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Strategic environmental assessment for low-carbon development: developing an analysis framework

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Understanding of strategic environmental assessment's (SEA) influence on low-carbon development (LCD) is critical as societies strive to decarbonize without jeopardizing economic growth. As best practice perceptions are still evolving, plausible conceptual and analytical frameworks are needed. This paper offers a conceptual clarification and proposes a framework for analyzing environmental reports. We employed a multi-phased, mixed-methods approach. The first phase involved an integrative literature review that combined theoretical insights from LCD and transition management with SEA's procedural aspects. The extracted data was used to develop an initial framework in the second phase. The third phase utilized an international case study and expert consultations to illustrate, validate and refine the framework. The resulting framework comprises five review areas to be verified by a series of review questions reflecting good practice. It could assist SEA researchers, practitioners, responsible authorities, policymakers and environmental agencies better understand, prioritize and address the issue of LCD.

Keywords: strategic environmental assessment; low-carbon development; analysis framework; environmental report; transition management

1. Introduction

Low-carbon development (LCD) has been hailed as a new planning agenda (Hunter *et al*. 2019; Williams 2013). There are multiple interpretations of LCD; however, simply put, LCD refers to pursuing development goals while also mitigating climate change (Mulugetta and Urban 2010; Urban and Nordensvärd 2013). This model is essential because greenhouse gas (GHG) emission levels in the atmosphere are so high that carbon-intensive development patterns are no longer viable (Deep Decarbonization Pathways Project 2015; Zenghelis 2019). The recent Intercontinental Panel on Climate Change report, for example, stressed the need to decarbonize future development, warning that global warming of 1.5 °C and 2°C will be exceeded during this century unless GHGs are drastically reduced in the coming decades (IPCC 2021, 18). It has thus become critical for governments at all levels to promote LCD.

Given the inherent inertia of incumbent development paradigms (Seto *et al*. 2016), strategic environmental assessment (SEA) can be both valuable and obstructive to low-carbon transitions. A widely accepted definition of SEA is that it is a tool for integrating environmental factors at the early stages of decision-making, along with economic

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and social factors into proposed policies, plans and programmes (PPPs) in a transparent, efficient and accountable manner (Partidário 2015; Therivel, Jones, and Jenkins 2016). In principle, SEA should lay the groundwork for all forms of sustainability transitions by thoroughly assessing strategic options, trends, and drivers and feeding to lower decision-making levels (Nwanekezie, Noble, and Poelzer 2021; Noble and Nwanekezie 2017; Partidário 2012). It allows for the identification of preferred development directions, priorities and strategies for the future development and management of sectors and regions (Gunn and Noble 2012; Josimović, Cvjetić, and Furundžić 2021). However, the process is much more complex in practice; it can unfold inefficiently and potentially become a hindrance. Therefore, if we understand how SEA is carried out, we will be better equipped to strengthen the practice.

Even though it is the process that matters, a post-hoc evaluation of environmental reports (SEA reports) can help indirectly determine whether SEA was carried out well (Riki Therivel 2004). In this regard, some organizations and researchers (Larsen, Kørnøv, and Driscoll 2013; do Nascimento Nadruz *et al*. 2018; Chang and Wu 2013; Posas 2011; European Commission 2013; Environment Agency 2011; The Scottish Government 2010; Levett-Therivel Sustainability Consultants 2007) have proposed evaluation guides addressing low-carbon issues. A significant advancement in the evaluation of environmental reports has been the development of objective criteria for evaluating their quality. To analyze the influence of planning on decision making, existing academics have specified their evaluation frameworks in terms of planning goals and procedures (e.g. Posas 2011). However, few recognize the complexity surrounding LCD, particularly concerning the unique dynamics of low-carbon transitions, socio-technical change, actors and networks, political and institutional structures, and the hurdles posed by path-dependencies and lock-ins within socio-technical systems (Geels *et al*. 2017). Consequently, researchers attempting to evaluate SEA reports may lack conceptual and methodological guidance upon which they can rely with confidence and clarity to conduct rigorous analyses.

This work is an effort to address that gap. It aims to develop an analysis framework for evaluating SEA reports to determine the extent to which SEA practice advances LCD. We sought to help clarify how the integration of LCD measures into SEA can be operationalized, compared and improved. Specifically, the following research question guided this study: *How can we underpin, elaborate and assess the treatment of LCD in SEA processes, considering the quality of environmental reports*?

This paper contributes to the literature interrogating planning's role in facilitating sustainability transitions, particularly as it focuses on SEA's strategic role in supporting low-carbon transitions. The proposed framework clarifies the SEA-LCD linkages. It could assist SEA researchers, practitioners, responsible authorities, policymakers, environmental agencies, and other users to better understand, prioritize and address the issue of LCD.

The rest of this paper unfolds as follows. After this introduction, we discuss the theoretical background to situate our research within the wider literature body. In section 3, we explain our methodological approach. We then present the results in section 5, followed by a discussion in section 6. The final section outlines our concluding remarks.

2. Theoretical background

For this paper's theoretical basis, we draw on perspectives from the strategic-based SEA model and transition management to assist in structuring the role of SEA in managing low-carbon transitions.

2.1. Strategic-based SEA model

SEA is increasingly becoming a standard component of sectoral and regional/spatial planning worldwide to complement project-level environmental impact assessment (EIA) (Josimović, Cvjetić, and Furundžić 2021). The extent to which SEA can help plan low-carbon transitions depends on how it is interpreted and applied. The literature distinguishes between two main approaches; the proactive, strategic-based, opportunities-constraints approach and the reactive EIA-based approach (Söderman and Saarela 2010; Partidário 2012, 2015). Scholars contend that framing SEA as a tool for operational decision-making thwarts its transformational potential (Fundingsland Tetlow and Hanusch 2012; Fidler and Noble 2012). This suggests that ensuring adequate consideration of LCD requires embracing the strategic-based SEA model that allows a broad and forward-looking perspective (Hacking and Guthrie 2008). This model exhibits the following features (Partidário 2009):

- Establish a framework of participation and institutional governance and acknowledge different perspectives
- Develop a strategic reference framework (SRF) – development of strategic objectives and assessment benchmarks for working toward a sustainable future
- Identify critical factors for decision-making (CFDs) – set strategic priorities based on the fundamental strategic issues for development, the relevant environmental factors and the macro-level policy framework defined by the SRF
- Analyze trends in the strategic context, focusing on dynamic analysis, rather than static analysis
- Carry out sectoral studies than analyze CFDs and the assessment to offer information to decision-makers
- Assess strategic options for different future scenarios
- Explore and prioritize plausible options that allow choice, foresight, exploring opportunities and avoiding risks
- Formulate and propose guidelines that drive possible pathways, avoid the paradigm of mitigation
- Support the strategy with follow-up processes

SEA practice varies depending on planning context and design; however, the generic process comprises five main SEA phases (Table 1). It is typically iterative, with public engagement occurring at every SEA stage.

The aforementioned procedural steps are accomplished using various techniques and methods to collect, analyze and present data (Souloutzoglou and Tasopoulou 2020; Noble, Gunn, and Martin 2012). These include checklists, questionnaires, matrices, SWOT analyses, spatial analyses, multi-criteria analyses, vulnerability analyses, scenario analyses, cause-effect analyses, risk analyses and assessment of environmental capacity (Josimović, Cvjetić, and Furundžić 2021). There is no single methodological approach that will apply to all PPPs. The appropriate method depends on contextual factors, whose discussion is beyond our scope. Generally, SEA is informed by major planning theories. More specifically, as a form of impact assessment, SEA parallels the rational planning process (Lawrence 2000). According to the rational planning theory, impact assessment is the process of gathering, evaluating and documenting environmental information to facilitate rational decision-making, specifically to manage adverse consequences of the proposed action (Alexander and Faludi 1989). The theory

Table 1. Summary of SEA main phases and related activities.

SEA phase	Key steps/tasks
1. Conceptualization	• Perform screening to determine the need for SEA • Identify strategic visions and objectives • Identify critical decision factors • Undertake scoping studies to identify salient strategic issues to be studies in detail • Identify links with other strategic actions
2. Detailed Assessment	• Analyse the baseline context and trends • Identify strategic options and pathways to meet the vision • Consider short term and long-term risks and opportunities • Perform scenario analyses of future possibilities • Assessing uncertainties
3. Decision-making framework	• Develop operational guidelines and frameworks, including guidelines for project-level EIAs and conditions to be adhered by decision-makers and developers. • Make arrangements for sharing the SEA report and disseminating findings
4. Monitoring and follow-up	• Develop indicator systems for strategic options • Perform monitoring and follow-up studies • Assign responsibilities to sectoral and government agencies
5. Participation and consultation	• Identify and engage constituencies and interest groups from a broad range of sectors relevant for PPP formulation and implementation

(Partidário 2012; Esterhuyse 2018; Polido and Ramos 2015; Dalal-Clayton and Sadler 2017).

of socio-ecological idealism (SEI) emphasizes integrating environmental and social substance into the planning procedures (Lawrence 2000).

Therefore, in an increasingly carbon-constrained world, deploying SEA to promote LCD is only rational. Research in the LCD field has led to the development of different conceptual frameworks to conceptualize and understand the dynamics of LCD processes, as well as how to guide and support such processes. Transition management is one such concept. Next, we highlight some important aspects of this concept.

2.2. Transition management

There has been an explosion of transition management literature over the recent decades in response to perceived path-dependencies and lock-ins in society hampering necessary transitions to a more sustainable future (Markard, Raven, and Truffer 2012). This literature conceptualizes sectors such as transportation, energy supply, industry and water supply as socio-technical systems, consisting of networks of actors (firms, individuals, social groups), institutions (laws, regulations, standards of good practice and norms) as well as knowledge and material artifacts (Markard 2011; Geels 2004). The system's various components interact, and together they provide particular services to society (Markard, Raven, and Truffer 2012). In this context, a transition develops as a co-evolutionary process where socio-technical processes interact and reinforce one another (Kemp and Rotmans 2005). This process involves the following key elements (Kemp and Rotmans 2005):

- The end state (new equilibrium)
- The pathway toward the end state, consisting of different options and stages
- Transition constraints that hamper the process
- Multiple developments, external and internal, to a given system that shape the transition outcomes.

A sustainability transition is a major shift toward a more sustainable society, responding to various persistent problems modern contemporary societies face (Grin, Rotmans, and Schot 2010). All sustainability transitions have the following features that offer crucial insights for successful transition management (Köhler *et al*. 2019):

- Multidimensionality and co-evolution: they are non-linear, co-evolutionary processes involving changes in a range of dimensions and elements
- Multi-actor process: they are enacted by a range of social groups and actors with different capabilities, resources, beliefs, interests, and strategies
- Stability and change; They involve forces of path-dependency and stability and innovative changes
- Long-term process; they are long-term processes, taking up to decades to unfold
- Uncertainty and open-endedness; There are multiple transition pathways with possibilities that are impossible to predict
- Values, contestation and disagreement; different interest groups are bound to compete and disagree on goals and transition pathways
- Normative directionality; Market forces have limited incentives to address public goods such as sustainability due to prisoner's dilemma and free-rider problems; therefore, public policy must play the central role in directing the transitions

Low-carbon transitions are connected to the recent discussions regarding the need to shift to low-carbon ways of doing, producing and consuming as part of the broader sustainability transition (Loiseau *et al*. 2016; Andrade and Puppim de Oliveira 2015; Bush and Bale 2019). They entail major shifts in energy, transport, building and other systems that substantially improve energy efficiency, curtail demand or involve a shift from fossils to renewables (Geels, Berkhout, and van Vuuren 2016). Transition management involves proactively managing and accelerating such shifts (Markard, Raven, and Truffer 2012). It is within this context that we investigate the potential role of SEA. We explain our methodological procedures in the next section.

3. Methodological approach

This study aimed to develop an analysis framework for understanding and evaluating SEA reports concerning the inclusion of LCD issues. Analysis frameworks allow for comprehensive assessment while reducing user interpretation and subjectivity (Retief 2007), an inevitable feature of any document review. Therefore, for this work, we consider research to be a systematic and creative work undertaken to expand the stock of knowledge (OECD 2015a). We use the critical realism philosophy of science to guide our view of reality and knowledge (Bhashkar 1978). Critical realism combines the constructionist and positivist approaches to offer a thorough account of epistemology and ontology (Gorski 2013). An important assumption in this paradigm is that our knowledge of the world is transitive; it is open to criticisms and change (Haigh *et al*. 2019).

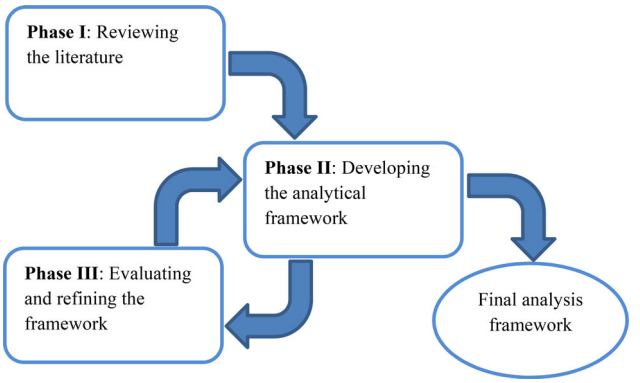


Figure 1. Framework development process.

With this ontological position in mind, we acknowledge that the analysis framework that we develop may in time be modified, extended or even rejected despite our efforts to ensure its practical adequacy and validity.

We adopted a mixed methodological, three-phased approach (Figure 1) informed by McMeekin *et al*. (2020) and Ng'etich, Voyi, and Mutero (2021) in order to construct a framework that more accurately characterizes and explains reality (Lawani 2021).

3.1. Phase 1: Reviewing the literature

We started by conducting a narrative literature review to generate a theoretical review (Paré *et al*. 2015), resulting in an initial set of theoretical insights and practicable ideas for operationalizing LCD within SEA. We conducted what Torraco (2016) referred to as an integrative literature review, which involved reviewing, critiquing and synthesizing representative literature on the subject in an integrated way to situate the salient features regarding the research question.

The literature search was an open-ended iterative process where the research question was honed over time as evidence became clearer (Finfgeld-Connett and Johnson 2013). We started by identifying key search terms, as previous researchers (e.g. White and Noble 2013; Rodrigo-Ilarri *et al*. 2020; Fischer and Onyango 2012) had done. These include, but not limited to, "impact assessment", "strategic impact assessment", "SEA", "climate change", "climate change mitigation", "low-carbon development", "low-carbon growth", "low-carbon transition", "low-carbon society", "low-carbon economy", "sustainability transitions" and "transition management". We searched for relevant scientific and gray literature in English language in three databases; Google Scholar, Web of Science and Scopus. We chose these databases for their well-known comprehensiveness. We did not set strict inclusion/exclusion criteria to allow for creativity and flexibility. Instead, we focused on literature pieces that appeared to be exciting and relevant for the topic. We used backward and forward literature snowballing to identify additional sources from the initial sources (Jalali and Wohlin 2012). We searched both recently published and older literature to ensure a balanced search (Torraco 2005).

The final selection consisted of peer-reviewed scholarly articles, books, working papers, book chapters, conference papers, and working papers, was based on English

language literature covering the topic directly. A staged review process (Torraco 2016) (i.e. title, abstract, body, conclusion) was used to examine each literature piece.

3.2. Phase 2: Developing the analytical framework

Data extracted from the literature review were used to build an initial analysis framework in the second phase. This process involved synthesizing and amalgamating theoretical insights, guidance and existing frameworks. We focused on two categories of data that formed the framework's basic structure. The first relates to the procedural steps and analytical processes in SEA, which formed the framework's initial building block. The second relates to insights about LCD and transition management, which established the conceptual linkages between SEA and LCD. The key information was extracted using thematic analysis (Braun and Clarke 2006), identifying emerging themes and patterns and entering them into a predefined table (McMeekin *et al*. 2020). The three authors then discussed the results of this exercise. Based on the literature review, we developed a preliminary review framework comprising review areas, review parameters and review criteria. This was subsequently subject to validation and refinement in the last phase.

3.3. Phase 3: Evaluating and refining the framework

The last phase followed a two-staged approach to validate and fine-tune the draft framework:

1. In the first stage, we used a case study to test the feasibility of and fine-tune the initial framework. A case study is "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin 2009, 18). In the context of developing and validating an analysis framework, a case study can help test assumptions and generate a comprehensive understanding using a real-life example. In addition, the case study was necessary to ensure that framework comprises indicators appropriate to current practice. The case study SEA report was downloaded online in PDF format and content-analysed inductively to identify emerging themes and subthemes (Krippendorff 1989).
2. In the second stage, we solicited expert feedback to refine the draft framework further, particularly regarding clarity and adequacy. This stage utilized inputs from purposefully selected SEA experts. Selection criteria included having at least one recent international peer-reviewed publication on a strategic-based SEA topic and/or participation in at least one SEA study. We judged an individual who met either or both of these two criteria to have sufficient expertise to provide relevant inputs. The draft framework, alongside a brief summary of the PhD project, was emailed to 10 SEA experts; 5 local and 5 international. The experts were asked two open-ended questions: 1) is the framework clear enough? And 2) are there any redundant or omitted components? This approach avoided direct confrontation amongst experts, which is a major drawback of traditional Delphi studies (Barrett and Heale 2020), while still achieving a level of consensus. After sending several reminders over a period of one month, we received responses from 5 experts; 3 local and 2 international. We subsequently revised the draft framework

accordingly. The final review framework was thus deduced from combining theoretical insights, case study analysis and expert opinions.

3.4. Case study description

We selected the SEA report for the Project Ireland 2040 – National Planning Framework (NPF) in Ireland as a case study (Government of Ireland 2018). Launched in February 2018, the NPF is a high-level policy planning document that sets the vision and offers a framework for making strategic choices about future investment and development in Ireland. In the context of this ambitious strategic plan, the Irish government committed to directing and mandating infrastructure investment and planning in Irish towns, cities and rural areas, as well as different sectors, in order to sustainably cater for Ireland's growing population for the next two decades (Carroll and O'Sullivan 2020). The strategic plan outlines various strategic investments, totaling €21.8 billion, intended to accelerate the country's transition to a low-carbon and climate-resilient economy by 2050 (Carroll and O'Sullivan 2020). It sets out a goal of reducing carbon dioxide gas emissions by at least 80% (relative to 1990 levels) in the energy, transport, built environment, forestry and agriculture sectors (Government of Ireland 2018).

According to the European Union's Directive 2001/42/EC (SEA Directive), the plan was subject to SEA, which mandates that its environmental consequences be assessed and conditions for accomplishing its objectives be established (González *et al*. 2019). As such, the SEA process offered a means for integrating and implementing the NPF's climate goals. We chose this case study because it demonstrates good practice internationally concerning how SEA can help to shape low-carbon decision-making. We believed that it could help test and validate the framework and stimulate further discussion around the topic.

4. Results

This section describes the study's main findings, which are presented in the order shown in Figure 1 in our methodological approach.

4.1. Theoretical contributions

The literature review yielded several theoretical insights, offering generalized considerations to be included in the various SEA phases. These are described below and summarized in Table 2.

4.1.1. Conceptualization

Conceptualization-related ideas pertained to considerations that set the context for exploring and evaluating low-carbon alternative options.

- International climate regimes such as the Paris Agreement and the UN 2030 Agenda have established a worldwide process of cooperation and engagement for a more equitable, effective and efficient climate regime (Annesi *et al*. 2021; Teng, Lu, and Chiu 2020; Lima *et al*. 2020).

- Transitions require the creation of guiding visions to mobilize actors and resources and guide change (Hunt and de Laurentis 2015; Kemp and Rotmans 2005).

Table 2. Summary of literature review results.

Review area	Review parameter	Review criteria	Contributors
Conceptualization	Strategic issues	Verify if important strategic issues such as climate change, energy security, and GHG emissions been outlined	Annesi *et al.* (2021); Teng, Lu, and Chiu (2020); Lima *et al.* (2020), Hunt and de Laurentis (2015), Kemp and Rotmans (2005)
	Strategic objectives	Verify if strategic objectives relevant for LCD been identified Verify if LCD-relevant strategic objectives and activities of other relevant strategic actions have been linked to the assessed PPP	
	Decision-factors	Verify if local, regional, and international frameworks relevant for addressing climate change and decarbonization been outlined	
Detailed scientific analysis	Baseline data	Verify if important historical and future trends in factors influencing carbon sources and sinks been adequately described Verify if important socio-economic trends have been described	Bengt, Bauer, and Nilsson (2020), Chester *et al.* (2014), Budde (2013), Yin and Shi (2021), Shukla and Chaturvedi (2012), Jakob *et al.* (2014), Steckel *et al.* (2011), Lieu *et al.* (2020), Nikas *et al.* (2017)
	Strategic alternative options	Verify if strategic alterative options related to LCD been identified Verify if different scenarios for the strategic options related to LCD been described	
	Methods and Techniques	Verify if the methods and techniques are appropriate for assessing LCD implications Verify if suitable specialist consultants were used	
	Strategic risks and opportunities	Verify if relevant LCD values, interests, opportunities and risks have been identified for the different options under different scenarios.	
	Uncertainties	Verify if uncertainties related to low-carbon options and their evaluation methods have been adequately described	
	Pathways	Verify if the identified pathways are appropriate for advancing LCD	

(*Continued*)

Table 2. (*Continued*).

Review area	Review parameter	Review criteria	Contributors
Informing and influencing decision-makers	Implementation guidelines and frameworks	Verify if specific actors for implementing SEA recommendations at different levels and tiers been identified Verify if the report outlines LCD-relevant conditions that must be adhered by decision-makers and developers Verify if LCD-relevant responsibilities and implementation tasks have been outlined	Hunt and de Laurentis (2015), Smith, Stirling, and Berkhout (2005), Cunha *et al.* (2021)
Monitoring and follow-up	Monitoring arrangements	Verify if the report identifies LCD-relevant issues that need to be monitored Verify if the proposed arrangements adequate to monitor the effect of PPP on LCD, including indicators to track direct and indirect divers of changes in carbon profiles including future land-use changes been identified	Wang *et al.* (2019), Deep Decarbonization Pathways Project (2015), Bengt, Bauer, and Nilsson (2020), OECD (2015b)
Public participation	Stakeholder groups	Verify if LCD-relevant stakeholders have been engaged	Hölscher, Wittmayer, and Loorbach (2018), Farla *et al.* (2012), Van Vliet *et al.* (2020), Peters, Fudge, and Hoffman (2013)
	Stakeholder issues	Verify if LCD-relevant issues that transpired during the public participation processes were described	
	Influence on LCD	Verify if the report describes how consultations influenced the PPP's content and direction to advance LCD	

4.1.2. Detailed scientific assessment

Detailed scientific assessment insights related to the measures for collecting and analyzing information to understand the risks and opportunities of LCD pathways.

- Assessing low-carbon transitions is crucial for learning about the feasibility of various pathways (Bengt, Bauer, and Nilsson 2020).
- Despite considerable knowledge of how to reduce carbon emissions from technologies and infrastructures, institutional, cultural and physical forces continue to constrain engineering approaches (Chester *et al.* 2014).
- Uncertainties about transition pathways in terms of future emissions, markets, technologies, regulations, and consumer behavior are pervasive in low-carbon transitions (Budde 2013).

- Establishing low-carbon pathways needs an effective transition from fossil fuel-based sources to renewables, enhancing energy efficiency, offsetting emissions and adjusting production and production patterns (Yin and Shi 2021).
- Assessing low-carbon and energy transitions requires the comparison and analysis of different scenarios, including under business-as-usual assumptions (Shukla and Chaturvedi 2012; Jakob *et al*. 2014; Steckel *et al*. 2011).
- In assessing low-carbon pathways, it is necessary to weigh their benefits and costs, uncertainties, tradeoffs and consequences on various contextual factors such as environmental quality, social justice, technological development and economic development (Lieu *et al*. 2020).
- While replacing traditional technologies and behaviors with low-carbon alternatives may provide socio-economic and environmental benefits, it may also have negative consequences, such as job losses, investment requirements, or resource imports (Nikas *et al*. 2017).

4.1.3. Informing and influencing decision-makers

This category of ideas is related to the mechanisms proposed for informing decision-makers and coordinating action:

- Articulating low-carbon visions require mechanisms for mobilizing and coordinating responses between various decision-makers and interest groups (Hunt and de Laurentis 2015; Smith, Stirling, and Berkhout 2005).
- Countries are revising their legal frameworks to facilitate widespread civic engagement in energy markets in order to promote the transition to a low-carbon society (Cunha *et al*. 2021).

4.1.4. Monitoring and follow-up

This area describes ideas for post-decision monitoring of decision frameworks and the evolution of the baseline conditions during PPP implementation:

- Managing low-carbon transitions requires a system of indictors to track and measure development trends, including the drivers and barriers (Wang *et al*. 2019; Deep Decarbonization Pathways Project 2015).
- Monitoring can address direct outcomes such as GHG emissions or the diffusion of low-carbon technologies as well as other conditions for the low-carbon transition such as determine readiness for change such as technology readiness, knowledge, feasible policies and instruments, innovation networks, and social norms (Bengt, Bauer, and Nilsson 2020).
- In collaboration with regional and national governments and other institutions, local governments need to measure and monitor progress using indicators that allow comparisons at the local, regional, national and international levels as well as in different sectors (OECD 2015b).

4.1.5. Public participation

Public participation is about evidence for whether and the extent to which various actors and interest groups get an opportunity to be engaged in the SEA process.

- Actors play essential roles in shaping desirable transformations and transitions through transformative governance and agency (Hölscher, Wittmayer, and Loorbach 2018)
- Low-carbon transitions do not just involve consumers and firms but a broader range of actors such as the media, civil society groups, political parties, city authorities, local residents, government ministries and advisory bodies (Farla *et al*. 2012)
- It is critical to involve experts and academics, as well as other stakeholder groups such as NGOs, government, and business, in order to have a more balanced identification of the risks and opportunities associated with low-carbon transitions (Van Vliet *et al*. 2020)
- Tapping into and boosting the drive and cohesiveness of existing community groups and social networks opens up new intriguing possibilities for engaging citizens in low-carbon lifestyles (Peters, Fudge, and Hoffman 2013).
- The risks and opportunities of low-carbon transitions are a matter of stakeholder perceptions; what is a risk for some may be an opportunity for others (Lieu *et al*. 2020).

4.2. Case study illustration

In this subsection, we employ the Irish case study to illustrate, validate and refine the framework. Overall, the case study illustrates the use of SEA to plan for LCD and demonstrates the applicability of the framework in analyzing SEA reports. The evaluation results, summarized in Table 3, indicate that the SEA process for the draft NPF addressed LCD extensively, building a solid foundation for the low-carbon transition in all Irish sectors and regions. All the review criteria were comprehensively addressed except for uncertainties. Additional review criteria were also discerned.

4.3. Expert inputs

Inviting experts to provide feedback has proven beneficial in revealing some of the framework's potential strengths and flaws. The five experts unanimously agreed that, to a large extent, the draft framework adequately reflected the key elements. Nonetheless, two minor concerns were raised; these were about the framework's structure and the issue of social equity. These are highlighted in the following two excerpts:

> I believe the main aspects related to the structure of a SEA report are covered in the framework. I think an essential aspect not presented is related to how the review questions will be evaluated? On 3 levels? two levels? It would be good to explore these aspects based on guiding the analysis that will be carried out. (Expert #4)

> Overall, I think it looks great – it appears very useable for the purpose of reviewing and evaluating SEA documents… ….Shifting to LCD presents opportunities to simultaneously address various forms of inequality, but only if it is done thoughtfully and intentionally (e.g., traditionally the energy sector has been very male-dominated, but as we shift to green energy, there is opportunity to achieve more 'good' jobs/ opportunities for women). It could be important for SEAs to consider the ways in which different segments of the population might be negatively or positively impacted by LCD options and ensure those groups are included as stakeholders. (Expert #5)

Table 3. Summary of findings from the case study evaluation.

SEA Phase	Review parameter	Key findings
Conceptualization	Strategic issues	• Identifies "climate change" and "building a resource-efficient, low-carbon economy" as some of the strategic issues
	Strategic objectives	• Outlines minimizing GHG emissions as one of the strategic objectives, within the context of environmental protection objectives at the national and EU levels
	Decision-factors	• Reviews several national, European and international frameworks, and identifies The National Climate Change Mitigation Plan and The National Renewable Energy Action Plan as some of the influential plans
Detailed scientific assessment	Baseline data	• Outlines the levels and changes in GHG emissions and use of fossil fuels in the country • Identifies some major drivers of environmental change and GHG emissions, including land use change and climate change • Identifies the major contributing sectors, including agriculture, manufacturing industry and transport • Refers readers to a national report, The Republic of Ireland National Statistics Report (CSO 2017) and the 2007 IPCC report • Reports that manmade GHGs are likely to increase in the future even in the absence of the plan • Outlines the current state and changes in the energy mix; the share of energy sources including renewables • Additional review criteria: Verify if trends in baseline GHG emissions and carbon sinks in the absence of the proposed PPP have been described
	Strategic alternative options	• Outlines six strategic options, including the "business as usual" option and various alternative scenarios for each, describing broad socio-economic targets and visions linked to the strategic environmental objectives • Explains how the preferred option will maximize gains, including reducing transport-related emissions.
	Methods and techniques	• The use of secondary data such as national reports and datasets • Environmental sensitivity analysis using geographical information systems (GIS) • The use of forestry inventory planning systems

(*Continued*)

Table 3. (*Continued*).

SEA Phase	Review parameter	Key findings
	Strategic risks and opportunities	• Describes the broad positive and negative impacts of the preferred option on the strategic environmental objectives • Reports that combined with policies that promote road transport, there will be an overall increase in transport-related GHG emissions • Identifies the impacts of the plan on climate change and low-carbon economy in combination with several other PPPs related to the electrification of the transport sector and uptake of renewable energy will result in net positive impacts
	Uncertainties	• Does not acknowledge uncertainties directly, but concedes that short-term impacts are difficult to assess due to the lack of details at the strategic planning level, e.g. site details.
	Pathways	• Numerous pathways have been proposed to help realize a low-carbon, sustainable future, including reducing carbon footprint by integrating climate action into planning, promoting renewable energy generation and green infrastructure, and electrification of the transport sector toward zero emissions • The report terms most the pathways as key enablers
Informing and influencing decision-makers	Implementation guidelines and frameworks	• The report identifies some key actors responsible for implementation including local authorities and environmental agencies • The report identifies several existing plans that provide an implementation framework and guidelines , e.g. Local Development Plans and The Renewable Energy Development Framework • The report recommends further feasibility studies for several pathways • Recommends lower planning tiers such as city and county plans to consider climate mitigation and carbon footprints across sectors such as transport, agriculture, energy and built environment
Monitoring and follow-up	Monitoring arrangements	• Identifies several qualitative and quantitative targets, indicators and data sources for tracking progress toward achieving reaching strategic environmental objectives , including the EPA Annual GHG emissions Inventory Reporting

(*Continued*)

Table 3. (*Continued*).

SEA Phase	Review parameter	Key findings
		• Identifies the transition to a low-carbon economy as one of the targets • Identifies reductions in energy use and GHG emissions and the promotion of renewable energy as targets • Identifies the number of actions delivered through the National Mitigation Plan (2007), net annual reduction in GHG emissions and carbon neutrality in various relevant sectors as some of the indicators • Identifies several plans and programmes that are already collecting monitoring data • Identifies the department of Communications, Climate Action an Environment (DCCAE) as one of the responsible bodies • Recommends the identification of appropriate bodies and departments for monitoring activities • Additional review criteria: Verify if other ongoing LCD-relevant monitoring programmes and datasets are identified
Public participation	Stakeholder groups	• Identifies several statutory and non-statutory stakeholder groups that were consulted
	Stakeholder issues	• Identifies renewable energy and the transition to a low-carbon economy as some of the issues raised by stakeholders
	Influence on LCD-content of the report	• It is mentioned that the stakeholder comments were incorporated into the SEA report.

Following the above suggestions, two important changes were made to the framework:

- We excluded review parameters from the final framework
- We added a review question addressing the issue of social equity under the detailed scientific assessment review area.

4.4. Final analysis framework

The development of the final framework was informed by lessons derived from the literature, case study review and expert recommendations. The proposed framework (Table 4) offers a logical approach to evaluating SEA reports hinged on the five main SEA phases. It comprises two elements; review area and review questions. The review area corresponds to the main SEA phases, which provide structure to the framework. The other element identifies the specific questions to be asked during the report review process. Answering

the questions uncovers elements of good practice, enabling judgment about the quality of the environmental reports regarding their ability to inform decisions toward LCD.

5. Discussion

Few studies have explored the parallels between SEA and LCD, and proposed analysis frameworks for guiding and evaluating SEA practice. One of the main assumptions of the planning theory is that planning is a rational process that utilizes available knowledge and information to formulate an optimal course of action (Alexander and Faludi 1989). In the current study, we identified the most important considerations for including LCD measures in SEA and developed an analysis framework for reviewing SEA reports to determine the extent to which the SEA process furthers LCD. The developed framework, which comprises five review areas and twenty four review questions (Table 4), represents a starting point in understanding SEA-LCD integration. It also offers simple guidance for evaluating the practice. Decision-makers, practitioners, researchers, responsible authorities, environmental agencies and other interested parties can use the framework in various ways, such as:

- Performing evaluation studies; single case studies, comparative and longitudinal analyses
- Developing terms of reference for SEA studies
- Determining whether all relevant SEA tasks were performed and climatic factors were assessed comprehensively
- Identifying any additional assessment tasks and information, required to improve the reports
- Determining whether all essential stakeholders and interest groups have been consulted
- Determining the adequacy of SEA guidelines and regulations as well as that of climate change strategies and roadmaps

The developed framework has several strengths. First, there was an intentional effort to be realistic in designing it, acknowledging that this is an emerging topic and evaluation of SEA practice will be imperfect until this analysis framework and the data sources upon which it is based are developed further. It is thus contingent on empirical studies and theoretical breakthroughs. The review questions are comprehensive and not restricted to a specific planning context. As such, the framework remains within the critical realism paradigm (Fletcher 2017; Archer *et al*. 2013), but introduces more pragmatism regarding methodology, which allows for creativity. It confronts the critical realism dilemma that, although knowledge is transitive, we must still be able to distinguish "good" from "bad" SEA practice (Haigh *et al*. 2019).

The framework is underpinned by the strategic-based SEA model. This is an important strength because it has been argued that adopting more strategic thinking opens up more opportunities for achieving sustainable development (Partidário 2015). Our framework can help SEA actors improve their understanding to design and implement more impact-oriented SEA processes (Dalal-Clayton and Sadler 2017). Furthermore, while direct application can be found at the strategic level, it is also relevant for project-level evaluations; in jurisdictions with functional tiering arrangements, our framework should offer a useful frame of reference for EIA actors. Overall, our

Table 4. Framework for reviewing SEA reports.

Review area	Review question
Conceptualization	1. Are important strategic issues such as climate change, energy security, and GHG emissions outlined?
	2. Are strategic objectives relevant for LCD identified?
	3. Are local, regional, and international frameworks relevant for addressing climate change and decarbonization outlined?
	4. Are important historical and future trends in factors influencing carbon sources and sinks described?
	5. Are important socio-economic trends described?
Detailed scientific analysis	6. Are the trends in baseline GHG emissions and carbon sinks in the absence of the proposed PPP described?
	7. Are strategic alterative options related to LCD identified?
	8. Are different scenarios for the strategic options related to LCD described?
	9. Are the linkages between the LCD-relevant strategic objectives and actions of the assessed PPP and other relevant strategic actions described?
	10. Are the methods and techniques appropriate for assessing LCD implications?
	11. Are suitable specialists used?
	12. Are relevant LCD values, interests, opportunities and risks for the different options under different scenarios described?
	13. Is the distribution of LCD risks and opportunities across social groups described?
	14. Are uncertainties related to low-carbon options and their evaluation methods described?
	15. Are the identified pathways appropriate for advancing LCD?
Informing and influencing decision-makers	16. Are specific stakeholders for implementing SEA recommendations at different levels and tiers identified?
	17. Are LCD-relevant conditions that must be adhered to by decision-makers and developers described?
	18. Are LCD-relevant responsibilities and implementation tasks described?
Monitoring and follow-up	19. Are LCD-relevant issues that need to be monitored identified?
	20. Are the proposed arrangements adequate to monitor the effect of PPP on LCD, including indicators to track direct and indirect divers of changes in carbon profiles, including future land-use changes identified?
	21. Are ongoing LCD-relevant monitoring programmes and datasets described?
Public participation	22. Were LCD-relevant stakeholders engaged?
	23. Are LCD-relevant issues that transpired during the public participation processes described?
	24. Is the influence of consultations on PPP's content and direction to advance LCD described?

proposed framework allows for objective verification of whether SEA practitioners follow the strategic philosophy.

The derivation of the framework is informed by a theoretical framework that offers a more realistic understanding of LCD dynamics. Combining perspectives from planning theory and transition management has offered deeper meaning levels and nuances behind the idea of applying SEA to plan transitions. This broad understanding highlights a number of critical and yet neglected questions; how every draft PPP necessarily provides a

representation of socio-technical issues to be addressed, how such representations contain assumptions that are frequently overlooked, how these representations shape issues in ways that restrict low-carbon transitions, and how SEA can help actors vision, experiment, learn and evaluate low-carbon options. Overall, our framework stresses the need for addressing social and institutional innovations in addition to technological solutions.

Finally, the validity and reliability of our framework was enhanced through triangulation and validation (Grossoehme 2014). Our methodological approach, which was based on theoretical reasoning combined with practical validation and expert inputs, permitted an iterative process that enabled a deep and thorough exploration of ideas and the generation of rich content covering multiple important LCD aspects. Furthermore, the derived framework remains novel in guiding SEA actors and evaluating how SEA reports inform LCD decisions. Particularly, the widespread explicit consideration for low-carbon measures in our case study demonstrates that such an exercise is not only necessary and valuable as theorized but also practical. We were able to show that the transition to a low-carbon society is becoming an important consideration in development planning and that SEA can help define low-carbon objectives and assess low-carbon options and pathways, and that this process can be evaluated.

5.1. Limitations and future research

Our analysis has several limitations, which may open up future research opportunities. First, our framework only considers one aspect of SEA effectiveness: the quality of the SEA report, which, alone, does not tell the whole story or guarantee meaningful action (González *et al*. 2019). Of course, we must not underestimate its power in influencing decision-making (Larsen, Kørnøv, and Wejs 2012). Therefore, besides analyzing SEA reports, further analyses focusing on SEA legislation, regulations, guidelines and administrative bodies' capacity to set and enforce basic quality standards (Alexander and Faludi 1989) as well as post-approval processes are paramount. These are, thus, avenues for future research.

Second, our framework is far from definitive. Instead, it is a list of important indicators that can make a huge difference in supporting LCD, and it is likely to call for changes in SEA procedures. Although it is sufficiently generic for broad application, some review questions may be more or less relevant for specific PPPs and decision-makers. Therefore, its adequacy can only be evaluated in the light of specific decision-makers' information needs. Developing adapted frameworks will thus be an ongoing challenge for scholars. Using in-depth interviews and surveys, future research could explore the information needs of distinct decision-makers in particular sectors.

The third limitation concerns the assessment approaches. According to the literature, SEA reports can be assessed qualitatively or quantitatively (Posas 2011). The analyst's subjectivity is a typical criticism of qualitative approaches, while quantitative methods have been accused of reductionism. This has created confusion over which approach is more suitable. We intentionally did not recommend a suitable approach to avoid stifling creativity. This is a limitation in part because we anticipate a problem in objectively selecting the appropriate methodology for consistent and comparable analyses. As a result, more research is needed to establish the conditions under which various approaches are appropriate, and build scoring systems where necessary.

Last, but not least, although validation of the framework through a case study and inputs from experts aided in evaluating its adoption, utilization and acceptability, these

processes are dictated by broader political and socio-cultural dynamics that were not considered here. This is another important avenue for future research.

6. Conclusions

This research has contributed to the existing literature by proposing an analysis framework that clarifies SEA's potential to advance LCD. Our ultimate goal was to help planners, analysts, researchers, and other SEA actors conduct objective, transparent evaluations of this emerging practice. The case study has illustrated that SEA can help plan LCD where best practices are followed and that the framework is applicable. The transition management theory has offered a broad and deep perspective on how SEA can play a more strategic, proactive role in supporting sustainability transitions. Planners, policy-makers and practitioners should look beyond technological fixes and also consider how social systems can be managed effectively. Therefore, using the framework to evaluate SEA reports may lead to a better understanding of various SEA systems and their flaws and directions for reforms.

SEA cannot substantively contribute to sustainable development unless LCD is achieved. Overall, the proposed framework offers a new way of thinking about the aims and scope of SEA application, which signals more ambitious PPPs. There are many policy and practical implications of our framework. For example, it can play a crucial role in developing SEA terms of reference, controlling the quality of SEA reports, strengthening SEA guidance, and developing SEA training programmes. Ultimately, it can contribute to enhancing the quality of decision-making processes. Further validation research to test its practicality is required.

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