



# Envisioning carbon-free land use futures for Sweden: a scenario study on conflicts and synergies between environmental policy goals

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Received: 19 December 2018 / Accepted: 16 February 2020 / Published online: 5 March 2020  
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## Abstract

In climate change mitigation, backcasting scenarios are often used for exploring options for achieving a single environmental goal, albeit at the expense of other goals. This paper assesses potential conflicts and synergies between multiple environmental policy goals based on four future scenarios on Swedish rural land use, assuming zero GHG emissions in 2060. The assessment shows that goal conflicts are apparent, and policy makers need to make trade-offs between goals. The choice of strategy for dealing with these trade-offs yields conflicts or synergies. The assessment shows that a transition to zero GHG emissions provides opportunities for Sweden to shift to carbon free land-use planning. Overall, there are alternative ways with different underlying assumptions to achieve zero GHG emissions, which will feed discussions on new opportunities to overcome multi-scale and multi-sectoral goal conflicts. Multi-target backcasting scenarios are considered more suited to account for the multi-dimensional aspects of goal conflicts. This requires a comprehensive multi-target backcasting approach, which combines the strengths of multicriteria analysis, nexus approaches and backcasting, for supporting a transition to zero GHG emissions.

**Keywords** Backcasting scenarios · Goal conflicts · Synergies · Climate change mitigation

## Introduction

In the face of global climate change, there is growing international momentum to reduce carbon emissions and mitigate the impacts of climate change, with the Paris Agreement cherishing the aspiration to limit global temperature increase to 1.5 °C above pre-industrial levels (Hooper et al. 2018). Progressing from aspiration to action, decisions on climate

change mitigation options are needed for reducing the socio-economic and socioecological impacts of climate change. This requires policy makers to have a sound understanding of all climate change mitigation options available and thorough approaches for making such decisions. Over the last decades, scenario development has become commonplace in exploring climate change mitigation options (Agnolucci et al. 2009; van Drunen et al. 2011). The risk of irreversible climate change increases the need for more ambitious policy goals and actions (IPCC 2014), which also resonates in research showing that taking immediate action for extensive emissions reductions and full use of available technology may still limit global warming to below 2 °C (Luderer et al. 2013). Therefore, it is an urgent matter to formulate what changes are actually required in order to achieve ambitious climate goals like the Paris Agreement's long-term temperature goal.

Although exploratory scenario approaches have become mainstream in climate change mitigation research, particularly for the purpose of reducing carbon emissions and mitigating the effects of climate change (Giddens 2009), they have limitations too (Van der Voorn et al. 2017). Exploratory scenario approaches are well equipped for mapping uncertainties but do not account for normative preferences or desirability (Quist 2007; Van der Voorn et al. 2012). By comparison, normative

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Communicated by Helmut Haberl

**Electronic supplementary material** The online version of this article (<https://doi.org/10.1007/s10113-020-01618-5>) contains supplementary material, which is available to authorized users.

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foresight approaches such as backcasting are better equipped for the shortcomings of exploratory scenario approaches due to their applicability at various scales, their compatibility with various tools and methods and their ability to support various forms of stakeholder engagement (Quist et al. 2011; Van der Voorn et al. 2017). Backcasting has been proposed as a suitable approach for developing low-carbon pathways and dealing with global climate change (Giddens 2009).

In climate change mitigation, scenarios, particularly backcasting scenarios, can play a role in illustrating what the future could be like when goals are fulfilled and what kind of societal transformations are required (Robinson 1988; Vergragt and Quist 2011) and also contribute to a discussion of which priorities are to be made in decision-making processes (Höjjer et al. 2011; Van der Voorn et al. 2012). A backcasting scenario refers to a description of how a desirable future may unfold based on a chain of 'if-then' propositions.

Although scenarios, particularly backcasting scenarios, generate options for attaining mitigation targets, they do not typically account for potential conflicts between proposed measures and their impact on the fulfilment of multiple environmental goals (Fauré et al. 2017). A goal conflict arises when efforts to achieve one goal (or set of goals) is at the expense of achieving another goal (or set of goals) (Edvardsson-Björnberg 2009b). Goal conflicts can thus constitute major policy challenges for decision makers. Unless goal conflicts are properly assessed, there is a risk that climate mitigation strategies will not only counteract the achievement of other goals and values but also reinforce existing vulnerabilities. Edvardsson-Björnberg (2009a) have identified such conflicts regarding adaptation to climate change and concluded that adaptation measures can conflict with mitigation of climate change and also with other policy goals.

In this paper, we describe how backcasting scenarios can support identifying conflicts between environmental goals. Section 2 proposes a definition of goal conflict and describes different approaches for dealing with such conflicts. Section 3 describes the approach for the qualitative environmental assessment of scenarios to identify conflicts and synergies in regard to a broad range of environmental targets (e.g., reduction of biodiversity loss, viable habitats for flora and fauna). The scenarios illustrate options for the purpose of reduced climate impact and zero net emissions of greenhouse gases. The results of the assessment are presented in Section 4. Section 5 discusses the results, whereas the methodological implications are discussed in Section 6. The conclusions are presented in Section 7.

## Approaches for dealing with goal conflicts

### Defining goal conflicts

Although interconnected, many global sustainability challenges, like climate change, have been addressed separately,

at times reducing one problem at the expense of another (Liu et al. 2018). Effective and sustainable solutions to these challenges will require greater understanding and consideration of the linkages and interdependencies between these sectors such as water, energy and food. As a consequence of these interdependencies, decision makers in all sectors face the significant challenge of accounting for synergies, goal conflicts and potential trade-offs between these sectors at multiple spatial and temporal scales (Leck et al. 2015).

Despite the central role played by goal conflicts in environmental decision making, surprisingly few systematic efforts have been made to define and categorise the various types of goal conflicts involved. Nilsson et al. (2012) and Nilsson et al. (2016) are two notable exceptions. There is an extensive literature in philosophy, psychology, decision theory and related disciplines on value conflicts (Keeney and Raiffa 1976; Levi 1986), conflicts of desires (Marino 2009), interests (Axelrod 1967), and practical dilemmas (Hansson 1988; Höjjer et al. 2006). However, the policy implications of those theoretical works are seldom analysed, or even referred to, in the environmental policy literature.

In this paper, it is not our ambition to elaborate on these policy implications, but rather propose a definition of goal conflict that can be used to explore appropriate approaches for dealing with such conflicts. In doing so, we first consider value conflict and goal conflict as two different, though complementary concepts. Value conflicts refer to situations in which values are inconsistent, whereas goal conflicts concern situations in which desired end states or preferred outcomes are incompatible (Le Pelley et al. 2015). Value conflicts are more fundamental than goal conflicts in the sense that they are firmly rooted in belief and cognitive systems. Therefore, goal conflicts manifest themselves at a more operational level.

In line with Edvardsson-Björnberg (2009b), we refer to a goal conflict as a situation that often emerges from efforts to achieve one goal (or set of goals) at the expense of another goal (or set of goals). As noted by Nilsson et al. (2012), there are different dimensions along which goal conflicts can arise. Goal conflicts can occur within a single policy domain (e.g., between the biodiversity conservation goal of natural and cultural assets and ecosystem services), or they can involve different policy areas (e.g., climate mitigation policy vs. transport access policy). Goal conflicts can arise between goals set at the same institutional level (e.g., within a municipality or by a government), or they can involve different levels of governance (e.g., EU policy goals vs. goals adopted at the member state level). In addition, goals can conflict in various degrees. Nilsson et al. (2016) identify three degrees of goal conflict: *constraining* (efforts to achieve one goal limit options on another goal), *counteracting* (efforts to achieve one goal clash with another goal), and *cancelling* (efforts to achieve one goal make it impossible to reach another goal) interactions.

## Multicriteria analysis

Many of the complex problems faced by decision makers involve multiple conflicting goals (Leck et al. 2015). In the literature, several approaches can be found for dealing with conflicting goals. Multicriteria analysis (MCA) or multiobjective decision making, for example, is a type of decision analysis tool (Larichev 1999). MCA is particularly applicable to cases where a single-criterion approach (such as cost-benefit analysis) falls short, especially where monetary values cannot be assigned to environmental and social impacts. MCA allows decision makers to address a full range of social, environmental, technical, economic and financial criteria when dealing with complex decisions (Silva et al. 2017). Principally, MCA is useful for dividing such decisions into smaller, more understandable and analysable parts and integrating these parts to produce a meaningful solution. However, the major shortcomings of MCA arise when one option would be better against a second criterion but worse against another in the performance matrix. This is a matter of trade-off that occupies a central place in decision-making having multi-dimensional aspects. Weighting or ranking becomes necessary to handle such cases, but with their own associated methodological difficulties. This becomes a really critical issue to which no fully satisfactory answer is available. MCA is also weak with regard to making inter-temporal comparisons. When it comes to the selection of certain parameters (e.g., the inter-temporal discount rate), it is the lack of objectivity that can tilt the balance in favour of certain options over others (Beria et al. 2012). Consequently, MCA runs short in addressing normative aspects of trade-offs.

## Nexus approaches

Nexus approaches have gained significant interest as a potentially effective approach for dealing with trade-offs and conflicting goals (Leck et al. 2015). Recent studies have revealed that nexus approaches can uncover synergies and detect negative trade-offs among sectors (Daher and Mohtar 2015). By identifying positive synergies and negative trade-offs, nexus approaches can support sustainability pathways through promoting high resource use efficiency, lower production of CO<sub>2</sub> emissions and wastes, and more coherent policies. Many tools and methods can be used for quantitatively analysing nexus relations (Liu et al. 2018). Nexus approaches, if well implemented, have the potential to reduce unexpected consequences (Rasul 2014). For example, due to the water intensive production processes involved, biofuels as part of the solution to decrease CO<sub>2</sub> emissions from burning fossil fuels have significant negative consequences for water scarcity and food security (Lane 2016). Nexus approaches can also promote integrated planning, management and governance. It does so, by accounting for cross-sectoral and transboundary

interlinkages in planning and governance to ensure system resilience and sustainability in the face of future uncertainties. The system(s) of interest can be socially or spatially defined or bounded, and their boundaries may be geographical, political or administrative (Conway et al. 2015). However, the application and implementation of nexus approaches are still in their infancy. To further implement nexus approaches and realise their potential, Liu et al. (2018) emphasise the need for more systematic procedure and nexus frameworks that consider interactions among more sectors, across scales and between adjacent and distant places.

## Backcasting

Scenario development provides an approach for going beyond post-hoc analysis of environmental and social implications of negative trade-offs and positive synergies (Hooper et al. 2018). Scenarios can be seen as an assumed sequence or development of events, and can be either explorative (considering the evolution of possible futures from pre-set storyline) or normative (exploring preferred ways to achieve a specific future objective), with also possible intermediate approaches (van Vuuren et al. 2015). Scenario development takes into account alternative futures and their evolution from the present, providing insights into the decisions required in the near-term, mid-term or long-term (Hughes et al. 2013). Normative scenarios, in particular backcasting scenarios, are used to examine paths to alternative futures that vary according to their desirability (Kok et al. 2011). These value-driven scenarios are often either preferable and optimistic, or disagreeable and pessimistic. Such scenarios typically result from target-oriented backcasting, in which the emphasis is on the need to develop and describe images of the future as goal-fulfilling (Höjer et al. 2011). A goal is typically expressed in a quantitative manner, such as 10% decrease in CO<sub>2</sub> emissions, but the route to that goal can be approached in a quantitative (feasibility of measures) and qualitative (desirability of measures) manner. The rationale for stressing goal fulfilment is that it challenges the imagination to identify more solutions and to go beyond what is considered probable or feasible according to MCA. Basically, target-oriented backcasting is about exploring the question of what can change (Wangel 2011). It is a key approach when uncertainty is high, the problem is complex and persistent, and a long-term view is essential (Dreborg 1996). Backcasting recognises the irreducibility of uncertainties about future developments (e.g., uncertainty associated with climate and societal change) and externalities of actions yet to be taken but also the need to account for these uncertainties by assessing the risks of undertaking (precautionary) action (Höjer and Mattsson 2000; Quist et al. 2011).

Equally importantly, backcasting draws on an integrated systems approach for realising a whole systems change, taking

into account the linkages and interdependencies between various sectors (energy, water, food) or systems (e.g., social-ecological systems) (Quist 2007; Van der Voorn et al. 2012; Van der Voorn et al. 2017). In this regard, nexus approaches and backcasting adopt an integrated approach for ensuring system resilience and sustainability. However, more efforts are yet needed to develop, implement and apply comprehensive nexus frameworks, incorporate overlooked drivers and regions, expand and diversify nexus toolboxes, mainstream nexus approaches into policy making, governance and management and coordinate knowledge integration and stakeholder engagement across sectors (Liu et al. 2018). By comparison, backcasting provides a more comprehensive approach for achieving system resilience and sustainability in climate change mitigation (Sharmina 2017). Backcasting is considered suitable due to its applicability at various temporal and spatial scales, compatibility with various tools and methods, and its ability to support various forms of stakeholder engagement (Quist et al. 2011; Van der Voorn et al. 2017). Nonetheless, backcasting and nexus approaches are complementary rather than conflicting approaches. In backcasting, there is the aim to assess the physical (quantitatively) and social feasibility (qualitatively) of the pathway towards a desired future. This assessment requires identifying the necessity of measures and actions for bringing about that future, but would also benefit from employing nexus tools and methods to quantify the positive or negative consequence of these measures.

## Case study: emission scenarios for Swedish rural land use

### Introduction

Assessments of environmental goal conflicts are limited in the scientific literature, but in Swedish environmental policy, goal conflicts have been on the agenda ever since a national system of environmental quality objectives was put in place in the late 1990s. Goal conflicts are discussed in several reports from the Swedish Environmental Protection Agency (SEPA), both in terms of different interests or stakes that can create conflict and demand dialogue (Almstedt et al. 2006), and in terms of conflicts between fulfilment of different goals or policy areas (SEPA 2007). The SEPA (2007) concludes that both synergies and goal conflicts are common in the Swedish system of environmental objectives, both internally (among the environmental quality objectives) and externally (between the environmental quality objectives and other environmental goals). However, knowledge about how different goals interact and how to address the problem of goal conflicts is at best limited and, thus, in need for further investigation.

### Research method

The scenarios used to test the assessment method described in this paper have been described in Milestad et al. (2014). These scenarios illustrate the fulfilment of the Swedish environmental policy goals for reduced climate impact and zero net emissions of greenhouse gases. The assessment in this paper concerns how the scenario assumptions and adopted strategies for mitigating climate change could impose on or influence other environmental policy goals. This assessment of potential synergies and goal conflicts was made through a systematic comparison of the content of the four scenarios in relation to the Swedish environmental goals, i.e. the 16 Swedish National Environmental Quality Objectives (Gov. Bill 1997/98:145; Gov. Bill 2000/01:130; Gov. Bill 2004/05:150) and the overarching generation goal (Gov. Bill 2009/10:155). One goal (A protective ozone layer) was omitted from the assessment since it has already been reached. The qualitative assessment of goal conflicts and synergies in this paper is made in relation to Swedish environmental policy goals. Since the method was used on scenarios for Sweden, the Swedish Environmental Quality Objectives were used (SEPA 2013). However, the assessment could just as well have been carried out in relation to other sets of policy goals, such as the global sustainable development goals (United Nations General Assembly 2015). The purpose of assessing scenario outcomes in relation to other policy goals is to avoid that goal conflicts are considered as side effects, and that synergies are not taken into account. We argue that if the results and suggestions of backcasting studies are to be useful to planning and policy, we need to make sure that there are no severe side-effects for societal policy objectives.

The qualitative assessment draws on the scenarios and conflicts identified by other authors in scientific papers, reports and policy documents (see, e.g., references to Supplementary Material). This was done first individually by one of the authors, and later the preliminary results were discussed and adjusted together with two of the authors in a workshop format. This analysis is summarised using a compatibility matrix (Table 1). For each goal, aspects of the goal, as described in policy documents, were compared to the content of the scenarios, and we focused on aspects that were described explicitly in the scenarios and/or could be deduced from the scenario descriptions.

### Description of the analysed scenarios

The four scenarios that were analysed were developed in a Swedish research project dealing with strategies for mitigating climate change (Milestad et al. 2014) and are summarised in Fig. 1. The scenarios describe images of the future when Sweden has achieved a goal of zero GHG emissions in

**Table 1** Synergies and conflicts between policy goals and mitigation of climate change in the scenarios centralised governance and biomass focus, centralised governance and electricity focus, localised governance and biomass focus and localised governance and electricity focus. Red fields = conflict, green fields = synergy, white fields = no

Objective	Critical aspect of the goal	U	U	L	L
<b>2. Clean Air</b>	Emission from traffic	Green	Green	Green	Green
	Small scale wood burning	Green	Green	Red	Red
	Ground level Ozone	Green	Green	Green	Green
<b>3. Acidification</b>	Emission of NOx	Red	Green	Red	Green
	Emission of sulphur dioxide	Red	Green	Red	Green
<b>4. Non-toxic environment</b>	Pesticide use	Red	Green	Green	Green
	Supervision and control	Green	Green	Red	Red
<b>6. Radiation</b>	Closure of nuclear plants	Green	Green	Green	Green
<b>7. Eutrophication</b>	NOx emissions from biofuels	Green	Green	Green	Green
	Distances in food systems	Red	Green	Green	Green
	Ploughing of agricultural land	Green	Green	White	White
	Catch crops and buffer zones	Red	Green	Red	Green
	Small scale sewage systems	Green	Green	Red	Red
<b>8. Lakes &amp; streams</b>	Meat production and import	Green	Green	Green	Green
	GMOs	Red	Green	Green	Green
	Natural & cultural assets	Red	Green	Red	Green
	Ecosystem services	Red	Green	Red	Green
<b>9. Groundwater</b>	Small scale hydro-power	White	White	White	Red
	Pesticide residues	Red	Green	Green	Green
	Water protection areas	Red	Green	Red	Green
<b>10. Marine Env., Coastal Areas &amp; Archipelagos</b>	Decreased ground-water levels	Red	White	White	White
	Use of salt on roads	Green	Green	Green	Green
	Oil spills	Red	Green	Red	Green
<b>11. Wetlands</b>	Recreational values (noise..)	White	Red	White	Red
	Human disturbance	Green	Green	Red	Red
<b>12. Forests</b>	Protect and reestablish wetlands	Red	Green	Red	Green
	Forestry methods	Red	Green	Red	Green
<b>13. Agricultural landscape</b>	Forestry methods effect	Red	Green	Red	Green
	Protected areas	Red	Green	Red	Green
	Climate change	Red	Green	Red	Green
	Agricultural landscape diversity	Red	Green	Red	Green
<b>14. Mountain landscape</b>	Energy forests/open landscape	Red	Green	Red	Green
	Sustenance of Swedish land races	Red	Green	Red	Green
	Exploitation (mining)	Red	Green	Red	Green
<b>15. Built environment</b>	Noise	Green	Red	Green	Red
	Traffic noise	Green	Green	Green	Green
<b>16. Diversity plant and animal life</b>	Public transportation	Green	Green	Green	Green
	Green areas close to residential	Red	Green	Red	Green
	Safeguard habitats & ecosystems	Red	Green	Red	Green
	Wind turbines?	Green	Green	Green	Green

2060. The red thread in the scenarios is the link between an international climate change mitigation treaty and the energy sources used. The focus lies on describing how land in Sweden can be used. In all scenarios, the import of goods and energy have decreased, there is less transportation, and the domestic production support area is sufficient for covering net consumption needs.

## Results of the assessment

The results of the assessment are summarised in Table 1. The table indicates if potential goal conflicts or synergies have been identified in each scenario. For each Swedish environmental quality objective, the aspects that the assessment focused on are shown along with an indication of potential synergies and conflicts. Green colour indicates that there is synergy, red colour that there may be a potential goal conflict between fulfilling the goal of zero emission with the other policy goals. If the box is white, no assessment could be made. In the Supplementary Material includes a more thorough explanation of the environmental quality objectives, the selected aspects, and a motivation for why these aspects are critical in the scenario assessment. The critical aspects are based on the specifications of the goals in the policy documents, the information was gathered from the Swedish Environmental

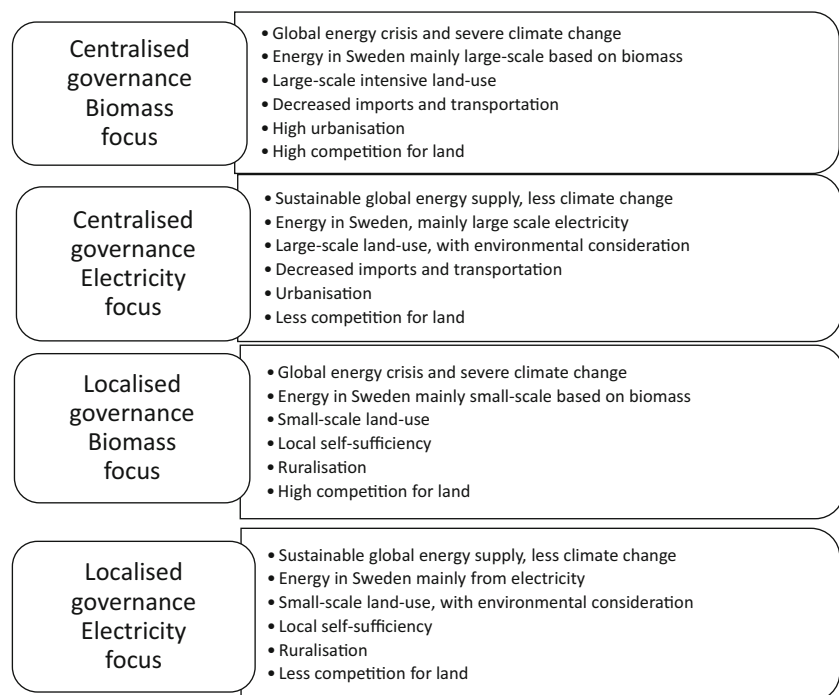
Objectives Portal (SEPA 2013). Additional sources of information supporting the assessment are indicated in the table.

The assessment shows that there are more potential goal conflicts in the biomass-based scenarios. It also shows that there are a lot of potential synergies in the electricity-based scenarios. The local electricity based scenario has the fewest potential conflicts, but the difference in comparison with centralised electricity based scenario is small.

## Discussion

In this paper, the conflicts and synergies identified in the assessment relate to strategies proposed by the scenarios and current Swedish policies. These scenarios may not be representative for future policy developments. Some conflicts and synergies may remain unrevealed, depending on how local and global contexts or the environmental policies change. For example, the assessment identified several synergies that were related to the intensity and scale of agricultural production. Decreased use of pesticides and increased opportunities for nutrient recycling in the local scenarios could result in synergies with several environmental goals (Supplementary Material: item 4). However, current policy does not favour small-scale and extensive farming, which is the main model in the local scenarios. The EU and Swedish agricultural policies, as well as the market development, rather work in the

**Fig. 1** Summary of characteristics of the four scenarios, showing central features as regards the energy system, the global context and land use



opposite direction. For example 8 out of 10 dairy farms have closed down in Sweden in the past 30 years although milk production has only decreased by 20% (SBA 2012). This means that the strategy of increased local self-sufficiency cannot be used for mitigating climate change unless there are policies that counteract this development.

As illustrated in Table 1, in this assessment, more potential conflicts with other environmental goals were identified in the biomass-based scenarios. These scenarios assume developments in which there is no climate agreement and where Sweden carries on in fulfilling the zero emission target anyway. Many of these conflicts are related to use of biomass for energy and fuel (concerns several goals related to traffic) and large allocation of land for energy production (e.g., conflicts related to the goals Thriving wetlands and Sustainable forests). The potential conflicts are related to several different issues, many of which could be avoided with sound measures and strategies.

The conflicts related to competition over land is a result of intensive land use, which creates conflicts with aspects that require less pressure on the land, such as diversity in the agricultural landscape (Supplementary Material: item 13). In the scenarios, these conflicts are also related to the use of biomass for energy supply because they are dependent on whether the transition to a zero GHG emission society is planned: either in collaboration with other countries and accompanied with investments for an electricity-based energy system, or done more in isolation with less room and time for investments (in a global energy crisis). A quick transition is likely to be based on biofuels, and increased use and intensive cultivation of biofuels might lead to several potential goal conflicts, e.g., emissions from biofuels and effects on biodiversity (Supplementary Material: item 7). Regardless of these assumptions, possibilities for avoiding conflicts over land use lie in decreasing pressure on the land resource. That is to say that land-demanding activities are reduced or replaced. In these scenarios this is done in the electricity-based scenarios through development of electricity as a source of energy.

Based on the assessment summarised in Table 1, one could argue that the pursuit of a transition to zero GHG emissions in Sweden is only meaningful if it coincides with global efforts to transition to zero GHG emissions. However, the results of the assessment provide no evidence for this argument because the scenarios do not account for future developments in the rest of the world. When other countries/regions face an energy crisis without being prepared for it (as the storyline in the biomass-based case describes), the situation there may become much worse economically and socially than described in the same scenarios for the Swedish context. Secondly, some conflicts (e.g., expansion of forestry in conflict with a magnificent mountain landscape, Table 1: items 12 and 14) directly relate to climate change and appear if global GHG emissions are not sufficiently reduced.

And thirdly, if Sweden would take the lead in demonstrating that achieving zero GHG emissions is realistic, and also potentially beneficiary in the long term, it could inspire other governments. To aid the transition to zero GHG emissions, the Swedish government can play a pro-active role in the creation of lead markets for renewable energy innovations. Lead markets of environmental innovations may lead to price advantages, demand advantages, transfer advantages, export advantages and strict regulation (Porter-effect) in the long run (Beise and Rennings 2005).

## Methodological implications

Most backcasting scenarios like the ones analysed in this paper relate to the fulfilment of one single target (Höjer et al. 2011; Svenfelt et al. 2011). The essence of backcasting scenarios is to illustrate that transitions to zero GHG emissions are possible, by going beyond the hindering structures in the present (Dreborg 1996). However, if potential goal conflicts or problems are not adequately addressed, there is the risk that the implemented measures may have unexpected and unintended side-effects like social or environmental impacts. Traditional scenarios usually opt for one specific goal regardless of other goals, which can lead to an accumulation of conflicts albeit unintentional. We argue that a solution to this dilemma is multi-target backcasting scenarios. Such scenarios provide a way to avoid goal conflicts, by addressing several goals simultaneously (Svenfelt et al. 2019). However, postponing mitigation action simply to avoid potential conflicts with other policy goals is a short-term solution that is unlikely to render significant benefits in the long run. Avoidance is likely to incur additional future costs (Stern 2006). A conscious decision not to take any mitigation action is considered a conflict-postponing strategy rather than a way of preventing goal conflicts. Therefore, we suggest that it is important to investigate the dynamics of conflicts and synergies across different temporal scales (short-term, mid-term and long-term) and spatial scales (local, national and global) and sectors (industry, energy, food and water).

The development of multi-target backcasting scenarios can be methodologically challenging because how does one manage several targets simultaneously? One such multi-target scenario study has been carried out by Svenfelt et al. (2019) in Sweden, in which four sustainability targets were used as a basis to develop scenarios for sustainable futures beyond GDP-growth.

More efforts are yet needed to develop a comprehensive approach for multi-target backcasting. The development and application of such an approach would also benefit from a methodological extension to nexus approaches and MCA. As discussed in Section 2.3, nexus approaches and backcasting can be seen as complementary approaches. Both

adopt an integrated, systems approach for ensuring system resilience and sustainability, taking into account the linkages and interdependencies between various sectors or systems. Goals may be motivated by practical problems that require understanding of specific interrelationships among various sectors or analysing nexus dynamics across these sectors. The analysis of nexus relationships can be supported by using a variety of tools and methods such as life-cycle assessment, material flow analysis and input-output analysis. These tools and methods can also support identifying the necessary measures and actions for bringing about that future, but also to quantify the positive or negative consequence of these measures. However, nexus approaches run short in addressing normative aspects (desirability) in resolving goal conflicts.

To some extent, MCA can be useful for dividing goal conflicts into smaller, more understandable and analysable parts and integrating these parts to produce a meaningful solution. As argued by Munda (2009), providing systematic information about goal conflicts can help to arrive at political compromises by making a complex situation more transparent to policy-makers and lay people. As discussed in Section 2.2, MCA becomes rather challenging when facing the lack of objectivity that can change the balance in favour of certain options over others. Although MCA typically falls short in addressing normative aspects of trade-offs, there are examples of participatory MCA studies e.g., (Garmendia and Gamboa 2012), where the idea was to bring together actors so that different values can be raised. In this regard, MCA and multi-target backcasting can play complementary roles: MCA is useful for prioritising between different options, whilst multi-target backcasting can address normative aspects in priority setting. In sum, a comprehensive approach for multi-target backcasting, which combines the strengths of MCA, nexus approaches and backcasting, would have the potential to ensure system resilience and sustainability.

## Conclusions

In this paper, we assessed four future scenarios on Swedish rural land use in light of a transition to zero GHG emissions in 2060. The scenarios include many goals to reach out to a non-fossil fuel future. The assessment shows that goal conflicts are apparent and policy makers need to make trade-offs between goals. The choice of strategy to meet a goal can resolve conflicts or create synergies. The following major conclusions can be drawn from the assessment. Firstly, a transition to zero GHG emissions provides opportunities for Sweden to shift to a carbon free land-use planning and carbon free society. Secondly, land use and how to deal with competition over land is a pressing issue if climate change mitigation is to be taken seriously. Thirdly, extracting electricity from wind, water and sun relieves pressure on land resource. Overall, there

are alternative ways with different underlying assumptions to achieve zero GHG emissions, which will feed discussions about future goal conflicts in climate change mitigation. Different perspectives on mitigation strategies and the diffusion in the creation of lead markets for renewable energy innovations will provide new opportunities to overcome future goal conflicts.

The main benefit of analysing the nature of goal conflicts and suggesting potential strategies for resolving them is that goal conflicts can be anticipated in early phases of planning and management processes. One way to do so is through using scenarios and integrating the analysis of conflicts and synergies into an iterative, participatory scenario development process. A step further would be to develop multi-target scenarios, which are better equipped to deal with the drawbacks of single-target scenarios. The development and application of an approach for multi-target backcasting would benefit from a methodological extension to nexus approaches and MCA. A comprehensive multi-target backcasting approach, which combines the strengths of MCA, nexus approaches and backcasting, would have the potential to ensure system resilience and sustainability and support a transition to zero GHG emissions.

**Funding information** Open Access funding provided by Projekt DEAL. The research presented in this paper was funded by the Swedish research council Formas.

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