios, including the baseline condition.

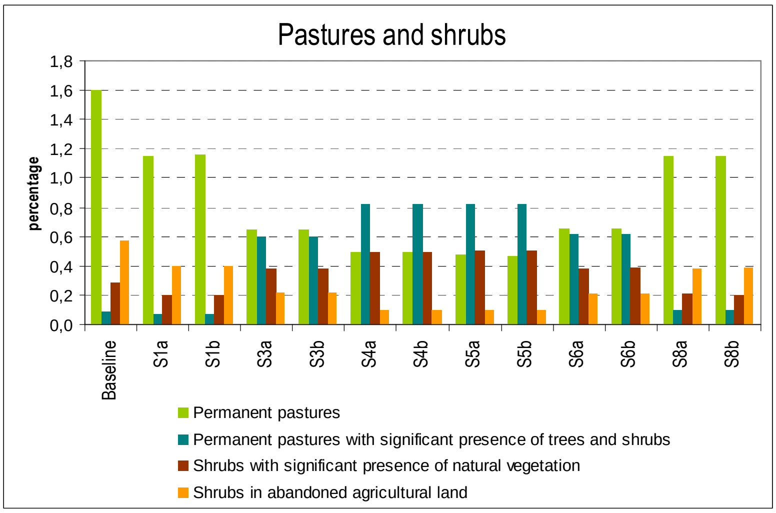


Figure 7.7: Pastures and shrubs under different scenarios

Finally, a slight additional decrease of agricultural land and forests is expected for both spatial planning alternatives under conditions 4, 6 and 8, due to the realisation of the highway corridor, even though this could be mitigated by the planned measures (i.e. green buffer zone, etc.).

7.3.2 Expected changes in surface runoff

The results of the surface runoff indicator refer to:

1. the daily trend (trend of the indicator during a rainfall event of 24-hour);
2. the value of a rainfall event of 6-hour; and
3. the weighted average value for the overall region.

In particular, the first was applied to illustrate the different performance of those relevant LUC categories used to generate LUC scenario; the second was chosen to visualise the difference of the spatial distribution of the indicator between each scenario and the baseline condition (all the maps are included in Appendix 4). And the third was applied to compare the overall performance of spatial planning alternatives under different future conditions.

Firstly, artificial surfaces (i.e. continuous and discontinuous urban fabric, road networks) showed similar trends of indicator under different scenarios. Specifically, it exceeds 80% after a rainfall event of 1 hour, 6-hour and 12-hour, respectively for roads, continuous and discontinuous urban fabric, suggesting a large contribution of these LUC classes to the regional surface runoff, which can indirectly affect urban drainage systems and increase flooding risk. Figure 7.8 shows the daily surface runoff for artificial surfaces for baseline condition and under three different scenarios (i.e. 1b, 5a, 6b), confirming a similar daily trends under different future conditions with respect to these LUC types.

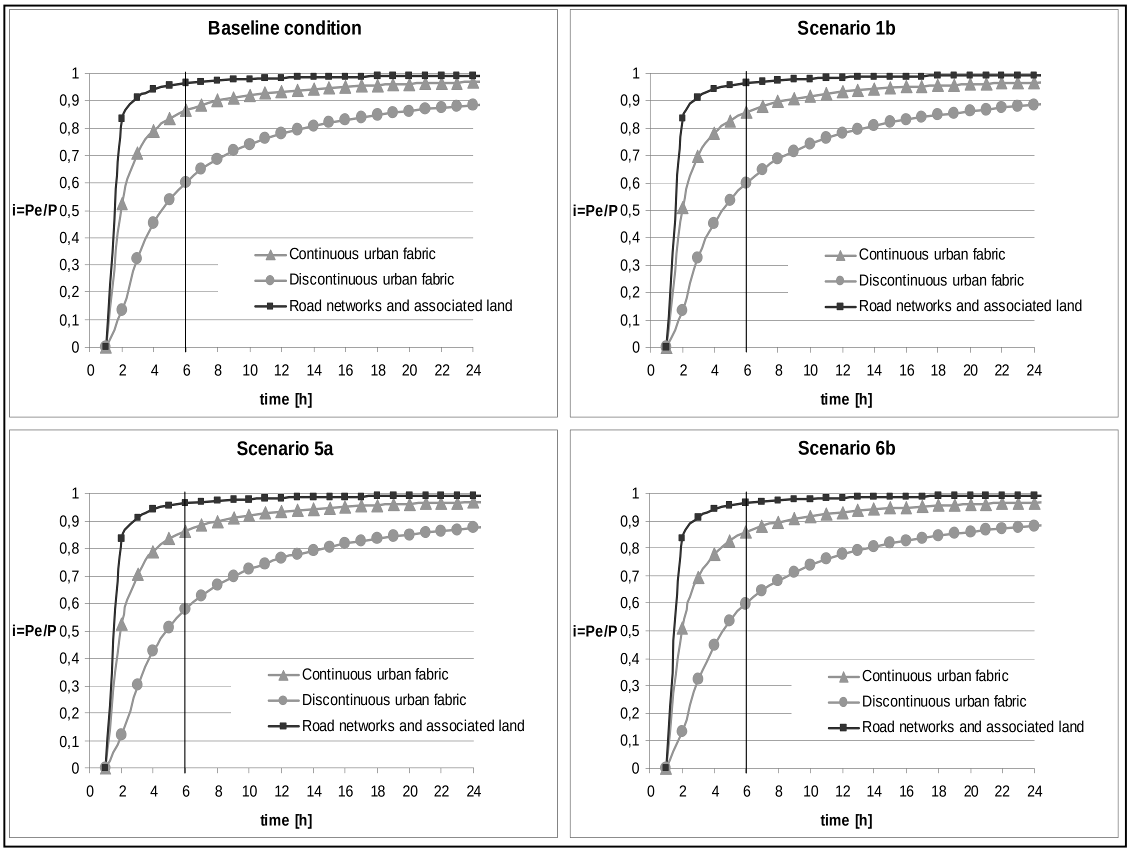


Figure 7.8: Daily surface runoff – artificial surfaces (Baseline condition and scenarios 1b, 5a and 6b)

However, residential patterns showed a different performance mainly due to the amount of open spaces included in. In particular, discontinuous residential areas allowed rain water to infiltrate more than continuous urban fabric, by potentially contributing to avoid drains to exceed their capacity. Therefore, major increases of runoff are expected in case of locally driven development (case a) under combination 1, 3, 6 and 8 due to both a rise of continuous urban fabric and a net loss of semi-natural and rural fringes.

At the opposite, a set of different trends of daily surface runoff are expected in urban green areas according to the condition of their natural cover (see Figure 7.5). Figure 7.9 shows the variability of the indicator within the "*gardens and parks*" LUC classes, highlighting a maximum range for a rainfall event of 6 hour, and showing a net decrease if urban green areas are improved (from poor to good), particularly under scenario 5a which supposed a net increase of 3,3% of parks in good conditions (see Appendix 4). And this seems to be mainly important in case of gardens and parks located in dense, medium-dense and discontinuous urban patterns such as the central part of the region due to their role in mitigating the effect of artificial soil sealing on water flow, particularly for critical rainfall events and high intensity precipitations.

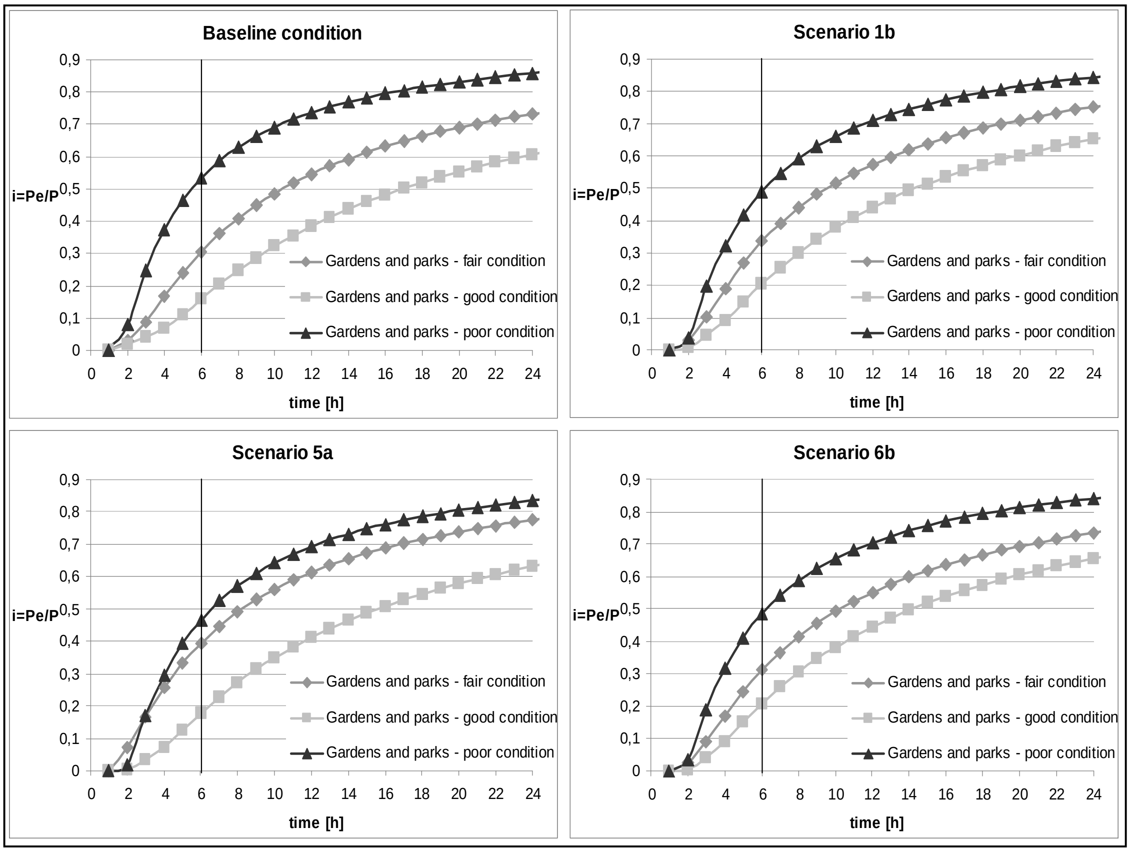


Figure 7.9: Daily surface runoff – green urban areas (Baseline condition and scenarios 1b, 5a and 6b)

Secondly, by comparing alternative scenarios with baseline condition, if no enhancements of semi-natural and green patterns are expected (scenario 1a, 1b, 8a and 8b), the surface runoff indicator showed an overall increase scattered over the region mainly due to the net conversion of semi-natural and rural areas into artificial urban lands (Figure 7.10), confirming that local spatial plans, even though regionally driven (case b), may cumulatively contribute to alter the water regulation capacity of regional green infrastructure, with likely negative consequence on water recharge and flooding risk.

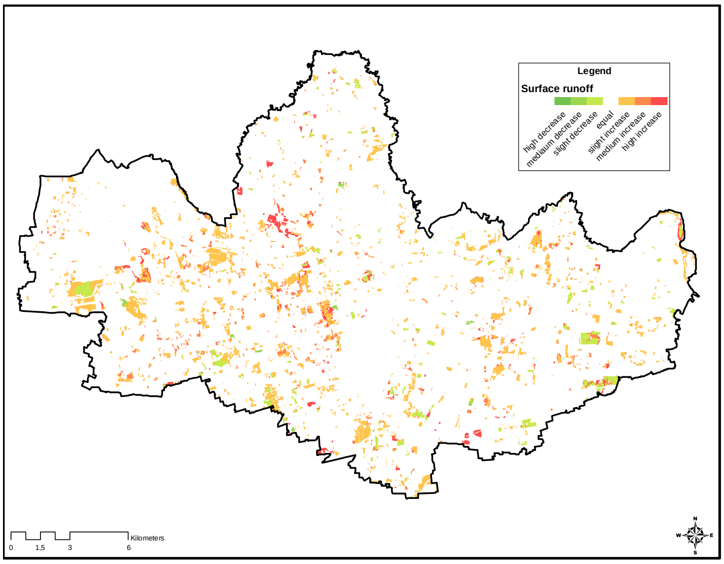


Figure 7.10: Difference of surface runoff between scenario 1b and baseline condition

At the opposite, the surface runoff indicator showed a wide improvement over the region under combinations 4 and 5 due to additional enhancements of semi-natural and rural patterns are expected, not only in protected areas and regional rural network, but even on river and irrigation ditch banks, flooding areas, etc., contributing to an overall decrease in surface runoff, particularly relevant in rural areas mainly located over the eastern sector of the case study region (Figure 7.11).

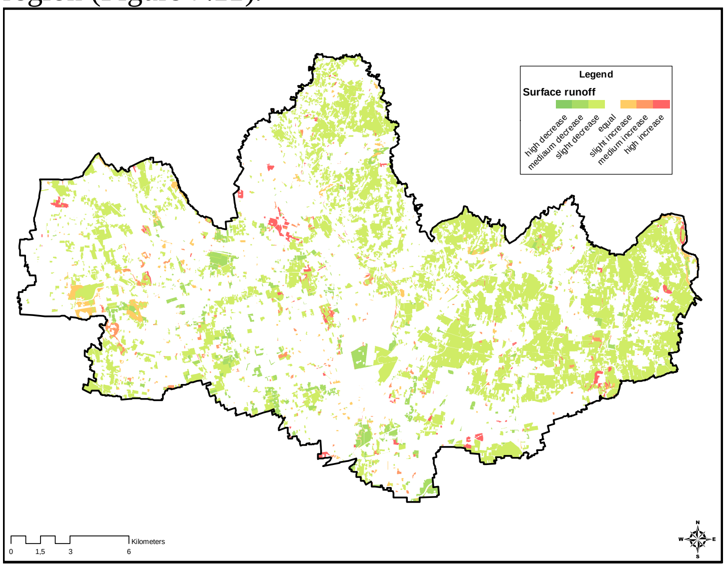


Figure 7.11: Difference of surface runoff between scenario 5a and baseline condition

Finally, if the highway is realised (combinations 4, 6 and 8), an increase of surface runoff is expected along the corridor as direct effect of soil sealing (Figure 7.12). However, the indicator showed the effect can be slightly mitigated by the planned green buffer zone, especially when it is co-located in higher infiltrating soils. Moreover, green buffer zone can further play a multifunctional role, by filtering road atmospheric pollutants (e.g. PM_{10}, NO_x, etc.), as well as in providing to a recreational corridor (walking and cycle paths, etc.).

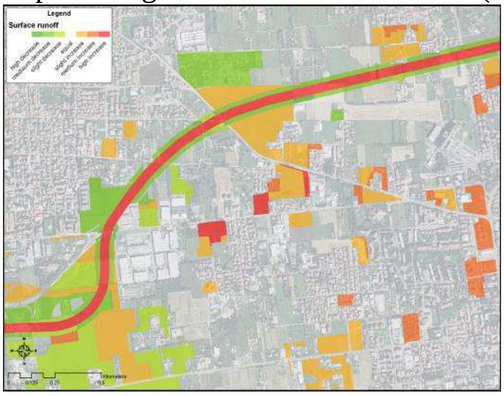


Figure 7.12: Difference of surface runoff along the road corridor (scenario 8b)

Finally, the weighted average value of the indicator (mean of surface runoff indicator weighted for the surface of land use types) allowed different scenarios to be compared both with baseline condition and between them (Figure 7.13), suggesting several considerations.

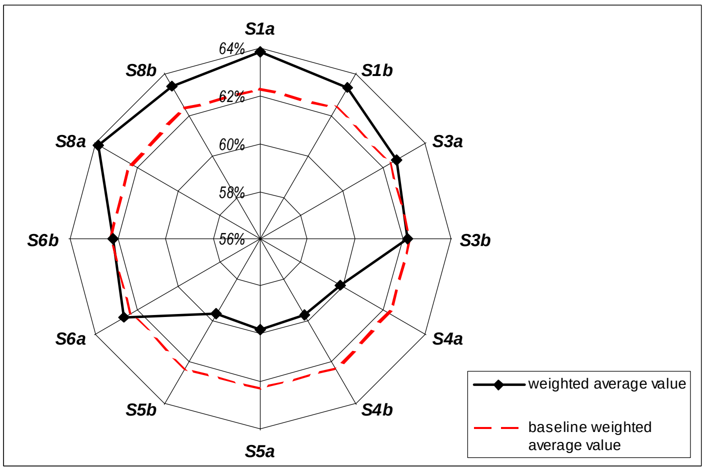


Figure 7.13: Weighted average surface runoff – comparison between scenarios

Firstly, spatial planning alternatives (case *a* and *b*) similarly performed under the same future combination, even though case *a* showed a slight increase (about 0,05%) under combination 1, 3, 6 and 8 due to the intensification of artificial surfaces within previously urbanised lands. Secondly, the indicator highlighted the positive role of enhancements of open spaces and rural areas in controlling surface runoff, suggesting them as potential ‘compensation’ measures to be envisaged in order ensure surface runoff to, at least, not exceed the average value of the baseline condition (scenarios 3a, 3b, 6a and 6b), or, alternatively to decrease (scenarios 4a, 4b, 5a and 5b).

7.3.3 Expected changes in surface emissivity

The results of surface emissivity refer to:

1. the estimated value;
2. the weighted average value for the overall region.

In general, the values of surface emissivity index estimated for the region ranged from -2,2 of medium-high density coniferous forest to 7,1of continuous urban fabric (see Appendix 4).

Firstly, referring to the baseline condition it mainly showed a negative value[2] (ranging from -2 to 0) in protected areas where most of natural covers are located (residual forests, riparian vegetation, green areas in good condition, etc.); and in the large urban green park (*Parco di Monza*) situated in the middle of the region due to its relevant tree cover (Figure 7.14). And this generally confirmed the current role played by the regional infrastructure (VEC) in regulating local climate, by contributing to maintain the natural flow of heat exchange between land surface and air temperature.

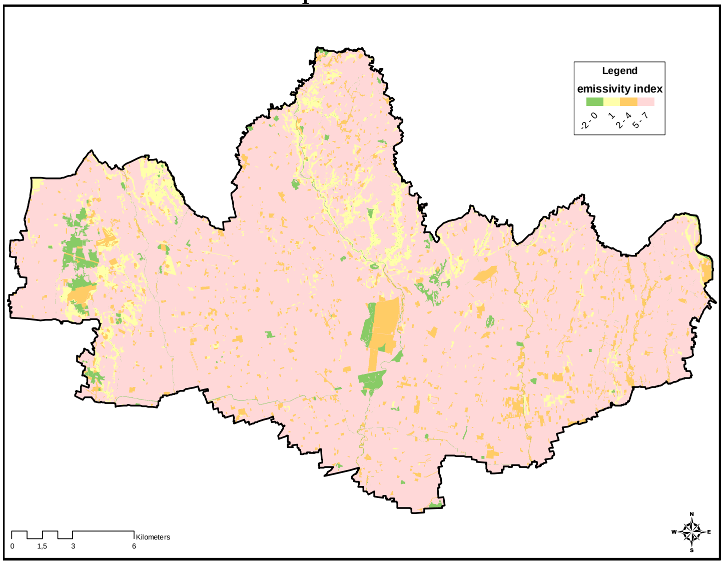


Figure 7.14: Emissivity index – baseline condition

Secondly, when the total implementation of local spatial plans is expected to occur with no coordination with protected area plans and rural policies (combinations 1 and 8), the index showed a scattered increase, particularly within protected areas due to both a net loss of

[2] According with the method adopted in order to calculate the surface emissivity index (see Box 2 in § 7.2.2), negative values correspond to land covers with less emissivity value than the reference, where reference value is the emissivity of green urban area in good conditions.

woodlands, and a scarce enforcement of improvements in green and open spaces. Figure 7.15 maps the distribution of the index over the region, by showing the spatial difference between scenario 1b and the baseline condition (all the maps are included in Appendix 4).

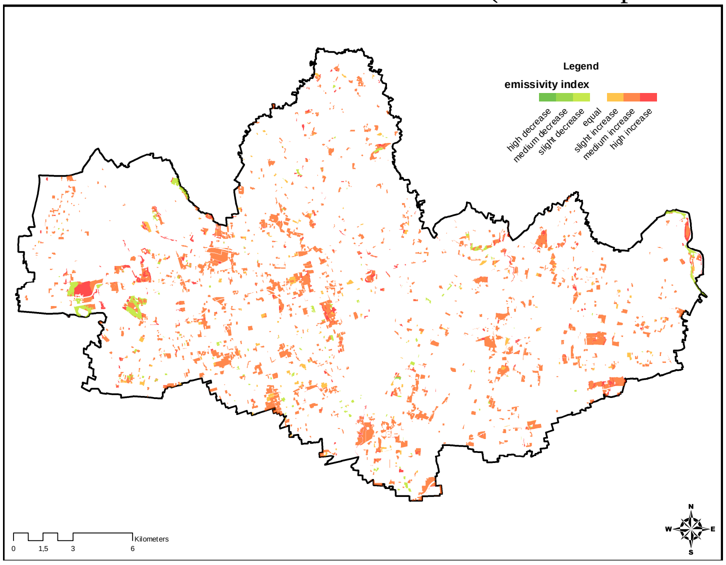


Figure 7.15: Difference of emissivity index between scenario 1b and baseline condition

Thirdly, under future combinations 4 and 5, the emissivity index showed a general decrease over the region as a consequence of ecological enhancements both in rural areas and open spaces are largely expected. Figure 7.16 shows the distribution of the index under scenario 5a and its difference with respect to the baseline condition.

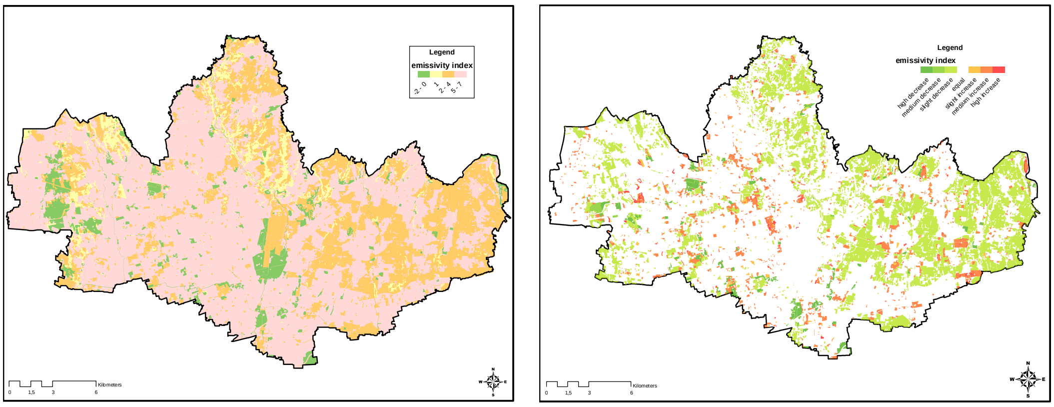


Figure 7.16: Emissivity index – scenario 5a (*on the left*) and difference with baseline (*on the right*)

Fourthly, if highway is realised (combinations 4, 6 and 8), the index showed a direct increase due to the replacement of vegetated areas with asphalt. However, as in case of surface runoff, it showed that the effect can be slightly mitigated by a green buffer zone which may contribute to compensate the augment of local air temperature. Nonetheless, it could negatively contribute to local climate due to an increase of CO_2 emissions from transportation which may globally change climate conditions, and local compensations could be not enough effective in offsetting this consequence, requiring a better integration between spatial, transportation and climate strategies at different levels of decision-making.

Finally, by comparing the weighted average value (mean of surface emissivity index weighted for the surface of land use types) of different scenarios, the indicator showed a better performance with respect to the baseline condition only under combinations 4 and 5 (Figure 7.17), confirming that the cumulative effect on VEC in respect of the regulation of local climate could be positive only if enhancements are achieved.

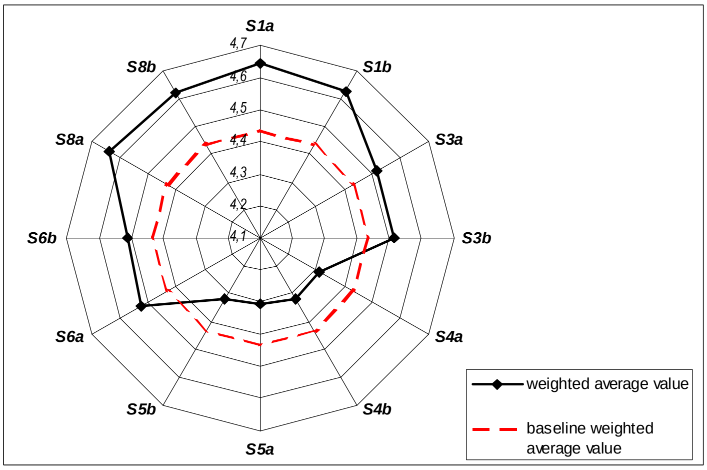


Figure 7.17: Weighted average emissivity – comparison between scenarios

And this seems to be particularly important in case of rural fringes and open spaces located in medium-dense and discontinuous urban areas, such as the central part of the case study region. In fact, due to higher radiance of artificial surfaces, local temperature may increase, especially during the summer, leading to a rise in heat island effects and human discomfort.

7.3.4 Expected changes in evapotranspiration

The evapotranspiration pattern mainly followed the distribution of vegetated and water surfaces[3], showing the direct role of regional green infrastructure in reducing temperature, by cooling, storing and reradiating less heat than built-up surfaces. Furthermore, a significant contribution to evapotranspiration resulted from the large urban green park (*Parco di Monza*) situated in the middle of the region which is further playing a recreational role (Figure 7.18).

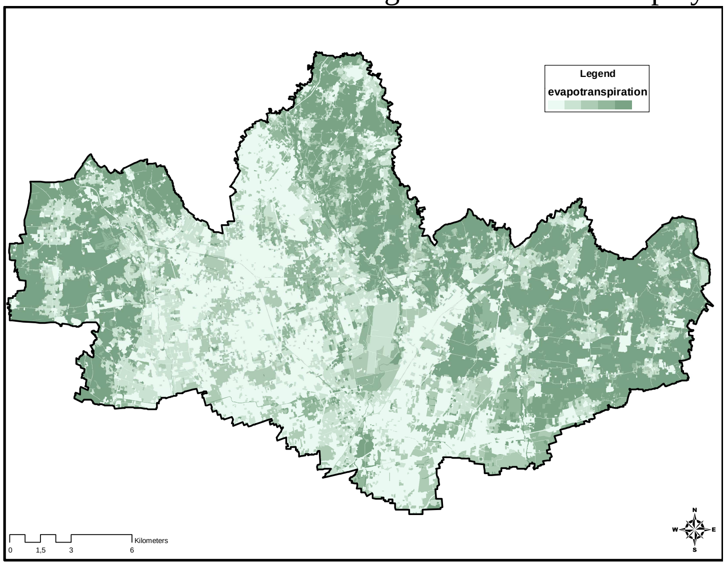


Figure 7.18: Evapotranspiration – baseline condition

However, the current evapotranspirating patterns are expected to be negatively influenced by the total implementation of local spatial plans, especially under combinations 1 and 8 due to the intensification of urban developments which implies a net loss of vegetated surfaces and, thereby, a decrease of evapotranspirating areas (all the maps are included in Appendix 4).
Nonetheless, even when a strong integration among policies is expected (combinations 4 and 5), the indicator did not show a better performance with respect to the baseline condition due to the low value of soil available water capacity characterising the central part of the region which seemed to strongly influence its performance even in case of enhancements of green and rural areas are implemented (Figure 7.19).

[3] The case study region showed a current distribution of woodlands and natural vegetation in protected areas mostly located in the western and northern central parts (see Figure 6.5b). While the eastern sector is mainly characterised by homogeneous rural areas.

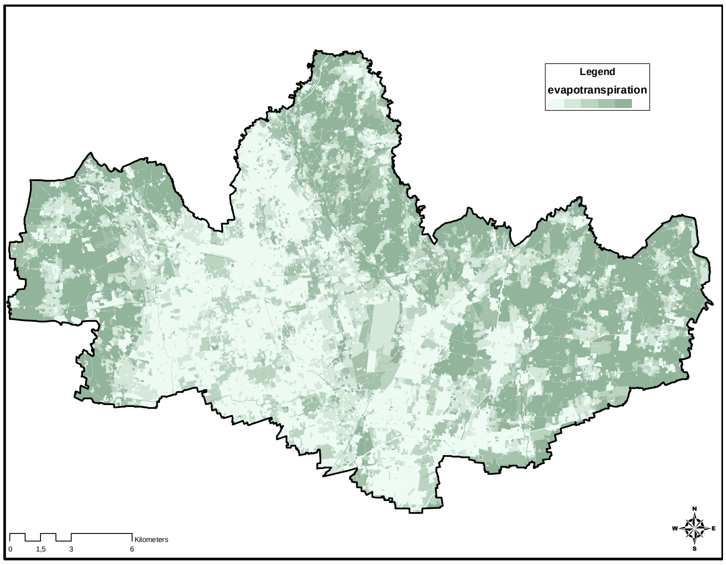


Figure 7.19: Evapotranspiration – Scenario 5a

In addition, if the highway is realised (combinations 4, 6 and 8), a decrease of evapotranspiration is expected along the road layout due to the net loss of vegetated areas. And mitigation buffer zones seemed to not compensate this negative consequence, except for areas with high soil AWC (i.e. eastern sector of the region).

Finally, by comparing the weighted average value of different land use cover scenarios for the overall region, the indicator did not significantly change, ranging from 0,92 (combination 4) to 0,93 (baseline condition). However, it showed to be sensitive to: firstly, the net loss of vegetated surfaces as none of the scenario performed better than the baseline condition; and, secondly, the AWC value as when significant land use changes where expected in high soil AWC (i.e. eastern sector of the region), it changed (combination 4 and 5), otherwise it performed as the same (combination 1, 3, 6, and 8) (Figure 7.20).

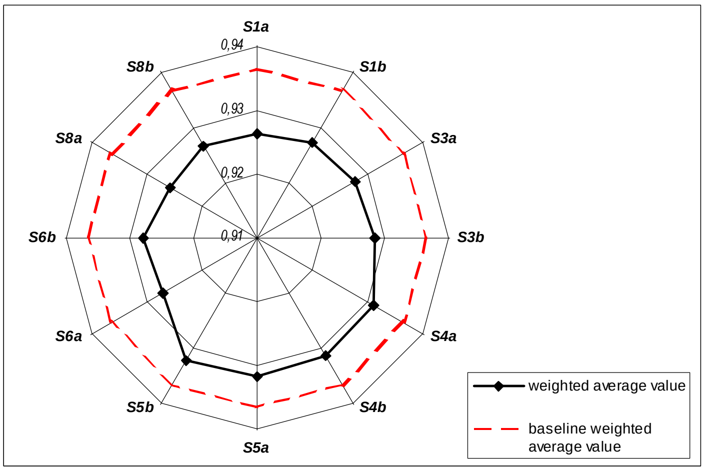


Figure 7.20: Weighted average evapotranspiration – comparison between scenarios

7.3.5 Expected changes in ecological connectivity

Two connectivity indexes were calculated both for core areas and stepping stones. Core areas were considered the overall regional forest; while stepping stones were selected among natural and semi-natural LUC categories (i.e. shrubs with significant presence of natural vegetation; riparian vegetation; gardens and parks in good conditions; permanent pastures with significant presence of trees and shrubs; and arable land with significant presence of trees) identified within the regional ecological network. Table 7.1 summarises results for each scenarios.

Table 7.1: Connectivity indexes

Indicator / Scenarios	Connectivity index			
	LSI – forest	*MSI – forest*	*LSI – stepping stones*	*MSI – stepping stones*
S-base	63,665	1,844	20,214	1,797
S1a	63,099	1,791	23,833	1,831
S1b	63,099	1,791	23,866	1,832
S3a	63,099	1,791	36,212	1,685
S3b	63,099	1,791	37,072	1,682
S4a	63,236	1,798	39,145	1,693
S4b	63,236	1,798	39,493	1,695
S5a	63,099	1,791	38,436	1,685
S5b	63,099	1,791	38,780	1,687
S6a	63,236	1,798	37,723	1,703
S6b	63,236	1,798	38,070	1,696
S8a	63,236	1,798	26,901	1,857
S8b	63,236	1,798	26,958	1,854

With respect to core areas, both indicators decreased in all scenarios comparing with the baseline condition due to a net loss of forests over the case study region (see § 7.3.1) and, consequently, a decrease of compactness level of their patches. However, it can be noted that they mostly changed whether the highway is expected to be realised (combinations 4, 6 and 8), confirming the negative role of road corridor in contributing to habitat fragmentation.

Referring to stepping stones, connectivity indexed showed an opposite trend among scenarios. Although all scenarios performed worst comparing with the baseline condition, if a significant increase of stepping stones is expected (combinations 3, 4, 5 and 6), while the overall compactness of patches increases (LSI), their average values (MSI) decrease due to an augment of patch numbers (Figure 7.21).

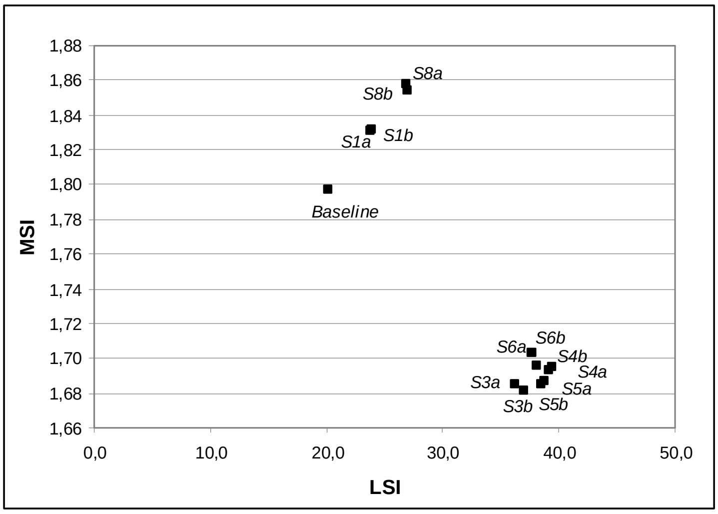


Figure 7.21: Correlation between stepping stones MSI and LSI

And this suggests that protecting natural areas could be not enough in order to preserve biodiversity, even though analysis with more level of detail seems to be required. As a result, supporting spatial plans to improve regional ecological connectivity by designing multi-scale ecological networks and enhancing their ecological conditions seem to be particular important in order to preserve structures and functions of habitats and ecosystems, particularly in case of peri-urban regions such as the case.

7.3.6 Overview of the performances of scenarios

The performances of alternative scenarios can be additionally compared against the overall indicators. Table 7.2 qualitatively summarises the results which are subsequently portrayed.

Table 7.2: Performances of future scenarios*

Indicators / **Scenarios**				**Connectivity indexes**		
	Surface runoff	**Emissivity Index**	**Evapotran-spiration**	*LSI – stepping stones*	*MSI – stepping stones*	*LSI and MSI – forest*
S1a	▲	▲	▼	▲	▲	▼
S1b	▲	▲	▼	▲	▲	▼
S3a	◄►	▲	▼	▲	▼	▼
S3b	◄►	▲	▼	▲	▼	▼
S4a	▼	▼	▼	▲	▼	▼
S4b	▼	▼	▼	▲	▼	▼
S5a	▼	▼	▼	▲	▼	▼
S5b	▼	▼	▼	▲	▼	▼
S6a	◄►	▲	▼	▲	▼	▼
S6b	◄►	▲	▼	▲	▼	▼
S8a	▲	▲	▼	▲	▲	▼
S8b	▲	▲	▼	▲	▲	▼

* ◄► = as baseline condition; ▲ = better that baseline; ▼ = worse that baseline

Firstly, the performance of different planning alternatives (case *a* vs. case *b*) under the same future condition (e.g. S3a and S3b) was mainly detectable through the surface runoff indicator and, to some extent, through the ecological indexes, while the rest of indicators did not significantly vary. In fact, while all of indicators showed to be sensitive to small changes on natural patterns (quantitative amount and qualitative condition), only surface runoff and LSI changed due to small increment and/or intensification of artificial surfaces.

Secondly, although all scenarios exceeded the soil regeneration threshold as a consequence of the overall implementation of the expected small local land use changes assumed (see § 6.5), the indicators highlighted how different expected changes of natural and semi-natural patterns (VEC) performed under different future conditions, showing that:

1. scenarios under weak role of protected areas conservation plans and rural policies (1a, 1b, 8a, 8b) generally performed worst against all the proposed indicators, suggesting that the only coordination among local and regional spatial plans could be not enough, not only in avoiding soil regeneration threshold to be exceeded, but also in preserving

all the environmental services considered (e.g. ecological connectivity, regulating of water balance, etc.);

2. scenarios under strong role of protected areas conservation plans and weak role of rural policies (S3a, S3b, S6a, S6b) showed an overall intermediate performance, anticipating that, despite a strong role of protected area conservation plans could be not enough effective in containing urban developments, the enhancement of VEC within the regional protected network could be of particular benefit to the control of surface runoff and, to some extent, to the regulation of local climate. In addition, more detailed studies seemed to be required at lower tier assessment with respect to biodiversity issues, even though ecological indexes pointed out a general improvement of the overall compactness of semi-natural patches;
3. scenarios under strong role of protected areas conservation plans and rural policies (scenarios S4a, S4b, S5a, S5b) showed the best performance with respect to the baseline condition and between them. In fact, even though the soil regeneration threshold will be exceeded, if enhancement of VEC are expected, not only in regional protected and rural networks, but also along river corridors, irrigation ditch banks, etc., indicators showed a great improvement of VEC in both controlling surface runoff and regulating local climate. While for the biodiversity issues, indicators have suggested the need of more detailed studies, as previously underlined.

Finally, only the ecological indexes allowed the effects of the realisation of the highway to be detected, showing slight differences. In particular, all the values increase more under scenarios 4, 6 and 8 comparing to the scenarios 5, 3 and 1 due to the realisation of the highway corridor, predicting a higher fragmentation of natural (LSI, MSI – forest) and semi-natural patches (LSI, MSI – stepping stones), despite the realisation of the green buffer zone.

Next table summarises the overarching results, by grouping them into similar future conditions.

Table 7.3: Overarching results

Future conditions	Expected land use changes*	Overall performance
1 and 8	▪ Increase of artificial surfaces and net loss of open spaces, rural areas and woodland ▪ Increase of urban green areas with no significant enhancements ▪ Highway under combination 8	▪ Worst performance comparing to the baseline condition ▪ Ecological indexes increase more under scenarios 8 with respect to the scenarios 1 due to the realisation of the highway
3 and 6	▪ Increase of artificial surfaces and net loss of open spaces, rural areas and woodland ▪ Increase of urban green areas with enhancements in protected areas ▪ Additional enhancements of semi-natural and rural areas in protected areas ▪ Highway under combination 6	▪ Intermediate performance between the worst cases (1 and 8) and the best one (4 and 5) ▪ Surface runoff performance better than emissivity index ▪ Not significant changes of evapotranspiration ▪ Ecological indexes increase more under scenarios 6 with respect to the scenarios 3 due to the realisation of the highway ▪ Improvement of the overall compactness of semi-natural pattern (LSI) ▪ Decrease of the average compactness of semi-natural pattern (LSI)
4 and 5	▪ Increase of artificial surfaces and net loss of open spaces, rural areas and woodland ▪ Increase of urban green areas with significant enhancements ▪ Additional enhancements of semi-natural and rural areas in protected areas and regional rural network ▪ Additional enhancements of semi-natural along river corridors, irrigation ditch banks, etc. ▪ Highway under combination 4	▪ Best performance comparing to the baseline condition and among all scenarios ▪ Net improvement surface runoff and for the emissivity index over the overall region ▪ Slight changes of evapotranspiration in the eastern part of the region ▪ Ecological indexes increase more under scenarios 4 with respect to the scenarios 5 due to the realisation of the highway ▪ Improvement of the overall compactness of semi-natural pattern (LSI) ▪ Decrease of the average compactness of semi-natural pattern (LSI)

* Section 6.5 underlines the comprehensive description

7.4 Discussion

The results allowed several methodological and contextual considerations to be underscored. In addition, a discussion on uncertainty's sources is presented.

7.4.1 Methodological considerations

The methods applied to compute indicators generally showed a straightforward and time-fashion approach to quantitatively predict and map CE on VEC, requiring a small amount of data and spatial information. Additionally, they provided an easy and evidence-based way to 'link' the land use cover type approach adopted to defined LUC scenarios to the quantification of their effects, by associating LUC features to environmental processes and effects. However, several methodological considerations and limitations are following discussed for each indicator.

Firstly, the surface runoff indicator was only calculated for normal antecedent moisture condition or CN_{II} (see note 1), even though, being runoff affected by the soil moisture before a precipitation event, results could largely differ under dry or moist conditions, namely CN_{I} and CN_{III}. Moreover, being the permeability map used as input derived from a qualitative description of soil texture properties, there may be biases on results. In addition, the values of curve numbers (CN) assigned to different land use categories; as well as the precipitation value chosen to estimate the runoff can further influence the results. Consequently, a thorough scoping on regional baseline conditions seemed to be necessarily required in order to fix those parameters.

Secondly, the surface emissivity values extracted for each land use class were inevitably affected by the local climate conditions characterising the acquisition time of the thermal scene (about 10.00 am), since differences between land use classes due to cooling effects of evapotranspiration can be higher in the evening (see also Gisotti, 2008). Furthermore, they presented a large variability, especially for those land use categories characterising by small extents (see also standard deviation values in Appendix 4). On the one hand, this was an unavoidable consequence of the gap between the levels of detail of the two input maps (a raster satellite data with resolution of 60m and a vector land cover map with a scale of 1:10,000). On the other, this could be improved, by validating and correlating emissivity values extracted from more than one thermal image, should them be available; or, even, by calibrating results with field survey (e.g. available air temperature values, etc.).

Thirdly, the evapotranspiration index was calculated starting from a set of formulas partially based on empirical measures obtained under different climate conditions (Leipzig urban region, Germany) and, thereby, the results could be partially affected by assumptions made for that situation (e.g. enough water is available for evapotranspiration, etc.). Furthermore, the AWC map used as input was indirectly derived from the soil type map, by reclassifying it. And this could probably affect results, being the available water capacity of soils one of the most variable feature of soil in term of spatial distribution.

Fourthly, the connectivity indexes were calculated for several LUC types, assuming their ecological conditions from the land cover map, even though, as discussed in Section 6.7.1, LUC types may not always match to those hypothetical conditions. Furthermore, the required conversion of vector maps into raster maps to computed ecological connectivity indexes further affected results, being ecological connectivity relying on spatial extent of patches and species-specific.

Finally, being the approach adopted to generate LUC scenarios and to calculate three of the indicators (i.e. surface runoff indicator, emissivity index and evapotranspiration) based on LUC features, there may be a correlation on results between them, suggesting that the distribution of the phenomenon over the region could be further concluded from expected land take (§ 7.3.1). And this can be particularly noticeable for the emissivity index due to the method adopted for estimating it. On the contrary, in case of the surface runoff and evapotranspiration, the relationship was not linear as other geographical parameters concurred to the estimation and drove the spatial distribution of the indicators (i.e. soil permeability, water available capacity). For instance, the role of the AWC parameter was largely noticeable, demonstrating few changes on the regional evaportranspirating pattern, even under scenarios which assumed extensive increment natural land use changes (e.g. S4a, S4b). In addition, it would be possible to statistically test the correlation between indicators and LUC classes, as well as among indicators. For instance the emissivity index of each LUC classes could be compared with the evapotranspiration values, being both an indirect measure of the local climate conditions.

However, considering the purpose of this research and the broad scale of the analysis, it can be argued that the selected methods: firstly, allowed important contextual considerations to be advanced (§ 7.4.2); secondly, they could be applicable to other case studies, should data and spatial information be available (see also Schwarz *et al.*, 2010); and, finally, they provided an easily comprehensible means for SEA and planning practitioners, at least within the European context, being the starting point the land cover map whose LUC types are those used also by the European Corine Land Cover (CLC) data set.

7.4.2 Contextual considerations

The results allowed important considerations to be highlighted with respect to the case study region. Firstly, the supposed role of VEC in regulating and preserving several important environmental processes and issues was confirmed, underlining, through an evidence-based approach, that spatial plans at local and regional level could maintain the ecological condition of VEC, by preserving and enhancing inter-urban green infrastructure (e.g. open spaces, natural fringes, vegetated plots, etc.) and promoting the creation of new greenspaces.

However, all indicators demonstrated that spatial plans under weak coordination with other relevant PPPs (combinations 1 and 8), even though regionally driven (case *b*), may cumulatively contribute to negatively affect the regional green infrastructure (VEC), leading to an incremental degradation of its functions. Therefore, a stronger integration between local and regional spatial plans and other PPPs (in particular under combinations 4 and 5) seemed to be required in order to ensure the multi-functionality of VEC over the case study region (i.e. controlling surface runoff, regulating local climate and conserving biodiversity). Additionally, a better coordination between regional spatial plans and local level decisions seemed to be further required to ensure that the enhancements of VEC are achieved and, then, implemented.

In particular, the application suggested that existing thresholds as the regional soil-regeneration adopted in order to control the phenomenon of urban sprawl (see note 2 in Chapter 6), could be coupled with regional enhancement targets such as the average emissivity or surface runoff as those proposed, assuming, for instance, the baseline condition as the maximum allowable limit, and then, ensuring that, at least, the condition does not worsen. However, due to the large regional scale and different patterns of development, targets should be: on the one side, tailored for particular sub-areas (e.g. rural sectors, high build-up areas, etc.) or land use types (parks, pastures, etc.); and, on the other, shared and 'negotiated' between different administrative levels, allowing them to be translated into operational measures (e.g. ecological compensations/restorations, etc.).

In addition, the application of indicators proposed a suitable approach to support both 'how' and 'where' enhancement measures could be addressed over the region. Firstly, several LUC types, mainly those with a significant tree cover (i.e. woodlands, parks and gardens in good conditions; arable land with significant presence of trees, etc.), resulted particularly important in regulating both surface runoff and local climate due to their lower values; as well as in preserving biodiversity. And this suggested that the ecological restoration in peri-urban regions may be addressed trough SEA as a means to achieve several cumulative benefits due to: the compensation of urban growth; the likely avoidance of significant negative consequences at regional scale (flooding risk, biodiversity loss); and the adaptation of region to climate change (see also Gill *et al.*, 2007).

Secondly, spatially explicit indicators showed that the effectiveness of enhancements rely on their pattern and spatial distribution. For instance, open spaces showed to be more effective in mitigate surface runoff if co-located in high infiltration soils and/or planned in river and irrigation ditch banks, flooding areas, etc. Therefore, restrictions on local developments should be achieved where soils have a high infiltration capacity in order to favorite water infiltration. However, this may be not desirable for the overall region, as there may be sectors where the potential impact on soil and groundwater from nonpoint source pollution load is preferred to be avoided. And this also applied to the evapotranspirating patterns, since the indicator showed an improvement only if vegetated surfaces were co-located in soils with a high available water capacity, suggesting, for instance, that preserving and enhancing the rural pattern over the eastern part of the region may be crucial to regulate local climate.

7.4.3 Uncertainty discussion

The prediction of large-scale issues and future time frames involved both scientific and policy uncertainties (Figure 7.22). The first mostly included methods and data applied to simulate CE on VEC and exogenous factors which could contribute to additional changes. Whilst the second mainly referred to the effectiveness of management measures and the success of collaborative efforts on which assumptions of future management scenarios based on (see also § 6.7.2).

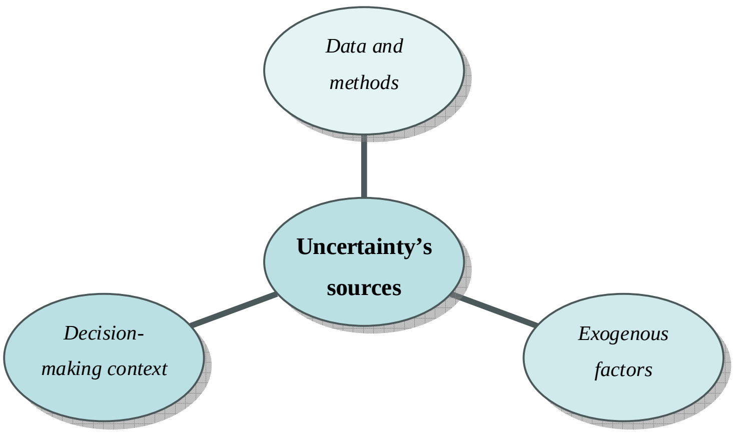


Figure 7.22: Sources of uncertainty

The predicted results may be firstly biased as a consequence of lack of data, resolution of spatial information and methods applied to compute indicators which simplify complex environmental processes and dynamics (e.g. hydrological cycle, energy exchanges, etc.).
In particular, surface runoff and evapotranspiration indicators were influenced by a large variability of soil hydrological conditions such as the curve numbers (CN) and the available water capacity (AWC) respectively assigned to different land use and soil types. The emissivity index resulted mainly influenced by a scale bias issued from the crossing of raster satellite data (resolution: 60m) and vector land cover map (scale 1:10,000). Finally, the ecological connectivity indexes were affected by the selection of land use types, especially for ‘stepping stones’.
In addition, there may be exogenous factors affecting predictions and, thereby, contributing to increase the level of uncertainty. With respect to the case study region and the selected VEC, under particular concern is the variation of future climate conditions as climate change is expected to contribute to: an intensification of precipitation in terms of intensity; and an increase of air temperature over the case study region during the next century (IPCC, 2001). However, predicting those consequences in a quantitative way may require a large amount of information and complex models which are out of the purpose of the proposed approach. Nonetheless, to provide an example of the level of uncertainty correlated to a likely change of climate conditions, the runoff indicator was recalculated, by assuming an increment of precipitation’s intensity[4].
According with the model used (see BOX 1 in § 7.2.1), results showed a direct increase of surface runoff with precipitation’s intensity for all scenarios ranging from an average value of 0,60 under scenarios 4 and 5 to 0,86 under scenarios 1 and 8 (Figure 7.23). However, the variability of the average runoff among different LUC scenarios tended to decrease with the augment of precipitation’s intensity as a consequence of the minor role of vegetated areas and open spaces in mitigating greater precipitation events, suggesting that enhancement measures, even though generally considered as climate adaptations (see also Gill *et al.*, 2007), required to be coupled with a broader strategy in order to face on future climate conditions and consequences (e.g. risk of flooding, etc.). Nevertheless, considering the large variability of the average values under each different scenarios, a range of values rather than an unique measure could be associated to each surface runoff average values in order to reasonably account for future climate uncertainties.

[4] Three additional values of precipitation were selected, besides the value previously used to compute the indicator (see § 7.2.1). They were extracted from the IDF curves (Intensity Duration Frequency) for the region referring to three different return periods of a precipitation event: 10 years (value used to design an urban drainage system networks); 100 years (value used to foresee flood events in rural areas); the 100 years plus an increment of the ratio between the two previous extracted values (10 and 100 years).

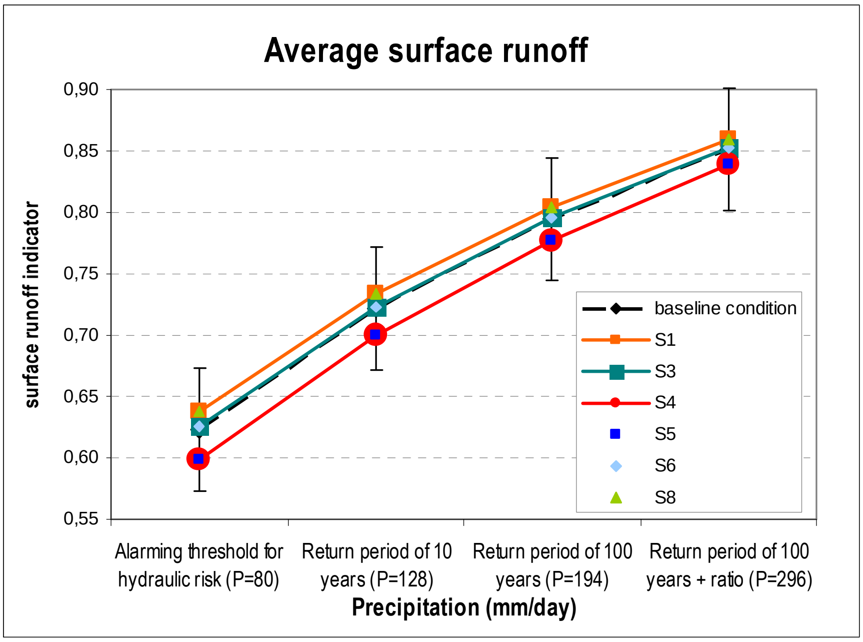


Figure 7.23: Weighted average surface runoff under different LUC scenarios and precipitation events

7.5 Summary of the application of the proposed approach

During the last 15 years the region has experienced an unprecedented conversion of agricultural land into urban areas due to an incessant demand of land majorly for housing and transportation, fuelled by globalised economics and private real estate interests. However, the area is mostly characterised by low-density urban patterns, rural-urban fringes and scattered semi-natural areas which are playing an important role for the regional ecology.

Firstly, the regional green infrastructure has been selected as that resource particularly valued for the community and vital to the healthy functioning of the environment (VEC). In particular, a trend analysis of the expected encroachment of rural areas and open spaces due to small local developments has allowed the significance of this nibbling degradation of VEC to be assessed against the *soil-regeneration threshold* (i.e. maximum acceptable land take assuring the multi-functionality of soil: production, landscape character, naturalness, water availability, etc.). Secondly, three relevant '*other foreseeable future actions*' (i.e. planned highway transportation corridor, the conservation plans of protected areas, and several rural policies) have been identified with respect to their likely contribution together with the spatial plan to changes on VEC. Thirdly, two reasonable planning alternatives and a range of future land use scenarios have been developed, assuming a different level of coordination among local and regional spatial plans, and simulating their implementation under different level of integration of those PPPs previously selected. Then, by adopting a land cover type approach, they have been made spatially explicit, starting from a couple of regional land use maps. Fourthly, a core set of indicators, mainly quantitative and spatially explicit, have been proposed to predict the regional cumulative effects on VEC (e.g. surface runoff, surface emissivity, ecological connectivity etc.). They have been all selected and computed starting from land cover data, allowing the combined effects to be quantified and land use scenarios to be compared.

The comparison of the performances of different land use scenarios has showed that a greater integration between local and regional spatial plans and other PPPs is actually required in order to ensure that the regional green infrastructure (VEC) maintains its role in preserving important environmental services over the case study region (i.e. controlling surface runoff, regulating local climate and conserving biodiversity).

In particular, although the soil regeneration threshold was expected to be exceeded in all land use scenarios as a consequence of the overall implementation of the expected small local land use changes, the results have majorly illustrated the role of VEC in facing on important regional environmental consequences, by anticipating and mapping how different expected changes of natural and semi-natural patterns (VEC) performed under different future conditions, foreseeing that:

1. the only coordination among local and regional spatial plans (scenarios 1a, 1b, 8a, 8b) could be not enough, not only in avoiding soil regeneration threshold to be exceeded, but also in preserving all the environmental services considered (e.g. ecological connectivity, regulating of water balance, etc.). In fact, all the indicators performed worst with respect to the baseline condition;
2. a strong role of protected area conservation plans (S3a, S3b, S6a, S6b) could be not enough effective in containing urban developments. However, indicators have showed that the enhancement of VEC within the regional protected network could be of particular benefit to the control of surface runoff and, to some extent, to the regulation of local climate. While for the biodiversity issues, the results have suggested a general improvement of the overall compactness of semi-natural patches, even though more detailed studies seemed to be required at lower tier assessment;
3. a great integration between spatial plans and relevant PPPs (scenarios S4a, S4b, S5a, S5b) showed the best performance among scenarios and with respect to the baseline condition. In fact, even though the soil regeneration threshold will be exceeded, if enhancement of VEC are expected, not only in regional protected and rural networks, but also along river corridors, irrigation ditch banks, etc., indicators have showed a great improvement of VEC in both controlling surface runoff and regulating local climate. While for the biodiversity issues, indicators have suggested the need of more detailed studies, as in case of previous scenarios.

Chapter 8

8 Conclusions

This dissertation started from the hypothesis that there is a gap between SEA theory and practice in treating cumulative effects. In fact, while the substantive nature of SEA has been broadly emphasised as a proactive means to treat cumulative effects, SEA practice seemed to remain far from achieving this intention. In the light of this, the main purpose of this research was to develop and apply a methodological approach to improve the consideration of cumulative effects in SEA of spatial plans, with particular reference to the Italian spatial planning system and urban regions.

This overall goal was achieved by pursuing the following specific objectives:

1. to understand how SEA for spatial planning works in practice;
2. to explore how CE are currently treated in SEA of spatial plans;
3. to develop a methodological approach to improve the consideration of cumulative effects in SEA of spatial plans;
4. to apply the proposed approach to a case study, by empirically testing its applicability.

8.1 Reconsidering CE in SEA of spatial plans

The review of current literature has demonstrated a lack of conceptual and methodological frameworks for treating strategic level CE, suggesting the need to firstly provide a rationale for the inclusion of CE into the spatial planning context, by '*contextualising*' its overarching concept. Then, the importance to consider cumulative effects in spatial planning has been advised as mainly relying on:

- its hierarchical tiering, being spatial planning general based on tiered systems whose decisions could mutually interact between different decision-making levels, giving higher levels the opportunity to manage the cumulative consequence of lower tiers;
- the kind of actions under spatial plans' agenda which often concern small developments and actions individually minor and, mainly not subjected to EIA (e.g. housing, retail and road developments), but collectively significant in terms of environmental consequences (e.g. land take, biodiversity loss, etc.).

Accordingly, having SEA the opportunity to support a better management of scale-lag effects arising from small local decisions; two crucial considerations have emerged. The first referred to the requirement of adopting a more resource-based approach, by focusing and 'enlarging' the assessment of CE only for key resources. The second regarded the need to better orient the assessment of CE towards the future, by adopting a more adaptive perspective, allowing reasonably foreseeable futures to be, firstly, based on feasible operational measures and secondly, explored.

Moreover, given the intrinsic spatial nature and the importance of the management of space for spatial planning, a third consideration dealt with the integration of 'spatial evidence' into an SEA methodology and process, suggesting several opportunities of adopting a spatially explicit approach for better treating strategic level CE (§ 2.4.3).

In addition to what has emerged from academic literature, a gap with respect to the treatment of CE in SEA practice has further came out from the results of the international expert survey and the review of SEA reports, confirming the need to advance the investigation on this topic.

The first has allowed important trends in current SEA practice to be highlighted with respect to the overall SEA process, and the treatment of CE, including both contextual and methodological aspects. Whilst the second has further targeted the research to relevant methodological aspects (e.g. CE and strategic aspects, assessment approaches and methods, etc.), by exploring whether and how CE are considered in SEA of Italian and English local and regional spatial plans.

By integrating the overarching findings, it has been concluded that:

1. a better CE scoping could improve to: deal with scale-lag effects, by capturing those minor effects which may become significant at higher level; provide evidence to the selection of VEC, by defining trends and thresholds; and increase the management capacity of CE, by identifying those relevant other PPPs which could share blames to face on CE;
2. a future-oriented approach could be of benefit to SEA in treating strategic CE and managing the uncertainty characterising future decisions and complex effects, by supporting the definition of reasonable planning alternatives, including assumptions on foreseeable management responses to CE such as mitigation/compensation and enhancement measures (e.g. habitat restoration, sustainable water drainages, etc.);
3. a baseline-led approach could advance the treatment of CE, by supporting inter-tier decisions through more evidence. Additionally, spatially explicit approach could further add spatial evidence to land use decisions, by helping to manage CE through the spatial simulation of future developments and their likely effects.

These considerations have been the major inputs for the development of the methodological proposal whose general advantages and limitations are following discussed.

8.2 Advantages and limitations of the proposed methodology

The main advantage of the proposed framework is that its tasks could be appropriately integrated into common practice, supporting a better consideration of CE into the ordinary stages of SEA. Nonetheless, it has only covered preliminary SEA steps, by assuming that the earlier CE are addressed the better they are considered. And this is only partially the case, considering that it has disregarded one of the most important step for the management of CE, namely follow-up or monitoring, neglecting a proper linking between preliminary assumptions and predictions with likely remedial actions which should be triggered if the outcomes of what was most likely proved false, as in sound adaptive environmental management.

At the conceptual heart of the framework is the Valued Ecosystem Components (VEC), being the selection of those vital resources at the core of the tasks proposed. And this is to ensure that the key of the CE assessment is the VEC as, on one hand, it would be ineffective and resource-consuming carry out this analysis for each environmental issues such as listed by the EU-SEA Directive; and on the other, relevant concerns may vary with physical context and planning issues, further encompassing aspects with a social or economical values (e.g. recreational areas, local communities, sensitive categories of people, etc.).

As for the identification of those relevant PPPs, it has been suggested to adopt a management perspective, by selecting them, not only based on their role in likely contributing to cumulative negative and positive consequences on VEC; but also on their capacity in managing those consequences (avoiding or enhancing) through effective planning tools and instruments. And this has the advantage to: firstly, ensure that relevant '*other foreseeable future actions*' influencing the VEC are considered as in common SEA practice is seldom the case; and, secondly, support a better triggering of management actions, by earlier exploring likely and feasible management tools which can be effectively addressed though SEA (compensations, enhancements, etc.). In addition, the method has recommended to establish the spatial extent and the areas of influence of those selected relevant PPPs, at least for those characterised by a direct spatial explicitness.

Relating to the definition of spatial planning alternatives and future conditions, the proposed approach has suggested to explore what if the effect will be according to different level of implementation of both spatial plans and relevant PPPs, assuming the effects of different combinations of PPPs on VEC as cumulative and adopting a management perspective. Moreover, it has been proposed to make future conditions (i.e. planning alternatives and future land use scenarios) spatially explicit, at least for those decisions characterised by a direct spatial explicitness. And this is to add 'spatial thinking' to decision-makers in order to improve the understanding and the perception of the spatial cumulative consequences of their decisions.

However, on the one hand, not all decisions may be easily made spatially explicit as there may be strategic actions significantly contributing to CE on VEC which could be not directly convertible into maps. And, on the other, the definition of future alternatives may be hampered by the indeterminacy of future, involving a limited understanding and predictability of possible future dynamics; as well as their subjection to arbitrary institutional and societal choices.
Concerning the assessment of CE on VEC, the approach has proposed to make use of quantitative indicators, by selecting them based on their suitability to describe changes on VEC in terms of pattern and/or feature. And this is to support the comparison of alternative future scenarios through a more evidence-based identification of regional cumulative effects on VEC arising from *minor actions* which in common practice resulted particularly disregarded. However, being indicators VEC and scale dependant, as well as likely affected by bias, they must be carefully selected and thoroughly computed.

8.3 Lessons learned from the case study

The general framework has been tested in a case study selected in the peri-urban region of Milan, reproducing the similar structural patterns and socio-economic features of the central European urban region with significant environmental problems arising from an intensive use of land (e.g. poor air quality, traffic congestion, noise, etc.). The major lessons learned are following portrayed.

Firstly, the application has showed how the resource-based approach can better support SEA to only focus on relevant key issues such as the case of the regional green infrastructure, by supporting to expand the scoping of environmental and policy boundaries only for it and improving the consideration of relevant '*other foreseeable future actions*' and the analysis of their likely combined consequences on during the overall application.
In addition, other VECs could be identified with respect to the study area. For example, if air quality had been further selected as VEC due to it is frequently closed to breach a threshold (e.g. concentration of fine particulate matter, nitrogen oxides), other projects such as waste treatment plants could be selected due to their likely role in cumulatively contributing to decrease air quality. While the road corridor would play a different role with respect to the regional green infrastructure. Furthermore, the regional transportation plan and a range of health and safety policies could be selected do to their relevant role in promoting sustainable urban transport trough new public transportations and incentives to healthier life styles, cumulatively contributing to improving air quality. However, the boundaries would required to be expanded as that issue likely concerns an interregional area (i.e. Po valley) both in terms of

environmental consequences and management. Consequently, although the method has been applied in a peri-urban case study and tailored for the selected VEC (regional green infrastructure), it appears suitable to other case study areas, at least reproducing the same urban and peri-urban patterns; as well as to other VECs.

Secondly, the application has showed an operative approach in order to define planning alternatives and future scenarios, by adopting a land use cover type approach allowing policies and decisions to be transferred into maps through a straightforward GIS-based way. Nonetheless, being one of the criteria driving the selection of relevant '*other foreseeable future actions*' their spatial explicitness, it is worth noting that there might be other decisions contributing to CE on VEC which could have been neglected. However, the land use cover type approach has provided the opportunity to:

- base the definition of planning alternatives and future land use cover scenarios on reasonable assumptions as required by the SEA Directive;
- support the envisagement of enhancements and positive CE; and
- add spatial evidence to decisions whose consequences are seldom mapped such as the likely enhancement of urban green spaces, the restoration of rural areas, etc.

As for the development of planning alternatives, the reasonable assumptions have been mostly based on:

1. firstly, the mutual interaction between regional and local spatial plans, by generating two alternative standing on different coordination among local and regional levels in terms of housing development and public services (i.e. urban green spaces);
2. secondly, the relative influence of these two planning levels with respect to different planning issues, having local level decisions the upper hand on urban and housing issues;
3. thirdly, the irreversibility of transformations from non urban to urban uses, having the increase of their land value a direct consequence on land revenue and land use change.

However, the two planning alternatives developed have not encompassed a comprehensive range of reasonably foreseeable options for the region, being mostly generated to test the applicability of the approach. Therefore, additional assumptions can be underlined in order to improve the exploration of alternative patterns of futures, including for instance: the enforcement of urban growth on previously development lands, the provision of other services (new railway stations, retail, commercial areas, etc.); the different degrees of implementation of local small developments, etc.

As for the generation of land use scenarios, the assumptions have been mostly based on the implementation and integration of other PPPs with spatial plans (e.g. whether or not the

highway corridor will be realised, strong and week role of protected areas conservation plans and rural policies in supporting the improvement of VEC). On the one hand, the simulation of the enhancement of VEC through the creation, preservation and restoration of vegetated surfaces (residual natural and semi-natural areas, rural fringes and parks) within particular sectors of the region (e.g. regional rural network, protected areas, etc.) has suggested a good way to support SEA not only in mitigating and compensating negative cumulative consequences, but in further spatially driving positive management solutions and enhancements which in current practice seemed to be completely disregarded. On the other hand, it has appeared that the assumptions should be better linked up with resource-based limits and operative tools in order to support the identification of effective remedial actions if they are proved untrue. And this should further support to better tackle the uncertainty characterising the effectiveness of future decisions, being the way in which a policy will be implemented among the most cited source of uncertainty in common SEA practice.
Additionally, the generation of future scenarios has not encompassed trends unrelated to specific planned decisions, even though they may often be significant for the VEC such as: the people lifestyle influencing the preservation of rural areas by supporting local food production or the variation of the climate conditions which can influence the regulating services provided by the regional green infrastructure. However, the application has suggested that the enhancements of VEC may be, to some extent, deemed as adaptation measures to climate change, being the role of the green infrastructure largely agreed as important in order to adapt cities and urban regions to unexpected consequences of future climate (see also Gill *et al.*, 2007).

Thirdly, the application has showed a straightforward way to quantify and compare regional cumulative effects on VEC of different land use scenarios through the use of quantitative and spatially explicit indicators.
In particular, they have seemed mainly suitable in supporting to:

- suggest resource-based targets such as the average emissivity or surface runoff values, and therefore management measures (e.g. restoration of open spaces, creation of higher standard urban green areas, improvement of rural areas, etc.), in order to ensure the condition of VEC does not worsen;
- address both ‘how’ and ‘where’ enhancement measures could be implemented, showing, for instance, that several land use types (e.g. woodlands; arable land with significant presence of trees, etc.) could be particularly important in regulating both surface runoff and local climate and preserving biodiversity at regional scale; or that the

enhancements could be more effective if located in particular sectors of the region (e.g. areas with high infiltration soils, irrigation ditch banks, etc.);

- inform lower tier assessments, suggesting for instance the requirement of more detailed analysis for several issues as indicated by ecological indexes;
- confirm that a greater inter-sectoral and inter-institutional effort is required in order to manage combined consequences on key resources.

However, the application has discussed how the indicators may be affected by limitations as well as bias, showing how the results varied if several inputs had been differently fixed (see § 7.4).

Finally, mainly due to time constraints (the extent of the research period), the application has not had the opportunity to follow a real-life spatial planning process. However, the awareness achieved on SEA and spatial plans during the research period, especially in respect of the Italian context, on the one hand, has supported to develop a more soundly and ‘fit for the purpose’ approach; and on the other, has allowed several important considerations to be advanced with respect to the potential application of the approach into real-life SEA procedure as following discussed.

8.4 Implementing the methodology in SEA practice

This section advances a number of considerations potentially related to the application of the methodological approach in common SEA practice. They are mostly listed according to those SEA stages which the tasks are proposed to be integrated in, namely: CE scoping, definition of CE future conditions and prediction of CE.

Firstly, the SEA scoping should include the selection of VEC and the identification of those other relevant PPPs. These tasks can be largely supported by the consultation with environmental agencies, local stakeholders, public administrations and organisations, etc. which, at least with respect to the Italian SEA system, occur more frequently during the preliminary SEA stages.

Referring to the selection of VEC, its significance can be assessed through a baseline trend analysis or, well again, compared to a threshold in order to support a more evidence-based selection as demonstrated in the case study. However, the application had the opportunity to apply a well established and existing regional threshold. And this could be not always the case since the assessment can be hindered by a lack of such thresholds, especially in quantitative terms and for particular VEC (e.g. ecosystems, sensitive areas, etc.) and establishing maximum levels of change that they can withstand before the desired conditions of ecological functioning

and human quality of life deteriorate could be out of the feasibility of SEA practice mainly due to lack of time and resources. Additionally, considering that those important limits can drive the management as well as the monitoring of CE, by suggesting measures and tools (e.g. compensations, remedial actions) to avoid their breaching (for negative CE) or achievement (for positive CE), it is worth noting that they required to be largely shared among decision-makers and stakeholders in order to be effectively integrated into local decisions. As for the case study, the *soil regeneration threshold* has been established by the regional spatial plan as a management tool to face on cumulative consequences arising from local small decisions, restricting or constraining the local developments through an evidence-based instrument. However, it appeared that this kind of regional strategies required to be widely shared between different spatial planning tiers in order to be effectively translated into local operational mandates, otherwise local planning processes turn into a negotiation with higher tier in order to amend those limits through multi-scale trade-off based on political and private interests, especially for Italian decision-making context.
In addition, the selection of VEC can be further supported by qualitative assessment techniques (e.g. Delphi methods, virtual maps, etc.), in order to establish how it is perceived by stakeholders, or in other terms, its relative importance for that particular region, encompassing the involvement of experts and different target or range of public. However, even though these additional tasks can improve the transparency of the process, there can be not enough interest in carrying out them as they result often perceived ineffective and resource-consuming by both stakeholders and decision-makers.
Referring to the identification of other PPPs, a screening of those relevant other planning actions which together with the spatial plan could contribute to CE on VEC can start from the list of the most important plans and programmes usually carried out in scoping documents in order to outline the relationship with other relevant plans and programmes as required by the EU-SEA Directive. Subsequently, their scoping can be enlarged for the selected VECs, encompassing projects and exogenous factors. And this seems to be particularly suitable in SEA current practice as requiring a minimum effort. However, the selection of other PPPs does not merely imply to identify an action likely contributing to CE on VEC, but to additionally support the selection of those appropriate instruments which can be envisaged to avoid negative CE, as well as to enhance positive benefits. And this can be largely hampered by fragmented and uncoordinated instruments among different planning levels (e.g. isolated compensations based on local trade-off; different building regulations; etc.).

Secondly, the definition of spatial planning alternatives and future conditions can support the regional spatial planning process, by improving the exploration of different ways to manage crowding effects arising from minor decisions and highlighting spatial conflicts and potential solutions. And this could be further add spatial evidence to small decisions, leading to facilitate a better negotiation between regional and local spatial planning tiers, as well as a better coordination among spatial planning and environmental resources management, being the regional spatial planning process based on inter-institutional and inter-sectoral meeting and accords. However, even though the method has provided a suitable way to help the discussion on both the regional future development and the likely environmental CE, this task seems the most difficult, among those proposed, to carry out in practice. And this mainly relies on the limited remit of SEA in proactively support the plan to introduce reasonable assumptions on both: urban issues, as proposed for generating spatial planning alternatives, and environmental management as proposed for the development of future scenarios. On the one hand, a lack of higher strategies and sustainable targets on urban and housing developments (the national urban act dated 1942) and a traditional strong power and interest of local authorities on those issues are often the main barrier to achieve a cohesive regional spatial development and avoid the negative CE of local small decisions (see § 5.6). On the other hand, the assumptions on the implementation of CE management measures (e.g. enhancement of greenspaces, improvement of rural areas, etc.) and the collaborative inter-institutional efforts on which future scenarios based on, seem to be extremely challenging to set in practice due to a scarce coordination among spatial and sectoral tiers and instruments (e.g. protected areas conservations plans and spatial plans, etc.). Furthermore, the efforts of local decisions in minimising or neutralising negative or enhancing positive effects at regional scale can be perceived ineffective and such uncertain that decision-makers could prefer to not implement them. In addition, although mandatory required, the creation or the improvement of public services (e.g. schools, public green areas, cycle paths, etc.) are frequently neglected due to the lack of long-term perspective and prevailed private interests (building estate companies, local lobbies, etc.).

Thirdly, the prediction of CE can be carried out during the common assessment SEA stages. On the one side, the quantitative and spatially explicit indicators can support SEA practice to add evidence to the predictions and, with respect to the Italian context, this could be particularly of benefit to SEA and spatial plans, being comprehensive regional plans sometimes formulated in fuzzy terms which often threaten to understand and predict what the proposals will imply in practice (see also Geneletti *et al.*, 2007). On the other side, they are based on: freely available data which were all downloadable from the web (e.g. land cover, soil maps, regional environmental reports, etc.); and basic GIS operations (i.e. overlay and map calculation), requiring minimum technical skills and low cost operations, ensuring a good level of reproducibility of the approach in common SEA practice.

In particular, the proposed indicators seemed mainly suitable in supporting to: set resource-based targets for the region or sub-regional sectors, such as the average emissivity or surface runoff; and envisage the 'how' and 'where' of measures to cope with CE (e.g. within the regional rural networks). However, on the one hand, regional limits and targets require to be largely shared as discussed for the selection of VEC; and on the other, they need to be converted into effective adaptive tools supporting the triggering of remedial actions if the outcomes of what was most likely proved false. Consequently, linking those indicators with effective planning measures could be particularly challenging in common practice as monitoring the effectiveness of plan and triggering remedial actions are frequently disregarded. Therefore, according with Thérivel and Ross (2007), the effectiveness of any management measures is primarily determined by individual decision makers and their responsiveness to the CE assessment findings. Then, cumulative effects are only managed if decision makers decide that they should be managed, and if they have the clout to impose management measures. Accordingly, even though the proposed approach put the 'ingredients' to clear the way for a better treatment of CE in SEA of spatial plans, more research is actually needed, especially in order to support the exploration of future ways to manage CE and associated uncertainty; and ascertain the effectiveness of SEA in managing CE as following advanced.

8.5 Recommendations for further research

There are several directions for further research with respect to the topic of this work. Among others, two of them should receive the priority:

1. the exploration of future ways to manage CE and associated uncertainty;
2. the investigation of the effectiveness of SEA in managing CE.

The first appears crucial to improve the proposed approach, by further covering those SEA stages not included in, and providing a more comprehensive perspective to the management of CE in practice. The second seems fundamental to test whether or not SEA could have any discernable impact on the management of CE and, subsequently, on the environmental quality of the region in which the spatial plan would be applied.

The benefit to predict CE of different future scenarios, and, thereby, the opportunity to support decision-makers to strength awareness about future cumulative consequences, has been showed and discussed through the application of the proposed approach. However, the approach has showed several limitations that could be improved, particularly with respect to the treatment of the uncertainty characterising both decisions, assumptions and predictions.

To improve the treatment of the institutional and societal uncertainty (or volition), the extension of the approach to the overall SEA process is proposed, by including SEA follow-up.

Among others, the resource-based indicators can be, firstly, linked with a core set of multi-tiered management measures and remedial actions (e.g. ecological compensations; growth on previously developed land; new renewable energy sources, etc.) tailored for the selected VEC. And secondly, their suitability and feasibility could be proactively assessed through a multicriteria analysis in order to support the most desirable measure to be envisaged, and the most desirable action to be triggered. And this could allow the robustness of future response options to be better tested, by encompassing, for instance, expert opinions (e.g. renewable energy source to be preferred among different, etc.) and public participation (e.g. allocation of new green areas).

To support planning in proactively facing on unexpected consequences such as extreme climate events, economic instabilities ('real estate bubble', etc.), assumptions on relevant exogenous factors can be introduced, by exploring CE arising from surprising future events. One possible approach to do it is to make use of visioning and participatory techniques during the definition of future scenarios in order to explore what the future situation will be, by going beyond the business as usual future. In doing so, the role of spatial information and techniques would shift from decision support systems to discussion support systems (de Wit *et al.*, 2009), by enlarging the thinking of stakeholders towards what may or may not necessarily occur.

To improve the uncertainty characterising predictions, a sensitivity analysis may be introduced in order to test the robustness of results and the validity of assumptions, by changing crucial inputs parameters as briefly advance in § 7.4 through the simulation of surface runoff indicator under alternative precipitation events.

Lastly, it would be important to test in an extensive way the proposed methodology during the SEA real-life process. Accordingly, the ideal way for such an analysis is to set a series of surveys to explore strengths, weaknesses, opportunities and threats both in technical and non-technical terms in order to test to what extent the method has fulfilled the purpose. In particular, different stakeholders might be involved (SEA practitioners, planners, public administrators, environmental agencies, etc.) and questions of surveys might vary based on their expertise on the topic.

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Appendices

Appendix 1 contains the questionnaire distributed among experts described in Chapter 3.

Appendix 2 contains: the review framework, the list of SEA reports and the synthesis of the results relating to the review described in Chapter 4.

Appendix 3 contains a detailed description of the land use cover scenarios presented in Chapter 6, by reporting land use cover change rules. It further includes an in depth description of land use cover scenarios in terms of percentage surface and pattern.

Appendix 4 contains a detailed description of the performance of land use cover scenarios presented in Chapter 7, including the emissivity values used to compute the emissivity index and the results of indicators (land take, surface runoff, emissivity and evapotranspiration) for each scenario.

Appendix 1

International expert survey

SEA and cumulative effects: practices, developments, suggestions

The information derived from this questionnaire will be part of an on going PhD project on the design of a methodology to support the prediction of cumulative effects in the Strategic Environmental Assessment process of spatial plans. The individual answers will be kept confidential. The treatment of results collected in the questionnaire will, however, be published in the final research document.

Name:____

Position:____

Country of activity:____

1) How many SEA processes have you been involved in/commented on/reviewed?
   ☐ Less than 10 ☐ Between 10 and 30 ☐ more than 30

2) How many Strategic Environmental Reports (ERs) have you read?
   ☐ Less than 10 ☐ Between 10 and 30 ☐ more than 30

Based on your experience with SEA:

3) Are the following SEA stages adequately addressed in the ER:
   a. Scoping
   ☐ Yes, satisfactory ☐ No, not satisfactory ☐ Occasionally satisfactory

Comments____

   b. Definition of SEA objectives
   ☐ Yes, satisfactory ☐ No, not satisfactory ☐ Occasionally satisfactory

Comments____

   c. Definition of alternatives/options
   ☐ Yes, satisfactory ☐ No, not satisfactory ☐ Occasionally satisfactory

Comments____

   d. Prediction of effects
   ☐ Yes, satisfactory ☐ No, not satisfactory ☐ Occasionally satisfactory

Comments____

e. Proposition of mitigation or compensation measures
☐ Yes, satisfactory ☐ No, not satisfactory ☐ Occasionally satisfactory

Comments____

f. Monitoring/Follow-up
☐ Yes, satisfactory ☐ No, not satisfactory ☐ Occasionally satisfactory

Comments____

g. Consultation and public participation
☐ Yes, satisfactory ☐ No, not satisfactory ☐ Occasionally satisfactory

Comments____

4) Prioritise the most frequent environmental issues (up to five), among those listed in Annex 1 of EU-SEA Directive, that have been most extensively dealt with:

☐ Biodiversity ☐ Population ☐ Human health ☐ Fauna and flora
☐ Soil ☐ Water ☐ Air ☐ Climatic factors
☐ Cultural heritage ☐ Landscape ☐ Interrelationships?

Comments____

5) Prediction/assessment methodologies applied in ERs have been generally based on:

☐ matrices ☐ checklists ☐ GIS
☐ scenario analysis ☐ MCA ☐ sensitivity analysis
☐ modeling ☐ causal-effects analysis ☐ Combination of methods

6) If combination of methods, prioritise the three most frequently applied:

☐ matrices ☐ checklists ☐ GIS
☐ scenario analysis ☐ MCA ☐ sensitivity analysis
☐ modeling ☐ causal-effects analysis

Comments____

7) How often ERs have considered cumulative effects:

☐ always ☐ frequently ☐ occasionally ☐ never

8) How often in ERs uncertainty has been addressed (assumptions/impact predictions):

☐ always ☐ frequently ☐ occasionally ☐ never

9) How often ERs have included spatial contents?

☐ always ☐ frequently ☐ occasionally ☐ never

10) Prioritise the most frequent SEA stages (up to four) in ERs where GIS and spatial techniques are applied:

- Scoping
- Definition of SEA objectives
- Definition of options
- Prediction of effects
- Proposing mitigation or compensation measures
- Monitoring/Follow-up
- Consultation and public participation

Comments____

11) Prioritise the most frequent environmental issues (up to five), among those listed in Annex 1 of EU-SEA Directive, that have been *mostly mapped* (for scoping and/or for assessing the likely significant effects on them) (*the question differs from n.4; difference is remarked by italics*):

Biodiversity	Population	Human health	Fauna and flora
Soil	Water	Air	Climatic factors
Cultural heritage	Landscape	Interrelationships?	

Comments____

12) Has any specific technique been applied in order to scope, predict or assess cumulative effects?

Yes not often not at all

Comments____

13) Has any of the following techniques been applied in order to define alternatives/options?

Workshops	Expert opinions	Scenario analysis
SWOT analysis	others	

Comments____

14) Has any of the following methods been applied in order to address uncertainty?

Expert opinions	Scenario analysis	Sensitivity analysis
others		

Comments____

15) Could GIS maps and spatial techniques:

a. Help to better understand environmental issues?
   Yes maybe not at all

Comments____

b. Help to treat (identify, predict and assess) cumulative effects?
   Yes maybe not at all

Comments____

c. Help to uncover uncertainty?
☐ Yes ☐ maybe ☐ not at all

Comments____

d. Support in the visualization of SEA objectives?
☐ Yes ☐ maybe ☐ not at all

Comments____

e. Assist in the visualization of alternatives/options?
☐ Yes ☐ maybe ☐ not at all

Comments____

f. Assist in the assessment of alternatives/options?
☐ Yes ☐ maybe ☐ not at all

Comments____

g. Support in the visualization of mitigation or compensation measures?
☐ Yes ☐ maybe ☐ not at all

Comments____

h. Contribute to monitoring/follow up? (Even though it could be early to provide this info)
☐ Yes ☐ maybe ☐ not at all

Comments____

i. Assist public participation and consultation processes?
☐ Yes ☐ maybe ☐ not at all

Comments____

16) Could you provide for:

a. three examples of ERs that have included spatial contents.

____

b. one (or more) ER example where GIS or spatial techniques have contributed to the assessment of cumulative effects.

____

c. one (or more) ER example where GIS and spatial techniques have contributed to defining alternatives/options and predicting their effects.

____

Thank you for your collaboration.
Chiara Bragagnolo

Appendix 2

Review of SEA reports

The review framework

Does SEA report:

1. include any explicit definition/consideration of CE?
   □ Yes □ No □ Partially
2. follow any term of reference for the treatment/assessment of CE?
   □ Yes □ No
3. separately treat CE?
   □ Yes □ No
4. describe how reasonable alternatives were identified, considering objectives and scope of the plan?
   □ Yes □ No □ Partially
5. identify other PPPs (in CEA literature referred to as current and reasonable foreseeable future actions) which together with the plan have the potential for CE?
   □ Yes □ No □ Partially
6. predict the combined effects of different alternatives/options?
   □ Yes □ No □ Partially
7. consider ways of mitigating/compensating CE?
   □ Yes □ No □ Partially
8. predict the effects of their likely implementation?
   □ Yes □ No □ Partially
9. provide information on uncertainty?
   □ Yes □ No □ Partially

When does SEA report:

1. analyse potential CE?
2. predict potential CE?

How does SEA report:

1. identify potential CE?
2. identify alternatives/options?
3. predict CE?
4. uncover uncertainty?

List of UK and Italian SEA reports consulted

ID	Plan	SA/SEA document	Date
UK1	Regional Spatial Strategy for the South East (South East Region)	Final Revisions and Final South East Plan – Sustainability Appraisal Report	May 2009
UK2	Regional Spatial Strategy for East of England (East of England Region)	Review of the East of England Plan – Integrated Sustainability Appraisal Report	March 2010
UK3	Local Development Framework of Wigan (North West Region)	Core Strategy 'Preferred options' Sustainability Appraisal Report	May 2009
UK4	Local Development Framework of London Borough of Haringey (London Region)	Core Strategy 'Preferred options' Sustainability Appraisal Report	May 2009
UK5	Local Development Framework of Test Valley Borough (South East Region)	Core Strategy 'Preferred options' Sustainability Appraisal Report	January 2008
UK6	Local Development Framework of Croydon (London Region)	Scoping Report	December 2008
UK7	Local Development Framework of St. Helens (North West Region)	Core Strategy Publication Draft Development Plan Sustainability Appraisal Report	April 2009
UK8	Local Development Framework of East Hertfordshire (East of England Region)	Core Strategy 'Issues and Options' Sustainability Appraisal Report	April 2010
UK9	Local Development Framework of Maidstone Borough (South East Region)	Scoping Report	March 2006
UK10	Local Development Framework of South Cambridgeshire (East of England Region)	Core Strategy Final Sustainability Appraisal Report	January 2006
ITA1	Provincial Spatial Coordination Plan of Forlì-Cesena (Region: Emilia Romagna)	Provincial Spatial Coordination Plan – SEA Environmental Report	2005
ITA2	Provincial Spatial Coordination Plan of Milan (Region: Lombardia)	Provincial Spatial Coordination Plan – SEA Environmental Report	2002
ITA3	Review of Provincial Spatial Coordination Plan of Cremona (Region: Lombardia)	Review of Provincial Spatial Coordination Plan – SEA Environmental Report	2009
ITA4	Review of Provincial Spatial Coordination Plan of Mantova (Region: Lombardia)	Review of Provincial Spatial Coordination Plan – SEA Environmental Report	2010
ITA5	Provincial Spatial Coordination Plan of Foggia (Region: Puglia)	Provincial Spatial Coordination Plan – SEA Environmental Report	2006
ITA6	Local Spatial Plan of Acerra (Region: Campania)	Local Spatial Plan – SEA Environmental Report	2008
ITA7	Local Spatial Plan of Madesimo (Region: Lombardia)	Local Spatial Plan – SEA Environmental Report	2004
ITA8	Review of local Spatial Plan of Falconara Marittima (Region: Marche)	Local Spatial Plan – SEA Environmental Report	2006
ITA9	Local Spatial Plan of Ferrara (Region: Emilia Romagna)	Local Spatial Plan – SEA Environmental Report	2008
ITA10	Local Spatial Plan of Monopoli (Region: Puglia)	Local Spatial Plan – SEA Environmental Report	2007

Synthesis of the results

ID	CE and key strategic aspects									Stage of consideration		Approach and methods			
	1	2	3	4	5	6	7	8	9	1	2	1	2	3	4
UK1	Y	Y	Y	P	Y	N	Y	N	P	Appraisal of preferred options	Appraisal of preferred options	Analysis of potential cumulative impacts through the identification of causes, thresholds, receptors, other PPPs, mitigations	Qualitative description of regional planning alternatives developed in the plan preparation process	Qualitative discussion (matrix based)	----
UK2	P	Y	N	P	N	N	P	N	P	Thematic and /sub-areas appraisal of growth strategy (preferred options)	Thematic and /sub-areas appraisal of growth strategy (preferred options)	Focus on key issues – planning and environmental	Qualitative description of regional planning alternative developed in the plan preparation process	Qualitative discussion for two levels of detail: thematic appraisal (on sustainability topics) of RSS and sub-areas appraisal	----
UK3	N	Y	N	P	N	N	P	N	P	Appraisal of preferred options	Appraisal of preferred options	Focus on thematic issues and core policy principles	Discussion on reasoning for developing spatial options. Qualitative description of 'thematic options' of preferred spatial option	Sum of core policy principle/site scores (matrix based)	----
UK4	Y	Y	Y	P	Y	N	P	N	P	Appraisal of preferred options	Appraisal of preferred options	Focus on policy options and identification of other PPPs	Qualitative description of spatial options developed in the plan preparation process and development of an additional alternative (BAU) + Qualitative description of policy options of preferred spatial option	Qualitative discussion on: cumulative problems and benefits of Core strategy in combination with other PPPs; CE of the Preferred policy options on SA objectives (matrix based)	----
UK5	N	Y	N	P	N	N	P	N	N	Appraisal of spatial options and preferred options	Appraisal of spatial options and preferred options	Focus on core strategy objectives	Qualitative description of broad locations of strategic development of preferred spatial option	Qualitative discussion on CE of Core Strategy objectives on SA objectives (matrix based)	----
UK6	N	N	N	-	N	-	-	-	N	----	----	----	----	----	----
UK7	Y	Y	Y	P	N	N	P	P	Y	Appraisal of preferred options	Appraisal of preferred options	Focus on Core Strategy Spatial Objectives	Qualitative description of policy options for each issue considered	Qualitative discussion on CE of Core Strategy Spatial Objectives – analysis of potential for the policies to address the sustainability issues (matrix based)	Uncertainty scoring
UK8	N	N	N	P	N	N	P	N	P	----	----	----	Qualitative description of	----	----

ID	CE and key strategic aspects									Stage of consideration		Approach and methods			
	1	2	3	4	5	6	7	8	9	1	2	1	2	3	4
													future development strategy options and visions developed in the plan preparation process (spatially explicit)		
UK9	N	N	N	-	N	-	-	-	N	----	----	----	----	----	----
UK10	Y	Y	Y	P	N	N	P	N	P	Appraisal of preferred option	Appraisal of preferred option	Focus on strategy policies and general policy areas	Qualitative description of policy options for each policy area considered	Qualitative discussion on CE of policies general policy areas on environmental issues (matrix based)	----
ITA1	N	N	N	P	N	P	N	N	N	Prediction of effects	Prediction of effects	Focus on planning and environmental issues	Suitability analysis, transportation models (spatially explicit)	Qualitative discussion on CE of regional plan based on quantitative indicators	----
ITA2	N	N	N	P	N	P	N	N	N	Comparison of planning alternatives	Comparison of planning alternatives	Focus on planning issues	Suitability analysis and transportation model (spatially explicit)	Dashboard aggregated index (combination of different indicators)	----
ITA3	N	N	N	N	N	N	Y	N	P	Prediction of effects	Prediction of effects	Focus on environmental and planning issues	----	Qualitative discussion on negative CE of planning objectives on environmental issues based on quantitative indicators (matrix based)	----
ITA4	N	N	N	N	Y	N	Y	N	P	Prediction of effects	Prediction of effects	Focus on environmental and planning issues; identification of other PPPs	----	Qualitative discussion on CE of planning objectives on environmental issues based on quantitative indicators (matrix based)	----
ITA5	N	N	N	P	N	P	N	N	N	Comparison of planning alternatives	Comparison of planning alternatives	Focus on planning objectives and relevant environmental and planning issues	Qualitative description of implementation of different planning objectives	Semi-quantitative assessment + scores (matrix based)	----
ITA6	N	N	N	P	N	P	P	P	P	Comparison of planning alternatives	Comparison of planning alternatives	Focus on relevant environmental and planning issues	Suitability analysis and transportation model (spatially explicit)	Spatially explicit indicators performed for different future alternatives	----
ITA7	Y	N	N	P	Y	P	P	N	P	Comparison of planning alternatives	Comparison of planning alternatives	Focus on key issues and receptors; identification of relevant PPPs	Qualitative description of implementation of different planning actions	Qualitative discussion on potential CE of different future planning alternatives (matrix based)	----
ITA8	N	N	N	N	N	N	P	N	P	Comparison of future trends of relevant topics without the plan	Comparison of future trends of relevant topics without the plan	Focus on relevant environmental and planning issues	----	Dashboard aggregated index (environmental indicators) for comparing baseline condition and	----

ID	CE and key strategic aspects									Stage of consideration		Approach and methods			
	1	2	3	4	5	6	7	8	9	1	2	1	2	3	4
														future trend (only without plan)	
ITA9	N	N	N	N	N	N	P	N	P	Prediction of effects	Prediction of effects	Focus on relevant environmental and planning issues	----	Qualitative discussion + map overlay	----
ITA10	N	N	N	N	N	N	P	N	N	Assessment of strategic sites	Assessment of strategic sites	Focus on local environmental sub-contexts	Suitability analysis (spatially explicit)	MCA and map overlay	----

Appendix 3

Land use cover scenarios

Land use cover changes rules

Following tables do not include land use cover classes expected to remain the same

COMBINATION 1

Urban transformations – Artificial surfaces

Case a **Case b – within pole municipalities** *Baseline land use cover*	*Expected land use cover*
Discontinuous residential urban fabric	Medium-dense residential urban fabric
Nucleated residential urban fabric	Discontinuous residential urban fabric
Sparse residential urban fabric	Nucleated residential urban fabric
Construction sites Abandoned and degraded sites Gardens and parks Non-agricultural vegetated areas	Discontinuous residential urban fabric
Arable land Permanent crops Pastures	Discontinuous residential urban fabric
Forests	*if within a distance of 200m from urban fabric*: Discontinuous residential urban fabric *if within a distance of 400m from urban fabric*: Nucleated residential urban fabric *otherwise*: Sparse residential urban fabric
Shrubs	Discontinuous residential urban fabric

Case b – outside pole municipalities *Baseline land use cover*	*Expected land use cover*
Construction sites Abandoned and degraded sites Gardens and parks Non-agricultural vegetated areas	Discontinuous residential urban fabric
Arable land Pastures	*if <1 ha surface*: Discontinuous residential urban fabric *if >1 ha surface*: Nucleated residential urban fabric
Permanent crops	Discontinuous residential urban fabric
Forests	*if within a distance of 200m from urban fabric*: Discontinuous residential urban fabric *if within a distance of 400m from urban fabric*: Nucleated residential urban fabric *otherwise*: Sparse residential urban fabric
Shrubs	Discontinuous residential urban fabric

Urban transformations – Urban green areas

Case a and b	
Baseline land use cover	*Expected land use cover*
Mine and construction sites	Gardens and parks – poor conditions
Arable land	Gardens and parks – poor conditions
Permanent crops	Gardens and parks – fair conditions
Permanent pastures Shrubs in abandoned agricultural land	Gardens and parks – fair conditions
Permanent pastures with significant presence of trees and shrubs Broad-leaved forest	Gardens and parks – good conditions

COMBINATION 3

Urban transformations – Artificial surfaces

Case a **Case b – within pole municipalities**	
Baseline land use cover	*Expected land use cover*
Discontinuous residential urban fabric	*if out of protected areas:* Medium-dense residential urban fabric *if within protected areas:* Discontinuous residential urban fabric
Nucleated residential urban fabric	*if out of protected areas:* Discontinuous residential urban fabric *if within protected areas:* Nucleated residential urban fabric
Sparse residential urban fabric	*if out of protected areas:* Nucleated residential urban fabric *if within protected areas:* Sparse residential urban fabric
Construction sites Abandoned and degraded sites Gardens and parks Non-agricultural vegetated areas	*if out of protected areas:* Discontinuous residential urban fabric *if within protected areas:* Nucleated residential urban fabric
Arable land Permanent crops Pastures	*if out of protected areas:* Discontinuous residential urban fabric *if within protected areas:* Nucleated residential urban fabric
Forests Riparian vegetation	*if out of protected areas:* *and within a distance of 200m from urban fabric*: Discontinuous residential urban fabric *and within a distance of 400m from urban fabric*: Nucleated residential urban fabric *otherwise*: Sparse residential urban fabric *if within protected areas:* *and within a distance of 400m from urban fabric*: Nucleated residential urban fabric *otherwise*: Sparse residential urban fabric
Recent forest Shrubs	*if out of protected areas:* Discontinuous residential urban fabric *if within protected areas:* Nucleated residential urban fabric

Case b – out of pole municipalities	
Baseline land use cover	*Expected land use cover*
Construction sites Abandoned and degraded sites	*if out of protected areas:* Discontinuous residential urban fabric

Gardens and parks Non-agricultural vegetated areas	*if within protected areas:* Nucleated residential urban fabric
Arable land Permanent crops Pastures	*if out of protected areas:* *and <1 ha surface*: Discontinuous residential urban fabric *and >1 ha surface*: Nucleated residential urban fabric *if within protected areas:* Nucleated residential urban fabric
Forests Riparian vegetation	*if out of protected areas:* *and within a distance of 200m from urban fabric*: Discontinuous residential urban fabric *and within a distance of 400m from urban fabric*: Nucleated residential urban fabric *otherwise*: Sparse residential urban fabric *if within protected areas:* *and within a distance of 400m from urban fabric*: Nucleated residential urban fabric *otherwise*: Sparse residential urban fabric
Recent forest Shrubs	*if out of protected areas:* Discontinuous residential urban fabric *if within protected areas:* Nucleated residential urban fabric

Urban transformations – Urban green areas

Case a **Case b – within pole municipalities**	
Baseline land use cover	*Expected land use cover*
Mines	Gardens and parks – poor conditions
Construction sites Abandoned and degraded sites	*if out of protected areas:* Gardens and parks – poor conditions *if within protected areas:* Gardens and parks – fair conditions
Gardens and parks Non-agricultural vegetated areas	*if out of protected areas:* Gardens and parks – fair conditions *if within protected areas:* *and <3ha:* Gardens and parks – fair conditions *and >3ha:* Gardens and parks – good conditions
Arable land Permanent crops	*if out of protected areas:* Gardens and parks – poor conditions *if within protected areas:* *and <3ha:* Gardens and parks – fair conditions *and >3ha:* Gardens and parks – good conditions
Permanent pastures Low density broad-leaved forest Recent forest Shrubs in abandoned agricultural land	*if out of protected areas:* Gardens and parks – fair conditions *if within protected areas:* Gardens and parks – good conditions
Permanent pastures with significant presence of trees and shrubs Medium-high density broad-leaved and mixed forest Riparian vegetation Shrubs with significant presence of natural vegetation	Gardens and parks – good conditions

Case b –out of pole municipalities	
Baseline land use cover	*Expected land use cover*
Mines	Gardens and parks – poor conditions
Construction sites Abandoned and degraded sites	*if out of protected areas:* Gardens and parks – poor conditions

	if within protected areas: Gardens and parks – fair conditions
Gardens and parks Non-agricultural vegetated areas	*if out of protected areas:* Gardens and parks – fair conditions *if within protected areas:* *and <3ha:* Gardens and parks – fair conditions *and >3ha:* Gardens and parks – good conditions
Arable land Permanent crops	*if out of protected areas:* Gardens and parks – poor conditions *if within protected areas:* *and <3ha:* Gardens and parks – fair conditions *and >3ha:* Gardens and parks – good conditions
Permanent pastures Low density broad-leaved forest Recent forest Shrubs in abandoned agricultural land	*if out of protected areas:* Gardens and parks – fair conditions *if within protected areas:* Gardens and parks – good conditions
Permanent pastures with significant presence of trees and shrubs Medium-high density broad-leaved and mixed forest Riparian vegetation Shrubs with significant presence of natural vegetation	Gardens and parks – good conditions

Additional land use cover changes within protected areas

Case a and b	
Baseline land use cover	*Expected land use cover*
Abandoned and degraded sites Non-agricultural vegetated areas	*<3ha:* Gardens and parks – poor conditions *>3ha:* Permanent pastures
Homogeneous arable land	Arable land with significant presence of trees
Permanent pastures	Permanent pastures with significant presence of trees and shrubs
Shrubs in abandoned agricultural land	Shrubs with significant presence of natural vegetation

COMBINATION 4

It corresponds to combination 5 except for LUC changes in green buffer zone (mitigation of highway)

Case a and b	
Baseline land use cover	*Expected land use cover*
Gardens and parks – fair conditions	Gardens and parks – good conditions
Abandoned and degraded sites Non-agricultural vegetated areas	Permanent pastures
Homogeneous arable land	Arable land with significant presence of trees
Permanent pastures	Permanent pastures with significant presence of trees and shrubs
Shrubs in abandoned agricultural land	Shrubs with significant presence of natural vegetation

COMBINATION 5

Urban transformations – Artificial surfaces

Case a **Case b – within pole municipalities**	
Baseline land use cover	*Expected land use cover*
Construction sites Abandoned and degraded sites Gardens and parks Non-agricultural vegetated areas	Nucleated residential urban fabric
Arable land Permanent crops Pastures	Nucleated residential urban fabric
Forests Riparian vegetation	*within a distance of 200m from urban fabric*: Nucleated residential urban fabric

	otherwise: Sparse residential urban fabric
Recent forest Shrubs	Nucleated residential urban fabric

Case b – out of pole municipalities	
Baseline land use cover	*Expected land use cover*
Construction sites Abandoned and degraded sites Gardens and parks Non-agricultural vegetated areas	Sparse residential urban fabric
Arable land Permanent crops Pastures	Sparse residential urban fabric
Forests Riparian vegetation Recent forest Shrubs	Sparse residential urban fabric

Urban transformations – Urban green areas

Case a and b	
Baseline land use cover	*Expected land use cover*
Mines Construction sites Abandoned and degraded sites	Gardens and parks – fair conditions
Gardens and parks Non-agricultural vegetated areas	*if <3ha surface:* Gardens and parks – fair conditions *if >3ha surface:* Gardens and parks – good conditions
Arable land Permanent crops Permanent pastures Permanent pastures with significant presence of trees and shrubs Shrubs in abandoned agricultural land	*if <3ha surface:* Gardens and parks – fair conditions *if >3ha surface:* Gardens and parks – good conditions
Forests Riparian vegetation Shrubs with significant presence of natural vegetation	Gardens and parks – good conditions

Additional land use cover changes within protected areas

Case a and b	
Baseline land use cover	*Expected land use cover*
Abandoned and degraded sites Non-agricultural vegetated areas	*<3ha:* Gardens and parks – poor conditions *>3ha:* Permanent pastures
Homogeneous arable land	Arable land with significant presence of trees
Permanent pastures	Permanent pastures with significant presence of trees and shrubs
Shrubs in abandoned agricultural land	Shrubs with significant presence of natural vegetation

Additional land use cover changes within regional rural network

Case a and b	
Baseline land use cover	*Expected land use cover*
Gardens and parks – poor and fair conditions	*if within flooding areas or with high permeability:* Gardens and parks – good conditions *otherwise*: Gardens and parks – fair conditions
Abandoned and degraded sites Non-agricultural vegetated areas	*<3ha:* Gardens and parks – poor conditions *>3ha:* Permanent pastures
Homogeneous arable land	Arable land with significant presence of trees
Permanent pastures	Permanent pastures with significant presence of trees and shrubs
Shrubs in abandoned agricultural land	Shrubs with significant presence of natural vegetation

Additional land use cover changes out of protected areas and regional rural network

Case a and b	
Baseline land use cover	*Expected land use cover*
Gardens and parks – poor and fair conditions	*if within flooding areas or with high permeability:* Gardens and parks – good conditions *otherwise*: Gardens and parks – fair conditions
Abandoned and degraded sites Non-agricultural vegetated areas	*if within flooding areas or with high permeability:* Permanent pastures *otherwise*: as baseline land use cover
Homogeneous arable land	*if within flooding areas or with high permeability:* Arable land with significant presence of trees *otherwise*: as baseline land use cover
Permanent pastures	*if within flooding areas or with high permeability:* Permanent pastures with significant presence of trees and shrubs *otherwise*: as baseline land use cover
Shrubs in abandoned agricultural land	*if within flooding areas or with high permeability:* Shrubs with significant presence of natural vegetation *otherwise*: as baseline land use cover

COMBINATION 6

It corresponds to combination 3 except for LUC changes in green buffer zone (mitigation of highway)

Case a and b	
Baseline land use cover	*Expected land use cover*
Gardens and parks – fair conditions	Gardens and parks – good conditions
Abandoned and degraded sites Non-agricultural vegetated areas	Permanent pastures
Homogeneous arable land	Arable land with significant presence of trees
Permanent pastures	Permanent pastures with significant presence of trees and shrubs
Shrubs in abandoned agricultural land	Shrubs with significant presence of natural vegetation

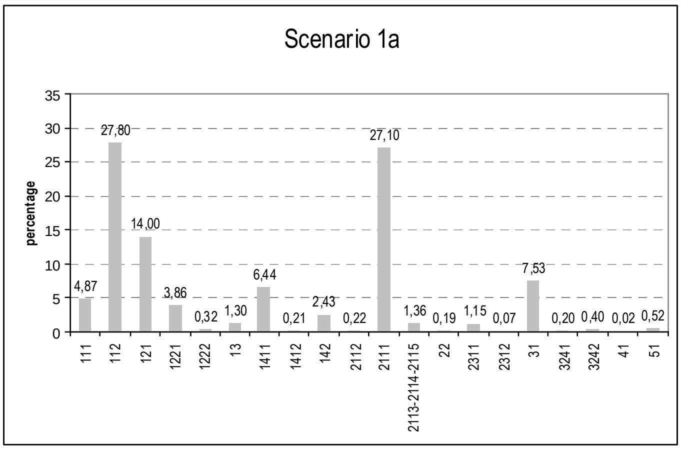
COMBINATION 8

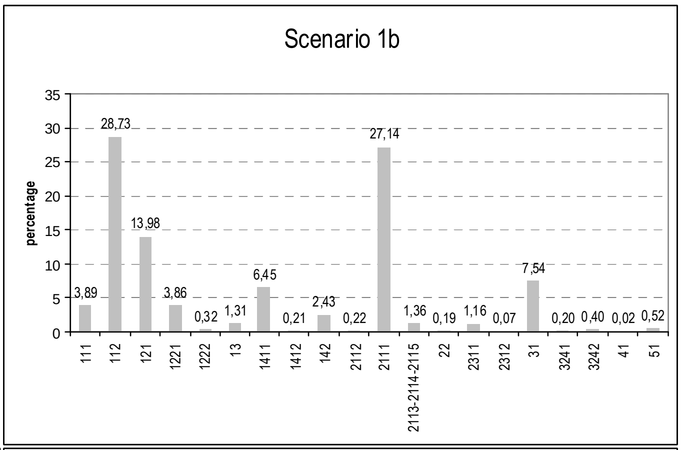
It corresponds to combination 1 except for LUC changes in green buffer zone (mitigation of highway)

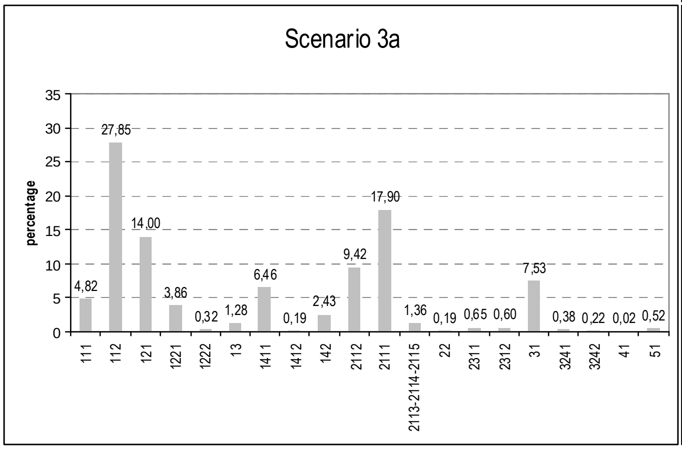
Case a and b	
Baseline land use cover	*Expected land use cover*
Gardens and parks – fair conditions	Gardens and parks – good conditions
Abandoned and degraded sites Non-agricultural vegetated areas	Permanent pastures
Homogeneous arable land	Arable land with significant presence of trees
Permanent pastures	Permanent pastures with significant presence of trees and shrubs
Shrubs in abandoned agricultural land	Shrubs with significant presence of natural vegetation

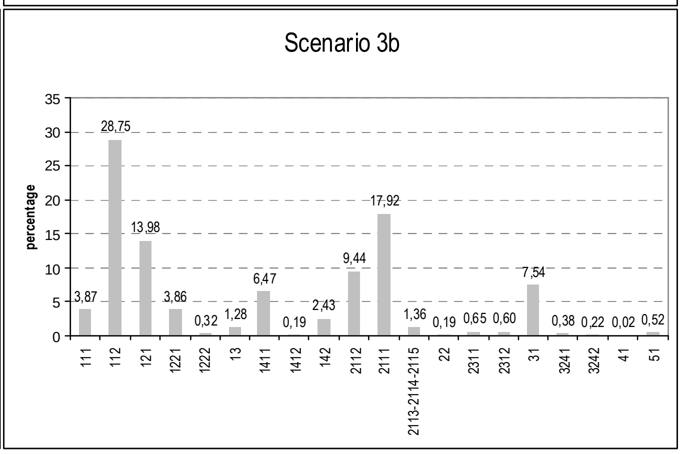
Land use cover scenarios – percentage of LUCs surface

ID	LUC class
111	Continuous urban fabric
112	Discontinuous urban fabric
121	Industrial, commercial and service units
1221	Road networks and associated land
1222	Rail networks and associated land
13	Mine, dump and construction sites
1411	Gardens and parks – poor conditions
1412	Non-agricultural vegetated areas
142	Sport and leisure facilities
2111	Homogeneous arable land
2112	Arable land with significant presence of trees
2113-2114-2115	Other arable land
22	Permanent crops
2311	Permanent pastures
2312	Permanent pastures with presence of trees/shrubs
31	Forests
3241	Shrubs with presence of natural vegetation
3242	Shrubs in abandoned agricultural land
41	Inland wetlands
51	Inland waters

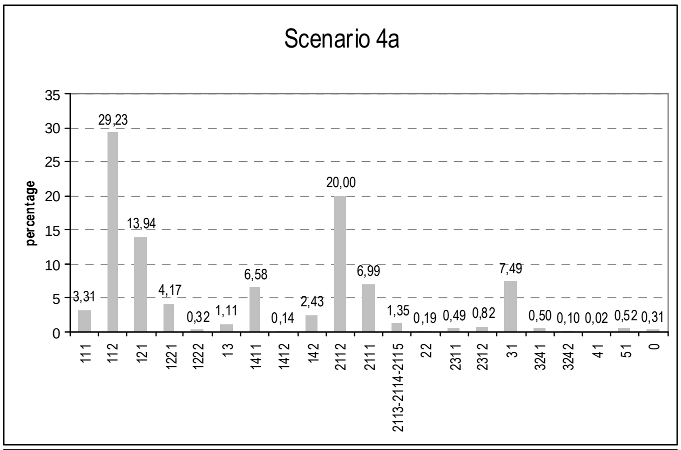


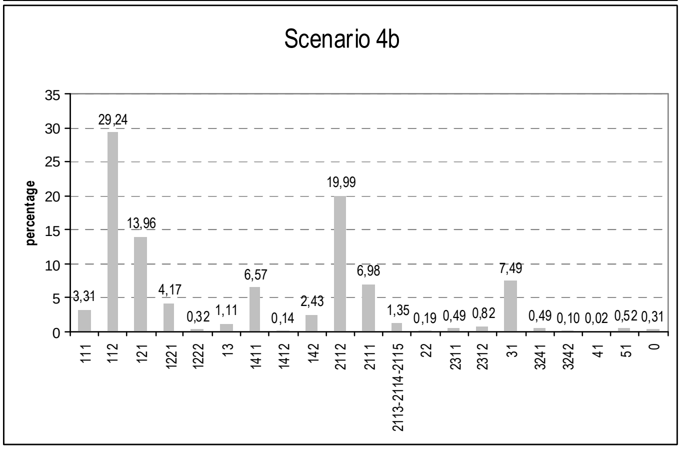


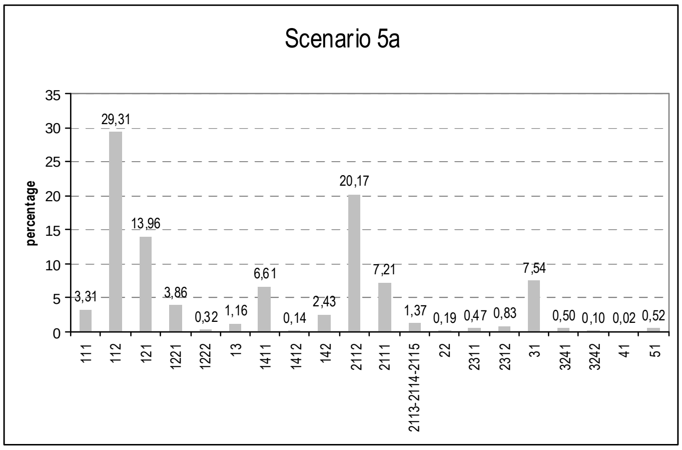


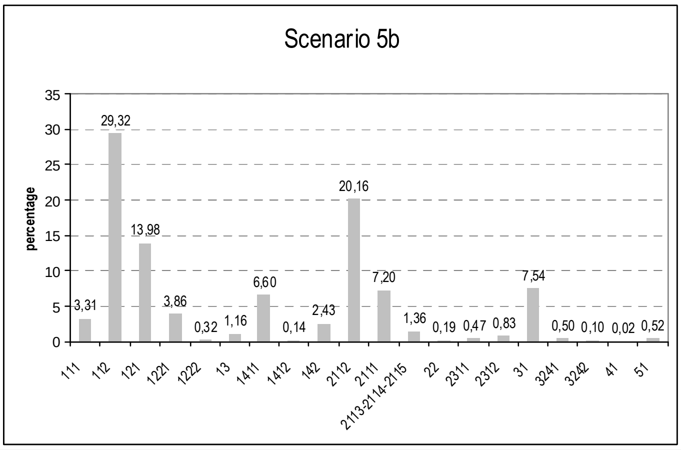


ID	LUC class
111	Continuous urban fabric
112	Discontinuous urban fabric
121	Industrial, commercial and service units
1221	Road networks and associated land
1222	Rail networks and associated land
13	Mine, dump and construction sites
1411	Gardens and parks – poor conditions
1412	Non-agricultural vegetated areas
142	Sport and leisure facilities
2111	Homogeneous arable land
2112	Arable land with significant presence of trees
2113-2114-2115	Other arable land
22	Permanent crops
2311	Permanent pastures
2312	Permanent pastures with presence of trees/shrubs
31	Forests
3241	Shrubs with presence of natural vegetation
3242	Shrubs in abandoned agricultural land
41	Inland wetlands
51	Inland waters









ID	LUC class
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112	Discontinuous urban fabric
121	Industrial, commercial and service units
1221	Road networks and associated land
1222	Rail networks and associated land
13	Mine, dump and construction sites
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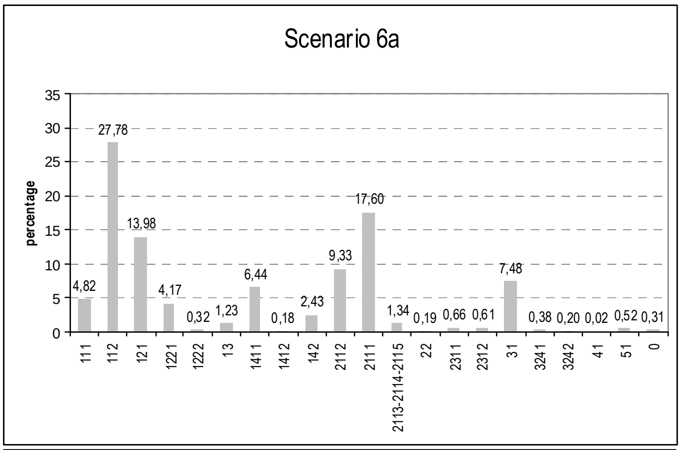
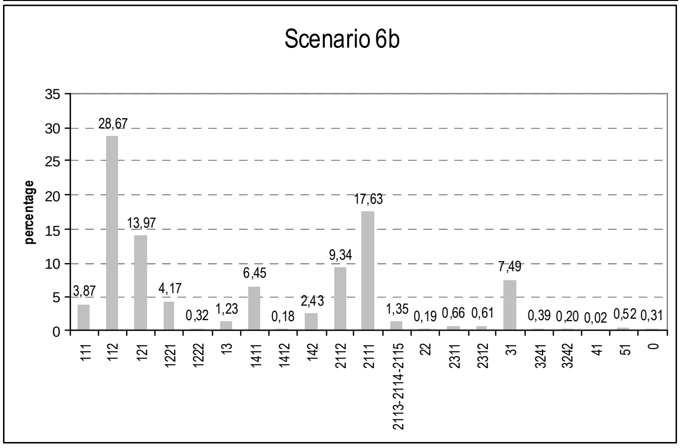
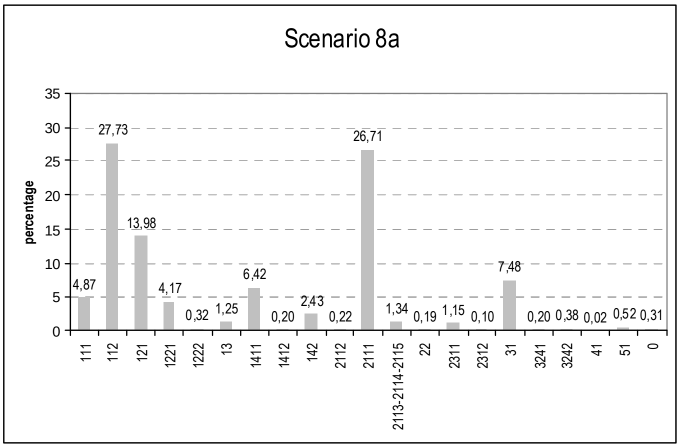
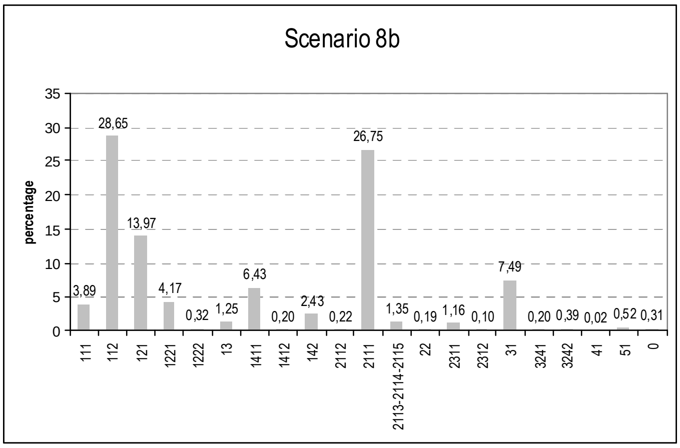
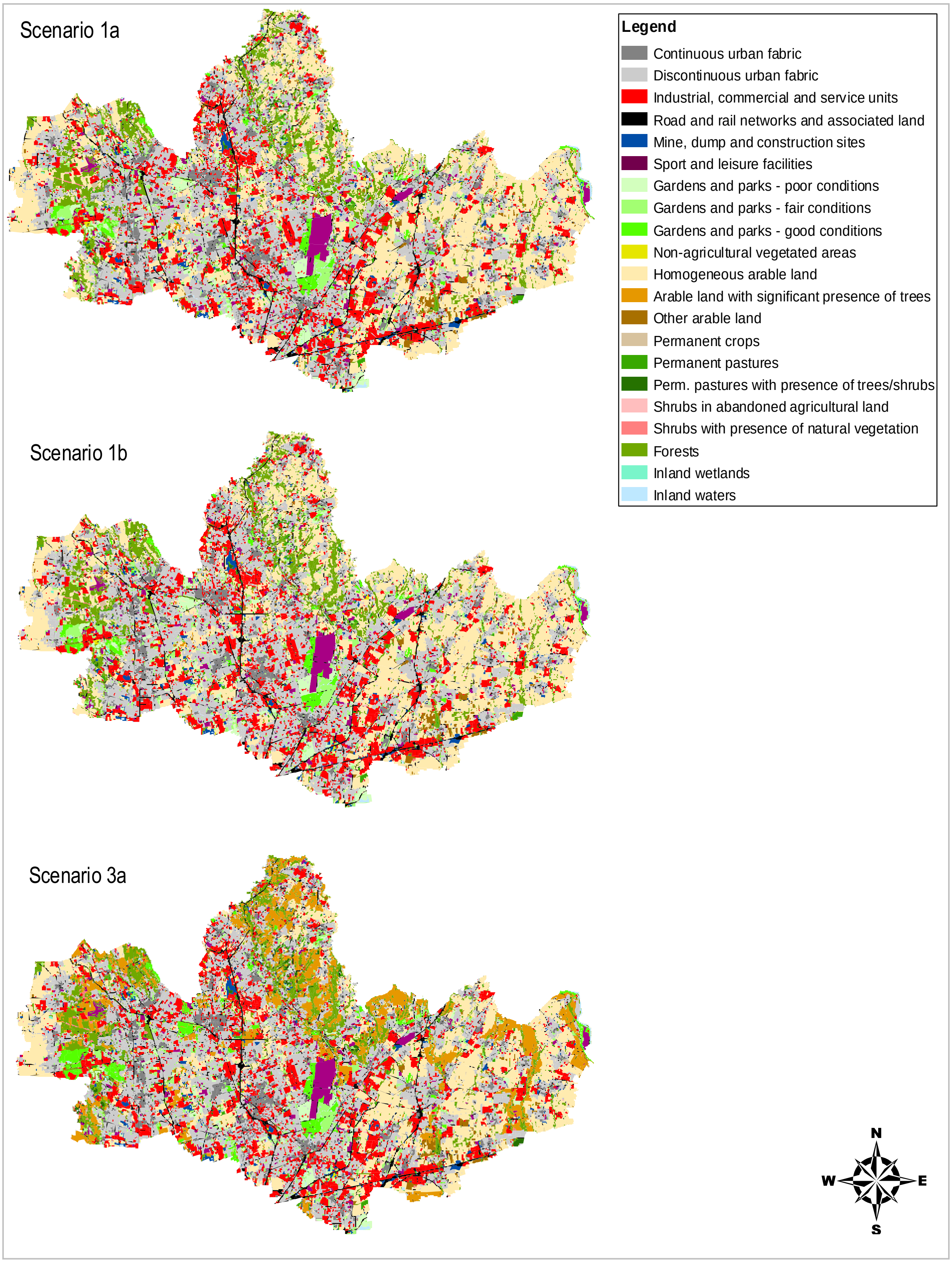


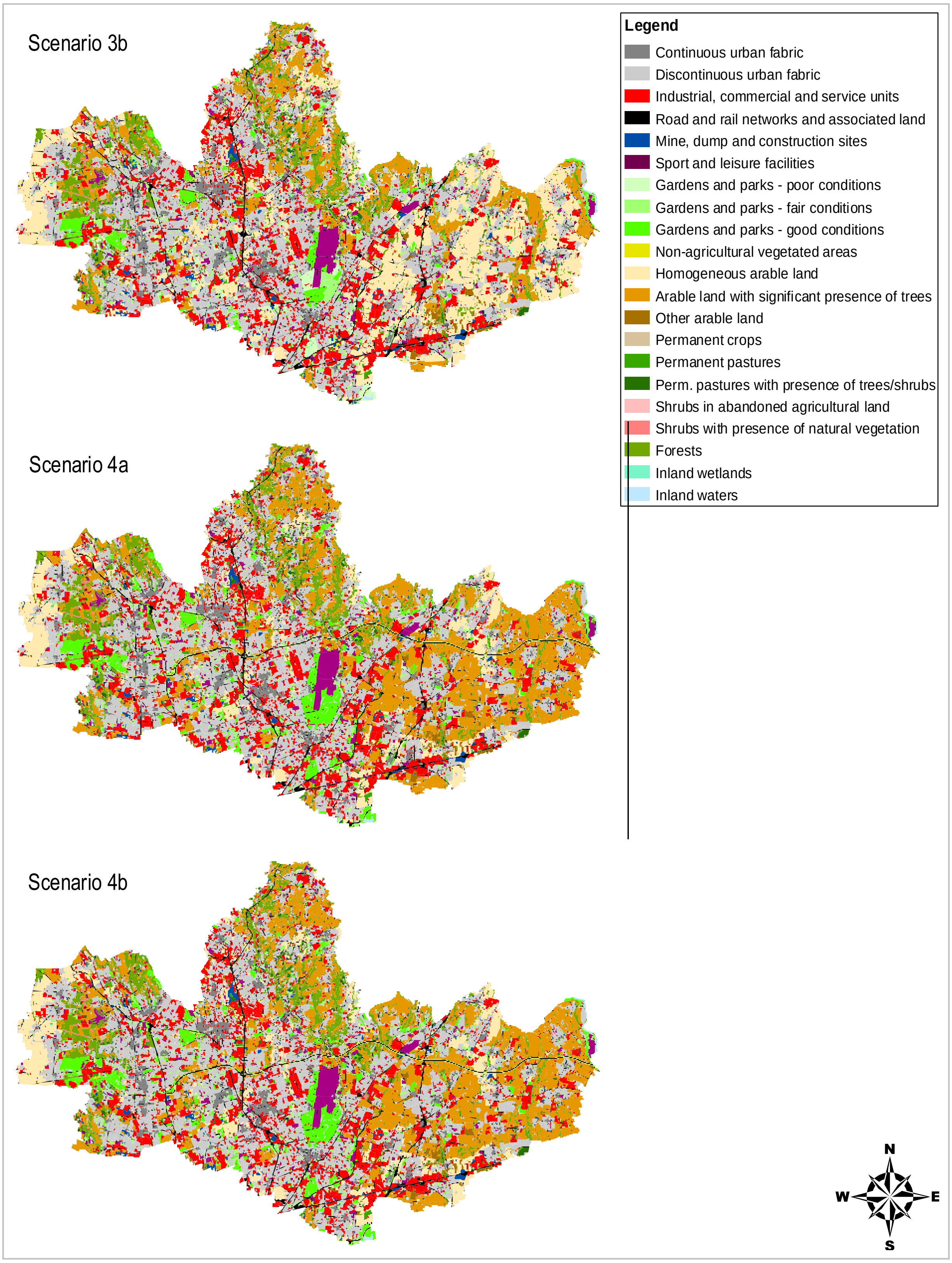






Land use cover scenarios – pattern




Scenario 3b
Scenario 4a
Scenario 4b
Legend
Continuous urban fabric
Discontinuous urban fabric
Industrial, commercial and service units
Road and rail networks and associated land
Mine, dump and construction sites
Sport and leisure facilities
Gardens and parks - poor conditions
Gardens and parks - fair conditions
Gardens and parks - good conditions
Non-agricultural vegetated areas
Homogeneous arable land
Arable land with significant presence of trees
Other arable land
Permanent crops
Permanent pastures
Perm. pastures with presence of trees/shrubs
Shrubs in abandoned agricultural land
Shrubs with presence of natural vegetation
Forests
Inland wetlands
Inland waters
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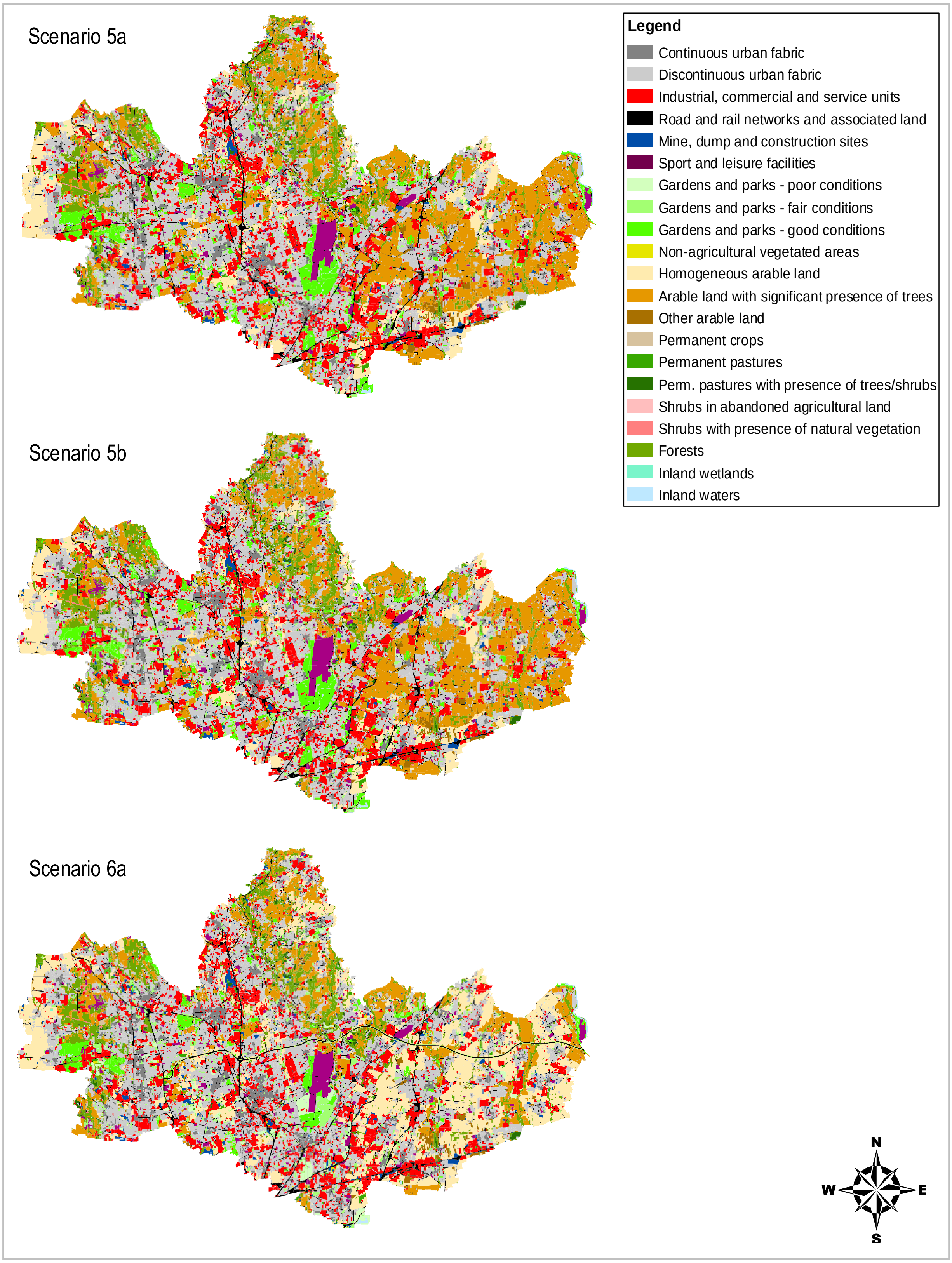
Scenario 5a
Scenario 5b
Scenario 6a
Legend
Continuous urban fabric
Discontinuous urban fabric
Industrial, commercial and service units
Road and rail networks and associated land
Mine, dump and construction sites
Sport and leisure facilities
Gardens and parks - poor conditions
Gardens and parks - fair conditions
Gardens and parks - good conditions
Non-agricultural vegetated areas
Homogeneous arable land
Arable land with significant presence of trees
Other arable land
Permanent crops
Permanent pastures
Perm. pastures with presence of trees/shrubs
Shrubs in abandoned agricultural land
Shrubs with presence of natural vegetation
Forests
Inland wetlands
Inland waters
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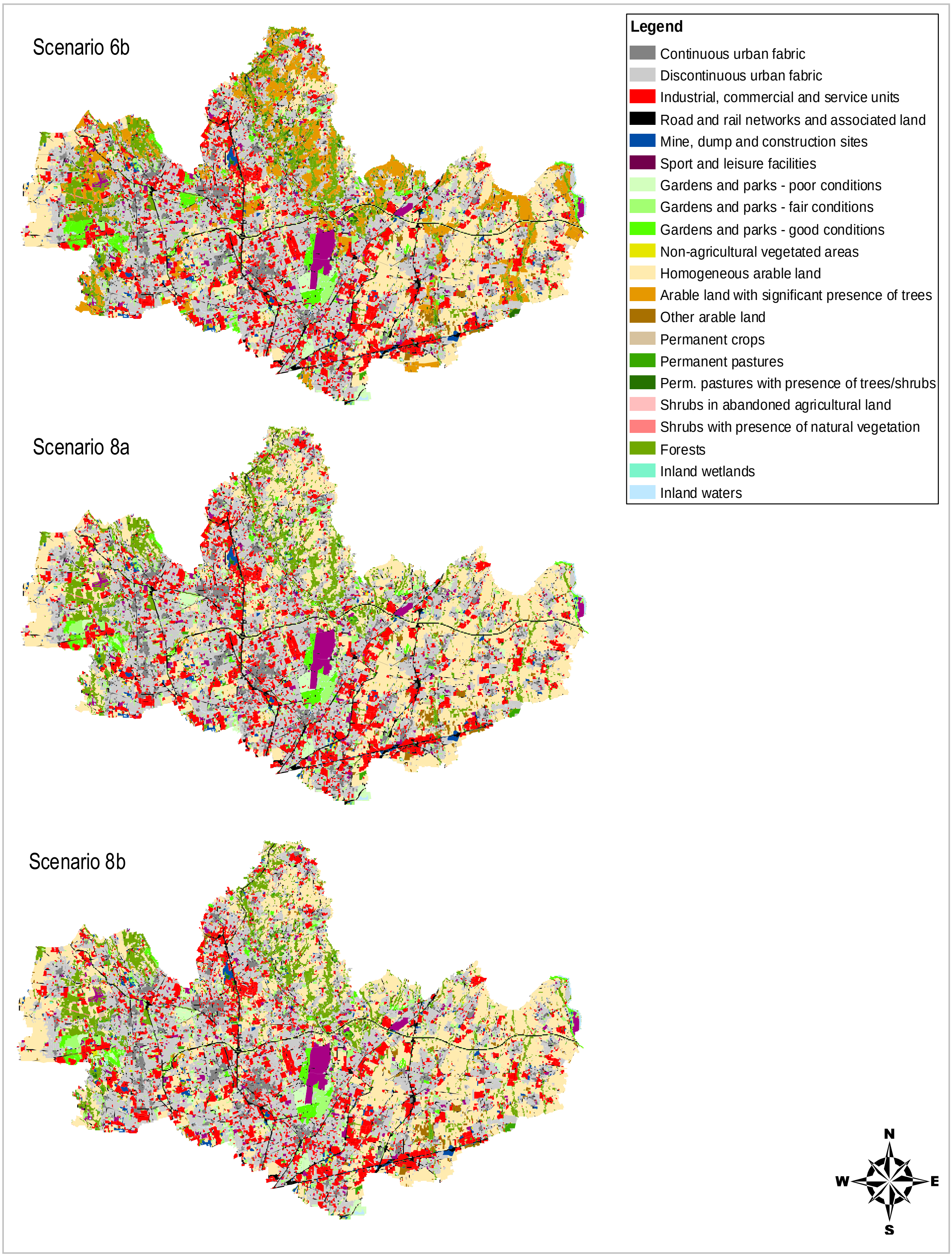

Scenario 6b
Scenario 8a
Scenario 8b
Legend
Continuous urban fabric
Discontinuous urban fabric
Industrial, commercial and service units
Road and rail networks and associated land
Mine, dump and construction sites
Sport and leisure facilities
Gardens and parks - poor conditions
Gardens and parks - fair conditions
Gardens and parks - good conditions
Non-agricultural vegetated areas
Homogeneous arable land
Arable land with significant presence of trees
Other arable land
Permanent crops
Permanent pastures
Perm. pastures with presence of trees/shrubs
Shrubs in abandoned agricultural land
Shrubs with presence of natural vegetation
Forests
Inland wetlands
Inland waters
N
W
E
S

Appendix 4

Performance of land use cover scenarios

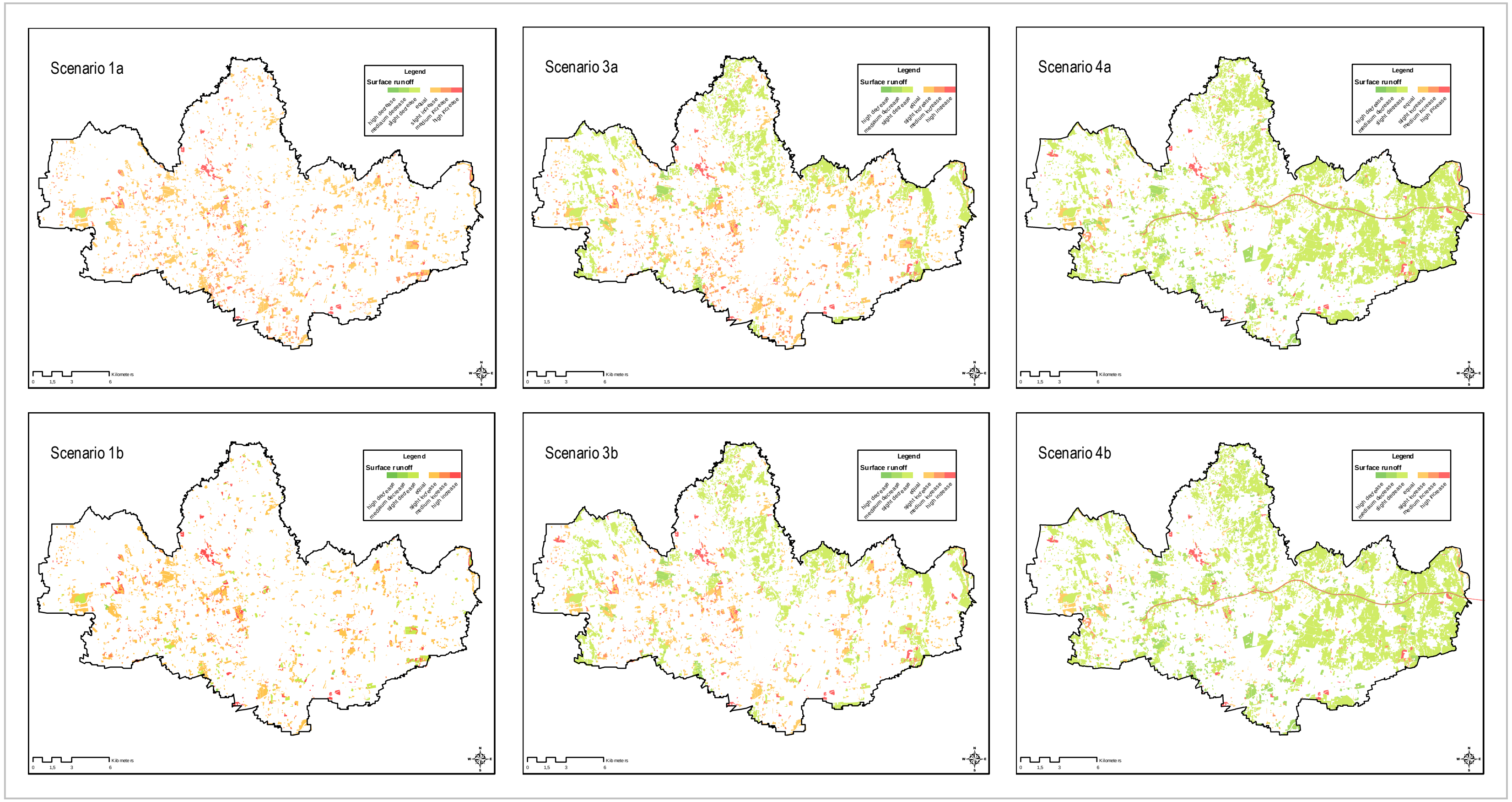
Emissivity of land use cover classes

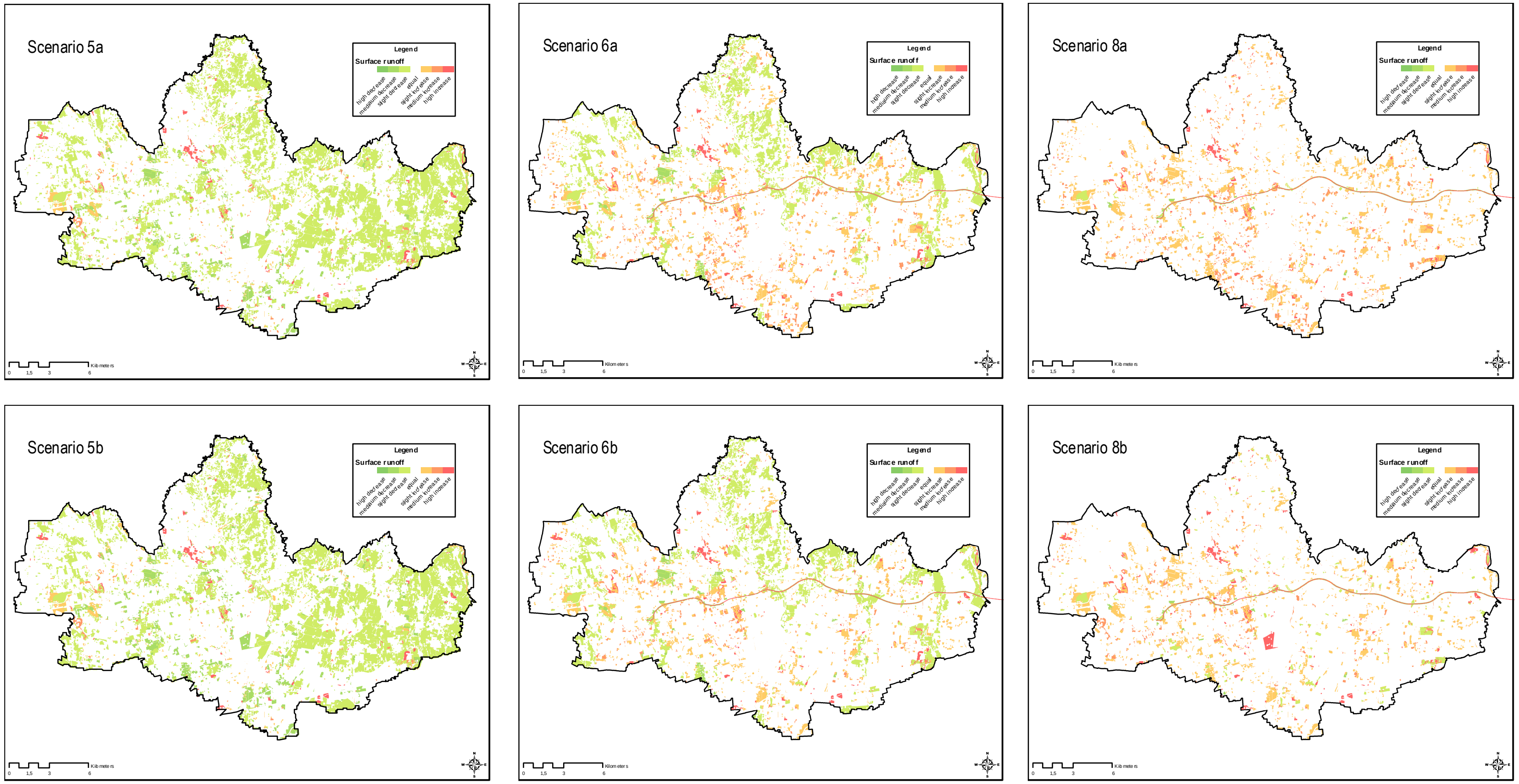
ID	Land cover class	Average emissivity (DN)	Emissivity (SD)	Emissivity index (%)
111	Continuous urban fabric	144,3	5,33	7,1
112	Discontinuous urban fabric	142,4	5,76	5,7
121	Industrial, commercial and service units	143,0	7,65	6,1
1221	Road networks and associated land	141,9	6,46	5,3
1222	Rail networks and associated land	142,6	6,74	5,8
131	Mineral extraction sites	140,6	5,52	4,3
132	Dump sites	143,7	5,54	6,7
133	Construction sites	141,7	6,29	5,2
134	Abandoned and degraded sites	139,9	6,96	3,8
1411	Gardens and parks	142,5	5,56	5,8
1411	Gardens and parks - good condition	134,8	6,43	0,0
1412	Non-agricultural vegetated areas	141,5	5,86	5,0
142	Sport and leisure facilities	138,8	6,59	3,0
2111	Homogeneous arable land	139,5	6,18	3,5
2112	Arable land with significant presence of trees	138,6	5,90	2,8
21131-21141	Open horticulture	139,3	5,73	3,4
21132-21142	Greenhouse horticulture	139,9	5,99	3,8
2115	Vegetable plots	140,0	5,44	3,9
22	Permanent crops	137,6	5,08	2,1
2311	Permanent pastures	139,8	6,30	3,7
2312	Permanent pastures with significant presence of trees and shrubs	139,4	6,53	3,4
3111	Medium-high density broad-leaved forest	136,1	7,07	1,0
3112	Low density broad-leaved forest	139,4	6,49	3,4
3113	Riparian vegetation	137,0	7,10	1,6
3121	Medium-high density coniferous forest	131,9	0,72	-2,2
3131	Medium-high density mixed forest	132,8	6,32	-1,5
314	Recent forest	142,2	5,12	5,5
3241	Shrubs with significant presence of natural vegetation	138,0	6,71	2,4
3242	Shrubs in abandoned agricultural land	139,0	6,82	3,1
41	Inland wetlands	135,2	5,58	0,3
51	Inland waters	135,1	9,06	0,2
0	Highway green buffer zones	138,0	6,71	2,4

Land take – percentage of land taken with respect to the baseline condition

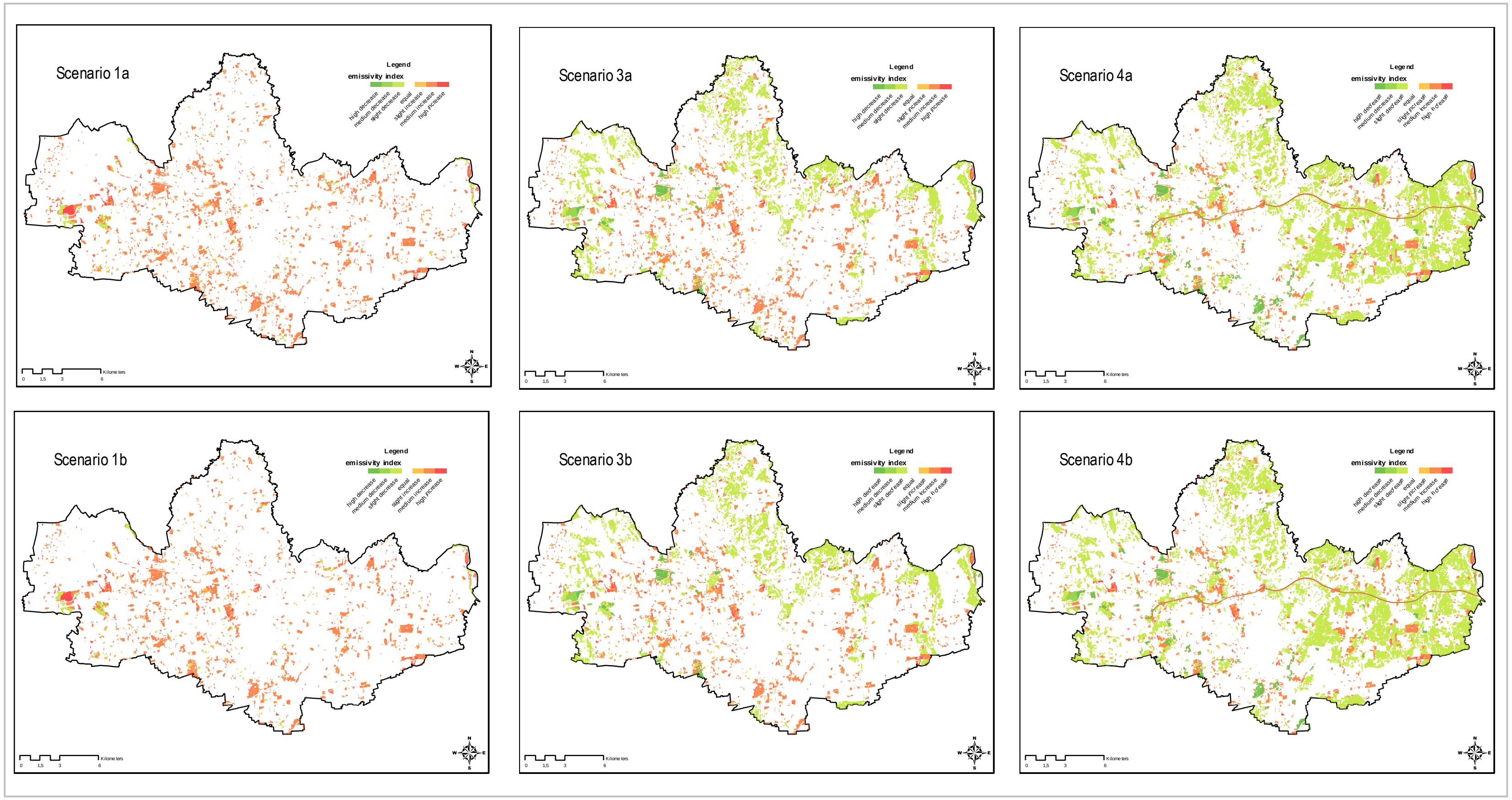
Scenario / **Land use cover**	**S1a**	**S1b**	**S3a**	**S3b**	**S4a**	**S4b**	**S5a**	**S5b**	**S6a**	**S6b**	**S8a**	**S8b**
Continuous urban fabric	1,57	0,59	1,52	0,57	0,00	0,00	0,00	0,00	1,52	0,57	1,57	0,59
Discontinuous urban fabric	3,05	3,93	3,10	3,95	4,44	4,45	4,51	4,52	3,03	3,88	2,98	3,86
Industrial, commercial and service units	0,46	0,42	0,46	0,42	0,38	0,40	0,40	0,42	0,44	0,40	0,44	0,40
Road networks and associated land	0,01	0,00	0,01	0,00	0,30	0,30	0,00	0,00	0,31	0,30	0,31	0,30
Mine, dump and construction sites	-0,65	-0,65	-0,68	-0,68	-0,85	-0,85	-0,80	-0,80	-0,73	-0,72	-0,70	-0,70
Gardens and parks	3,20	3,20	3,23	3,23	3,33	3,32	3,36	3,35	3,20	3,20	3,18	3,18
Abandoned green areas	-0,08	-0,08	-0,09	-0,09	-0,14	-0,14	-0,14	-0,14	-0,10	-0,10	-0,08	-0,08
Homogeneous arable land	-5,03	-5,03	-14,24	-14,24	-25,18	-25,19	-24,96	-24,97	-14,54	-14,54	-5,42	-5,42
Arable land with significant presence of trees	-0,05	-0,05	9,16	9,16	19,72	19,72	19,89	19,89	9,07	9,07	-0,06	-0,06
Other arable land	-0,24	-0,24	-0,24	-0,24	-0,26	-0,26	-0,24	-0,24	-0,26	-0,26	-0,26	-0,26
Permanent crops	-0,14	-0,14	-0,14	-0,14	-0,14	-0,14	-0,14	-0,14	-0,14	-0,14	-0,14	-0,14
Permanent pastures	-0,45	-0,45	-0,95	-0,95	-1,11	-1,11	-1,13	-1,13	-0,94	-0,94	-0,45	-0,45
Permanent pastures with significant presence of trees and shrubs	-0,02	-0,02	0,51	0,51	0,73	0,73	0,74	0,74	0,53	0,53	0,01	0,01
Forests	-1,23	-1,23	-1,23	-1,23	-1,27	-1,27	-1,23	-1,23	-1,27	-1,27	-1,27	-1,27
Shrubs with significant presence of natural vegetation	-0,09	-0,09	0,09	0,09	0,21	0,20	0,21	0,21	0,10	0,10	-0,08	-0,09
Shrubs in abandoned agricultural land	-0,17	-0,17	-0,35	-0,35	-0,47	-0,47	-0,47	-0,47	-0,36	-0,36	-0,18	-0,18
Highway green buffer zones	0,00	0,00	0,00	0,00	0,31	0,31	0,00	0,00	0,31	0,31	0,31	0,31

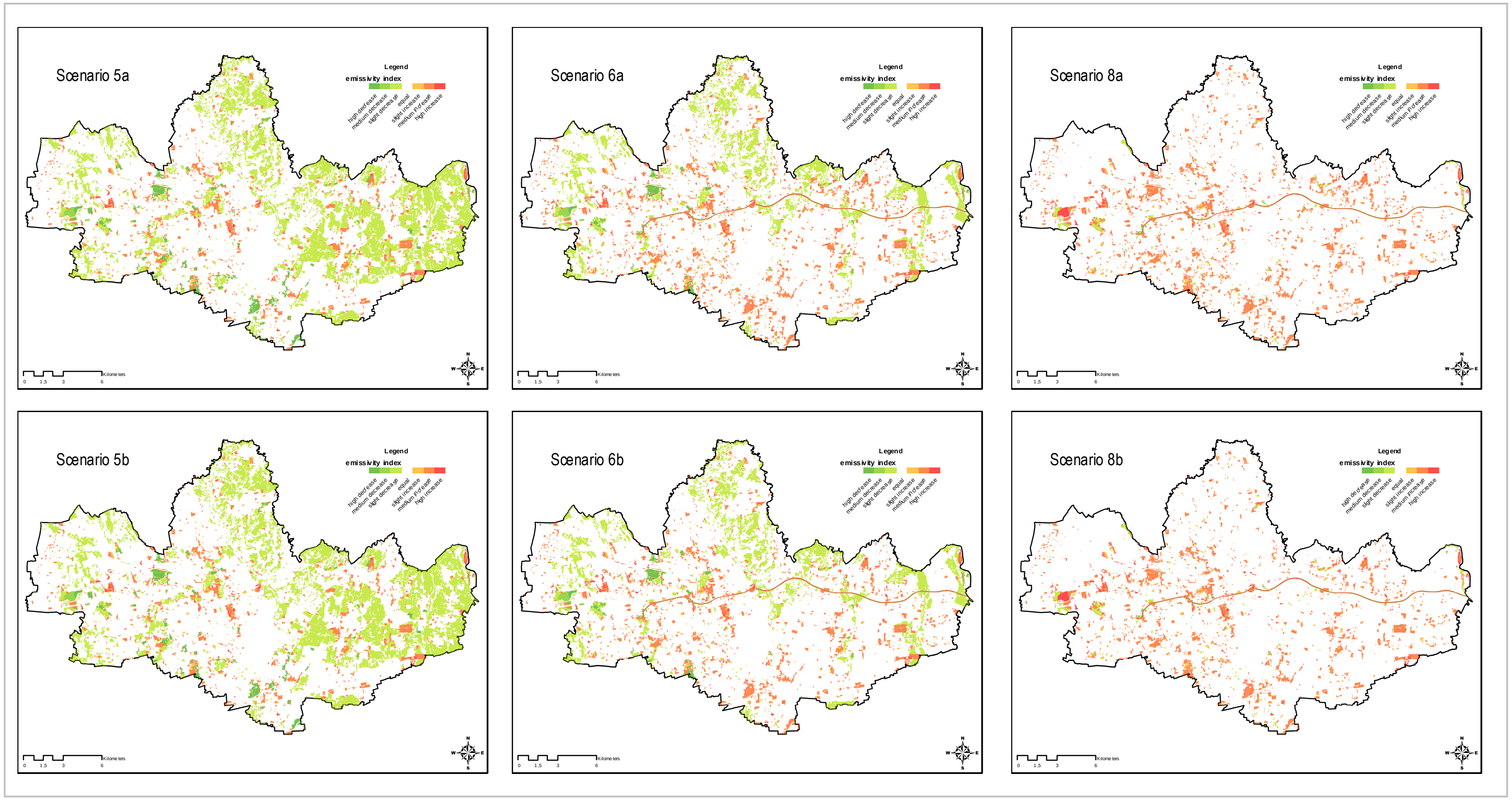
Surface runoff indicators – difference with respect to the baseline condition



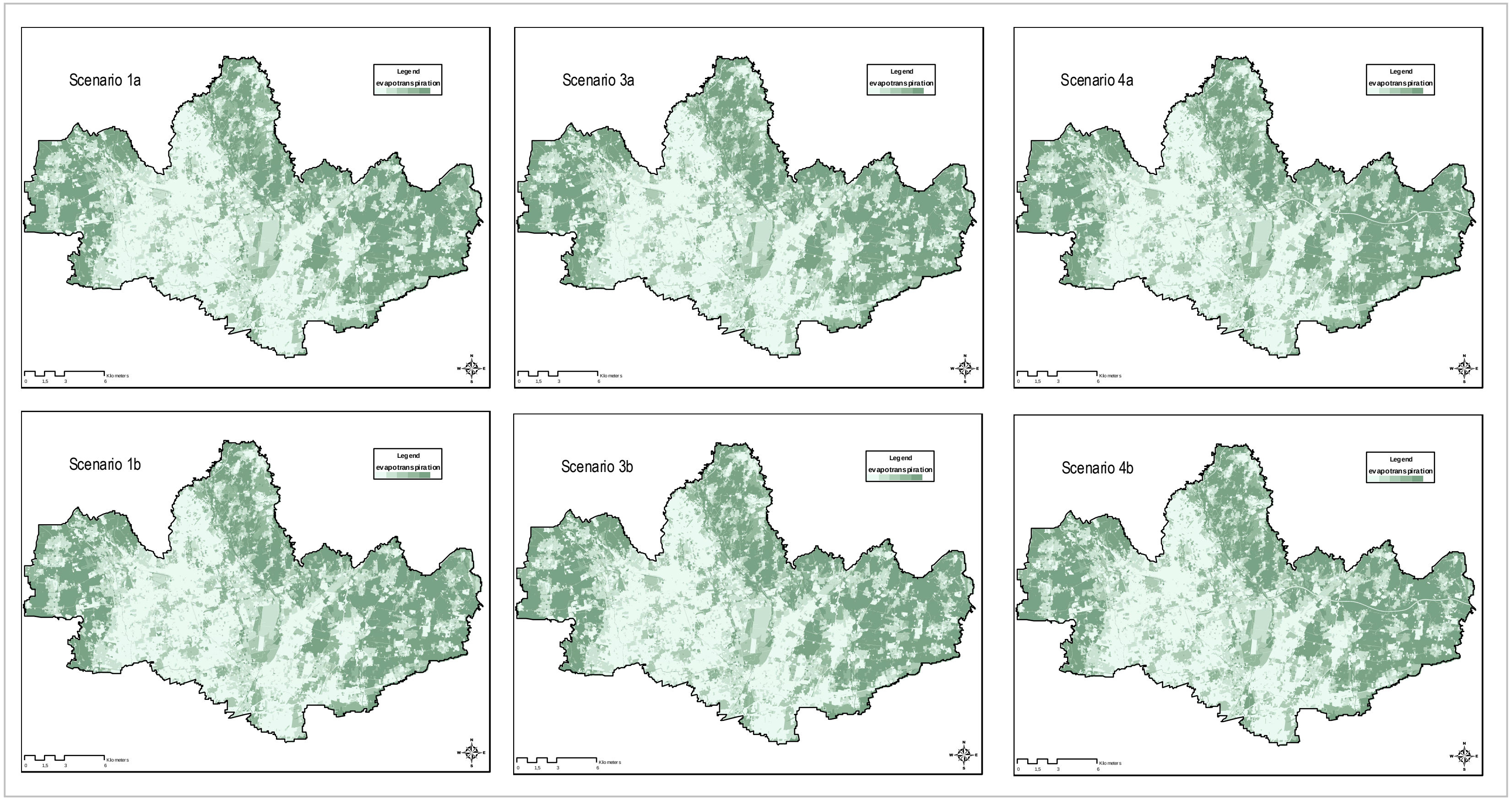

Scenario 5a
Legend
Surface runoff
high decrease
medium decrease
slight decrease
equal
slight increase
medium increase
high increase
0 1,5 3 6 Kilometers
Scenario 6a
Legend
Surface runoff
high decrease
medium decrease
slight decrease
equal
slight increase
medium increase
high increase
0 1,5 3 6 Kilometers
Scenario 8a
Legend
Surface runoff
high decrease
medium decrease
slight decrease
equal
slight increase
medium increase
high increase
0 1,5 3 6 Kilometers
Scenario 5b
Legend
Surface runoff
high decrease
medium decrease
slight decrease
equal
slight increase
medium increase
high increase
0 1,5 3 6 Kilometers
Scenario 6b
Legend
Surface runoff
high decrease
medium decrease
slight decrease
equal
slight increase
medium increase
high increase
0 1,5 3 6 Kilometers
Scenario 8b
Legend
Surface runoff
high decrease
medium decrease
slight decrease
equal
slight increase
medium increase
high increase
0 1,5 3 6 Kilometers

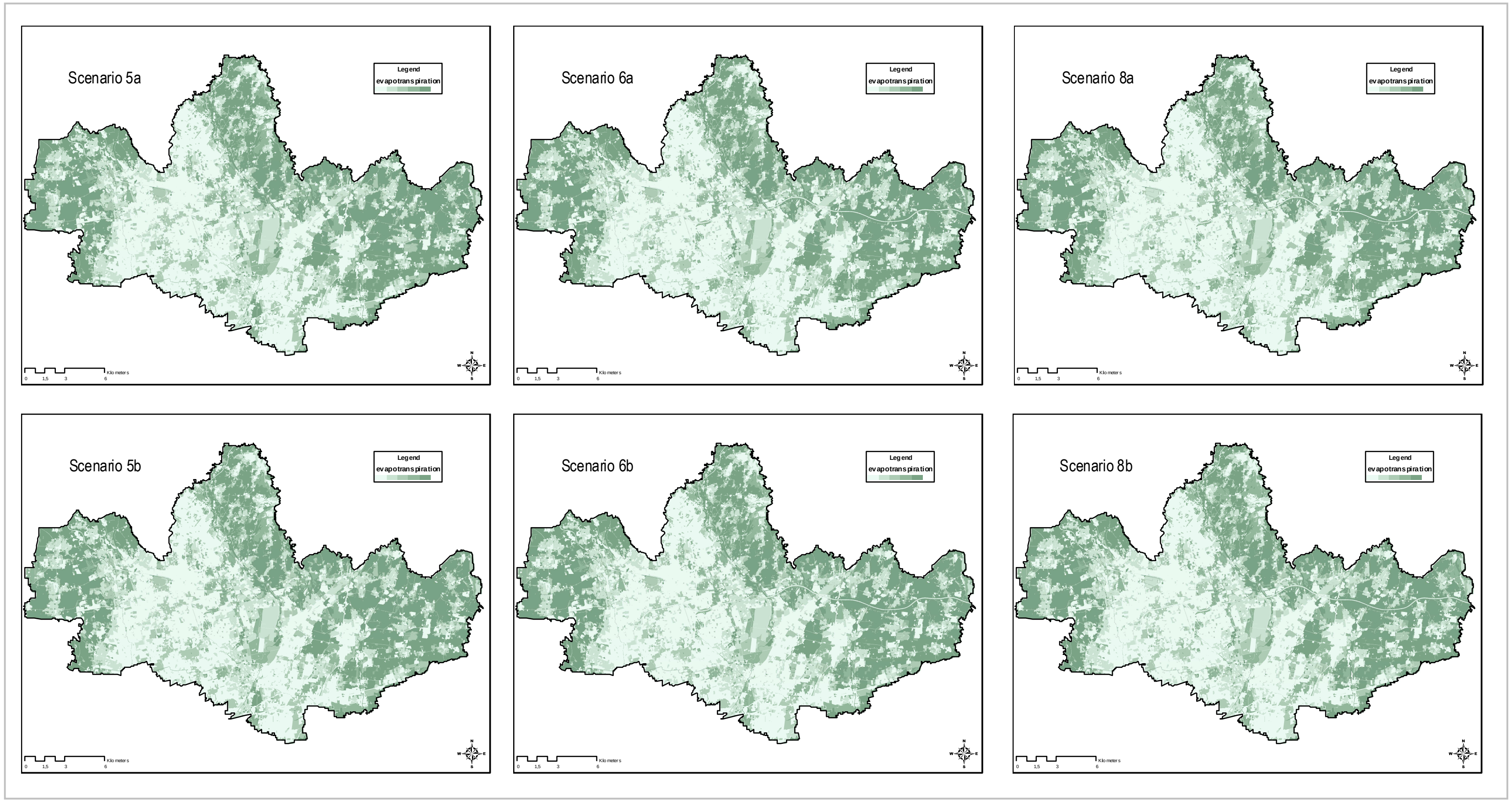
Surface emissivity – difference with respect to the baseline condition




Scenario 5a
Scenario 6a
Scenario 8a
Scenario 5b
Scenario 6b
Scenario 8b
Legend
emissivity index
high decrease
medium decrease
slight decrease
equal
slight increase
medium increase
high increase
0 1,5 3 6
Kilometers
N
W
E
S

Evapotranspiration




Scenario 5a
Legend
evapotranspiration
Kilometers
0 1,5 3 6
Scenario 6a
Legend
evapotranspiration
Kilometers
0 1,5 3 6
Scenario 8a
Legend
evapotranspiration
Kilometers
0 1,5 3 6
Scenario 5b
Legend
evapotranspiration
Kilometers
0 1,5 3 6
Scenario 6b
Legend
evapotranspiration
Kilometers
0 1,5 3 6
Scenario 8b
Legend
evapotranspiration
Kilometers
0 1,5 3 6