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Addressing cumulative effects in Strategic Environmental Assessment of spatial planning

Strategic environmental Assessment (SEA) is a decision support instrument for predicting and evaluating the likely environmental effects of implementing a policy, plan or programme. SEA can consider the cumulative impacts of more than one project or activity on the same environmental component. This paper discusses the analysis of cumulative effects in SEA, with reference to spatial planning by: providing a review of key concepts and methods related to cumulative effects literature; presenting a rationale for the inclusion of cumulative effects in SEA of spatial plans; advancing a proposal to address cumulative effects in different SEA stages. The paper concludes that SEA offers the opportunity to support a better management of cumulative effects arising from many local-level spatial planning decisions. Three aspects emerged as critical to ensure good practices: the selection of valued environmental components, the adoption of future-oriented approaches, and the use of spatially-explicit information.

Keywords: *Strategic Environmental Assessment, cumulative impacts, spatial planning*

Parole chiave: *Valutazione Ambientale Strategica, impatti cumulativi, pianificazione territoriale*

JEL: *Q20, O20, R50*

1. Introduction

Strategic environmental Assessment (SEA) can be defined as a decision support instrument for predicting and evaluating the likely environmental effects of implementing a policy, plan or programme (PPP) (Sadler and Verheem, 1996). Hence, SEA aims at assisting the design of PPPs by "greening" their content and anticipating negative consequences on the environment. 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), due to the recognition that in practice decision- and policy-making processes are complex and they do not follow a rational procedure owing to subjective norms, values and interests of different systems and actors involved (Kørnøv and Thissen, 2000). The overall purpose of SEA can be summarised as follows (Fischer, 2007):

- SEA should support the systematic consideration of environmental and other sustainability aspects during the decision-making process;
- 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;
- SEA should support more effective and efficient decision-making, by facilitating consultation between authorities, enhancing public involvement and improving governance.

The proactive and strategic nature of SEA allows facilitating: the earlier consideration of environmental consequences; the examination of a wider range of potential alternatives; and the opportunity to address a wide range of effects (Eggemberger and Partidário, 2000; Fischer, 2003; Thérivel, 2004). In particular, SEA has been widely acknowledged as an important addition to project Environmental Impact Assessment (EIA) because it can adequately consider cumulative impacts of more than one project or activity on the same environmental receptor at larger scale.

This paper discusses the analysis of cumulative effects in SEA, with particular reference to spatial planning, by investigating theoretical concepts and methodological approaches, with the aim to provide the state of art concerning the treatment of cumulative effects at strategic-level assessment. Section 2 contains a review of key concepts and methods related to cumulative effects literature. Section 3 presents a rationale for the inclusion of cumulative effects in SEA of spatial plans. In section 4, a proposal to address cumulative effects in different SEA stages is advanced. Finally, section 5 draws some conclusions.

2. The assessment of cumulative effects

2.1 Concepts

The concept of environmental cumulative effects (CE) has been discussed in the literature since before the inception of environmental assessment (EA) practices. Various authors observed that significant environmental changes may result from the combination of individually minor effects of multiple actions over time. This has been referred to as the "*destruction by insignificant increments*" (Gamble, 1979) and the "*tyranny of small decisions*" (Odum, 1982). However, the systematic recognition of CE 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 EIA.

Then, the concept of CE has been firstly defined by the US Council on Environmental Quality (CEQ, 1978)[1] and later detailed by other scholars (Canter, 1999; Ross, 1998; 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[2]);

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[1] 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.

[2] 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

2. the accumulation of individually minor effect of multiple actions over space and time.

The concept of *Valued Ecosystem Components* (VEC) has been proposed in CE literature to better define the main focus of CEA (Fig. 1).

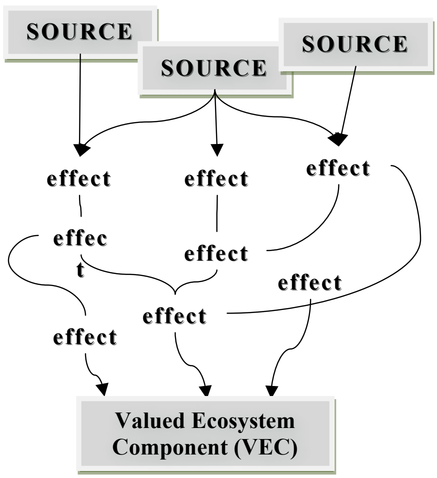
This causal-effects model has been later applied to:

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

Nonetheless, no internationally accepted definition of CE still exists, leaving the assessment of CE deceptively simple (MacDonald, 2000; Cooper and Sheate, 2002; Wärnbäck *et al.*, 2009).

This conceptual lack led to well recognised barriers to assess CE in practice. Among others, these are: setting the assessment boundaries (Piper, 2001b; Noble, 2008); choosing what sources or activities have to be considered (existing guidance typically refer to past, present and likely future plans and projects) (CEQ, 1997; Hegmann *et al.*, 1999; Hyder Consulting, 1999), establishing a priority to select an adequate number of VECs (Duinker and Greig, 2006; Thérivel and Ross, 2007), etc.

Figure 1. Cumulative effects: conceptual framework.



the basis of cultural values or scientific concern (Hegmann *et al.*, 1999). VECs need not to be necessarily biophysical in nature; rather they may encompass aspects with social or economical values such as recreational areas, local communities, sensitive categories of people, etc.

2.2 Project-based vs. strategic based assessment

The process of systematically analysing and assessing cumulative environmental changes, or Cumulative Effects Assessment, is mandatory required by many countries around the world, especially at project-level. However, it has been widely recognised that determining the cumulative environmental consequences of a project requires delineating the complex causal-effect relationships between multiple actions and resources (CEQ, 1997). Therefore, the assessment of CE should go beyond the evaluation of site-specific and direct project impacts. This consideration has moved forward the EA legal frameworks from EIA to regional CEA SEA.

Project-level assessment supports the information-generating and the integration of considerations on CE in project approval procedures, whereas strategic-level assessment tends to use planning principles and procedures to support the avoidance and management of CE at higher tier of decision-making. Within the EU, this strategic approach was formalised by the SEA Directive (42/2001/EC) which mandatory requires CE to be assessed. The latter suggested SEA as the best "framework law that establishes a minimum common procedure for certain official plans and programmes" (Dalal-Clayton and Sadler, 2005). However, 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. Therefore, it is currently difficult to give an exact account of formal SEA systems globally due to terminological differences. In Canada, for instance, 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 (Gunn and Noble, 2011; Hegmann and Yarranton, 2011, Johnson *et al.*, 2011).

By summarising the main reasons for better addressing cumulative effects at strategic level, Cooper and Sheate (2004) pointed out 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;
4. 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.

However, although the recognition of the importance to adopt a strategic approach to appropriately deal with CE has been agreed amongst the scientific, regulatory and practitioner communities, the advancement of CEA beyond the individual project is evolving slowly, especially in practice (Gunn and Noble, 2011; Canter and Ross, 2010; Bragagnolo et al. 2012). 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 them has been tailored to project-level CEA and fitted for North American procedures, further presenting a number of limitations (Fuller and Sadler, 1999). According to Gunn (2009), further investigation on this subject is needed as 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.

2.3 Overview of methods

Over the last few decades, impact assessment practice has 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 the uncertainty related to the effects of strategic actions.

Some authors have argued that new methodologies and procedural requirements are required for SEA, in order 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. And this is particularly appropriate for the formulation of strategic-level actions, where cumulative effects on a VEC at one tier of decision-making can be offset with benefits at other tiers.

An overview of methods and tools proposed and/or applied to assess CE at strategic level is provided in Tab. 1.

2.4 Issues of scale

Setting the assessment boundaries is generally considered a challenging issue for EA. João (2002), for instance, showed how results of EIAs can be affected by changes of scale, in term of detail and spatial extent, concluding that scale choice can have important repercussions for the accuracy of an EIA study. Although this generally applies to EA, when it deals with CEA, the choice of spatial and temporal boundaries seems to become more difficult (CEQ, 1997; João, 2007). The importance to consider multiple actions often suggests to broad the spatial and temporal

Table 1. Methods and tools for assessing CE at strategic level.

Methods and tools	SEA task	References
Network analysis	Identifying cumulative impacts and assessing cause-effect relationships between actions and VECs.	Thérivel and Ross, 2007 Perdicoùlis and Piper, 2008 Cooper, 2010
Indicators and multi-metric indices	Describing baseline conditions of VECs. Predicting the cumulative consequences of multiple actions. Identifying and evaluating incremental and cumulative effects of VECs against threshold. Developing effective mitigation measures for incremental effects. Planning and implementing regional or strategic-level management measures.	Canter and Atkinson, 2011 Cooper, 2011
Modeling (Quantitative, habitat suitability, etc.)	Quantifying cause-effect relationships leading to CE (eg air, hydrological, water quality, noise, transport)	Canter and Atkinson, 2011 Noble, 2008
Adaptive management tools	Addressing CE monitoring and follow-up. Dealing with uncertainty resulting from CE.	Canter and Atkinson, 2010
Matrices	Identifying potential CE of development proposals on sustainability objectives.	Cooper, 2011
Expert opinion	Identifying and classifying environmental alternatives.	Swor and Canter, 2011
Spatial analysis and Geographic Information Systems (GIS)	Assessing the spatial distribution of cumulative effects on VECs (eg wetlands, water quality, wildlife species and habitat, etc.)	Atkinson and Canter, 2011
Scenario analysis	Predicting CE of future scenarios Assessing likely effectiveness of CE mitigation measures.	Duinker and Greig, 2007 Morris and Thérivel, 2009

boundaries in order to capture their cumulative effects. Nonetheless, 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 (Ross, 1998). 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.

As a result, the definition of spatial and temporal boundaries has been considered among one of the most inadequate task in CEA practice (Piper, 2001b; Cooper and Sheate, 2002).

By reviewing how scale issues are considered in CEA, Thérivel and Ross (2007) recently moved backwards through the process, 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, adopting a multi-scale approach has been suggested in order to inform the scope of downscale assessment and to avoid overlooking localised and point source problems (Duinker and Greig, 2006; Thérivel and Ross, 2007; Noble, 2008). A better linkage between different tiers of EA have been further advocated, suggesting the opportunity for strategic-level CEA to "*set the rules*" for lower tier EA (Thérivel and Ross, 2007; Gunn, 2009). Nevertheless, in practice this appears to be rarely the case as significant CE at broader scale are often neglected at lower tier decisions. The latter seems to be particularly relevant in the context of spatial planning as is subsequently argued.

3. A rationale for the inclusion of CE in SEA of spatial plans

Spatial plans – that include urban plans, as well as plans drawn at regional level – are among the sectors where SEA has been most extensively applied, as required by the EU SEA Directive and various national legislations (Jones *et al.*, 2005).

Spatial planning may be defined as a decision-making process aiming at managing the present and the future use of land and the physical organization of space, by:

- coordinating different socioeconomic sectors and their allocation;
- preventing environmental problems;
- ensuring that the development and use of land is in general "public interest" (Jones *et al.*, 2005).

The need to better consider cumulative effects in spatial planning relies on the kind of actions under spatial plans agenda. Spatial planning decisions often concern small developments which are individually insignificant in terms of the likely environmental consequences and, hence, not subjected to project EIA. Nevertheless, their effects 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 land take by small housing, retail and road developments promoted by local-level land use plans can lead to an overall degradation of the regional environment, due to: gradual loss of open spaces and fragmentation of habitats; increase of surface water runoff; increase of greenhouse gases emission and decrease of air quality, etc. And the boundaries of local-level plans are often inadequate to cover the scale-gap (spatial crowding and time delay) by which these effects become significant. Then, managing those planned activities, even though individually minor, could result more challenging than avoid impacts from human activities commonly considered hazardous or dangerous (eg waste treatment plants, energy production plants, etc).

Additionally, the opportunity to better consider cumulative effects in spatial planning relies on its particular tiered system, being the planning decisions interconnected between different scales and planning levels (ie local and regional). Accordingly, in order to support the treatment of CE, SEA of spatial plans should provide for:

- an adequate scoping of interrelationships between multiple activities/tiers and their likely consequences on relevant VECs;
- a proposal of inter-tier management frameworks in order to cope with CE across different levels of planning and tiers of decisions.

Finally, SEA provides an opportunity for 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.

4. Addressing CE in different SEA stages

To ensure an effective consideration of CE, they should be considered starting from the first SEA stages, considering that predicting, monitoring and managing several consequences mostly depend on how the environmental and policy context has been explored, with particular reference to scoping and definition of planning strategies (objectives, options, alternatives). According to 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 is 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.

4.1 Scoping of CE

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).

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 (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). However, 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; Fischer, 2003). 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).

4.2 Identification of 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).

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. Therefore, the definition of reasonable planning alternatives 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, in turns, may require different amount of information as well as different methodological approaches in order to be defined and assessed. This suggests that assessing the cumulative effects of cross-sectoral policies (eg. energy, transportation, etc.) can be one of the challenges of SEA for spatial plans.

Additionally, an earlier analysis of alternatives 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 many of European environmental assessment processes (Vanderhaegen and Muro, 2005) and the consideration of appropriate alternatives has been considered as one of the most critical SEA issues (Geneletti, 2012).

4.3 Prediction of CE

Generally speaking, strategic-level predictions require coping with considerable degree of uncertainty (Fischer, 2007). This uncertainty mostly relies on: the specific preferences of stakeholders; the assumptions made for predictions; and 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.

Referring to 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. 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; Canter and Ross, 2010). Nevertheless, due to the involvement of multiple agencies/authorities it requires, an effective management of CE could be more difficult to achieve.

Accordingly, SEA provides an opportunity for early assessing adaptive strategies to manage CE. This can be done for instance, by simulating what if the combined effects of planning alternatives or multiple decisions are likely under different management frameworks and future conditions which may be greatly uncertain. Scenario analysis can help SEA to integrate a more adaptive perspective into spatial plans. Fuzzy logics, a popular technique to handle imprecise information originally formalized by Zadeh in the 1960s (Zadeh, 1965), can also be applied to formalize stakeholder opinion and judgments in condition of uncertainty.

4.4 Use of spatially-explicit information

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. Although various approaches and techniques may be used in assessing CE (see Table 1), 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 (Vanderhaegen and Muro, 2005; Geneletti *et al.*, 2007).

In general, the use of spatial data and techniques allows relevant environmental and planning issues to be simultaneously considered at different scales. This is particularly relevant for predicting CE of land use plans since the potential significance and magnitude of an impact largely depend on the spatial distribution of proposed actions, VECs 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.

Furthermore, the use of a spatially explicit approach can also contribute to the transparency of decisions, enhancing the understanding and the perception of the distribution of environmental issues and effects within a geographical and political context, by facilitating more effective communication, consultation and participation. It can further assure a more thorough consideration of CE during the preparation of plans.

5. Conclusions

SEA offers the opportunity to support a better management of cumulative effects arising from spatial planning decisions. Concerning this, two important conclusions are discussed. The first one refers to the requirement of performing a scoping of CE, by focusing the assessment only on key VECs. Assessing the cumulative impacts on all the environmental issues listed by the EU-SEA Directive could be time-consuming and ineffective in capturing relevant consequences. Concerning spatial planning, a better CE scoping could improve the treatment of scale-lag effects, by capturing those minor effects – both positive and negative – which may become significant at higher level (e.g. loss of biodiversity due to small land use changes, decrease of CO_2 emissions due to the production of renewable energy from point sources, etc.). It could also provide evidence to the selection of VEC, by defining trends and thresholds; and increase the capacity to manage CE, by identifying those relevant other PPPs which share responsibilities to prevent negative impacts or enhance positive synergies, facilitating the coordination between spatial and sectoral policies (e.g., energy sector, rural development, etc.).

The second conclusion concerns the need to better orient the assessment of CE towards the future, by adopting a more adaptive perspective. This is to allow reasonable futures to be better explored, supporting the definition of planning alternatives, which can include assumptions on possible adaptive measures to manage CE. For example, assessing future CE resulting from the implementation of several mitigation/compensation or enhancement measures (e.g. habitat restoration, sustainable water drainages, incentives to renewable energies, etc.) can be particular important to improve the consideration of CE in SEA for spatial plans.

Finally, given the intrinsic spatial nature and the importance of the management of space for spatial planning, a third consideration concerns the integration of 'spatial evidence' into SEA for better treating strategic level CE. Spatially explicit approaches can add more transparency to land use decisions and help to early capture the accumulation of effects on the ground.

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