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Integrated Landscape Approach: Closing the Gap between Theory and Application

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Abstract: Recently, the integrated landscape approach has gained increasing interest of the scientific community, as well as of organizations active in the field of sustainable development. However, the enthusiastic welcome is challenged by little consensus on theory, terminology and definitions. Moreover, the operationalization of the approach into practice is a major challenge. In this paper, we present a framework to operationalize the integrated landscape approach in practice by putting a long-term collaboration between scientists and various stakeholder at center stage. Based on encompassing understanding of landscape-level processes and interactions, four pillars addressing different steps of a joint-learning circle are described and illustrated with examples. We consider the integrated landscape approach to be a prime way of targeting the Sustainable Development Goals (SDGs), but novel forms of collaboration between scientists and other stakeholders based on long-term commitments will be needed for operationalization in practice.

Keywords: land change science; joint learning; transdisciplinarity; SDGs; indicators; stakeholder involvement; monitoring; modelling

1. Introduction

Acknowledging the risk of a global socio-ecological descent, the 2012 United Nations (UN) Rio+20 Conference on sustainable development decided to define a set of Sustainable Development Goals (SDGs), adopted 2015 by the UN General Assembly [1]. Addressing the multitude of global challenges expressed in the SDGs requires novel integrative approaches, such as integrative socio-ecological system analyses and more recently the landscape approach [2–4]. The growing importance of the landscape approach in the sustainable development agenda is due to its potential to overcome the problems of sectorial approaches [5], to address tradeoffs within larger spatial entities [4], enabling a better understanding of the processes of change and the resilience of local communities and their environment [6] and to tackle the aspects of place attachment in every-day landscapes [7]. A range of international organizations has adopted the Integrated Landscape Approach (ILA), e.g., the International Association for Landscape Ecology (IALE), the Global Landscapes Forum, the FAO-Initiative Landscapes for People, Food and Nature and the International Union of Forest Research Organizations (IUFRO) Landscape Ecology Group. The Global Landscapes Forum calls an integrated landscape approach "the most promising tool for realizing the Sustainable Development Goals (SDGs) and Intended Nationally Determined Contributions (INDCs) as outlined under the Paris Agreement".

A recent review of integrated landscape approaches revealed that there is, however, little consensus on theory, terminology and definitions [4]. At the same time, it found only very few documented examples of practical implementation [2,8]. There is of course an interrelationship between defining the approach and the number of case studies determined fitting this definition. Indeed, other reviews of (integrated) landscape approaches came up with longer lists of case studies [3]. In any case, there seems to be gaps between how readily the global development community adopted the term, what exactly is meant by it, and finally, how to operationalize the approach for its meaningful application in real-world situations.

The objective of this paper is to contribute to closing this gap by outlying a framework to operationalize the integrated landscape approach in practice based on the specific strengths of the integrated landscape approach beyond other established approaches.

2. Development and Characterization of the Landscape Approach

The landscape approach as newly adopted in the development context is rooted in integrative landscape research with a long tradition in geography, planning, urban and rural design going back to scholars like Carl Troll, the founder of the term landscape ecology [9,10]. While on one side of the spectrum, landscape research puts the analyses of pattern and processes within the landscape at center stage (e.g., [11]), on the other side, landscape research focusses on holistic approaches, in which landscape is understood as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" [12]. It is this school of thought that we believe holds most potential for solving real-world problems of landscape management.

In a scientific context, the landscape approach stands in a line of approaches aiming at conceptualizing and evaluating the interconnectedness of societies and their environment, such as the resilience approach [13], the socio-ecological system (SES) analyses [14], the driving forces-actors analyses [15], the landscape agronomy concept [16], integrative planning and modelling [17,18] and sustainable land management [19]. The development of scientific concepts was paralleled by the promotion of integrated management approaches since the 1990s [8], ranging from agrolandscape ecology [20], integrated ecosystem management [21] or the landscape service framework [22]. On first view, it seems as if the integrated landscape approach is therefore ill-defined and even not novel. What is it, though, that makes the landscape approach so appealing to the above-mentioned international organizations and the development community at large?

The term "integrated landscape approach" obviously has been filled with various meanings, which share some diffuse common ground, but a clear definition, which can easily be explained to stakeholders ranging from practitioners to donor agencies, is lacking [2]. Attempts to overcome this limitation go in various directions. Sayer et al. [5] formulated ten principles for a landscape approach, referring to a wide range of methodological starting points and providing a rough guideline, i.e., continual learning and adaptive management, common concern entry point, multiple scales, multifunctionality, multiple stakeholders, negotiated and transparent change logic, clarification of rights and responsibilities, participatory and user-friendly monitoring, resilience and strengthened stakeholder capacity. However, for practical implementation, further refinement is needed. Reed et al. provide a definition, including also some key concepts: "A landscape approach is a multi-faceted integrated strategy that aims to bring together multiple stakeholders from multiple sectors to provide solutions as multiple scales. By ensuring the equitable and sustainable use of land, a landscape approach is a potential mechanism to alleviate poverty in an equitable manner, conserve biodiversity, safeguard forests, sustainably manage natural resources, while maintaining food production and mitigating climate change" [4]. Freeman et al. [3] conclude participation, interdisciplinarity, multifunctionality and sustainability to be the main concepts shared by different studies trying to specify what an integrative landscape approach stands for. They, moreover, distinguish between different framings of the approach, ranging from interpreting the landscape approach as: (a) a conceptual framework; (b) a set of principles; or (c) a process. Rather than aiming to reconcile these different definitions and meanings, we aim at analyzing what these mean for operationalization in practice. Based on these different conceptual meanings, the principles and what is common among the described processes, we propose a framework for the operationalization of the integrated landscape approach in new projects or areas.

3. The Joint Learning Circle as a Pathway to Implementation

To make best use of the specific characteristics of the integrative landscape approach, a transdisciplinary workflow is needed that includes different stakeholders in specific roles at the different stages of operationalization and by explicitly including the actions towards prototyping and implementation as part of the project. Thus, we follow the understanding that the main merits of an integrative landscape approach unfold if interpreted as a process, in which a wide range of stakeholders is included and integrated from the start in a joint learning process between science and implementation [23]. Stakeholder integration of course is not novel, reflected in the strong focus on participatory approaches across science. However, the focus on participatory approaches has often neglecting the use of state of the art scientific knowledge and methods as a main input to the participatory process. This statement is supported by recent reviews of existing integrated landscape initiatives [24,25]. In these reviews, the great potential of the approach is advocated; however, most show little integration of scientific insights into the approach. Alternatively, bridging academic research on landscapes with the operational implementation of the landscape approach in practice will merge scientific analyses with local traditional knowledge, which has to be assessed and discussed at eye-level in a process of social learning, challenging notions and providing novel insights for all stakeholders involved. Therefore, the focus on socio-ecological dynamics should not come at the expense of considering state of the art insights into landscape-level interactions and conceptualizing landscapes as being shaped and driven by actors and drivers located on nested spatial, temporal and institutional scales. This latter aspect refers to a core characteristic of landscapes, which are not only the template of local livelihood and the result of long-lasting society-environment interactions, but also reflect interactions and feedback loops along nested scales [26]. Therefore, we consider a well-designed integration of scientific knowledge in close exchange with practitioners, decision makers and bearers of local knowledge brokers in a process-oriented learning circle to be an important component of implementing the integrated landscape approach. Hence, in our framework for implementation, we have paid specific attention to the role of scientists in bringing in insights and methods for operationalizing the landscape approach.

The proposed framework consists of four pillars, which are inter-connected by a circle of output feeding into the subsequent pillars (Figure 1). We interpret this structure as a circle of joint learning, negotiation and reflection. In the first pillar (P1), a thorough analysis aiming at understanding landscape functioning is conducted, resulting in spatially detailed system knowledge on land use and ecosystem services provided. This knowledge serves as input to Pillar 2 (P2), aiming at exploring the current, but also potential future societal demands under scenarios of landscape transformation and environmental change (i.e., target knowledge). Out of this, spatially-explicit scenario outputs and targets for design and adaptation can be generated resulting in the designing of future landscape options in Pillar 3 (P3) (i.e., transformation knowledge). Comparing the present and desirable future landscape results in land change requirements, i.e., negotiating interventions for transforming landscapes in Pillar 4 (P4), followed by prototyping and implementation. The circle is iterative in character. Prototyping and implementation in a real-world context will shed new insights in the functioning of the landscape and thus feed back into Pillar 1. Reflection on failures and successes in the transformation phase is essential to improve our system understanding and enter into a new round of improved design of potential interventions.

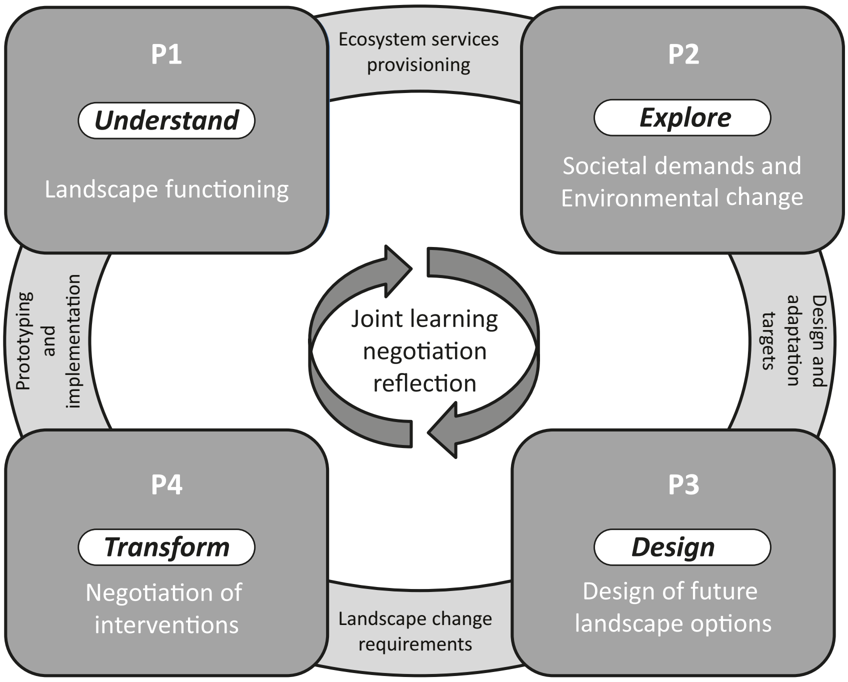

Figure 1. We propose to operationalize the integrated landscape approach as a process of joint learning, negotiation and reflection, consisting of four pillars to understand, explore, design and transform landscapes to increase their resilience in times of global change and to increase their overall value for society (adapted from [27]).

In the following, we will outline more specifically what the content of the four pillars is, and we will provide pillar-specific examples.

P1: Understanding of the functioning of the landscape:

Following the space-place theory [28], we conceptualize landscape as physical landscapes ("space"), represented by physical elements, such as fields, roads, etc., and as perceived landscape or the "place", which plays a decisive role for, e.g., place attachment and the cultural dimension. Land-use is driven by demand for ecosystem service (ES) provisioning and the underlying planning system [29,30]. Landscapes are only functioning when the demands and ES flows do not exceed or deteriorate the natural, social and cultural capital stock [31]. Over the centuries, this interplay between demand and supply has found its expression in cultural landscapes, such as the Bali water temples [32], which were challenged and transformed due to changes in relevant drivers.

Pillar 1 aims at reaching an encompassing understanding of landscape functioning based on analyzing composition, configuration, management and social capital of the landscape and the relevant land uses, by linking local ecological knowledge provided by local land users with institutional knowledge by government authorities and state of the art ecological knowledge derived from the scientific community (Table 1). Going beyond a single-scale analyses on the plot level to tackle a 'whole landscape' analysis differentiates the ILA from many of the other integrative approaches listed in the Introduction.

Table 1. Role and contributions of knowledge providers within the four pillars (P1 to P4) of the learning circle. ES, ecosystem service.

Knowledge Provider	P1	P2	P3	P4
Scientific community	-Methodology for synthesizing -State of the art ecological knowledge	-Climate change scenarios -Global change scenarios -Projections of ES demands	-Modelling framework -Optimization models	-Process moderating -Policy analysis -Prototype effectiveness evaluation
Citizens, local land users and community based organizations	-Local ecological knowledge	-Local needs considering climate/global change	-Scenario building -Participation in design of landscape options	-Participating in learning platforms (farmer to farmer)
Government authorities	-Institutional knowledge	-National/regional priorities	-Scenario building -Participation in design of landscape options	-Policy framing and opening
Development agencies	-Internationally demanded ES	-Locally adapted SDGs	-Official Development Assistance (ODA) agendas as input to scenario building and design of landscape options	-Resources to test identified development options
Success indicators	Improved system understanding, joint learning on landscape potentials and threats	Set of scenario inputs developed that both reflect the local needs, as well as fitting the national and global context and ambitions	Set of alternative landscape options adapted to varying scenario contexts on which ownership is shared by the different participants in the co-design process	Prototype for landscape options implemented or policy options put forward and discussed; increased commitment for action and implementation with all stakeholders

Considering the diversity of spatial, temporal and institutional drivers [33] is a core step in the system analyses. Next to insights in landscape functioning, this is one of the places where the scientific community is required to provide insights on the main system components, their functioning and interaction [34], to conduct spatially-explicit assessments of ecosystem services [35], including compiling information on their historical development, variability, time-lags, etc. [36]. Methodologies at hand include historical analyses, community asset mapping and ES modelling to obtain insight into the current functioning of the landscape, but also in the ways landscape functioning has changed across time. Such long-term analysis is embedded in the notion that landscapes reflect legacies of past human-environment interactions that still determine current-day (and future) functioning. In this sense, we follow the notion of van der Leeuw [37], who pleas for transforming an understanding of the past into lessons for the future. This has, e.g., direct implications for the analyses of ES, as both the capacity of landscapes to supply ES and the realization and recognition of key ES are likely to change over time [38]. Information on landscape composition, configuration and management is, for example, of great importance to integrative pest management: for example, the template of non-crop habitats, such as flowering crops, e.g., marigold *Tagetes* spp. on dykes in the vicinity of rice fields play a role in suppressing potentially devastating pests of rice crop, thus providing valuable ES in regulating pests. At the same time, these landscape elements may provide marketable flowers or vegetables and fruits, which can be harvested to provide a dual income and add to the diversity of diets and livelihoods. Prototyping landscape level measures, such as providing habitats for insectivorous birds to reduce insecticide use [39], directly rely on landscape analyses to help understand how to optimally use the functioning of different landscape elements.

This solid understanding of the ecosystem services provided by the landscape under study is based on the analyses of functions and processes, i.e., a system analysis, resulting in spatially-explicit information on past and present process-based relations between land use and provisioning of ecosystem services and insights into the institutional and social structures affecting landscape function, which in Pillar 2 is confronted with actual and potential future societal demands.

P2: Exploring societal demands and environmental change:

Landscape functioning is often expressed in terms of the ecosystem services (ES) produced to benefit society. At the same time, societal demands on the environment find their expression in the set of societally-recognized ecosystem services (ES) [38]. ES provisioning is not stable in time due to: (1) changes in the functioning of ecosystems and the landscape as a whole; and (2) changes in societal demand and preferences for services [38,40]. Global change results in direct pressures and challenges on future ES supply [41], but it also indirectly leaves traces in the development of societal demands on the landscape [40]. Such changes in demand may be telecoupled to other regions as a result of trade, connectivity in the hydrological system or the globalization of cultural values and preferences [42].

Pillar 2 explores present and potential future societal demand of ES, which can be contrasted with potential future ES supply [43]. The analyses will be based on considering the key bio-physical and management factors that determine agricultural production in a specific institutional, infrastructural, socio-economic and policy setting. Pillar 2 builds on participatory approaches to determine stakeholder demand and preferences for the services provided by the landscape, ranging from local land users, to government authorities providing information on regional and national priorities and to development agencies, sharing their views on what locally-adapted SDGs might look like. The scientific community can contribute to this process by providing, scenario analysis (including demographic scenarios), vulnerability assessment and other methods to explore the development of ES demand under the conditions of societal change and climatic change.

Important in this respect are the changing lifestyles and ways of living under urbanization and increases in welfare. Whereas urban residents are only indirectly impacting ecosystems by their demand for food, they are increasingly dependent on regulating services, as many of the urbanizing regions are located in places vulnerable to flooding. Services regulating streamflow and climate are often provided by ecosystems distant from the urban regions, thereby connecting ecosystem service demands in cities back to the rural hinterlands. Thorough analyses of the spatial distribution in vulnerability are therefore needed, be it in regards to the multitude of challenges affecting, e.g., urban areas [44] or the specific flooding risks due to the combined effects of climate change and socio-economic development [45]. Contrasting assessed vulnerability with existing risk-coping strategies and remaining adaptation needs, as, e.g., conducted by Harvey et al. based on a survey of 600 smallholder households in Madagascar, enables jointly determining crucial elements, such as access to extension services, small-scale infrastructural improvements, access to safety nets and sustainable management of natural ecosystems [46].

Pillar 2 provides an overview of synergetic and conflicting changes in societal demand for ES under different global change and climate change scenarios, which can be translated into a set of design and adaptation targets, which forms the basis for designing future landscape options.

P3: Designing future landscape options:

Science approaches related to landscapes and land use have a tradition of being strongly analytic to improve system understanding. Furthermore, in Pillars 1 and 2, mainly the system understanding and problem identification are targeted. Many have argued that this is insufficient to deliver 'transformative knowledge' [27,47,48]). Transformative knowledge aims at using the achieved knowledge and insight into the targets in the options for sustainability transitions. Especially in landscapes that are not only owned and managed by stakeholders, but also provide livelihood and sense of place to them, the co-design of landscape options with stakeholders is the only option to fully account for the needs, perceptions and ability of stakeholders. A full systems-based exploration of the options space and possibilities to use systemic changes in landscape management is needed to support a process of negotiation on future landscapes. Turner et al. [49] argued for 'landscape architecture' where novel spatial configurations of land uses and landscape elements are designed to enhance landscape functions in response to climate change and ecosystem service demand. This approach explicitly uses the spatial interactions between landscape units to enhance the functionality of the landscape. Giller et al. [27] propose a multi-level design method to enhance innovation and adaptation capacity within landscapes.

As such approaches normally do not simply emerge from understanding the landscape, they require novel methods, focused on producing transformative knowledge.

Therefore, we suggest to combine in Pillar 3 model-based exploration of land change scenarios to identify future threats and potential responses to contextual changes (urbanization, market integration, etc.), model-based optimizations [50] to identify the options space and minimize tradeoffs between the different functions of the landscape and a stakeholder co-design process [51], in which representatives from all stakeholder groups are involved in scenario building facilitated by foremost methodological input provided by the scientific community.

While each of the individual methods has been used widely and they are documented in the literature, we are not aware of any combination into one process as also argued for by [45]. Model-based analysis often falls short in capturing societal constraints and fails to account for social capital and cultural preferences [51]. At the same time, purely stakeholder-based solutions may not use the full options space derived from model-based studies. Stakeholder cooperation and negotiation may also result in weak compromises or even perverse effects ("fixes that dot work" [52]). Quantification and visualization of options provide a platform for negotiation and inspire stakeholders to think of alternative intervention options and move from negotiation to innovation [53,54]. The design procedure of alternative options has to be done in an iterative manner in which landscape level optimization approaches feed into a stakeholder co-design process and vice versa. This type of co-design procedure has been called for in multiple instances [27,49,55,56], but hardly operationalized in real-world situations. The process is unlikely to arrive at one, overall accepted option as tradeoffs between different interests are always reflected in the landscape. Instead, different alternative options to reach the targets may be the outcome of the design process.

An example of the power of scenario analysis as a boundary object for discussing and designing options for land management has been provided by Wardropper et al., 2016 [57]. In their study, the authors used a process of developing local scenarios against the backdrop of very large global changes to help the stakeholders think beyond the present-day challenges and envision future conditions that are very different from today. This way, the scenario thinking helps to move stakeholder-based design of landscape options from solving today's problems to a process of planning for the future.

Pillar 3 results in a discussed and co-designed set of options of landscape plans and interventions that aim at meeting the societal demands for alternative landscape development options, land change requirements and related specific interventions, which serve as input in Pillar 4.

P4: Transforming based on negotiated interventions:

Despite considerable emphasis on participation, learning does not automatically take place [58], and scientists tend to learn among themselves rather than with external stakeholders [59]. Open knowledge arenas [56] as joint learning platforms are essential to overcome key inhibitors of an effective transformative research, such as divergent objectives, needs, priorities, values [60,61] or power imbalances [62]. It is especially the engagement of the different stakeholders in the future of their landscapes and the strengthening of stakeholders in managing their landscapes that is promoted as a specific strength of the landscape approach [5]. The alternative landscape development options (Pillar 3) iteratively feed into such open knowledge areas.

Pillar 4 takes the design process resulting in landscape change requirements in Pillar 3 one step further by creating an enabling environment for transformations towards implementing sustainability solutions and reaching the SGDs. To reach implementation of the designed options, the extension beyond stakeholder participation towards societal learning processes is a key element and identified as a way to overcome difficulties in decision-making processes [63]. Various stakeholder-specific forms of societal learning processes are available, such as researcher to farmer, farmer to researcher and farmer to farmer learning platforms or community-based processes, including the whole diversity of stakeholders.

Prototyping can be a specific form of bridging the design and implementation and has been shown to be excellent as a platform for learning amongst stakeholders [64]. Within agronomic research, there are several good examples of prototyping applied to test and disseminate innovations towards sustainable cropping systems. As an example, [65] used prototyping to test transitions towards more sustainable cropping systems in Uruguay. Not only did the prototyping lead to a joint learning on the barriers and opportunities for implementation in practice, the prototyping also allowed the ex-post assessment of the anticipated benefits of the developed sustainability options to test if the options could indeed deliver on their promise. At the landscape level, participatory approaches and design sciences have so far remained largely unconnected [66]. A recent analysis of three participatory design methods reveals that improved collective learning through stakeholders' participation should be complemented by fostering processes to explore innovative solutions by identifying knowledge gaps and addressing ways to manage for the unknown, and several ways to promote such exploration processes are presented [66].

The application of designed landscape options in reality may lead to new system understanding not accounted before in the analytic and co-design phases of a project. Hence, learning from practice is essential in this phase, and issues may arise that feed into a next iteration of analysis and design, i.e., the next round of the learning circle. In that sense, prototyping fulfills a phase in the learning cycle before the upscaling of implementation is promoted. At the same time, prototypes may act as disseminators, showing the benefits of a novel approach in practice and convincing others to follow the example, thus leading to upscaling of the interventions.

Thus, Pillar 4 results in prototypes of implementation, insight in implementation and upscaling pathways. As such, Pillar 4 is not only the step towards transformation and implementation, it is also an essential element in informing scientific understanding by practical application and provides a reality check of all of the work done in the previous steps.

This description of the four pillars and their interconnections illustrates that although all stakeholders have a role in all pillars, their roles are different, both in terms of engagement or types of scientific method, as well as in the forms of engagement (Table 1). Thus, the framework proposed allows specifying the generic call for stakeholder engagement and clarifying the different roles along the joint learning circle.

4. Discussion

The joint learning circle proposed is intended to help operationalize the principles of the integrative landscape approach in practice. It is not meant as a strict protocol, but rather as a framework providing guidance by providing structure to the different elements of an ILA.

Specifying roles to generate locally-relevant forms of knowledge:

While recently, many have argued for co-design and other means of stakeholder involvement [47], these studies have given little clarification on the different roles of scientific knowledge in such processes. In our joint learning cycle, we show the different ways in which knowledge, which was created through a collaborative process between the scientists and different stakeholders, contributes to the design of more sustainable future landscapes. As a base, systems knowledge is needed to understand the characteristics, the history and the potentials of the landscape to provide ES demanded by society. Scientists can then help to analyze the spatial dependencies of people inside and outside the specific landscape on these ES, and they can also provide context information regarding future environmental conditions (e.g., due to climate change) to which this landscape has to adapt. In Pillar 3, scenarios, both exploratory and target-based optimizations, are used as starting points and boundary objects to trigger discussions about alternative futures of the landscape. Where exploratory scenarios provide a context that may help to imagine change, optimizations show the potential of the landscape to provide services. In the prototyping and implementation phase, the role of science is mostly towards evaluating successes and synthesizing these for joint learning. As shown in Table 1, scientists, as well as the various groups of stakeholders, hold different roles along the learning circle, and the four pillars distinguished provide much needed guidance on what these roles encompass.

Assessing the past for the future:

A specific feature of our framework is the use of both historic analysis and scenario studies. In contrast to many projects that aim to solve the problems stakeholders are faced with today, we strongly encourage adopting a dynamic perspective on ecosystems and ES through time, especially as global change effects are often at the core of challenges faced. This explicitly results in a 'planning for the future' principle, i.e., not only addressing today's problems, but using scenarios of demands and conditions in the future to ensure that the landscape is adapted to the future context and conditions and will provide the ES required by society.

Contributing to the SDGs:

Although the individual elements of the integrative landscape approach are appealing to many and there is a large agreement on the keywords, the real potential of the approach can only be reached when the elements are properly integrated and specific linkages to locally-adapted SDGs agreed upon and made conceptually clear [23]. Interpreting the ILA as a joint learning circle consisting of four pillars provides a suitable structure to define indicators to monitor and evaluate the processes and outcomes, as recently asked for by various authors [3], and such indicators will also be suitable to monitor progress towards reaching the national commitments for the SDGs [23].

Challenges along the circle:

The integrative landscape approach is very demanding in terms of stakeholder involvement, science information, collaboration, time allocation, funding, etc., and has high ambitions in terms of all of the aspects that need to be accounted for. This is inherent to the multiple claims, changing societal and environmental conditions and complex stakeholder networks involved in land use. Often, this leads to wicked problems: simple solutions are not available, and knowledge of the physical environment is insufficient to lead to implementation. Linear and simple approaches would likely be ineffective and lead to a waste of resources. Demotivation of stakeholders and the public might easily lead to a withdrawal from a joint learning circle, which might even lead to a withdrawal from the public space in general [67,68]. Consensus building workshops with visualizations or participatory GIS are well-established tools to overcome such barriers [69,70]. As the joint learning cycle proposed here focusses on landscape-level services, the motivation of the public and of stakeholders to get involved is generally high, because the landscape level is more planning relevant and more relevant to the every-day experience of the public [22,71]. The higher likelihood to arrive at feasible, legitimate and 'future-proof' solutions by implementing our framework comes with the tradeoff of higher investments in the process of implementation. Using decision support tools such as the Territory Balanced Scorecard (TBSc), developed for decision makers at the local authority level engaged in environmental management projects [72], might prove valuable, if adapted for participatory processes. As in all development projects, various additional challenges will arise during such a process, starting from selecting the stakeholders, potential conflicting interests among stakeholders, keeping stakeholder engagement throughout the whole circle, knowledge gaps in scientific knowledge, political and economic uncertainties, natural calamities, but also adjusted funding schemes: following the framework proposed is most likely to take a long time, and what can be achieved in a certain amount of time is limited. Long-term processes require long-term commitments and fitting long-term funding options. These requirements stand in contrast to many current research funding schemes that are providing the foremost short-term funding for system knowledge generation.

5. Conclusions

The framework proposed in this paper attempts to order the different elements into a logical process that optimally combines scientific information and local knowledge in a transdisciplinary process leading from problem identification, the design of solutions to the implementation of these in practice.

It is novel in the sense that researchers, decision makers and practitioners have to work together in every of the four pillars distinguished. It is not a sequence of tasks for specific groups, but true collaboration, not only in the first, but also in the subsequent rounds of the circle.

Putting the joint learning process at center stage fosters continuous capacity building, long-term commitment from the core partners and a continuous reflection on how the learning circle relates to the SDGs and the landscape level changes due to the interventions. This involvement in the process of joint learning, negotiation and reflection will result in long-lasting impact on a personal level for all stakeholders involved at the community level to manage natural resources, maintaining ecosystems services and contributing to achieving sustainability through local ownership.

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