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The water–energy–food–land–climate nexus: Policy coherence for sustainable resource management in Sweden

Malgorzata Blicharska[1] | Richard J. Smithers[2] | Magdalena Kuchler[1] | Stefania Munaretto[3] | Lotte van den Heuvel[1,4] | Claudia Teutschbein[4]

[1]Natural Resources and Sustainable Development, Department of Earth Sciences, Uppsala University, Uppsala, Sweden
[2]Ricardo Energy & Environment, Ricardo plc, Gemini Building, Didcot, UK
[3]KWR Water Research Institute, Nieuwegein, The Netherlands
[4]Air Water and Landscape Science, Department of Earth Sciences, Uppsala University, Uppsala, Sweden

Correspondence
Malgorzata Blicharska, Villavägen 16, 75236 Uppsala, Sweden.
Email: malgorzata.blicharska@geo.uu.se

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Abstract

The concept of a 'nexus' across issues regarding the management of natural resources has gained increasing academic attention in recent years, but there is still relatively limited research on the application of the nexus approach for evaluating policies. This study analyses coherence among the main goals of five policy areas (water, energy, food, land, and climate) in Sweden, drawing upon a desk review, expert assessment, and interaction with stakeholders. The main objective is to enhance understanding of opportunities and challenges posed by such a nexus, understand policy interactions in Sweden, and provide insights into the use of policy coherence analysis as an integral part of resource nexus assessments. The analysis reveals synergies and conflicts between policy goals. For example, Sweden's environmental quality objectives (EQOs) regarding land and all the goals regarding water are either synergistic or neutral. Likewise, climate policy goals are well aligned with the goals regarding energy and ground water quality. On the other hand, the key goal for agriculture, which is food production, is the least coherent with those of the other policy areas. There are conflicts between the EQOs and goals regarding agricultural and forestry production. Stakeholders also indicate that climate goals are treated with higher priority than the goals of other policy areas. Notably, some interactions between policy goals are synergistic or conflicting depending on the context or their interpretation. Implementation of existing goals depends on relevant stakeholders' interests, priorities and interpretations, and on existing prevailing discourses in society, often supported by higher level policies.

KEYWORDS
coherence analysis, natural resource management, policy coherence, Sweden, WEF nexus

1 | INTRODUCTION

The concept of a 'nexus' across issues related to the management and use of natural resources has gained increasing attention in recent years. The water–energy–food (WEF) nexus has attracted particular attention (Albrecht et al., 2018), and its focus has recently been broadened to include environmental considerations (de Grenade et al., 2016) and climate impacts (Dale et al., 2015). Nexus-thinking seeks to overcome a silo mentality in relation to natural resource management and sector-specific governance (Biggs et al., 2015; Lazaro et al., 2021), thereby addressing externalities and trade-offs across policy areas as well as exploiting potential synergies (Hoff, 2011; Lazaro et al., 2022; Urbinatti et al., 2020). More specifically, approaches to analyse the WEF nexus have sought to determine the trade-offs and synergies between the biophysical and socioeconomic components of systems and associated policies. Such integrative approaches have long been developed to address sustainable development challenges (Biggs et al., 2015), and sustainable development research has addressed the nexus between resource systems for nearly three decades (Allouche et al., 2014; Boas et al., 2016). Academic interest in the nexus as a concept in itself has been amplified by a recent focus on pathways to achieving the Sustainable Development Goals (SDGs) (Nilsson et al., 2016) and growing concerns about climate change (Howells et al., 2013).

There has been a proliferation of resource nexus analyses to describe complex interactions among multiple systems and policy areas (Albrecht et al., 2018). Research initially focused on quantitative studies of interactions between biophysical components of different systems (Grubert & Sanders, 2018; Sušnik, 2018; Sušnik & Staddon, 2021; Wichelns, 2017), and progressively embraced socioeconomic issues, such as resource efficiency (Ringler et al., 2013), sustainable livelihoods (Biggs et al., 2015) and environmental security (de Grenade et al., 2016). Lately, nexus research has focused on sustainability issues related to natural resource use, particularly on interactions between different SDGs (Bennich et al., 2020; Olawuyi, 2020).

Amid increased attention to socio-economic issues related to the nexus, there has been a notable rise in studies applying qualitative approaches to understand the WEF nexus (Albrecht et al., 2018). Consequently, the debate has developed into a discussion on the governance of the nexus, with the aim to integrate resource management across policies and regulations from different sectors to promote better allocation of resources and ensure more sustainable decisions (Lazaro et al., 2022; Märker et al., 2018; Urbinatti et al., 2020). For example, a study by Lawford et al. (2013) of the WEF nexus in national and transboundary basins revealed that national policies could be as incoherent with other national policies within a country as with those in bordering countries. Van den Heuvel et al. (2020) assessed physical interactions between policy areas across the WEF–land–climate nexus through an ecosystem-service lens and highlighted the lag between the generation of scientific knowledge and its application in policy. Scott et al. (2011) investigated institutional opportunities and challenges to joint policy making in the water–energy nexus and highlighted the need for improved coordination between these two policy areas. Similarly, Scott and Sugg (2015) revealed the pivotal role of institutional arrangements for the governance of the water–energy–climate nexus. Papadopoulou et al. (2020) assessed the coherence between policy objectives and instruments in the water–land–energy–food–climate nexus in Greece and highlighted the need for involving stakeholders in such assessments. These studies illustrate issues that the development of policy must address if it is to span the nexus across policy areas coherently.

With regard to governance, the nexus approach promotes policy integration and coherence as crucial prerequisites for managing the complexity of the nexus (Boas et al., 2016; Urbinatti et al., 2020). Policy coherence analysis aims to investigate synergies, conflicts and trade-offs among policy areas and identify optimal policy mixes across the nexus sectors. Such analysis, involving stakeholder engagement, was coined as an important tool to help understand the interactions between different sectors of the nexus from a governance perspective (Sušnik & Staddon, 2021). The results of a policy coherence analysis help to formulate recommendations about how policy-making processes can be integrated to mutual advantage and thereby improve the management of nexus resources (Lazaro et al., 2021, 2022; Mercure et al., 2019; Nilsson et al., 2012; Olawuyi 2020; Weitz et al., 2017). While coherence analysis is an integral part of ex-ante impact assessments and ex-post evaluations of EU policies (Nilsson & Weitz, 2019; see also the European Commission's Better Regulation Guidelines [EC, 2022]), policymakers often lack adequate information on the coherence between key policies at a national scale and how to address potential synergies, conflicts and trade-offs among policy areas. Despite the increase in publications on the WEF nexus, there is still relatively limited research on the application of the nexus approach for developing policy recommendations (Lazaro et al., 2022).

The overarching objective of our study was to perform a policy coherence analysis of the goals of five policy areas——water, energy, food, land, and climate——in Sweden. We use nexus approach as our analytical framework and apply policy coherence analysis as a tool to identify trade-offs and synergies between these policy areas. Through undertaking such an analysis of the extended WEF nexus, we seek to enhance understanding of the opportunities and challenges for governing such a nexus and suggest areas where improvements are needed. Sweden was deemed suitable as a case study because it is seen as a global leader in environmental management (OECD, 2014), particularly due to its recent substantial cuts in greenhouse gas (GHG) emissions and ambitious climate mitigation targets (Xylia & Silveira, 2017). However, Sweden is also facing numerous challenges, such as biodiversity decline, deterioration of water quality, and increasingly frequent extreme events linked to climate change (Lidskog & Sjodin, 2016; SEPA, 2018; Teutschbein et al., 2022, 2023; Yang et al., 2015). To address these challenges, a more holistic understanding of the interactions among policy areas is needed (SEPA, 2011b). In that light, the specific aim of our study was to assess horizontal policy coherence between goals at the same level of governance across the nexus (Kurze & Lenschow, 2016; Lenschow et al., 2018) by identifying and assessing interactions among the national goals of the constituent policy areas. In addition to strengthening our understanding of policy interactions in Sweden, the study was also intended to provide broader insights into the challenges and opportunities of using policy coherence analysis as an integral part of resource nexus assessments to evaluate cross-sectoral interactions at a national level, and to reveal challenges that need to be addressed when applying a nexus approach. As such, the results of this study has implications not just for Sweden but also for other countries with similar levels of economic development and governance structures.

2 | THEORETICAL BACKGROUND

The World Economic Forum Annual Meeting in 2008 was important for the development of nexus thinking related to the management and use of natural resources, as was a subsequent book on the WEF–climate nexus in relation to water security (World Economic Forum, 2011). The World Economic Forum proposed nexus thinking as an approach to improve resource efficiency and security (Allouche et al., 2014). Since then, numerous initiatives and publications have addressed the nexus approach (Albrecht et al., 2018; Leck et al., 2015; Simpson & Jewitt, 2019; Sušnik & Staddon, 2021; Valek et al., 2017; Wang et al., 2017), including the 2011 Bonn conference on the WEF nexus with its pivotal background paper (Hoff, 2011) and policy recommendations paving the way for further elaboration of nexus thinking. In general, the nexus approach highlights the complexity of interactions occurring across policy areas and the necessity to overcome silo thinking in decision making, and resource management and governance (Guerra et al., 2021; Olawuyi, 2020; Pahl-Wostl, 2017). Recently, the nexus approach has been discussed in relation to the implementation of the 2030 Agenda for Sustainable Development (UN, 2015) with several examples of analysis of trade-offs and synergies between different SDGs (Bennich et al., 2020; Fader et al., 2018; Liu et al., 2018; Weitz et al., 2014). It has been suggested that a nexus approach is necessary to develop coherent policies to achieve SDGs by minimising trade-offs and building on synergies (Nilsson et al., 2016; Weitz, 2014). Others have highlighted the potential of nexus thinking to exploit potential synergies and to negotiate critical trade-offs among affected parties (Allan et al., 2015; Hoff, 2011), with the ultimate goal to improve resource efficiency and ensure sustainable management of resources (Sharma & Kumar, 2020; Simpson & Jewitt, 2019).

Despite the increasing popularity of the nexus approach in relation to the management and use of natural resources, some scholars argue that the concept still lacks clarity (Benson et al., 2015; Wichelns, 2017). In addition, its usefulness in analysis and practice has been criticised by some scholars (Foran, 2015; Hoff, 2011; Smajgl et al., 2016; Wichelns, 2017). For example, it has been highlighted that the selection of nexus boundaries is somewhat arbitrary (Wichelns, 2017) and may cut out many important variables and interactions. It has also been asserted that, as water policy is often taken as an entry point for the nexus approach (Allouche et al., 2014; Wichelns, 2017), it is congruent with integrated water resource management. More generally, the novelty and added value of the nexus approach have been questioned (see Simpson & Jewitt, 2019), with scholars arguing that it is unclear how the nexus approach is different from other integrative approaches (Smajgl et al., 2016). In addition, it has been suggested that the nexus approach may not always be appropriate to use, as there can be situations in which a discrete focus on a policy area is required. For example, there may be policy areas related to the management and use of natural resources where there is little need for interdisciplinary interaction or in contexts lacking institutional capacity, human capital or finance for cross-sectoral discussions. Notwithstanding these reservations, many scholars see great potential in the nexus approach, especially for dealing with complex issues of resource use in the face of climate change and with regard to sustainable development (Guerra et al., 2021; Lazaro et al., 2021; Rasul & Sharma, 2016; Stephan et al., 2018).

In our study, we use the 'nexus approach' as defined by Lazaro et al. (2022) as 'the systematic and dynamic identification and management of trade-offs and synergies between policies across sectors'. Key traits of the nexus approach are its transdisciplinary lens and the fact that it does not take any specific sector as the entry point. A nexus is characterised by a number of policy areas comprising biophysical and socio-economic systems (Munaretto & Witmer, 2017). The WEF nexus is the most commonly addressed, but a nexus may comprise more or different policy areas. Once the boundaries of a nexus are defined in terms of the policy areas involved, it becomes the object of a nexus approach, which considers the interactions across policy areas and overcomes silo thinking. Appropriate identification of nexus boundaries is of great importance for what can be observed through the nexus lens and, thus, for the analytical output attained (Garcia & You, 2016; Zhang et al., 2018). On the one hand, narrow boundaries may exclude various horizontal or vertical interconnections between policies among or within areas of policy. On the other hand, wide nexus boundaries that include more policy areas, actors, linkages and processes among scales and levels may result in a complex assemblage that is difficult to assess. Our study's nexus boundaries concentrated our analytical lens on the horizontal coherence of Sweden's national policy goals in relation to water, energy, food, land, and climate. Although we excluded vertical interactions with policy goals at international or subnational levels, we are appreciative of the 'messiness' of policy-making (Weitz et al., 2017).

Consistent with the 'messiness' of policy-making observed by Weitz et al. (2017), Candel and Biesbroek (2016) argue that 'dimensions of integration do not necessarily move in a concerted manner'. In that sense, the dynamics of interactions between policies are nonlinear and partial, as they are characterised by different temporalities and degrees of integration along the (ongoing) decision-making process. As such, policy integration should be understood as 'a process of policy and institutional change and design in which actors play a pivotal role' (Candel & Biesbroek, 2016).

3 | METHODS

3.1 | Study area

The study focuses on the WEF–land–climate nexus in Sweden. A large number of lakes and streams characterise the Swedish landscape and provide a source of drinking water and hydropower. In general, Sweden has abundant water resources but has recently faced several challenges regarding water quantity and quality, particularly because of droughts. Biofuel is the largest energy source used in Sweden (ca. 28%), which mostly comes from forest residues arising from timber harvesting, followed by nuclear energy (ca. 27%), and hydropower (ca. 14%) (Swedish Energy Agency, 2022). Despite a relatively large per capita energy consumption, Sweden's economy is less dependent on fossil fuels and produces less GHG emissions per capita than other developed countries (Statista, 2019). Sweden also aims to achieve net zero emissions by 2045. Almost 59% of Sweden is covered in productive forest (SCB, 2019). Forests deliver social and environmental functions and generate important economic outputs. However, recent increased demand for bioenergy is leading to substantial pressures on forests (Helmisaari et al., 2014; Rytter et al., 2013). The second most common land use is for agricultural production, with 8% of the country managed for arable crops and livestock grazing (Statistics Sweden, 2019). Approximately 18% of Swedish agriculture is organic, which is the second largest share of all EU countries (SBA, 2018).

3.2 | Methodology

We applied policy coherence analysis, as outlined by Nilsson et al. (2012), as a tool to identify the trade-offs and synergies between the five policy areas in our case study. Our analysis focused on policy goals and horizontal coherence across the WEF–land–climate nexus (where 'land' encompasses agriculture and forestry).

The literature is inconsistent in its definition of policy coherence, and terms like coherence, integration, coordination and consistency have been used interchangeably (Bogers et al., 2022; den Hertog & Stross, 2011; Häbel & Hakala, 2021; Lazaro et al., 2022; Nilsson & Weitz, 2019; Nilsson et al., 2012; Weitz et al., 2017). In the environmental and natural resources domain much research has focused on policy integration (Bogers et al., 2022; Jordan & Lenschow, 2010; Weitz et al., 2017) and policy interactions (Bennich et al., 2020; Liu et al., 2018; Nilsson & Weitz, 2019; Oberthur & Gehring, 2006), with emphasis on the institutional arrangements associated with the policy-making process, or environmental policy integration, particularly with regard to EU policies (Ahlström & Sjåfjell, 2023; Grohmann & Feindt, 2023; Kurze & Lenschow, 2016). Recently, a particular focus of policy coherence studies has been on the implementation of Agenda 2030 (Righettini & Lizzi, 2022; Shawoo et al., 2022). In this paper, we adopt the definition of policy coherence of Nilsson et al. (2012), as 'an attribute of policy that systematically reduces conflicts and promotes synergies between and within different policy areas'. As such, the concept of policy coherence shares key features with the nexus approach, and policy coherence analysis is a suitable tool for nexus assessment.

As a first step, we undertook a desk study of each policy area associated with the nexus to identify their key goals. The main sources reviewed included government legislation, regulations, policies and strategies. In addition, peer-reviewed literature was searched using combinations of keywords ('nexus' AND 'Swed*'; 'policy' AND 'Swed*'), which led to the identification of 44 papers of relevance to the policy goals. Relevant media reports were also identified. These papers and media reports were then read in detail to gauge the level of public, political and scientific debate about the different policy goals. From this desk study, we selected the Swedish Government's national goals relevant to the WEF–land–climate nexus that: (1) were widely debated in news and media, for example, climate and energy goals; (2) were controversial and often discussed in political and scientific debates, for example, forest production versus Sweden's environmental quality objectives (EQOs) (SEPA, 2012); (3) could affect a larger region beyond Sweden, including the Baltic Sea, for example, water-related goals. Some of the selected goals were cross-cutting, as they were relevant to more than one policy area. This was particularly the case for some of the EQOs. We assigned such cross-cutting goals to the policy area within the nexus boundaries that seemed most relevant, for example, we ascribed EQOs relating to 'Zero eutrophication' and 'Natural acidification only' to water policy, although they may also be relevant to land policy and food policy.

Our next step was to create a screening matrix for assessing the coherence of the selected national goals (see Nilsson et al., 2012, 2016 for details). The matrix included all the goals divided into policy areas, both in rows and columns. A preliminary assessment of the coherence between each pair of goals was then made by three of the authors of this paper based on their expert knowledge and the reviewed literature. Nilsson et al. (2016) demonstrated that policy interactions that lead to either high or low coherence are not necessarily synergistic or conflicting (e.g., leading to trade-offs). Rather, they argue that policy interactions should be viewed as more dynamic and nuanced interplays encompassing a spectrum of potential challenges and opportunities. Hence, coherence between the national goals in each pair was assessed on a scale from −3 to +3, representing what Nilsson et al. (2016, p. 321) refer to as the 'strength of the interactions', that is, to what extent 'an action on one goal has a large or small impact on another' (Table 1). By assessing both 'directions' (i.e., positive or negative) of each interaction, we considered whether each policy goal could 'affect' the other goal. In some cases, interactions could be considered as positive and negative depending on how the goals could be achieved (see Nilsson et al., 2012 for details).

The preliminary assessment was then refined based on the results of an online survey in March 2018, which included questions on the coherence between each pair of goals. The survey was distributed among stakeholders from each of the five policy areas, that is, water, energy, food, land (agriculture and forestry), and climate. The stakeholders included individuals from authorities at different governance levels (from local to national), businesses, and research organisations. The survey was sent to 94 email addresses selected from the authors' contacts. In addition, the respondents were asked to forward the

TABLE 1 Assessment scale for the policy coherence analysis (Nilsson et al., 2012, 2016).

Strength of interaction	Interaction	Definition
−3	Cancelling	Negative interactions
−2	Counteracting	
−1	Constraining	
0	Neutral	No known interaction
1	Enabling	Positive interactions
2	Reinforcing	
3	Indivisible	
1/−1	Mixed effects	Interactions that can either be positive or negative depending on the context

survey link to other relevant actors. As such, the survey results are not representative of all stakeholders in Sweden with regard to the nexus. Nevertheless, they constitute an expert check on our preliminary assessment. A total of 101 stakeholders provided survey responses, although some only addressed questions on those policy areas or goals with which they were familiar. As the original assessment scale (Table 1) was deemed too complex for a survey (as it might have led to fewer responses), the respondents were asked to assess the coherence of pairs of goals on a scale from −1 (negative interaction) through 0 (neutral) to +1 (positive interaction). They were also asked to provide examples of both synergies and conflicts between the goals. Average scores from the survey informed the refinement of the preliminary assessment, and the resultant scores were reviewed by experts from the five policy areas at a workshop in April 2018.

The workshop was attended by 10 stakeholders, representing different sectors, who were presented with the matrix containing all the goals in rows and columns, with the different colours representing the direction and strength of the interactions. As the original assessment scale (Table 1) was deemed too complex to use in the workshop, it was translated into a five-point scale, from −2 to +2 (from very negative to very positive interaction, with 0 as neutral/no interaction). The stakeholders were divided into three groups, and asked to review the scoring of the interactions and, where they deemed it necessary, to provide alternative scores (positive or negative) justified with comments and examples (Figure 1). The further information resulting from the workshop was used by the authors to conclude the assessment of the interactions. Final scores were determined on the original assessment scale (Table 1), based on the authors' expert judgement in conjunction with the scores and comments provided by the stakeholders.

4 | RESULTS

4.1 | Nexus-relevant national goals

In the study's first step, 14 national goals associated with the water, energy, food, land, and climate policy areas were selected (Table 2). The goals focused on long-term sustainable and efficient use or management of natural resources (e.g., surface water, groundwater, forests, energy, etc.) and on climate mitigation. When the 14 goals were selected, a Swedish national climate adaptation strategy, including associated goals, was still in development. The strategy was not presented by the Government until March 2018 (Swedish Government, 2018), when our preliminary assessment and online survey had already been completed.

4.2 | Synergies

The analysis revealed several synergies between policy goals (Table 3). The climate goals and energy goals were particularly well aligned, which is an unsurprising outcome, as a 'Sustainable and environmentally friendly energy supply' (E1) and an 'Increase in energy

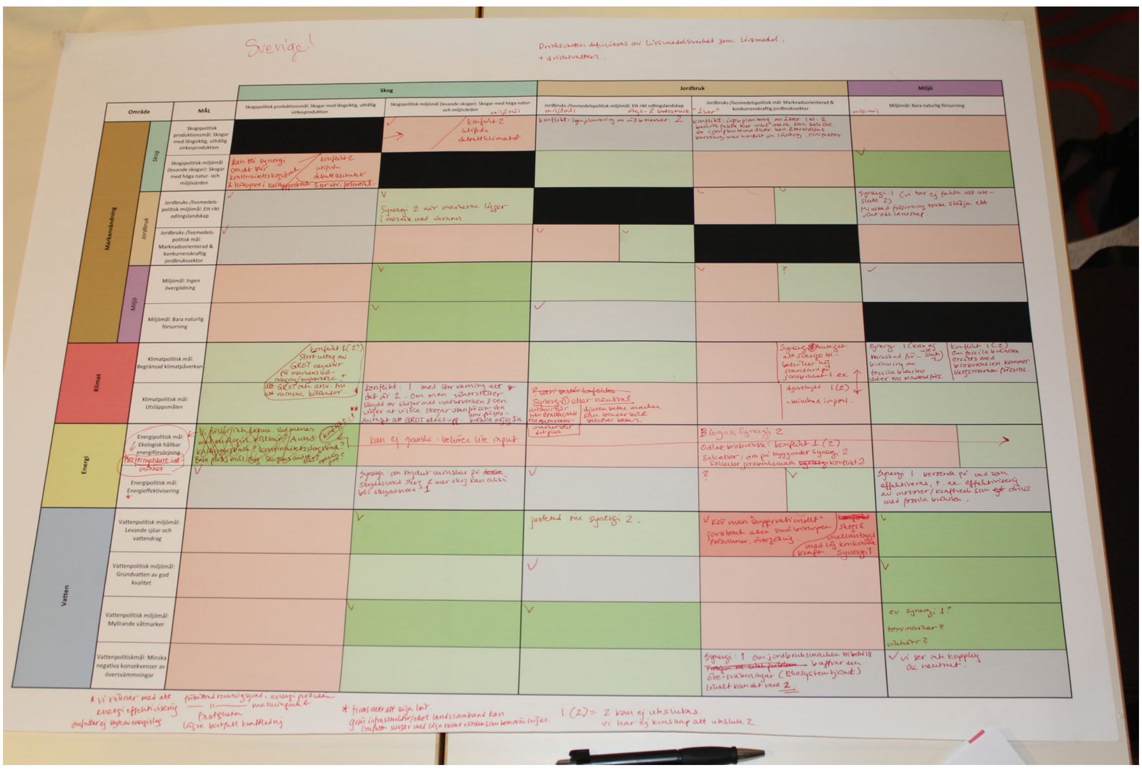
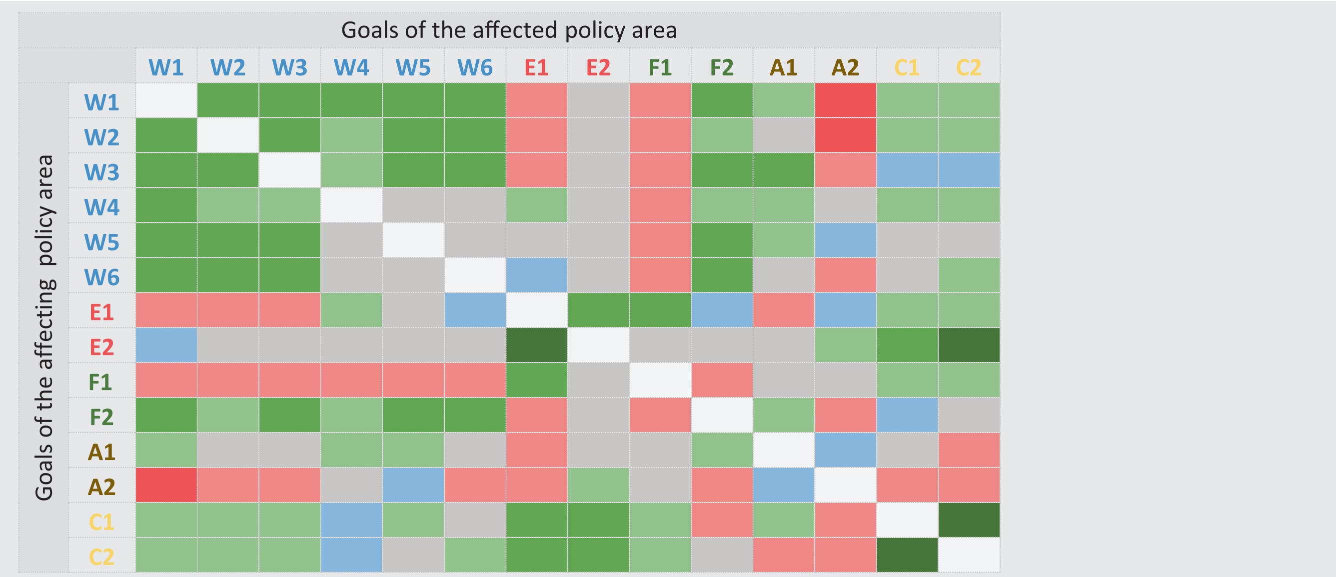


FIGURE 1 The matrix from the scoring exercise at the stakeholder workshop. The colours are explained in Table 1.

TABLE 2 Selected national goals.

Policy area	ID	National goal	Description
Water	W1	EQO: Flourishing lakes and streams	Natural productive capacity, biological diversity, cultural heritage assets and the ecological and water-conserving function of lakes and watercourses must be preserved in an ecologically sustainable way (SEPA, 2011a)
	W2	EQO: Good-quality groundwater	Groundwater must provide a safe and sustainable supply of drinking water and contribute to viable habitats for flora and fauna in lakes and watercourses (SEPA, 2011a)
	W3	EQO: Thriving wetlands	The ecological and water-conserving function of wetlands in the landscape must be maintained and valuable wetlands preserved for the future (SEPA, 2011a)
	W4	Reduce the harmful consequences of floods	Identify flood threats and flood risks for human health, the environment, cultural heritage and economic activity; develop risk management plans for the flood-prone areas (SR, 2009)
	W5	EQO: Zero eutrophication	Nutrient levels in soil and water must not be such that they adversely affect human health, the conditions for biological diversity or the possibility of varied use of land and water (SEPA, 2011a)
	W6	EQO: Natural acidification only	The acidifying effects of deposition and land use must not exceed the limits that can be tolerated by soil and water (SEPA, 2011a)
Energy	E1	Sustainable and environmentally friendly energy supply	Ecologically sustainable energy supply: continued high production of hydropower; increase the proportion of electricity from renewable energy sources; reduce energy use (Swedish Government, 2018)
	E2	Increase energy efficiency	Efficient use of electricity and other energy (Swedish Government, 2018)
Land (Forestry)	F1	Forestry production goal: Ensure a long-term sustained yield of timber	The forest and forest land must be used efficiently and responsibly so that it provides a sustainable good yield for the markets (SR, 1979)
	F2	EQO: Sustainable forests	The value of forests and forest land for biological production must be protected, at the same time as biological diversity and cultural heritage and recreational assets are safeguarded (SEPA, 2011a).
Land (Agriculture)	A1	EQO: A varied agricultural landscape	The value of the farmed landscape and agricultural land for biological production and food production must be protected, at the same time as biological diversity and cultural heritage assets are preserved and strengthened (SEPA, 2011a)
	A2	Food production goal: A market-oriented agricultural sector and a competitive food supply chain	Foods on the market must be safe and properly labelled; increase organic production and consumption of food; strengthen the competitiveness of the sector on market terms; greater production for both domestic and foreign markets; higher growth and employment in the industries concerned; increase exports, innovation power and profitability (ND, 2017)
Climate	C1	EQO: Reduce climate impacts	GHG concentrations in the atmosphere must be stabilised at a level that will prevent dangerous anthropogenic interference with the climate system (SEPA, 2011a)
	C2	Emission reduction targets	Reduce emissions of carbon dioxide and other GHGs (Swedish Government, 2018)

TABLE 3 Scoring of interactions between the different national goals.



Note: Colours representing scores are explained in Table 1.

efficiency' (E2) could 'Reduce emissions of carbon dioxide and other GHGs' (C2).

The EQOs regarding land (F2 and A1) and all the goals relating to water were perceived as synergistic or neutral in both directions. The synergistic effects occurred due to the application of specific measures/instruments in particular policy areas that, in turn, could lead to positive effects in other policy areas, thereby aiding their achievement. For example, improving the quality of lakes and streams (W1), groundwater (W2), and wetlands (W3) positively contributed to the forest and agricultural biodiversity (F2 and A1). The same was true for flood-reducing measures (W4), such as afforestation and the creation of wetlands, which foster landscape connectivity. Considered the other way around, forest conservation policy aimed to protect biodiversity (F2) by preventing over-fertilisation and buffering waterbodies. Such measures also helped achieve good water quality (W1–W3, W5 and W6) in forest systems. Moreover, increased structural ecosystem complexity resulting from biodiversity conservation (A1) helped retain water in forest systems and prevent flooding (W4). Biodiversity conservation policies in agriculture (A1) had fewer synergies with water-related EQOs. However, structural ecosystem complexity had positive effects on flood reduction (W4). Furthermore, biodiversity could have beneficial effects on soil quality, including increasing soil nitrogen, which potentially reduces the need for fertiliser and thereby lowers the risk of eutrophication (W5).

Finally, stakeholders suggested that greater energy efficiency (E2) could lead to agriculture being more competitive (A2).

4.3 | Conflicts

Our scoring particularly highlighted that the food-production goal (A2) was the least coherent with those of other policy areas (Table 3). It remains a great challenge to establish goals for market-oriented agriculture and a competitive food-supply chain that are synergistic with environmental and climate mitigation goals. Specifically, there was a conflict between the notion of competitive, market-oriented agriculture (A2) (equated with intensive, high-yield production) and the type of agriculture that would support high biodiversity (A1). At the same time, stakeholders at the workshop suggested that if Sweden built its market competitiveness on being an 'environmentally friendly' food producer, there would be greater coherence between the food-production goal and other goals. For example, it was mentioned that if 'competitive food production' was framed through a more 'environmentally friendly' lens (i.e., as food production aims to reduce overconsumption and industrial-meat production globally), there would be climatic and environmental gains. However, this was not yet happening, according to the stakeholders. In addition, stakeholders observed that Sweden imported half of its meat. As meat production was a key driver of global deforestation, they pointed out that if Sweden's food production was more competitive, it could reduce meat imports, which, in turn, would deliver 'the largest win' globally.

The analysis also revealed several conflicts between the EQOs and goals regarding agricultural and forestry production. According to the stakeholders, the goals to achieve high biodiversity in forests and agriculture (F2, A1) and the goals regarding good surface water, groundwater and wetland quality (W1–W3) seemed difficult to accomplish because agricultural and forestry production (A2, F1) represented dominant frames through which the other policy areas were (re)defined. As highlighted by the stakeholders, this dominant framing resulted in most production-oriented goals being prioritised (i.e., A2 and F1) over environmental goals (i.e., F2, A1, W1–3 and W5-6). For example, this resulted in more intensive production systems that did not support high biodiversity or led to decreasing water quality.

Stakeholders also indicated that, in addition to production-oriented goals, high priority was given to climate goals (C1, C2). This affected the pursuit of the other policy areas' goals, as they received lower priority. For example, the stakeholders mentioned that when implementing the Swedish climate goals, the role of agriculture and biodiversity goals was not given sufficient attention, as the dominant discourse was focused on climate mitigation issues. Another stakeholder pointed out that the relevance of other policy areas' goals might be undermined by prioritising climate and energy goals. Hence, the utility of policy goals regarding water, food, and land was questioned when their achievement was not prioritised.

Another point that emerged from the analysis was that climate goals might not always be in line with other EQOs. For example, producing more biomass to support climate mitigation (through substituting bioenergy or wood for fossil-fuel-intensive materials) might conflict with biodiversity conservation, as it requires more intensive forest management. According to the stakeholders, while the increased demand for bioenergy had not yet led to an increase in final felling (as most biomass was derived from forest residues and industrial waste), it might do so in the future if the Swedish Forest Agency implements the goal to 'Reduce climate impacts' (C1) by producing more wood/biomass that replaces alternatives that result in higher GHG emissions.

Similarly, it was suggested that increased agricultural production of energy crops (to fulfil climate goals) might increase fertiliser use, which could be detrimental to surface and ground water. It might also lead to increased use of land for crop monocultures, decreasing the potential for biodiversity (A1). In addition, some stakeholders suggested that there was a potential conflict between 'Emission reduction targets' (C2) and keeping 'A varied agricultural landscape' (A1). On this point, there was some discussion in Sweden about introducing a meat tax to decrease GHG emissions from meat production. However, if introduced, this could lead to fewer grazing animals, which stakeholders noted could negatively influence grazing areas and their biodiversity (A1).

4.4 | Mixed effects

For some interactions, it was unclear if there were synergies or conflicts between the goals, as both could occur depending on the context or interpretation of the goal. For example, whether 'Sustainable and environmentally friendly energy supply' (E1) conflicted with 'Sustainable forests' (F2) depended on how the former goal was interpreted. If 'Sustainable and environmentally friendly' was interpreted as 'Good for the environment' (i.e., that it had no negative environmental effects), then it could be synergistic. However, if 'Sustainable and environmentally friendly energy supply' (E1) was interpreted as 'renewable', this might lead to more intensified forestry activities to extract the renewable resource, which could reduce forest biodiversity and thereby impact on 'sustainable forests' (F2). Furthermore, a common comment from stakeholders in relation to some national goals, particularly those related to climate, energy, and forestry, was a need to differentiate between them and the practical means or policy instruments required for their achievement.

Similarly, the use of a 'Sustainable and environmentally friendly energy supply' (E1) to promote 'A market-oriented agricultural sector and a competitive food supply chain' (A2) could be either positive or negative. For example, use of biogas or photovoltaic cells on farm buildings were identified as synergistic but energy crops or ground-based photovoltaic cells that reduced the area of land available for food production could lead to conflict.

The effect of climate goals (C1 and C2) on flood mitigation (W4) was identified as context dependent. On the one hand, a decrease in GHG emissions that mitigates climate change could lead to less snow and, thus, less chance of spring floods. On the other hand, if GHG emissions continue to increase unabated then the total amount of precipitation in autumn and winter could increase leading to more rain and snow, resulting in increased water levels and more floods. However, climate mitigation (C1 and C2) was regarded by stakeholders as having few synergies with flood mitigation (W4), as they noted that hydropower development had reduced the effect of snow melting.

Finally, interactions between 'Thriving wetlands' (W3) and the climate goals were also found to have mixed effects. Wetlands sequester carbon and thereby mitigate climate change (C1 and C2), however, they may also be potential sources of methane; a very potent GHG.

5 | DISCUSSION

5.1 | Policy coherence in the Swedish WEF–land–climate nexus

While the body of research on the nexus approach for resource use has been growing in recent years, there are still relatively few examples of applications of the nexus approach for developing policy recommendations (Zhang et al., 2018) for natural resource management. In this study, we aimed to fill that gap by systematically using a nexus approach to identify trade-offs and synergies between 14 national policy goals across the WEF–land–climate nexus in Sweden. In addition to our study's implications for policy-making in Sweden, we also revealed challenges that need to be tackled when applying a nexus approach.

Our study identified a number of synergies and conflicts, as well as mixed effects between individual policy goals, indicating the possibility of positive or negative interactions, depending on context, interpretation or the way that the goals were pursued. In general, our analysis suggested that there may be more synergies than conflicts between the goals across the WEF–land–climate nexus in Sweden. This finding concurs with a report published by the Swedish Environmental Protection Agency (SEPA) about synergies and conflicts between the EQOs and the other goals (SEPA, 2011b). The report indicated that although there were some conflicts, particularly regarding conservation-oriented versus production-oriented goals, many potential synergies were perceived to exist, particularly between the

EQOs and the energy and non-EQO forestry goals. Our study also revealed strong synergies between climate and energy goals, which have also been identified in other contexts (e.g., Kurze & Lenschow, 2016; Papadopoulou et al., 2020). These synergies can be used to inform the formation of cross-sectoral policy implementation networks that collectively aim to reach policy goals (Wagner et al., 2021).

Our analysis showed that certain policy areas had prevailing national goals that overshadowed those of other policy areas. In particular, the production-oriented goals regarding land (i.e., forestry and agriculture) dominated in the aforementioned conflicts with EQOs. This may perhaps explain why only one of the 16 EQOs set in 2012 had been achieved (SEPA, 2019, 2021). None of the eight EQOs included in our analysis (W1, 2, 3, 5, and 6; F2 and 3; C1) had yet been attained, and indicators measuring the progress on 'Thriving wetlands' (W3) and 'A varied agricultural landscape' (A1) actually showed negative trends (Larsson & Hanberger, 2016; SEPA, 2021). While stakeholders did not provide reasons for the dominance of production-oriented goals, reviewed literature suggested that it might be explained by Sweden's discourse during recent decades framing production from natural resources in terms of economic growth. A production-oriented discourse is particularly apparent in forestry, where the sustainable yield principle (Angelstam et al., 2018) has long been the focus of attention. While the 'Forestry EQO' (F2) was established in 1993 (Bush, 2010) on par with the 'Forestry production goal' (L1), to date, these two goals seem not to have had parity in Swedish policy making. Such incoherence is relatively common with regard to forest management, not only in Sweden. For example, the National Forest Strategy of Finland has been shown to be strongly oriented towards wood and bioenergy production and was dominated by the economic growth paradigm, leading to conflict with biodiversity targets and policies supporting more multifunctional forest use (Blattert et al., 2022). A similar, long-standing conflict in Poland has been supported by deeply rooted discourses regarding forest management (Blicharska et al., 2020; Blicharska & Van Herzele, 2015). These studies show that even if relevant policies that go beyond production-oriented goals are in place, their implementation and goals will be prioritised depending on the political and governance context and dominant discourses within the paradigm of economic growth. However, improving coherence between policies and supporting the implementation of goals that focus on values other than productivity requires moving beyond the growth paradigm (Otero et al., 2020). While the conflict between economic growth and biodiversity conservation should be acknowledged in future policies, there is a need to explore socioeconomic trajectories other than economic growth if one is to balance it with biodiversity policies (Otero et al., 2020). Correspondingly, the conflict between the idea of competitive, market-oriented agriculture and agriculture that would support high biodiversity seems to be framed by the dominant discourse that conceives the former as intensive and highly productive. Similarly, a study on the implementation of the Common Agricultural Policy (CAP) in Germany has shown unavoidable trade-offs between its economic and environmental goals due to the dominant framing of the CAP's function, as the provision of financial support for the agricultural sector (Grohmann & Feindt, 2023).

Analogous results to those from our analysis were found in a study of the interactions between SDGs. The study identified that SDG 15 ('Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss') shared the most negative relationships with the other SDGs (Pradhan et al., 2017). The natural limits to humanity's growth were reached decades ago (Meadows et al., 1972), but our civilisation still tries to stretch the planetary boundaries with innovative technologies, such as artificial fertilisers, which allow further exploitation of natural resources and the degradation of ecosystems. A reductionist approach to solving this conflict is problematic, as it pitches economic, social and ecological scientific disciplines against each other (Vedeld, 1994). Instead, a common understanding can be created through an interdisciplinary approach that identifies and promotes synergies and avoids or manages conflicts (Vedeld, 1994). In highlighting the need to build on synergies and manage trade-offs, the nexus approach seems perfectly suited for such an endeavour. It provides the background knowledge for strategic action by imparting understanding of what is happening at the interface between different sectoral policies (Urbinatti et al., 2020).

Our analysis highlighted the priority given to climate mitigation goals in Sweden, which reflects the strength of policy framing that addresses climate change (Burns et al., 2019). Recent legislation that has been enacted comprises the Climate Policy Framework for Sweden (Gov. Bill 2016/17:146, passed in Parliament 15 June, 2017) and the new Climate Act, which entered into force in January 2018. This national legislation is reflective of and strongly supported by EU Climate Policy and the UN Framework Convention on Climate Change. An assessment of the effects of the Climate Policy Framework showed that many stakeholders believed that 'the prioritization of climate issues has increased within politics, in society, as well as among industry actors' (Matti et al., 2021, p. 1153). However, prioritising climate goals over other policy areas' goals may hinder the achievement of the latter, as outlined in Section 4.3. For example, Dooley et al. (2018) showed how land-based carbon removal to achieve negative emissions can have a negative effect on both food security and biodiversity. The latter may, in turn, have consequences for the achievement of climate goals, as healthy ecosystems can contribute to climate mitigation and strengthen the resilience of land-use systems to climate change (Blicharska et al., 2019; Wustemann et al., 2017), providing climate adaptation co-benefits (Boyd et al., 2022).

Clear conflicts between several of the policy goals and the focus on and priority given to particular goals across the WEF–land–climate nexus in Sweden, as perceived by stakeholders, indicated that there may be a relatively low level of policy coherence. If particular policy issues are narrowly framed, for example, in the case of the dominant growth discourse, the need for integration between policy areas may be neglected (Candel & Biesbroek, 2016). Moreover, the presence of dominating interests make the coherence between policies less likely

(Lenschow et al., 2018). In addition, stakeholders participating in the workshop suggested that they rarely had the opportunity to discuss cross-cutting issues with actors from other policy areas, which contributes to limited integration.

It has been suggested that nexus challenges are often linked to practices, interests and perceptions of key actors (Urbinatti et al., 2020) that should be understood in addition to (if not even before) providing technical expertise and solutions to deal with these challenges (Nilsson & Weitz, 2019). While we did not systematically assess the capacity-building outcomes of the workshop (as it was not the aim of this study), we noted that stakeholders participating in the workshop actively engaged and enjoyed 'talking across sectors', learning from each other and discovering policy trade-offs and synergies together. As such, the nexus approach may be a useful tool for supporting learning processes towards the development of more coherent policies that can better address inherent trade-offs (Papadopoulou et al., 2020). Developing a comprehensive legal framework that fosters WEF–land–climate integrated policies requires cooperation and coordination of diverse institutions and stakeholders willing to dismantle prevailing siloed regulatory solutions. Such a dialogue cannot happen without capacity building and increased awareness of the interconnectedness of bio-physical, socio-economic systems and related policy solutions (Guerra et al., 2021; Olawuyi, 2020; Zhang et al., 2018).

Candel and Biesbroek (2016) suggest that joint formulation of policy goals allows stakeholders to identify issues that need to be addressed and that a diverse range of instruments is necessary to deal with cross-cutting policy issues in order to reach a high level of policy integration. Our findings not only illustrated that stakeholders' perceptions were affected by policy framings and dominant discourses (and their interpretation), but also revealed that stakeholders from different policy areas clearly differentiated between policy goals and the instruments that could be used to achieve them. There can be situations where pursuing policy goals with certain instruments may limit the achievement of other goals because of the instruments used, or situations where certain instruments rely on other instrument types for achieving the defined goals (e.g., in policy mixes) (Blackstock et al., 2021). This suggests that policy goals, and the instruments to achieve them, need to be considered in consort. The method that we used to assess policy coherence is strongly dependent on clear identification of the assessment's context. In particular, it is important to be explicit about which interactions are being assessed. Depending on the policy goal, the focus of the analysis of interactions with other policy goals could be on the policy goals themselves, or current actions and instruments adopted to achieve the goals or future potential actions and instruments that may be considered for achieving the goals. There is, thus, a need for such analysis in the future to inform the development of instruments that simultaneously pursue multiple policy goals. While detailed analysis of policy instruments was beyond this study's scope, our analysis provided some insights in their regard, for example, instruments for delivering water policy goals were found to be supportive of biodiversity goals. Some studies have previously illustrated how policy coherence analysis can be used to identify trade-offs and synergies of policy instruments among sectors (e.g., Blackstock et al., 2021; Giest & Mukherjee, 2022; Papadopoulou et al., 2020). For that, involvement of stakeholder expertise is crucial (Papadopoulou et al., 2020) and the nexus approach can be a practical tool to harness such expertise.

Another aspect revealed by our study is that it was difficult to describe the interactions between policy goals in the Swedish WEF–land–climate nexus, without considering their vertical links to supranational issues. For example, stakeholders mentioned the impact of EU climate policy on the Swedish climate policy, and the influence of Swedish meat import on global deforestation. Thus, our findings have implications for understanding of the nexus as a bounded system (Creswell, 2007). While this study was focused on national policies, we acknowledge that policy making at one governance level does not happen in a 'void', and that policies and issues at supranational level interact with national decision-making (Weitz et al., 2017).

There is growing academic interest in policy coherence in relation to the broad concept of governance. Governments are increasingly turning their attention to so called 'New Governance Arrangements', as a potential means of grappling with wicked and complex problems that span multiple policy domains. Such arrangements are intended to facilitate more integrated and optimal governance, particularly in policy areas concerned with natural resources and the environment, and need crafting with care (Howlett & Rayner, 2006). However, existing governance arrangements are often deeply embedded in complex, static institutional structures. Hence, even when policy goals or priorities change, the outcomes may remain the same, as shown, for example, by the strong resistance of Sweden's forest policy to pressures to integrate biodiversity conservation (Sotirov & Storch, 2018). Thus, there may be a need to establish new governance arrangements rather than try to tailor existing ones to facilitate policy coherence across the nexus. Investigating policy coherence across nexus sectors, as in this study, can be a first step towards understanding such needs, enabling identification of necessary actions to enable exploitation of synergies and management of trade-offs between policy areas. Policy coherence analysis can also serve as a tool for raising awareness and building capacity of relevant actors across the nexus sectors and for catalysing dialogue and collaboration between them.

5.2 | Limitations of the study and implications for future research

One of the main challenges of policy coherence analysis across a nexus is performing an exhaustive assessment. Each of the five policy areas in the WEF–land–climate nexus consists of numerous elements that are not all represented in existing nexus analyses and may also change with time. For example, while Sweden's current forestry policy is strongly focused on wood production, forests can also provide many other (e.g., cultural) ecosystem services that may contribute to policy goals in the other policy areas. Hence, in the future, increased attention on the environmental and social values of forests could provide new opportunities and challenges for policy coherence across the

Swedish WEF–land–climate nexus (Sandström et al., 2011). Thus, it is important to assess nexus interactions collaboratively across policy areas on a regular ongoing basis.

The policy coherence analysis in this study was based on a pair-wise assessment of policy goals, as presented in Nilsson et al. (2012). This method has several limitations, one of which is that the pairwise assessment does not account for interactions between multiple policy areas simultaneously across the WEF–land–climate nexus. Currently, no quantitative methods are available to assess such interactions but simulation models (e.g., the iSDG model) have been used in the integrated assessment of policy coherence among SDGs (Collste et al., 2017) and could also be useful for assessing the WEF–land–climate nexus. The stakeholders at the workshop acknowledged interactions between multiple policy areas, which highlights the need to look at different trade-offs simultaneously enabled by the development of such methods.

Another limitation of the pair-wise assessment method is that it only focuses on ongoing interactions. However, future scenarios of interactions between policy goals can be projected based on past trends. The stakeholder workshops in this study facilitated some unstructured discussion on potential future policy interactions, which was insufficient to draw hard conclusions. Nevertheless, it helped to gain a better understanding of the diversity of interactions between policy goals across the WEF–land–climate nexus. Future research should focus on identifying potential future interactions to enable emergent synergies to be embraced proactively and to avoid the evolution of new conflicts.

6 | CONCLUSIONS

Our study shows that applying a nexus approach to the analysis of coherence between policy goals can promote understanding of existing synergies and trade-offs, build capacity among relevant actors, and encourage dialogue and collaboration across sectors.

While policymakers understand the need to assess policy coherence during ex-ante impact assessments and ex-post evaluations, the lack of synchronisation of policy cycles across both vertical and horizontal scales complicates such assessments. This situation is compounded by the limited time-windows and budgets available for policy coherence analyses and by the extent of stakeholder consultations required. Our hope is that the relatively straightforward approach presented here can facilitate comprehensive reviews of policies across the nexus and elsewhere. The results of such analyses can provide the background knowledge needed to revise policies or develop new policies coherently across the nexus in ways that promote their simultaneous, mutually reinforcing achievement.

Several issues that need to be taken into account when undertaking policy coherence analyses were revealed by our study. In particular, we noticed that while policies exist, their actual implementation depends on relevant stakeholders' interests, priorities and interpretations, which, in turn, may depend on existing prevailing discourses in society (e.g., the growth paradigm), often supported by higher level policies (e.g., the Paris Agreement). Ultimately, ensuring that policies across all sectors are coherent requires stakeholders to have the capacity to look beyond their silos. Involving stakeholders in a straightforward approach to policy coherence analysis across the nexus can build that capacity.

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ORCID

Malgorzata Blicharska https://orcid.org/0000-0001-7731-7039

REFERENCES

Ahlström, H., & Sjåfjell, B. (2023). Why policy coherence in the European Union matters for global sustainability. *Environmental Policy and Governance*, *33*, 272–287.

Albrecht, T. R., Crootof, A., & Scott, C. A. (2018). The water-energy-food nexus: A systematic review of methods for nexus assessment. *Environmental Research Letters*, *13*(4), 26.

Allan, T., Keulertz, M., & Woertz, E. (2015). The water–food–energy nexus: An introduction to nexus concepts and some conceptual and operational problems. *International Journal of Water Resources Development*, *31*(3), 301–311.

Allouche, J., Middleton, C., & Gyawali, S. (2014). *Nexus Nirvana or Nexus Nullity? A dynamic approach to security and sustainability in the water-energy-food nexus* (Working Paper). UK.

Angelstam, P., Naumov, V., Elbakidze, M., Manton, M., Priednieks, J., & Rendenieks, Z. (2018). Wood production and biodiversity conservation are rival forestry objectives in Europe's Baltic Sea region. *Ecosphere*, *9*(3), 26.

Bennich, T., Weitz, N., & Carlsen, H. (2020). Deciphering the scientific literature on SDG interactions: A review and reading guide. *Science of the Total Environment*, *728*, 138405.

Benson, D., Gain, A. K., & Rouillard, J. J. (2015). Water governance in a comparative perspective: From IWRM to a 'Nexus' approach? *Water Alternatives–An Interdisciplinary Journal on Water Politics and Development*, *8*(1), 756–773.

Biggs, E. M., Bruce, E., Boruff, B., Duncan, J. M. A., Horsley, J., Pauli, N., McNeill, K., Need, A., Van Ogtrop, F., Curnow, J., Haworth, B., Duce, S., & Irnanari, Y. (2015). Sustainable development and the water-energy-food nexus: A perspective on livelihoods. *Environmental Science & Policy*, *54*, 389–397.

Blackstock, K. L., Novo, P., Byg, A., Creaney, R., Juarez Bourke, A., Maxwell, J. L., Tindale, J., & Waylen, K. A. (2021). Policy instruments for environmental public goods: Interdependencies and hybridity. *Land Use Policy*, *107*, 104709.

Blattert, C., Eyvindson, K., Hartikainen, M., Burgas, D., Potterf, M., Lukkarinen, J., Snäll, T., Torano-Caicoya, A., & Mönkkönen, M. (2022). Sectoral policies cause incoherence in forest management and ecosystem service provisioning. *Forest Policy and Economics*, *136*, 15.

Blicharska, M., Angelstam, P., Jacobsen, J. B., Giessen, L., Hilszczanski, J., Hermanowicz, E., Holeksa, J., Jaroszewicz, B., Konczal, A., Konieczny, A., Mikusinski, G., Mirek, Z., Muys, B., Mohren, F., Niedzialkowski, K., Sotirov, M., Szwagrzyk, J., Winder, G. M., Witkowski, Z., … Winkel, G. (2020). Between biodiversity conservation and sustainable forest management – A multidisciplinary assessment of the emblematic Białowieża Forest case. *Biological Conservation*, *248*, 108614.

Blicharska, M., Smithers, R. J., Rönnbäck, P., Mikusinski, G., Harrison, P. A., Nilsson, M., & Sutherland, W. J. (2019). Biodiversity's contributions to sustainable development. *Nature Sustainability*, *2*, 1083–1093.

Blicharska, M., & Van Herzele, A. (2015). What a forest? Whose forest? Struggles over concepts and meanings in the debate about the conservation of the Białowieża Forest in Poland. *Forest Policy and Economics*, *57*, 22–30.

Boas, I., Biermann, F., & Kanie, N. (2016). Cross-sectoral strategies in global sustainability governance: Towards a nexus approach. *International Environtal Agreements: Politics Law and Economics*, *16*(3), 449–464.

Bogers, M., Biermann, F., Kalfagianni, A., & Kim, R. E. (2022). Sustainable Development Goals fail to advance policy integration: A large-n text analysis of 159 international organizations. *Environmental Science and Policy*, *138*, 134–145.

Boyd, D., Pathak, M., van Diemen, R., & Skea, J. (2022). Mitigation co-benefits of climate change adaptation: A case-study analysis of eight cities. *Sustainable Cities and Society*, *77*, 103563.

Burns, C., Eckersley, P., & Tobin, P. (2019). EU environmental policy in times of crisis. *Journal of European Public Policy*, *27*(1), 1–19.

Bush, T. (2010). Biodiversity and sectoral responsibility in the development of Swedish Forestry Policy, 1988-1993. *Scandinavian Journal of History*, *35*(4), 471–498.

Candel, J. J. L., & Biesbroek, R. (2016). Toward a processual understanding of policy integration. *Policy Sciences*, *49*(3), 211–231.

Collste, D., Pedercini, M., & Cornell, S. E. (2017). Policy coherence to achieve the SDGs: Using integrated simulation models to assess effective policies. *Sustainability Science*, *12*, 921–931.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches*. SAGE Publications.

Dale, L. L., Karali, N., Millstein, D., Carnall, M., Vicuña, S., Borchers, N., & Bustos, E. (2015). An integrated assessment of water-energy and climate change in Sacramento, California: How strong is the nexus? *Climatic Change*, *132*, 223–235.

de Grenade, R., House-Peters, L., Scott, C. A., Thapa, B., Mills-Novoa, M., Gerlak, A., & Verbist, K. (2016). The nexus: Reconsidering environmental security and adaptive capacity. *Current Opinion in Environmental Sustainability*, *21*, 15–21.

den Hertog, L., & Stross, S. (2011). Coherence in EU external relations: Concepts and legal rooting of an ambiguous term. *European Foreign Affairs Review*, *18*(3), 373–388.

Dooley, K., Christoff, P., & Nicholas, K. A. (2018). Co-producing climate policy and negative emissions: Trade-offs for sustainable land-use. *Global Sustainability*, *1*, e3.

EC. (2022). *European Commission's better regulation guidelines*. European Commission.

Fader, M., Cranmer, C., Lawford, R., & Engel-Cox, J. (2018). Toward an understanding of synergies and trade-offs between water, energy, and food SDG targets. *Frontiers in Environmental Science.*, *6*, 112.

Foran, T. (2015). Node and regime: Interdisciplinary analysis of water-energy-food nexus in the Mekong region. *Water Alternatives–An Interdisciplinary Journal on Water Politics and Development*, *8*(1), 655–674.

Garcia, D. J., & You, F. (2016). The water-energy-food nexus and process systems engineering: A new focus. *Computers & Chemical Engineering*, *91*, 49–67.

Giest, S., & Mukherjee, I. (2022). Evidence integration for coherent nexus policy design: A Mediterranean perspective on managing water-energy interactions. *Journal of Environmental Policy & Planning*, *24*(5), 553–567.

Grohmann, P., & Feindt, P. H. (2023). The importance of calibration in policy mixes: Environmental policy integration in the implementation of the European Union's Common Agricultural Policy in Germany (2014–2022). *Environmental Policy and Governance* in press.

Guerra, J. B. S. O. D., Berchin, I. I., Garcia, J., da Silva Neiva, S., Jonck, A. V., Faraco, R. A., Silva de Amorim, W., & Pereira Robeiro, J. M. (2021). A literature-based study on the water–energy–food nexus for sustainable development. *Stochastic Environmental Research and Risk Assessment*, *35*, 95–116.

Grubert, E., & Sanders, K. T. (2018). Water use in the United States energy system: A national assessment and unit process inventory of water consumption and withdrawals. *Environmental Science & Technology*, *52*(11), 6695–6703.

Häbel, S., & Hakala, E. (2021). Policy coherence for sustainable development and environmental security: A case study of European Union policies on renewable energy. *Environmental Policy and Governance*, *31*, 633–646.

Helmisaari, H.-S., Kaarakka, L., & Olsson, B. A. (2014). Increased utilization of different tree parts for energy purposes in the Nordic countries. *Scandinavian Journal of Forest Research*, *29*(4), 312–322.

Hoff, H. (2011). *Understanding the Nexus*. Background Paper for the Bonn2011 Conference: The water, energy and food security Nexus, Stockholm.

Howells, M., Hermann, S., Welsch, M., Bazilian, M., Segerstrom, R., Alfstad, T., Gielen, D., Rogner, H., Fischer, G., van Velthuizen, H., Wiberg, D., Young, C., Roehrl, R. A., Mueller, A., Steduto, P., & Ramma, I. (2013). Integrated analysis of climate change, land-use, energy and water strategies. *Nature Climate Change*, *3*(7), 621–626.

Howlett, M., & Rayner, J. (2006). Convergence and divergence in 'new governance' arrangements: Evidence from European integrated natural resource strategies. *Journal of Public Policy*, *26*(2), 167–189.

Jordan, A., & Lenschow, A. (2010). Environmental policy integration: A state of the art review. *Environmental Policy and Governance*, *20*(3), 147–158.

Kurze, K., & Lenschow, A. (2016). Horizontal policy coherence starts with problem definition: Unpacking the EU integrated energy-climate approach. *Environmental Policy and Governance*, *28*, 329–338.

Larsson, M., & Hanberger, A. (2016). Evaluation in management by objectives: A critical analysis of Sweden's national environmental quality objectives system. *Evaluation*, *22*(2), 190–208.

Lawford, R., Bogardi, J., Marx, S., Jain, S., Wostl, C. P., Knuppe, K., Ringler, C., Lansigan, F., & Meza, F. (2013). Basin perspectives on the water-energy-food security nexus. *Current Opinion in Environmental Sustainability*, *5*(6), 607–616.

Lazaro, L. L., Giatti, L. L., Bermann, C., Giarolla, A., & Ometto, J. (2021). Policy and governance dynamics in the water-energy-food-land nexus of biofuels: Proposing a qualitative analysis model. *Renewable and Sustainable Energy Review*, *149*, 111384.

Lazaro, L. L. B., Bellezoni, R. A., Puppim de Oliveira, J. A., Jacobi, P. R., & Giatti, L. L. (2022). Ten years of research on the water-energy-food nexus: An analysis of topics evolution. *Frontiers in Water*, *4*, 859891.

Leck, H., Declan, C., Bradshaw, M., & Rees, J. (2015). Tracing the water–energy–food nexus: Description, theory and practice. *Geography Compass*, *9*(8), 445–460.

Lenschow, A., Bocquillon, P., & Carafa, L. (2018). Understanding coherence between policy spheres. *Environmental Policy and Governance*, *28*(5), 323–328.

Lidskog, R., & Sjodin, D. (2016). Extreme events and climate change: The post-disaster dynamics of forest fires and forest storms in Sweden. *Scandinavian Journal of Forest Research*, *31*(2), 148–155.

Liu, J., Hull, V., Godfray, H. C. J., Tilman, D., Gleick, P., Hoff, H., Pahl-Wostl, C., Xu, Z., Chung, M. G., Sun, J., & Li, S. (2018). Nexus approaches to global sustainable development. *Nature Sustainability*, *1*, 466–476.

Matti, S., Petersson, C., & Söderberg, C. (2021). The Swedish climate policy framework as a means for climate policy integration: An assessment. *Climate Policy*, *21*(9), 1146–1158.

Meadows, D. H., Meadows, D. L., Randers, J., & Behrens, W. W., III. (1972). *The limits to growth*. Universe Books.

Mercure, J. F., Paim, M. A., Bocquillon, P., Lindner, S., Salas, P., Martinelli, P., Berchin, I. I., de Andrade Guerra, J. B. S. O., Derani, C., de Albuquerque Junior, C. L., Ribeiro, J. M. P., Knobloch, F., Pollitt, H., Edward, N. R., Holden, P. B., Foley, A., Schaphoff, S., Faraco, R. A., & Vinuales, J. E. (2019). System complexity and policy integration challenges: The Brazilian energy-water-food nexus. *Renewable and Sustainable Energy Review*, *105*, 230–243.

Munaretto, S., & Witmer, M. (2017). Water-land-energy-food-climate nexus: Policies and policy coherence at European and International Scale. Deliverable 2.1 SIM4NEXUS project – Horizon 2020–689150.

Märker, C., Venghaus, S., & Hake, J. F. (2018). Integrated governance for the food-energy-water nexus—The scope of action for institutional change. *Renewable and Sustainable Energy Review*, *97*, 290–300.

ND. (2017). *En livsmedelsstrategi för Sverige – fler jobb och hållbar tillväxt i hela landet Regeringens handlingsplan*. Stockholm, Sweden.

Nilsson, M., & Weitz, N. (2019). Governing trade-offs and building coherence in policy-making for the 2030 Agenda. *Politics and Governance*, *7*(4), 254–263.

Nilsson, M., Griggs, D., & Visbeck, M. (2016). Map the interactions of Sustainable Development Goals. *Nature*, *534*, 320–322.

Nilsson, M., Zamparutti, T., Petersen, J. E., Nykvist, B., Rudberg, P., & McGuinn, J. (2012). Understanding policy coherence: Analytical framework and examples of sector-environment policy interactions in the EU. *Environmental Policy and Governance*, *22*(6), 395–423.

Oberthur, S., & Gehring, T. (2006). *Institutional interaction in global environmental governance: Synergy and conflict among international and EU policies*. The MIT Press.

OECD (Organization for Economic Co-operation and Development). (2014). OECD environmental performance reviews: Sweden 2014. *OECD Publishing*. https://doi.org/10.1787/9789264213715-en

Olawuyi, D. (2020). Sustainable development and the water-energy-food nexus: Legal challenges and emerging solutions. *Environmental Science & Policy*, *103*, 1–9.

Otero, I., Farrell, K. N., Pueyo, S., Kallis, G., Kehoe, L., Haberl, H., Plutzar, C., Hobson, P., García-M'arquez, J., Rodríguez-Labajos, B., Martin, J.-L., Erb, K.-H., Schindler, S., Nielsen, J., Skorin, T., Settele, J., Essl, F., Gomez-Baggethun, E., Brotons, L., … Pe'er, G. (2020). Biodiversity policy beyond economic growth. *Conservation Letters*, *13*, e12713.

Pahl-Wostl, C. (2017). Governance of the water-energy-food security nexus: A multi-level coordination challenge. *Environmental Science & Policy*, *92*, 356–367.

Papadopoulou, C.-A., Papadopoulou, M., Laspidou, C., Munaretto, S., & Brouwer, F. (2020). Towards a low-carbon economy: A Nexus-oriented policy coherence analysis in Greece. *Sustainability*, *12*, 373. https://doi.org/10.3390/su12010373

Pradhan, P., Costa, L., Rybski, D., Lucht, W., & Kropp, J. P. (2017). A systematic study of Sustainable Development Goal (SDG) interactions. *Earth's Future*, *5*, 1169–1179.

Rasul, G., & Sharma, B. (2016). The nexus approach to water–energy–food security: An option for adaptation to climate change. *Climate Policy*, *16*(6), 682–702.

Righettini, M. S., & Lizzi, R. (2022). How scholars break down "policy coherence": The impact of sustainable development global agendas on academic literature. *Environmental Policy and Governance*, *32*, 98–109.

Ringler, C., Bhaduri, A., & Lawford, R. (2013). The nexus across water, energy, land and food (WELF): Potential for improved resource use efficiency? *Current Opinion in Environmental Sustainability*, *5*(6), 617–624.

Rytter, L., Johansson, K., Karlsson, B., & Stener, L.-G. (2013). Tree species, genetics and regeneration for bioenergy feedstock in northern Europe. In S. Kellomäki, A. Kilpeläinen, & A. Alam (Eds.), *Forest BioEnergy production: Management, carbon sequestration and adaptation* (pp. 7–37). Springer Science+Business Media.

Sandström, C., Lindkvist, A., Öhman, K., & Nordström, E.-M. (2011). Governing competing demands for forest resources in Sweden. *Forests*, *2*, 218–242.

SBA. (2018). *Swedish food production*. Swedish Board of Agriculture.

SCB. (2019). *Land use in Sweden* (7th ed.). SCB.

Scott, C. A., Pierce, S. A., Pasqualetti, M. J., Jones, A. L., Montz, B. E., & Hoover, J. H. (2011). Policy and institutional dimensions of the water-energy nexus. *Energy Policy*, *39*(10), 6622–6630.

Scott, C. A., & Sugg, Z. P. (2015). Global energy development and climate-induced water scarcity-physical limits, sectoral constraints, and policy imperatives. *Energies*, *8*(8), 8211–8225.

SEPA. (2011a). *Sweden's environmental objectives*. Swedish Environmental Protection Agency.

SEPA. (2011b). *Synergimöjligheter, målkonflikter och problem i miljömålsarbetet. En analys utifrån nyckelaktörers perspektiv*. Swedish Environmental Protection Agency.

SEPA. (2012). *Steg på vägen Fördjupad utvärdering av miljömålen 2012*. Swedish Environmental Protection Agency.

SEPA. (2018). *Miljömålen årlig uppföljning av Sveriges nationella miljömål 2018 – Med fokus på statliga insatser*. Swedish Environmental Protection Agency.

SEPA. (2019). *Miljömålen: Årlig uppföljning av Sveriges nationella miljömål 2019 – Med fokus på statliga insatser (Reviderad version)*. Swedish Environmental Protection Agency.

SEPA. (2021). *Miljömålen. Årlig uppföljning av Sveriges nationella miljömål 2021 – Med fokus på statliga insatser*. Swedish Environmental Protection Agency.

Sharma, P., & Kumar, S. N. (2020). The global governance of water, energy, and food nexus: Allocation and access for competing demands. *International Environtal Agreements: Politics Law and Economics*, *20*, 377–391.

Shawoo, Z., Maltais, A., Dzebo, A., & Pickering, J. (2022). Political drivers of policy coherence for sustainable development: An analytical framework. *Environmental Policy and Governance*, *33*, 339–350.

Simpson, G. B., & Jewitt, G. P. W. (2019). The development of the water-energy-food nexus as a framework for achieving resource security: A review. *Frontiers in Environmental Science*, *7*, 8.

Smajgl, A., Ward, J., & Pluschke, L. (2016). The water-food-energy Nexus – Realising a new paradigm. *Journal of Hydrology*, *533*, 533–540.

Sotirov, M., & Storch, S. (2018). Resilience through policy integration in Europe? Domestic forest policy changes as response to absorb pressure to integrate biodiversity conservation, bioenergy use and climate protection in France, Germany, The Netherlands and Sweden. *Land Use Policy*, *79*, 977–989.

Skogsvårdslag, SFS 1979:429 C.F.R. (1979). Förordning (2009:956) om översvämningsrisker.

SR. (2009). Sveriges Riksdag. Förordning om översvämningsrisker (Ordinance on Flood Risk). *SFS nr*, *2009*, 956.

Sušnik, J. (2018). Data-driven quantification of the global water-energy-food system. *Resources, Recycling and Conservation.*, *133*, 179–190.

Sušnik, J., & Staddon, C. (2021). Evaluation of water-energy-food (WEF) Nexus research: Perspectives, challenges, and directions for future research. *Journal of the American Water Resources Association*, *58*(6), 1189–1198.

Statista. (2019). Per capita greenhouse gas emissions in 2019. Retrieved from https://www.statista.com/statistics/478783/leading-countries-based-on-per-capita-greenhouse-gas-emissions/

Stephan, R. M., Mohtar, R. H., Daher, B., Irujo, A. E., Hillers, A., Ganter, C. J., Karlberg, L., Martin, L., Nairiz, S., Rodriguez, D. J., & Sarni, W. (2018). Water–energy–food Nexus: A platform for implementing the sustainable development goals. *Water International*, *43*(3), 472–479.

Swedish Energy Agency. (2022). *Energy in Sweden 2022*. Swedish Energy Agency.

Swedish Government. (2018). *Energipolitikens inriktning. Regeringens proposition*. Nationella strategin för klimatanpassning, Prop. 2017/18:163 C.F.R. Stockholm.

Teutschbein, C., Jonsson, E., Todorović, A., Tootoonchi, F., Stenfors, E., & Grabs, T. (2023). Future drought propagation through the water-energy-food-ecosystem nexus – A Nordic perspective. *Journal of Hydrology*, *617*, 128963.

Teutschbein, C., Quesada Montano, B., Todorović, A., & Grabs, T. (2022). Streamflow droughts in Sweden: Spatiotemporal patterns emerging from six decades of observations. *Journal of Hydrology: Regional Studies*, *42*, 101171.

UN. (2015). *Transforming our world: The 2030 Agenda for sustainable development*. United Nations.

Urbinatti, A. M., Benites-Lazaro, L. L., Monteiro de Carvalho, C., & Giatti, L. (2020). The conceptual basis of water-energy-food nexus governance: Systematic literature review using network and discourse analysis. *Journal of Integrative Environmental Sciences*, *17*(2), 21–43.

Valek, A. M., Sušnik, J., & Grafakos, S. (2017). Quantification of the urban water-energy Nexus in Mexico City, Mexico, with an assessment of water-system related carbon emissions. *Science of the Total Environment*, *590–591*, 258–268.

van den Heuvel, L., Blicharska, M., Teutschbein, C., Masia, S., & Susnik, J. (2020). Ecosystem services in the Swedish water-energy-food-land-climate nexus: Anthropogenic pressures and physical interactions. *Ecosystem Services*, *44*, 101141.

Vedeld, P. O. (1994). The environment and interdisciplinarity – Ecological and neoclassical economic approaches to the use of natural resources. *Ecological Economics*, *10*, 1–13.

Wagner, P. M., Paul, M., Torney, D., & Ylä-Anttila, T. (2021). Governing a multilevel and cross-sectoral climate policy implementation network. *Environmental Policy and Governance*, *31*(5), 417–431.

Wang, S., Cao, T., & Chen, B. (2017). Urban water-energy Nexus based on modified input-output Analysis. *Applied Energy*, *196*, 208–217.

Weitz, N. (2014). *Cross-sectoral integration in the Sustainable Development Goals: A Nexus approach*. Stockholm Environment Institute.

Weitz, N., Nilsson, M., & Davis, M. (2014). A Nexus approach to the post−2015 agenda: Formulating integrated water, energy, and food SDGs. *The SAIS Review of International Affairs*, *34*, 37–50.

Weitz, N., Strambo, C., Kemp-Benedict, E., & Nilsson, M. (2017). Closing the governance gaps in the water-energy-food nexus: Insights from integrative governance. *Global Environmental Change-Human and Policy Dimensions*, *45*, 165–173.

Wichelns, D. (2017). The water-energy-food nexus: Is the increasing attention warranted, from either a research or policy perspective? *Environmental Science & Policy*, *69*, 113–123.

World Economic Forum. (2011). *Water security. The water-food-energy-climate nexus*. Island Press.

Wustemann, H., Bonn, A., Albert, C., Bertram, C., Biber-Freudenberger, L., Dehnhardt, A., Döring, R., Elsasser, P., Hartje, V., Mehl, D., Kantelhardt, J., Rehdanz, K., Schaller, L., Scholz, M., Thrän, D., Witing, F., & Hansjurgens, B. (2017). Synergies and trade-offs between nature conservation and climate policy: Insights from the "Natural Capital Germany – TEEB DE" study. *Ecosystem Services*, *24*, 187–199.

Xylia, M., & Silveira, S. (2017). On the road to fossil-free public transport: The case of Swedish bus fleets. *Energy Policy*, *100*, 397–412.

Yang, W., Gardelin, M., Olsson, J., & Bosshard, T. (2015). Multi-variable bias correction: Application of forest fire risk in present and future climate in Sweden. *Natural Hazards and Earth System Sciences*, *15*(9), 2037–2057.

Zhang, C., Chen, X., Li, Y., Ding, W., & Fu, G. (2018). Water-energy-food nexus: Concepts, questions and methodologies. *Journal of Cleaner Production*, *195*, 625–639.

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