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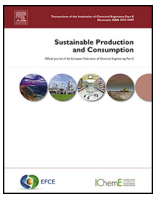

Research article

Towards a participatory systems approach to managing complex bioeconomy interventions in the agrarian sector

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ABSTRACT

Calls for a "sustainable bioeconomy" have recently begun to proliferate in academic and political circles as an answer to global challenges such as the rapidly increasing world population and changing environmental conditions due to climate change. To build economies that rely on various sources of biomass rather than on fossil-based resources, bioeconomy policies highlight a need to explore ways in which productivity in agriculture can be increased. While the focus on productivity growth has largely been inspired by technology optimism and modernisation thinking, the local knowledge of farmers and other rural stakeholders – as a means of contributing to socially and ecologically more sustainable bioeconomy pathways – has frequently been sidelined. This perspective article proposes and discusses a participatory approach to strategy formulation and evaluation in agricultural transformation and bioeconomy development that is based on the methodological toolbox MARISCO (Adaptive MAnagement of vulnerability and RISk at COnservation sites). By offering a means of developing a comprehensive knowledge map, bringing together both insights and perspectives from diverse local stakeholders, this approach enables a systemic evaluation of the social and ecological effects of intervention strategies on the ground. The article outlines the benefits – and challenges – of such a systemic and participatory approach and briefly sketches how the results can be utilised in more sustainable governance processes in the development of bioeconomy strategies. We conclude that our adapted MARISCO methodology offers a viable tool to make more visible the perspectives and knowledge of biomass producers for policymakers and to contribute to a much-needed discursive shift in bioeconomy debates towards more holistic and inclusive perspectives.

1. Productivity growth, knowledge hierarchies and the need for alternative approaches to the bioeconomy

As framed in various national and international bioeconomy strategies, the shift to a "sustainable bioeconomy" suggests a significant increase in biomass production as a prerequisite for its implementation. Much of this production increase would need to come from the agrarian sector, where productivity growth through technological modernisation seems to be the pathway of choice. To ensure its sustainability, this productivity growth should be decoupled from negative environmental impacts. Efficiency increases, smart farming solutions and other innovative (bio-)technologies are proposed to minimise inputs, increase yields and make production more resilient to increasing environmental stresses due to changing climates (see, for example, OECD, 2018; European Commission, 2018; BMBF and BMEL, 2020). Global agricultural production in its current form already exceeds several planetary boundaries, especially those identified for biosphere integrity and the nitrogen cycle (Gerten et al., 2020). The premise behind decoupling production growth from the excessive use of natural resources has been criticised as unrealistic and wishful thinking, as well as virtually impossible from a biophysical point of view (Giampietro, 2019; Backhouse et al., 2021). In this sense, bioeconomy policies are shaped by what Backhouse (2021, 26) describes as strong 'technology optimism', which is framed, on the one hand, by a rather linear view of biomass production that primarily relies on technical solutions, while on the other hand it neglects ecological limits and the complex social-ecological realities of production systems (see also Alff and Spies, 2020). These neglected aspects are interrelated, but we focus our attention in this paper on the last argument raised.

Larger global actors such as the European Union (EU) already rely on biomass imports, and this trend can be expected to increase alongside a growing bioeconomy – as outlined in their strategy papers (see Lühmann, 2021). One critique directed towards the bioeconomy strategies of the EU is that they pay little attention to the fact that the vast majority of agricultural producers worldwide are smallholder farmers in the Global South (Ebel, 2020). For small farmers, many – if not most – of the high-tech and smart farming solutions that dominate the debate are not an option, as their access to resources is limited. Moreover, another frequently raised criticism is the lack of involvement of societal

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stakeholders in bioeconomy strategy development and decision-making (Dieken et al., 2021; Lehmann, 2021; Pissarskoi et al., 2021). In particular, the perspectives, (locally adapted) knowledge and concerns of the majority of biomass producers often remain neglected in visionary bioeconomy strategies produced in the Global North, which in turn creates the risk of further marginalising them, to the benefit of agribusiness interests. These inequalities of 'extractive knowledge production' in the bioeconomy, as Backhouse (2021, 33) formulates it, not only reproduce or amplify existing social inequalities, but must also be regarded as a missed opportunity. As discussed in a rich body of literature on local and indigenous knowledge, there is much to be gained from the diverse experiences and perspectives of local producers and their sophisticated resource use practices that adapt to local contexts (see, for example, Berkes et al., 2000; Jiao et al., 2012). Thus, including bottom-up perspectives and acknowledging local land users as experts – in a similar way to technical experts and scientists, whose knowledge is currently valued so highly in the dominant bioeconomy discourse – will be crucial to widening the scope of the debate in order to identify alternative bioeconomy pathways. Some of these pathways may be less productivity-oriented, but they could nevertheless be socially and ecologically more sustainable than those suggested by the currently dominant modernisation paradigm. For instance, in many places worldwide, smallholder farmers have developed heterogeneous agricultural landscapes that are rich in agrobiodiversity and capable of adapting to environmental threats (see, for example, Padoch and Sunderland, 2013; Spies, 2019).

While much criticism has arisen around the pitfalls in current bioeconomy discourses, policies and strategies, there is still a lack of concrete, practice-oriented suggestions on what can be done to address them. Critical research has moved from quasi-rejecting the concept (Gottwald and Krätzer, 2014; Marsden and Farioli, 2015) to calling for a more constructive engagement with the field by outlining alternative bioeconomy futures and opening up the policy debate to society (Pissarskoi et al., 2021; Backhouse et al., 2021; Dieken et al., 2021). Moreover, while bioeconomy policies are here to stay, there is a need to not only lobby for paradigmatic changes at the policy level, but also to develop meaningful tools and approaches for co-designing, evaluating and implementing concrete bioeconomy strategies on the ground. The latter is particularly relevant, since, in the still rather novel debate, much more attention has been given to broadly defined policies than to actual implementation strategies tailored to local contexts.

In this perspective article, we want to argue for and introduce a systemic-participatory method for developing, critically evaluating and implementing locally adapted bioeconomy strategies that go beyond – but by no means exclude – mere technology- or productivity-oriented measures. By "systemic" we mean that social-ecological systems, which form the basis of a bioeconomy, need to be regarded as complex (adaptive) systems, the dynamics of which are always characterised by indeterminacy and non-linear feedbacks that require a holistic understanding of the manifold factors and actors shaping developments on the ground (see Spies and Alff, 2020). While primarily designed for local or regional contexts in both the Global South and the North, our approach also offers a way of structuring and "formalising" local or citizens' knowledge to elevate it to an equal footing with so-called "expert knowledge," in order to better inform broader bioeconomy policies.

By providing clear step-by-step guidance for thorough analysis, we find the MARISCO (Adaptive MAnagement of vulnerability and RISk at COnservation sites) approach particularly useful for our purpose, as it reveals the inherent complexity of social-ecological systems. MARISCO is designed to assess systematically the vulnerability of ecosystems, including agro-ecosystems, and involve resource users and other stakeholders in order to plan for adaptive management strategies aimed at reducing threats to and stresses on these systems (Ibisch and Hobson, 2014). Developed as part of an ongoing research project on agrarian transformations in Central and South Asia (see Alff and Spies, 2020), our adaptation of MARISCO aims particularly to address the social-ecological dimension of biomass production. By incorporating local knowledge and actors in assessing and designing a way of sustainably using locally available resources, we propose a more socially differentiated assessment of strategic interventions and their implications.

Due to ongoing restrictions and severe delays imposed by the COVID-19 pandemic, our MARISCO adaptation, unfortunately, currently remains untested, which means our work is restricted to a rather conceptual level. Nonetheless, we draw on a rich body of experience and knowledge provided by MARISCO applications, much of which has been documented in the literature (e.g. Ibisch and Hobson, 2014; Schick et al., 2018). The first author facilitated MARISCO workshops in India and Tajikistan, and all co-authors engaged in numerous conceptual-methodological workshops and discussions with experienced MARISCO trainers. While not explicitly using the term "bioeconomy," most – if not all – MARISCO applications have focused in some way on the use or management of biological "resources," among others in the fields of forestry (Blumroeder et al., 2018) and agriculture (Spies et al., 2021). Before sketching out our MARISCO-based methodology and discussing its potential for evaluating and designing bioeconomy strategies "from below," we will briefly review participatory approaches in related fields.

2. Systemic-participatory approaches to the bioeconomy

Farms, i.e. the main providers of biomass in the field of agriculture, are embedded in complex social-ecological contexts that need to be thoroughly understood before implementing policy strategies which might turn out to create unintended (or tacitly accepted) negative side effects. As a large body of critical agrarian research demonstrates, this has been a shortcoming of many agricultural policies. For instance, while boosting agricultural productivity, the technological innovations of the Green Revolution in South Asia have contributed to an increase in social inequalities in rural areas and environmental issues such as groundwater overuse and soil degradation (Shiva, 1991; Murgai et al., 2001; Niazi, 2012; Byerlee and Siddiq, 1994). Another prominent example may be the upsurge in the use of soybean, not only for consumption, industrial food processing and animal feed, but also for biodiesel (Backhouse, 2021), bioplastics and other bio-based products developed by the car industry, road-building, furniture and ink-making sectors (Dangelico and Pujari, 2010; South Dakota Soybean Association, 2016). Coupled with national policies that favour the upscaling of soybean production for export, such as in Brazil, a major producer worldwide, for example, this leads to dwindling rainforests as well as the loss of land and occupation of small-scale farmers (Rodríguez, 2021). With regard to soy production, the emphasis remains on (bio-) technology to enhance production and to increase industrial extraction of this highly demanded crop while neglecting the inequalities such a policy focus creates (Backhouse, 2021; Koch and Fritz, 2020). What these and other examples of narrowly growth-oriented policy interventions in the agrarian sector have in common is not only their lack of a systemic understanding of social-ecological contexts, but also their further marginalisation of certain stakeholder groups who did not have a say in policy development in the first place.

Thus, we argue that bioeconomy strategies and their implementation in the agrarian sector need to be redirected in two ways. First, systemic approaches to local and regional policy, which rigorously assess the potential social-ecological implications of interventions before implementation, need to be mainstreamed. Second, and interconnected with the first argument, strategies must not only be developed in consultation with bioeconomy expert bodies (such as, for instance, the German Bioeconomy Council; see Lehmann, 2021), but also be based on knowledge co-production approaches that seriously engage with the perspectives of local producers and other stakeholders from civil society. In this regard, participatory approaches provide a range of methods to not only make bioeconomy strategies more democratic and just, but

also to increase the public acceptability of related innovations that promote ecological regeneration, ensure long-term sustainability and avoid the pitfalls of previous policy interventions in the agrarian sector.

Based on a recent systematic literature review on stakeholder perceptions, Dieken et al. (2021, 1713) conclude that there is a 'concerning lack of public involvement' in bioeconomy debates, 'which challenges the bioeconomy concept's claim to contribute to sustainable development'. Nevertheless, a few publicly funded projects have explicitly addressed this gap by developing tools and approaches to facilitate citizen participation in policy dialogues on the bioeconomy. For instance, the "BioKompass – Communication and Participation for the Societal Transformation towards the Bioeconomy" project carried out so-called "future dialogues" with citizens and experts to jointly develop bioeconomy scenarios for different regions of Germany as a means to encourage societal debate and to increase public awareness of the concept (Kimpeler et al., 2021). In different European case study regions, the "BioSTEP – Promoting Stakeholder Engagement and Public Awareness for a Participative Governance of the European Bioeconomy" project applied a variety of participatory tools in the fields of education and information (e.g. exhibitions), stakeholder dialogues and consultations (e.g. web-based tools and policy workshops) and knowledge co-production ("living labs"; see BioSTEP, 2017; Gerdes et al., 2018). The project outcomes include helpful guidelines and practice examples on how to engage stakeholders and the general public better in regional (i.e. sub-national) bioeconomy policies. However, there seems to be some bias towards business stakeholders and innovation processes, as well as a rather narrow understanding of expert knowledge. For instance, in one of the two living labs conducted in the project, designed as a series of workshops aiming 'towards shared open innovation among stakeholders who work in the same geographical area,' it was decided to 'not involve civil society representatives due to their lack of knowledge on the bioeconomy' (Gerdes et al., 2018, 40, 42). We find this understanding of inclusiveness problematic. What is missing from the tools and methods outlined in the project is guidance on how to critically assess the social-ecological sustainability of bioeconomy strategies, which, we argue, should be the main objective of such a participatory process.

There is a rich body of literature on knowledge co-production and participatory tools for scenario-building and strategy development, but it has received only scant attention in bioeconomy debates and research (see, for example, Reed et al., 2013; Roue and Nakashima, 2018; Oteros-Rozas et al., 2015; Díaz-Reviriego et al., 2019; Sterling et al., 2019; Pimbert and Barry, 2021). In this regard, the field of agroecology is particularly noteworthy, on the one hand due to its emphasis on action-oriented research, and on the other hand because of its holistic – or systemic – understanding of farming systems that consider social, ecological and technical dimensions as inextricably linked (see, for example, Méndez et al., 2013; Bergez et al., 2019; Anderson et al., 2021). For example, the "TATA-BOX – Territorial Agroecological Transition in Action: a tool-Box for designing and implementing a territorial agroecological system transition in agriculture" project recently developed and tested a participatory method in two case study areas in south-western France to support local stakeholders in designing an 'agroecological transition' (Audouin et al., 2019, 177). Through a series of workshops, they developed a stepwise approach to analyse the agricultural system in a given territory, to develop scenarios relating to major exogenous forces and to jointly create an agroecological vision and design a concrete action plan for the transition (Audouin et al., 2019). The TATA-box approach primarily targeted stakeholders already sympathising with such farming methods.

Practical guidance can also be drawn from a set of methods originally rooted in the natural sciences and which serve the conservation of biodiversity and ecosystem management. The widely used and continuously developing Conservation Measures Partnership's Open Standards for the Practice of Conservation (short: Open Standards; Conservation Measures Partnership, 2013) presents an evidence-based research toolbox to propose design, implementation and learning from ecosystem-based adaptation interventions. Developed from the Conservation Standards, another two applications have recently taken the assessment of conservation planning to another dimension, namely the Conservation Standards to Ecosystem-based Adaptation (CoSEbA), initiated by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ and Conservation Measures Partnership, 2020), and Adaptive MAnagement of vulnerability and RISk at COnservation sites (MARISCO), promulgated by the Centre for Econics and Ecosystem Management at Eberswalde University for Sustainable Development (Ibisch and Hobson, 2014). CoSEbA puts the dependencies of livelihoods and well-being on ecosystem services to the fore. Here, socioeconomic factors contributing to threats become part of the analysis before formulating interventions. MARISCO, however, considers social and ecological services as equally contributing to well-being. Furthermore, by analysing and judging the systemic links leading to certain risks in local settings, it emphasises a broader analysis of local social and ecological complexities, system dynamics and change. MARISCO thus allows for formulating locally adapted strategies to make farming systems less risk-afflicted and more sustainable, as well as for systematically and critically assessing the local impacts of existing or planned intervention strategies that may have very different prospects in mind. All three approaches formulate a standardized but slightly different language for phenomena that are open to evaluation from multidisciplinary perspectives.

In its focus on a geographical setting, MARISCO differs from approaches such as the Social Life Cycle Assessment (sLCA), which has been designed to assess systematically the social aspects of products, from the sourcing of raw materials all the way through to consumption and disposal (Tokede and Traverso, 2020). While this method is fruitful for a critical analysis of particular products and their impact on societies, we find MARISCO more suitable for our objectives. The explicit focus on the place-based assessment and mapping of stakeholder knowledge encourages differentiated insights at the local level and thus allows for a broader assessment of locally adapted solutions to the social and environmental challenges of biomass production. Needless to say, both approaches can complement each other.

3. An adapted MARISCO toolbox for bottom-up bioeconomy strategy formulation

As outlined in the previous chapter, there is a need for systemic approaches that assess the social-ecological implications of bioeconomy-related interventions. We also established a need for a participatory approach to bioeconomy strategy formulation, in order to incorporate local perspectives, especially the viewpoints of those who are often marginalised from such processes.

MARISCO offers a primary toolbox to map the knowledge of various local stakeholders by contemplating and discussing a comprehensive model of ecological and social factors relevant to the specific local context. This is typically achieved by engaging a variety of stakeholders in a workshop-like format. By developing a comprehensive knowledge map, participants trace the complex interconnections between human well-being targets, social and environmental services and the respective provisioning systems, and to identify the key attributes, threats and factors relating to these systems. The methodology offers tools to map out the effects of existing and future interventions, by depicting the local context (Ibisch and Hobson, 2014; Blumroeder et al., 2018), and aims to co-create environmentally and socially adjusted future management strategies. The underlying theories of MARISCO are closely related to ecology and theories of complex (adaptive) systems (see e.g. Levin, 1998; Gunderson and Holling, 2002). The method has been framed as a 'radical ecosystem approach' that regards ecosystems as 'complex, nested systems that change permanently and dynamically' (Ibisch and Hobson, 2014, 37). Human or social systems are an 'integral and dependent part of the global ecosystem' (ibid.). Both social and ecological

systems are defined by their emergent self-organisational properties, but they are closely interrelated and subject to dynamic processes of non-linear change that always involves a multitude of social, ecological and political factors as well as complex feedback loops. Thus, management strategies can only be sustainable if they take these principles seriously, which makes a holistic analysis indispensable.

MARISCO has been successfully exercised on different scales for the management of diverse conservation projects around the globe, such as Jiangxi Province in China, Morona Santiago in Ecuador, the Carpathian Biosphere Reserve in Ukraine and the Peruvian Amazon (see www.marisco.training). More recently, it has been utilised to evaluate the effects of biodiversity-enhancing farming practices promoted by a development project in Tajikistan and north-east India (Spies et al., 2021). The method suggests a number of methodological steps that are structured into several consecutive phases, a detailed description of which is provided by Ibisch and Hobson (2014). In the present chapter, we detail our adapted MARISCO approach to incorporate the perspectives and knowledge of local agrarian stakeholders in the formulation and evaluation of locally adjusted bioeconomy strategies.

Our method deviates from MARISCO as outlined by Ibisch and Hobson (2014), in that we simplify it in some ways and complicate it in others. First, as the most important alteration, our approach dedicates more detail to the social dimension, among others, by necessitating the inclusion of "social systems" and "social services" in the knowledge map and by helping to distinguish between different social groups or strata in the analysis of threats and intervention impacts.[1] Second, to keep the workload manageable and to give the participants more room for creativity within the given methodological framework, some original MARISCO steps are omitted or simplified. Third, we adapt the criteria for rating and evaluating intervention strategies, as they were originally designed in MARISCO to assess and develop strategies relating to ecosystem conservation, while our focus is on bioeconomy strategies. Fourth, while keeping the logical order of steps defined by MARISCO, for the sake of simplicity we structure our approach in terms of two phases which correspond to the original MARISCO Phases I–III (Ibisch and Hobson, 2014, 15): (1) conducting a comprehensive situation analysis through knowledge mapping, which forms the basis for (2) evaluating and formulating bioeconomy strategies in a locally defined region. In the following introduction to our adapted methodology, we point out our additional deviations from MARISCO, where they apply.

3.1. Phase 1: systemic knowledge mapping

The first phase of the methodology refers to preparatory activities and a comprehensive workshop (or a series of workshops) intended to bring together local stakeholders, typically in groups of 15–25 participants, for systemic knowledge mapping in a given locality or region (Ibisch and Hobson, 2014; Schick et al., 2018). The methodology begins with an initial diagnostics analysis (called "Ecosystem Diagnostics Analysis" in MARISCO) by the planning team or "facilitators" of the participatory process, i.e. a rapid assessment of local characteristics and conditions (Schick et al., 2018). This can be achieved via desk research, virtual meetings with local stakeholders and field surveys of the study or target area. The latter can be as small as a village, including its farmland, but it can also cover a larger administrative region, a watershed or any other relevant spatial unit that needs to be clearly defined according to the assessment's objectives. Concurrently, a stakeholder analysis needs to be conducted to select workshop participants, which we add to existing MARISCO tools in an explicit preparatory step. This requires a good deal of care and sensitivity to ensure representation of 'the full social spectrum of local society' (Schick et al., 2018, 863), or, at the very least, include spokespersons from all groups potentially affected by bioeconomy-related interventions in the target area. This considers not only primary biomass producers, but also, for instance, all groups whose livelihood strategies may be compromised by agribusiness expansion into so-called "marginal land" that is already in use for livestock grazing or the collection of wild plants by these groups (see, for example, Backhouse et al., 2017). Here, it is important to collaborate from the beginning with local partners such as NGOs and farmers' organisations and to critically draw on their knowledge and networks during the preparatory steps and the selection of participants. The stakeholder analysis should also identify relevant decision-makers who should be included in the process. Here, and throughout the participatory process, questions of representation and legitimisation, as well as the scope and degree of stakeholder participation, need to be critically reflected and strategies applied, in order to avoid the distortion of ideas and the prevalence of bias in the outcome (see, for example, Reed et al., 2009; Anderson et al., 2017). The initial diagnostics analysis and the stakeholder analysis are crucial steps, as the facilitators need to gain sufficient knowledge of the local context and the relevant actor groups to prepare adequately for and guide the process. Once relevant stakeholder groups have been identified, their representatives will be invited to the workshops. Additional initial tasks include preparing the workshop venue and materials used.[2] In consultation with local actors, key concepts and rating criteria will be translated into a local (and non-academic) language with which the participants are most familiar. It is always possible to reformulate concepts into different operative terms, as long as they are used consistently. In past MARISCO applications, however, participants with diverse educational backgrounds have usually had no problems relating to applied concepts such as ecosystems and human well-being, since facilitators pragmatically introduced them in lay terms, often with the help of practical examples from previous MARISCO workshops. Conducting participatory workshops requires at least two skilled facilitators with sufficient experience in moderating group processes. In the case of language barriers, at least two experienced and well-prepared interpreters are needed. In order to include stakeholders with time and resource constraints in the workshops, incentives and, if appropriate, financial compensation should be provided. This may mean offering payments, catering at the workshop site and the organisation of transport services. Moreover, the workshop schedule needs to be adapted to the time availability of more disadvantaged stakeholders, for instance by avoiding the cropping season and the busiest daytime hours when working with small farmers.

3.1.1. Building the model

The first workshop of about two to three days begins with a participatory and transparent determination of the motivation, aims and geographical scope of the assessment, with the possibility for readjustments according to stakeholders' priorities. The main part of the workshop is then dedicated to a thorough analysis of social-ecological systems in the target area through building a comprehensive knowledge map.

Fig. 1 outlines the generic structure of this knowledge map – called a "conceptual model" in MARISCO terminology – that participants create during this phase. Using a large wall display and coloured cards representing different model elements (see Fig. 2), this MARISCO exercise typically takes one-and-a-half to two workshop days. The model also remains open to modification throughout the assessment process (Schick et al., 2018). The approach is also pivotal in terms of incorporating the knowledge of all relevant stakeholders on an equal footing, which means that there is no hierarchy between so-called "expert" knowledge and forms of knowledge that are not (yet) scientifically approved. For instance, while general element categories

[1] Some of these changes, in particular the mapping of social systems and social services (see Fig. 1), will also be included in "MARISCO 2.0," which is currently under development. MARISCO 2.0 will also include software for data entry and analysis (see https://www.marisco.training/marisco-2-0-software/).

[2] See the MARISCO manual (Ibisch and Hobson, 2014, 180–183) for a full list of requirements for a typical MARISCO workshop with 15–25 participants. For our adapted method, the requirements are more or less similar.

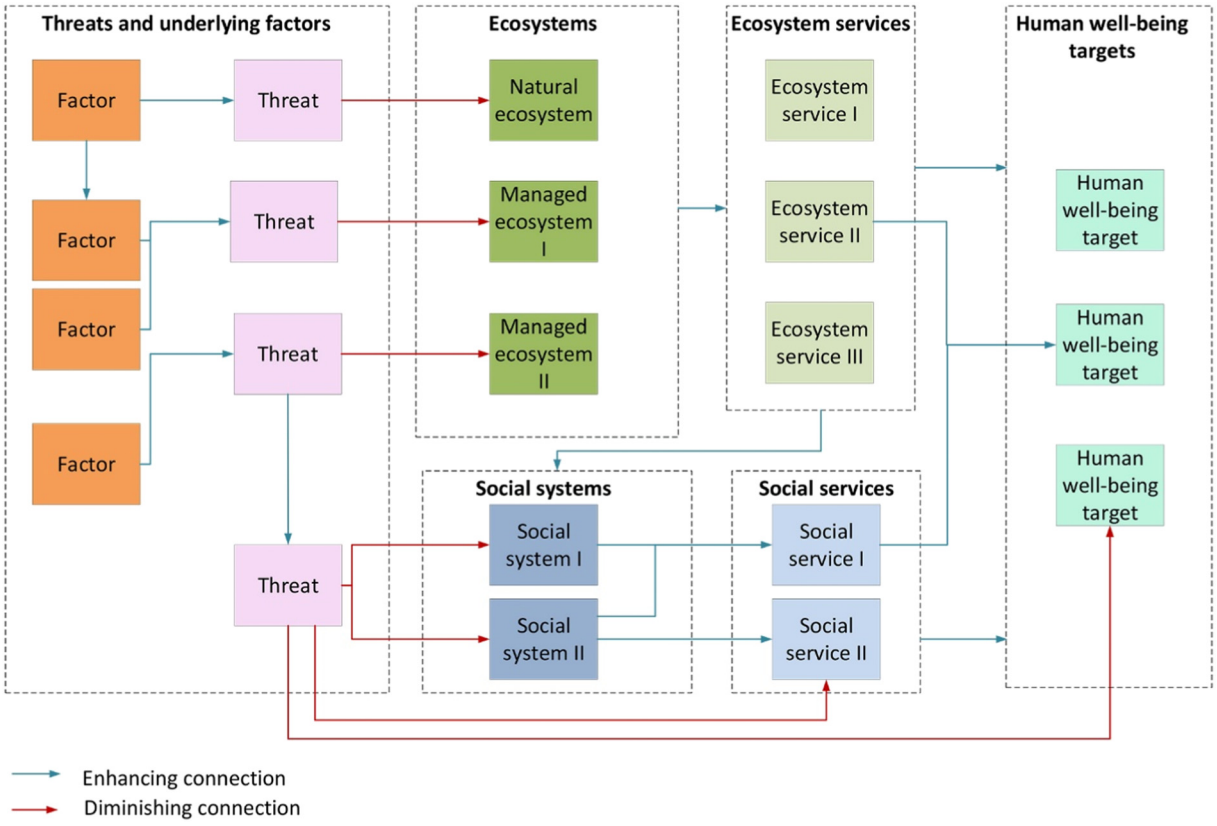

Fig. 1. Generic structure of the systemic knowledge map developed in Phase 1. Note that only the main types of postulated causal relations between different element types are depicted here. In fact, there are complex feedback loops and causal links between basically all types of elements.

such as ecosystems and threats (Fig. 1) are pre-determined as part of this adapted MARISCO approach, how these categories are interpreted is up to the participants and their mutual agreements. All elements and processes deemed relevant by the participants are included in the model, before jointly re-evaluating them at a later stage via detailed rating exercises.

Fig. 2. Rating of factors (yellow cards) and threats (violet) during a MARISCO workshop with farmers and local authorities in Mizoram, India. A score of four coloured grades (green = low, red = high) is used to rate the model elements according to various criteria (photograph taken by M. Spies in October 2018).

The participatory model-building process follows the logic of the generic model presented in Fig. 1 from right to left. The participants start by listing relevant human well-being targets (e.g. good health, secure income, etc.), which offers an easing into the methodology, as human well-being is a rather straightforward notion to which most persons, regardless of cultural background, can relate. It is entirely up to the participants how they choose to define and classify human well-being targets, although the workshop facilitators or "participatory workers," as Wakeford (2017) calls them, can offer some guidance. In general, the role of the facilitators is to guide people through the discussions and mapping exercises within the given methodological framework, not to impose their own ideas. Moreover, their role is to encourage participants to build trust in their own expert knowledge, as they have the expertise and practical knowledge for the given locality, not the facilitators, who, usually being outsiders, can only guide them through the process.

After determining the human well-being attributes, participants apply a stepwise procedure to develop the model from right to left, following a logic of basic causal relations. Here, working with moderation cards can encourage less outspoken individuals to contribute their ideas equally. Each step should begin with a silent brainstorming phase in which participants individually write their ideas on cards, which can then be handed over to the facilitators for (anonymously) mapping them onto the wall display. If possible, illiterate people can work in teams of two with a literate person.

The participants start by identifying the "social services" that ensure human well-being, followed by a determination of the "social systems" providing these services, including state institutions, community organisations and employers (Schick et al., 2018). Social systems are understood in a number of ways and are highly context-dependent. In the most abstract sense, and inspired by theories of complex adaptive systems, we regard them as systems of social interaction larger than households that encompass (a) emergent self-organisational properties and (b) a certain degree of temporal durability or permanency.

In a similar way, ecosystem services that provide benefits to human well-being, as well as their corresponding ecosystems, are identified and mapped. Ibisch and Hobson (2014) provide detailed guidance on how ecosystems and associated services can be defined, classified and operationalised for stakeholder workshops, albeit this cannot be elaborated in the context of this contribution. The concept of ecosystem services has been criticised, among others, for its anthropocentric focus and for implying a commodification of nature, although there are also various counter-arguments that we cannot discuss herein (see, for example, Schröter et al., 2014). While setting human well-being as the prime target makes the whole process anthropocentric, depending on the aims determined at the beginning of the workshop, this does not necessarily have to be the case: the participants may also decide to set the conservation of ecosystems as the prime objective, rather than the safeguarding and improvement of human well-being. Especially when applied in the field of nature conservation, previous MARISCO applications have usually combined both objectives by defining ecosystems, ecosystem services and human well-being as "conservation objects" (see Supplementary File 1). Nevertheless, in the first author's MARISCO experience, ecosystem services is a concept to which non-academic workshop participants can easily relate, for instance by asking the simple question, 'What does nature give us to feel good?'. Similar to social systems, "ecosystems" overlap, are nested within each other and are interrelated in complex ways. While it is clear that social and ecological systems do not exist in isolation to each other – strictly speaking, social systems are understood as being embedded in ecosystems – this conceptual distinction and graphical depiction (Fig. 1) is needed in order to operationalise the mapping exercise. We define agricultural systems as managed ecosystems, in that they provide a variety of ecosystem services, including food and bioenergy crops.

After mapping the basic components of the social-ecological setup of the target area, the conceptual model is completed with the mapping of "threats" and "underlying factors" that obstruct the ability of the identified systems to provide for human well-being.[3] Threats refer to 'pressing factors' (Schick et al., 2018, 864) that pose a direct or an indirect danger to the social-ecological system. Underlying factors can be understood as the root causes of these threats (Schick et al., 2017). For example, while soil salinisation may be a direct threat to irrigated cropland as a managed ecosystem, degraded irrigation infrastructure and misguided policies on water-intensive crops may be classed as underlying factors. This is the most crucial – but also most time-consuming – model-building step, as it requires a thorough analysis of the main threats in the study area as well as their underlying cause-effect chains. The latter usually involve a broad and diverse range of interrelated factors pertaining to governance, legislation, structural inequalities, biophysical changes and socioeconomic trends, among many other aspects (cf. Blumroeder et al., 2018; Schick et al., 2018).

Throughout this model-building process, facilitators should refrain from any input to the discussion. However, they can make suggestions to merge duplicate elements and cluster them to improve model legibility, and they should always encourage participants to identify gaps during additional revision rounds. All information added by individual workshop participants is considered relevant and credible, but merging, removing or moving elements to a different category (e.g. from ecosystem to social services) is only allowed with consensus among all participants.

3.1.2. Rating of elements and drawing causal connections

Once all of the conceptual model's elements have been laid out, the participants conduct a systematic rating exercise. While ecosystem and social services can also be rated (according to qualitative, quantitative and socially just provision), the main focus here is on systematically rating all identified threats and underlying factors. Rating criteria can be redefined by the workshop participants if they wish to do so, but they include by default *criticality*, as well as *manageability* and *level of knowledge*. To allow for a more detailed evaluation of factors and threats, criticality can be split into several sub-criteria: *scope*, *severity* and *irreversibility*, and, more important for strategy development, *past*, *present* and *future criticality*. While these terms may seem rather abstract, clear descriptions of each rating criterion and score should be carefully prepared in advance and in consultation with local actors, printed or written on large posters and thoroughly explained and jointly tested at the beginning of each rating step (see Ibisch and Hobson, 2014, 118–120, for a detailed description of the criteria and scores). The rating results play a crucial role in making sense of the complex knowledge map and identifying the most important factors and threats that need to be addressed by the proposed intervention strategies.

In MARISCO, the rating exercise is usually done based on consensus, thus making it necessary to find a compromise in the case of disagreements between different workshop participants. This, in turn, may lead to bias in the results towards the interests of more powerful stakeholders among the workshop participants; however, this can be circumvented by separating them into break-out groups of representatives of two or three a priori decided stakeholder groups, to conduct separate rating exercises at different times. These stakeholder groups should already be defined by the participants at the beginning of the workshop. Facilitators are allowed to intervene if dominant participants clearly threaten the workshop outcome by not allowing others to

[3] To reduce the overall time requirement, we deviate here considerably from MARISCO by omitting the two steps of mapping "key ecological attributes" (KEAs) and "stresses" into the model (see Supplementary File 1 for a "typical" MARISCO knowledge map). KEAs can be understood as the 'integral elements and properties' that maintain the function of ecosystems and 'provide the necessary adaptation and resilience to cope with perturbations' (Ibisch and Hobson, 2014, 74). A "stress" can be understood as the degradation of a KEA (Schick et al., 2019). To save time and reduce complexity, we subsume stresses under the element type threat, and we introduce an optional break-out session of mapping KEAs onto a separate flipchart to sensitise the participants for the subsequent step of mapping threats.

express their opinion. For instance, a similar situation was experienced by the first author during a MARISCO workshop in north-east India whereby representatives of the agriculture department seemingly influenced the opinions of participating small farmers. This could be diplomatically mitigated by the facilitators by suggesting four breakout groups based on location (farmers from three different villages) and status (one district-level expert group), which were then formed by the participants for a number of rating steps. Other criteria can include economic status or different livelihood sources, depending on the local social context. Additionally, forming break-out groups allows for representatives of typically marginalised groups to deliberate with a greater degree of freedom and to draw attention to issues specific to their groups' experiences and concerns. The aim of this socially stratified analysis is also to demonstrate that some threatening elements may be beneficial to certain groups and detrimental to others; for example, programmes favouring large farms may be viewed by smallholder farmers as a threatening factor, while large-holder farmers might naturally consider these a benefit.

Following the rating exercise, the final step in this phase is to identify and draw connections between the different factors, threats and other elements of the knowledge map. Depending on time constraints and the complexity of the model, the connections drawn by the participants usually need to be completed by the facilitators as part of the data entry and model digitisation process following the workshop (see also Schick et al., 2018).

3.2. Phase 2: strategy formulation and evaluation

The aim of the first phase is to conduct a comprehensive analysis of the status quo in the target area, resulting in a detailed knowledge map co-created by the involved stakeholders. This serves as the knowledge base for the second phase outlined herein, namely the formulation and systemic assessment of bioeconomy-related "strategies." A strategy can be defined as comprising 'a series of decisions related to the deployment of available resources (management) and the establishment of appropriate socio-institutional conditions (governance) that allows for effect[ive] action towards achieving desirable goals and objectives' (Ibisch and Hobson, 2014, 128).[4] In contrast to the very broad understanding of the term as relating to the "Bioeconomy Strategy" of the European Union (which we would call "policy"), a strategy in MARISCO is much more specific and needs to be formulated precisely to make its systemic evaluation possible. Strategies can be very local (e.g. the construction of a new biogas plant) or implemented on a national or even an international scale (e.g. price-regulating measures for certain crops), but their impact is always primarily evaluated within the defined target region.

In MARISCO, this phase typically involves preparatory steps taken by the facilitators, followed by a second comprehensive stakeholder workshop of about 1.5–2 days – ideally, but not necessarily, with the same participants as in the first workshops. The aims of this phase are twofold: (1) to identify and evaluate existing bioeconomy strategies and (2) to formulate and evaluate complementary or alternative strategies.

As a first preparatory step, existing bioeconomy-related strategies in the target area need to be identified. These may be existing approaches already being implemented or future interventions as outlined in policy documents. Depending on the overall objectives of the participatory process and practical considerations (e.g. time constraints), the identification of strategies for evaluation can be done prior to or as part of the stakeholder workshop.

Initially, the workshop includes a critical re-evaluation of the systemic knowledge map, which has been digitised and printed on large posters by the facilitators, and of the previously analysed rating results for the identified model elements. Next, the strategies to be assessed are thoroughly discussed until all workshop participants are acquainted with them. After the optional reformulation, prioritisation or reselection of the identified strategies, the evaluation usually starts with mapping the strategies into the systemic knowledge map next to the model elements they most directly address (typically factors or threats, see Fig. 3).

3.2.1. Evaluation of existing bioeconomy strategies

Intervention strategies in the agrarian sector are often developed and implemented with a top-down policy and without the subsequent assessment of their feasibility and potential impact. This can lead to a kind of "blind spot" management whereby political decision-makers and their technical advisors may have a limited understanding of the effectiveness of strategies for local conditions (Ibisch and Hobson, 2014); as highlighted above, this is also evident in currently dominant bioeconomy policies. Our approach addresses this shortcoming by building and visualising the systemic relationship between existing – and foreseen – strategies and other elements in the conceptual model. Through proactive involvement in the process, participants gain an understanding of how these strategies negatively or positively affect social and ecological conditions in the local context. By following a systematic evaluation of these strategies, participants can determine the feasibility and level of the negative or positive impacts they may have.

In order to achieve this aim, MARISCO offers systemic visualisation and impact simulation tools. This allows for the conversion of the systemic model into "results webs" that depict postulated effect chains of the intervention strategies while pointing out – potentially critical – neglected factors and threats (Ibisch and Hobson, 2014). In a MARISCO-based evaluation of the ecological effectiveness of Forest Stewardship Council (FSC) criteria for wood production in north-west Russia, Blumroeder et al. (2018) apply a similar method. Understanding them as strategies, they map all 56 FSC criteria into a conceptual model developed by local stakeholders and experts, and then they evaluate their systemic effects, taking into account, among others, the numbers and criticality of the factors and threats they address. The authors come to the conclusion that, overall, the FSC criteria are rather weak and ineffective. Fig. 4 provides a simplified illustration of this approach of mapping and determining the causal effects of strategy interventions within the conceptual model built in Phase 1.

Besides such advanced methods, which – depending on the complexity of the conceptual model – require considerable modeling work by the facilitators, MARISCO also offers a straightforward but systematic way of strategy rating that we propose herein with some modifications. The rating criteria, in both MARISCO and our adapted method, focus on two dimensions, namely "feasibility" and "impact". As in Phase 1, it makes sense to conduct this rating exercise in separate break-out groups with different stakeholder representatives to ensure that everyone's perspective is reflected. If there are members of marginalised groups who may feel threatened by other participants, it is advisable to facilitate separate strategy evaluation workshops with different stakeholder groups and then merge the outcomes afterwards.

Our adapted methodology modifies and expands evaluation categories compared to the original MARISCO methodology (see Supplementary Files 2 and 3 for a list of our proposed and the original MARISCO criteria). These criteria can – and should – always be adapted according to the stakeholders' preferences. Considering available resources, existing risks, acceptance, restrictions and conflicts, among other criteria, the feasibility criteria reveal to what extent certain strategies are likely to be implemented under current conditions in the target area (Ibisch and Hobson, 2014). The impact of a strategy, in turn, is evaluated from different social and ecological angles, measuring the effects and changes both within and outside the chosen target area that result in positive or negative consequences for the elements identified in the conceptual model. Other criteria address the effectiveness of strategies in directly improving human well-being and increasing ecosystem functionality, as well as equity in the distribution of benefits. Compared to

[4] These goals, of course, need to be clearly defined and agreed upon by the involved stakeholders, but in the broadest sense, an ultimate aim of MARISCO should always be to improve or at least protect the human well-being targets defined in Phase 1.

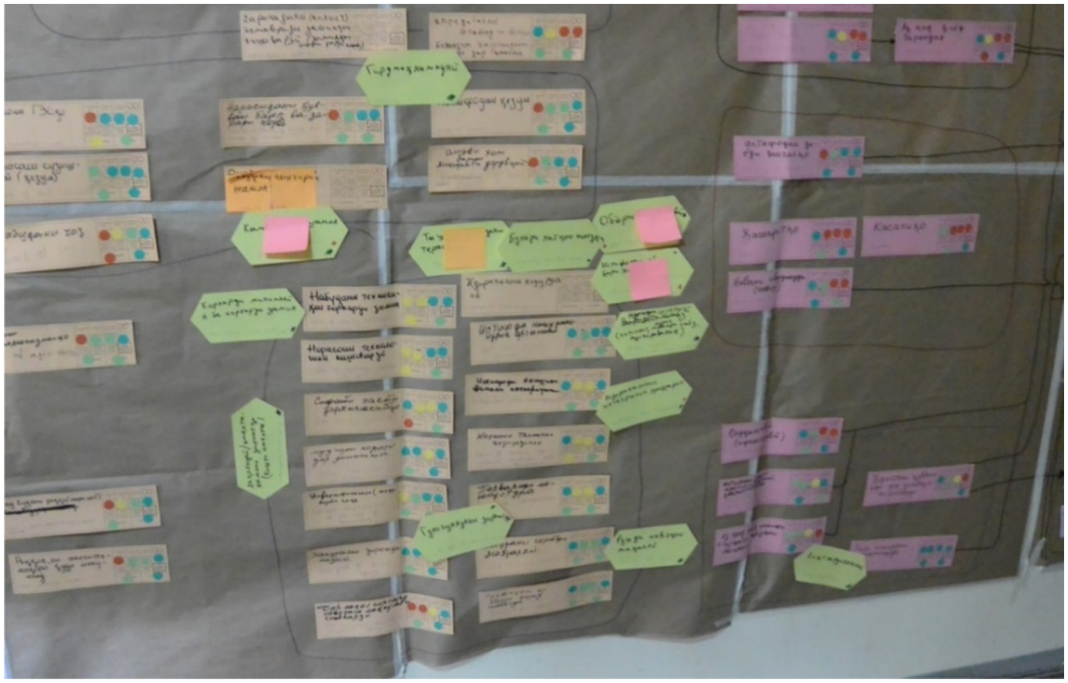

Fig. 3. Preliminary mapping of strategies (yellow hexagonal cards) into the knowledge map during a MARISCO workshop with farmers and decision-makers in Tajikistan (photograph taken by M. Spies in June 2018).

the rating of individual factors and threats in Phase 1, more time can – and again should – be dedicated to the evaluation of individual strategies. The rating process usually requires significantly more discussion between participants. Here, it is pertinent that the participants provide not only rating scores, but also qualitative descriptions of their expected and potential consequences, which need to be thoroughly recorded and later made available to decision-makers. To illustrate this semi-quantitative rating methodology combining scores with textual

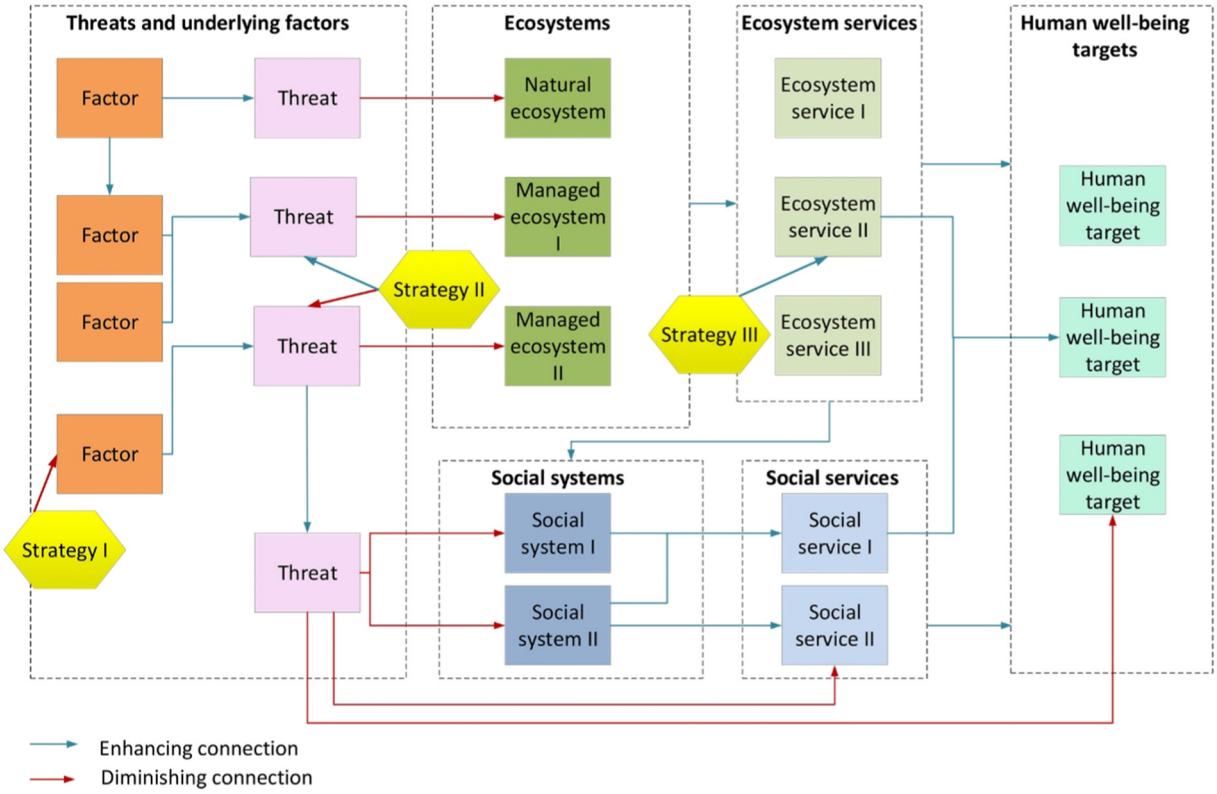

Fig. 4. Generic structure of the systemic knowledge map with depicted effects of strategies on different model elements.

descriptions, Supplementary File 2 offers a strategy rating example of four different hypothetical bioeconomy-related strategies that were developed during a methods workshop run by our research team.

As experienced by the first author in a MARISCO application with farmers in Tajikistan (Spies et al., 2021), combining both strategy mapping with systematic rating offers a more comprehensive way of evaluating strategies "from the ground." One of the evaluated strategies was Integrated Pest Management (IPM), promoted by an international NGO as a means to improve production while preserving biodiversity and minimising environmental impacts. Mapping the strategy into the systemic knowledge map revealed that IPM indeed addressed a variety of threats identified by the workshop participants, who also ranked it high in terms of positive impacts. However, its feasibility criteria received lower rating scores: as the farmers explained, applying IPM is rather time-consuming, requires new skills and knowledge and, due to the moderate prices of imported chemical pesticides, often rely on pesticide spraying as a more convenient solution.

3.2.2. Formulation and evaluation of alternative strategies

Our MARISCO adaptation can be used as a tool for a participatory assessment of existing bioeconomy strategies, using the systemic evaluation approaches presented so far. However, the same methods can also be utilised for developing and evaluating complementary, alternative or even counter-strategies from a bottom-up perspective.

After mapping existing strategies into the conceptual model, evaluating their systemic positive and negative effects and then conducting a systematic rating exercise, the workshop participants identify the main gaps (neglected critical factors and threats) and negative side effects of these strategies (e.g. marginalisation of certain groups, additional pressure on ecosystems). The next step is then dedicated to identifying and developing strategies – or a portfolio thereof – that address these gaps and avoid or counter the identified negative side effects.

Based on the experience of MARISCO facilitators, stakeholders have manifold ideas for concrete action in mind prior to engaging in the participatory process. Furthermore, the process of creating a comprehensive knowledge map and conducting a systemic evaluation of existing strategies helps to sensitise participants to the complexity of existing social-ecological challenges in the target area. The visualisation of the complex connections usually leads participants to recognise the impossibility of addressing challenges with only one-dimensional or blueprint solutions. Through guided brainstorming and strategy formulation exercises, in which facilitators can make use of additional tools such as World Cafés (Steier et al., 2015), the participants then develop and agree on a preliminary set of desired strategies that they would like to see implemented. Depending on the workshop's aims and geographical scope, the list of proposed strategies can be very extensive. For instance, when doing MARISCO applications in two conservancies in north-east Namibia, local stakeholders formulated about 50–60 different strategies to address the resource management problems identified in their region. This could only be assessed by applying a very simplified rating method utilising only five different criteria (Schick et al., 2018). Thus, a two-step rating exercise makes sense, in that it helps conduct a simplified rating exercise with all strategies before prioritising a subset of highest-rated strategies for more detailed assessment.

The final step in this phase is a thorough evaluation of the strategies formulated by the workshop participants with the same tools as presented above: a systemic assessment through impact mapping and simulation, and a detailed rating of the strategies in terms of their feasibility and impact. The feasibility criteria are particularly important in this step. A strategy might be well designed to effectively addressing factors identified as critical root causes of pressing environmental or social concerns; however, due to a lack of resources or opposition by influential decision-makers, it may hardly become realised. More generally, during this phase of the method, negotiations between participants become particularly important, especially when including stakeholders with very different interests in mind. On the one hand, this requires skills and experience by the facilitators to manage group dynamics and guide the participants to reach consensus or compromise, as discussed elsewhere (e.g. Reed and Abernethy, 2018; Spies et al., 2021). On the other hand, the structured rating approach of MARISCO also helps in this regard, because if consensus cannot be reached on a particular rating score for a particular strategy, the participants can chose to rate individually, before the average score is calculated and determined as a compromise. Only after the rating of all strategies is complete will the total rating score for each strategy be calculated (see Supplementary File 2) and serve as a transparently derived index for prioritising strategies for implementation.

In the last chapter of this perspective article, we further discuss some of the shortcomings of our method and of participatory approaches per se. We try answering the question why bioeconomy assessments nevertheless need such a method. Our proposed MARISCO-adapted toolkit measures and monitors social and environmental interactions and clearly aims to go beyond the productivity paradigm. This practice may offer a way of eventually improving the balance between economy, environment and society.

4. Discussion and outlook

Whereas increasingly more countries around the globe aspire to integrate bioeconomy strategies into their national policies (Dietz et al., 2018), we are witnessing growing pressure on environmental capacities through agricultural intensification and expansion, in particular on biodiversity, soil and water. As we have pointed out, most directives in relation to the bioeconomy rely heavily on growth maximisation and a "technological fix" for production challenges (see also Friedrich et al., 2021). For instance, the updated bioeconomy strategy paper by the EU regards 'biotechnology [as being] at the heart of bio-based processes' (European Commission, 2018, 27). While these bioeconomy framings position themselves in terms of sustainability and the sustainable use of natural resources, environmental limits and the complex socio-ecological realities of production systems often remain disregarded (Alff and Spies, 2020). This is exemplified by the fact that bioeconomy visions in the North imply considerable flows of biomass from the South, the production of which seems to be treated as a black box: as Lühmann (2021, 302) argues, the EU bioeconomy strategy pays very little attention to the fact that '[t]he European economy relies heavily on biomass imports and will do so even more in the future, especially when the resource needs of a growing bioeconomy are considered'. As the demand for – and thus the flow of – resources from the Global South and transition economies is likely to grow over the next few years and decades, the pressure on local production systems will increase further. Major bioeconomy actors such as the EU have acknowledged (at least to some degree) sustainability concerns related to global biomass production (Lühmann, 2021); hence, any reflection of both social and ecological sustainability in future bioeconomy strategies necessarily has to include both transnational and multi-scalar perspectives. On the one hand, this goes along with the need to lobby for paradigmatic changes at the level of bioeconomy policies, as emphasised in the introduction. On the other hand, we argue for making more use of tools and approaches of participatory strategy formulation and assessment, as well as for conveying their outcomes to higher governance levels on the regional and national scale and beyond.

Our adapted MARISCO method, first and foremost, offers a means to address strategy development on the local level of biomass producers. While primarily designed for agrarian settings, it can similarly be used, for instance, for assessing and developing strategies for sustainable forestry. We nevertheless acknowledge that such bottom-up strategy formulation may not be suited for direct translation into high-level bioeconomy policies that are designed with a much broader scope, such as the EU Bioeconomy Strategy. As meaningful approaches must always be adapted to the local social-ecological context, their

implementation is only appropriate in the geographical setting for which they have been formulated and thoroughly assessed. Still, when communicated through the right channels, the outcomes of such participatory assessment processes, we argue, can critically inform policy-making at higher levels in two ways. They do so first by providing a place-based assessment of the social-ecological impacts of existing bioeconomy-related policy measures, and as a result they can be fed back to national and transnational decision-makers through policy dialogues between state actors, civil society organisations and academic think-tanks, for instance. This includes, but is not limited to, conveying perspectives from biomass producers in the Global South to policy dialogues in the North. Second, by suggesting alternative sustainable biomass production strategies that may as well be appropriate in other geographical contexts, the outcomes of local participatory processes can provide "best practice" examples that may help, in particular, to push the field of international development cooperation more on the bioeconomy policy agendas of the Global North. In this regard, one of the advantages of our method is its semi-quantitative approach. By critically mapping and rating threats, factors and strategies, one of the outcomes of the participatory process is a set of concrete figures of the problems – and solutions – that matter most to biomass producers and other local stakeholders. This way, their knowledge and perspectives become more "formalised" and can thus provide an accessible information source for policymakers who often prefer "hard" data instead of detailed qualitative accounts.

More generally, we argue that a great deal can be gained from applying our method – and other systemic-participatory approaches – by contributing to a discursive shift in bioeconomy debates towards more holistic and social-ecologically-inclusive perspectives. While there is a rich and growing body of critical and empirically grounded research that redirects attention to the social and ecological dimensions of biomass production, there is still much scope for making the perspectives of local stakeholders more explicit, not only in higher-level policy discussions, but also in academia. As Dieken et al. (2021) find in a systematic review of bioeconomy-related research articles, most attention is given in the academic debate 'to political, research and industry actors,' which 'highlights a lack of research on actors from civil society and – surprisingly – biomass producers' (Dieken et al., 2021, 1711–1712). In particular, we argue that there is an urgent need to make the viewpoints of those more visible, who may bear the main risks of increasing pressure on and competition over global biomass resources. The outcomes of bioeconomy policies have a great impact on the specific environments and livelihoods of the people who inhabit the places where biomass is produced. This will become more acute as a result of growing bioeconomies in the Global North. In this regard, we want to emphasise that the bioeconomy strategies of both developing and transition countries are equally relevant and that these should not be considered mere producers of biomass – as often done by policymakers in the Global North.

As outlined earlier, for several reasons, we see a number of operational obstacles to the practice of participatory inquiries in agricultural settings and elsewhere; for instance, power relations on the basis of gender, age, ethnicity, faith, political opinion, linguistic capacity, literacy or occupation may interfere with the attempt to represent diverse voices equally. In addition, representatives of groups from dissimilar positions along the social strata may pursue contrasting interests in the evaluation and formulation of strategies. As we make clear in our methodological design, the accommodation of safe spaces, in order to provide participants with a platform to speak out, may be crucial to the assessment, especially in more authoritarian political settings. In addition, our approach of allowing for breakout groups or even separate workshops for different stakeholder groups helps draw a more differentiated picture of local viewpoints and discourses, in particular by being able to directly compare the outcomes of the strategy evaluation exercises, which include both quantitative figures and qualitative descriptions. The methodology can thus be used, for instance, to analyse what viewpoints of which local stakeholder groups are most in line with prominent bioeconomy discourses – and why. The usually limited availability of farmers or other local stakeholders is another challenge that needs to be considered in the planning period, and incentives should be created to accomplish the assessment from a truly locally grounded perspective. The aforementioned literature on previous undertakings in the broad field of participatory research, knowledge co-production and co-creation points to the various difficulties such projects may encounter in their realisation. A prior and thoroughly engaged study of the region and its ecological and social conditions is required for the facilitators of such processes. A holistic perspective that incorporates a comprehensive engagement with often very diverse local contexts has been proven to be time-consuming and restrained by resources. This remains also the main challenge for our methodology: taking its systemic approach seriously necessitates a comprehensive social-ecological assessment as the foundation for strategy formulation and evaluation, which in turn reduces the options for compromising on the methodology itself. However, a meaningful way to reduce the complexity – and thus workload – of such assessments is to narrow down their geographical scope, for instance by focusing on a village and its environs rather than on a district. At this relatively early stage of our own research project, our adaptations of the MARISCO method still have to prove their qualitative and quantitative outcomes in the materialisation of planned stakeholder workshops at selected sites in Central and South Asia, as well as their subsequent strategy formulation (see www.transect.de).

Given the central role of technology and the growth paradigm in current bioeconomy debates and policies, there may be strong obstacles to mainstreaming the outcome of participatory approaches that highlight the social-ecological complexities of local production systems – as the outcome may challenge hegemonic discourses of productivity and technological innovation. We still believe, however, that such approaches are the only way forward, as incorporating feedback from local stakeholders will not only assure a more grounded evaluation of policy measures, but also ensure best practices for more adequate natural resource use and management. This way, the promise of citizen or biomass producers' participation as a tool for the assessment of local problems and priorities may provide for an adjustment of existing policy designs or even co-create more horizontal new pathways, especially in the Global South as the main source of biomass. At best, it allows for maximising the positive interrelations between decision-makers, community, farming and nature.

Finally, by contributing with our systemic-participatory approach to the bioeconomy discourse, we promote an understanding of sustainability that highlights societal dependency on ecosystems and questions notions of productivity growth as a necessary means for development. In our view, the (bio-)economy needs to be subjected to the aims of maintaining well-functioning ecological and social systems in favour of human well-being for all.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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