Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in Environmental Sustainability

# Multi-level networks for sustainability solutions: the case of the International Partnership for the Satoyama Initiative

Raffaela Kozar[1], Elson Galang[1], Alvie Alip[1], Jyoti Sedhain[1], Suneetha Subramanian[2] and Osamu Saito[1]

The loss of biodiversity and ecosystem services in landscapes and seascapes creates complex sustainability challenges in climate, biodiversity and food that span local to global levels. Collaborative networks such as The International Partnership for the Satoyama Initiative (IPSI) link scales through knowledge frameworks and implementation of solutions in response to challenges and opportunities for achieving biodiversity conservation and sustainable development in social-ecological production landscapes and seascapes (SEPLS). Multi-level networks possess an array of locally relevant solutions across ecosystems and scales. When solutions are co-analyzed through a systematic approach such as societal-based solution scanning, they offer pathways to realize resilient and sustainable societies through their prioritization and integration in the management of social-ecological production landscapes and seascapes. In this study we reviewed the solutions of the IPSI network with a societal-based solution scanning method to demonstrate how such networks contribute to solving sustainability challenges and how a systematic approach can capture alternative knowledge of solutions to promote knowledge integration with science and policy-makers for sustainability solutions. Institutional and governance solution types are favored in the Asia region, particularly those that involve greater inclusion of different types of actors in planning, and more integrated management forms that can account for the complexity of addressing sustainability challenges. The multi-level interactions of the network help promote new actions and policy for sustainable use and management of SEPLS.

**Addresses**

[1] United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS), Tokyo, Japan

[2] United Nations University International Institute for Global Health (UNU-IIGH), Kuala Lumpur, Malaysia

Corresponding author: Saito, Osamu (saito@unu.edu)

**Current Opinion in Environmental Sustainability** 2019, **39**:123–134

This review comes from a themed issue on **Open issue**

Edited by **Eduardo Brondizio**, **Professor Opha Pauline Dube** and **William Solecki**

Received: 07 January 2019; Accepted: 05 September 2019

https://doi.org/10.1016/j.cosust.2019.09.002



## Introduction

Multiple sustainability challenges are threatening biodiversity and ecosystem services (BES) in mosaic land areas composed of diverse ecosystems and production systems. These areas, referred to in this paper as social-ecological production landscapes and seascapes (SEPLS), provide important food security and poverty alleviation benefits across Asia. Rapid economic growth, urbanization and agricultural expansion have enhanced human well-being in the Asia region, but the resulting settlements, pollution and changes in land use have led to an accelerating decline in BES, including agrobiodiversity.

Protected area coverage has been found to have substantially increased in the Asia and Pacific region while not covering additional areas of critical biodiversity in their management [1]. SEPLS in Asia are often critically located in areas of high biodiversity under other effective area-based conservation measures and offer areas for the study of solutions actually being applied to meet multiple sustainability challenges in areas facing a decline of BES.

SEPLS have in many places been traditionally managed for the sustainable use of natural resources by local communities in ways that have conserved biodiversity while providing human livelihoods. The Japanese traditional practices Satoyama and Satoumi are a way of managing rural land and coastal social-ecological systems for multiple benefits in rural and peri-urban areas of Japan [2–4].

Similar concepts of balancing the services obtained from multiple land uses for humans and nature comprise traditions of rural land management across Asia [5–7]. It has become increasingly recognized over the past two decades that changes to the balance among social, economic and environmental sustainability in places where communities have practiced sustainable use of natural resources share similar drivers of change worldwide (e.g. modernization of agriculture, urbanization, etc.). Because of these changing global land use patterns and accelerating loss of BES worldwide and in the Asia region, how to revitalize or restore these systems in production landscapes and seascapes based upon such traditional principles is the subject of multiple intergovernmental and international policy and action forums. For instance, the Convention on Biological Diversity (CBD), and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

In Japan, the Satoyama/Satoumi concept of nature in harmony with society was brought to national attention in the early 2000s as Japan developed a national sustainability strategy. The Satoyama concept took on a global agenda at a UNESCO hosted workshop in 2010 where the outcome, 'The Paris Declaration,' contained the aims for a global Satoyama Initiative to help restore SEPLS. The International Partnership for the Satoyama Initiative (IPSI) was formed to strengthen SEPLS activities on the ground, promote learning between partners and advocate for mainstreaming SEPLS in policy processes such as the CBD.

To reach global goals such as the Sustainable Development Goals (SDG) and the Paris climate agreement, the focus of international efforts in science and governance is increasingly orientated toward solutions that can account for these multiple sustainability challenges in climate, biodiversity, and food [8,9]. Multi-level networks have sprung up in response to complex environmental challenges that span social-ecological scales and systems as new modes of collaborative work to seek solutions to these problems. There is broad agreement that greater collaboration among stakeholders at different scales is necessary to reach global sustainability goals, while we do not yet fully have an understanding of how multi-level networks that aim to contribute to multiple goals in different sectors through their collaborative activities are contributing [10,11]. The science of what mix of solutions may make the best use of land for the desired ecosystem services, avert the continued loss of services and the impacts of climate change and reach multiple goals related to food security and biodiversity is yet underexplored [12•,13].

The convening of the IPSI platform in 2010 was a recognition that to meet global sustainability targets for climate, biodiversity and food, the revitalization of approaches to maintaining multiple services from SEPLS with new modes of governance were needed in many traditional land-use systems across the globe where BES are under threat. The Satoyama Initiative has grown to be an international forum that seeks to find solutions to these multiple sustainability challenges in climate, biodiversity and food in production landscapes [2,14]. Since its inception in 2010, the partnership has quadrupled its network from 51 members to 253 member organizations from 22 couontries in 2019, which represent diverse organizations including research, governmental, nongovernmental, private and community and indigenous groups. The concept of Satoyama is fully established as a model for achieving revitalized production modes that meet modern demands and maintain multiple benefits to nature and humans. The multi-level network that IPSI has grown to is a resource on integrated landscape/seascape approaches, and informs science-policy processes such as the CBD and IPBES on ways to meet international sustainability targets.

IPSI may be considered a representative case of a multi-level network for sharing good practices and experience-based knowledge. There are other multi-level networks that share experience-based knowledge on integrated approaches to managing social-ecological landscapes (e.g. Model Forest Network; Globally Important Agricultural Heritage Sites (GIAHS)). Other multi-level networks have been formed for research purposes in social-ecological systems (Program for Ecosystem Change and Society (PECS); Sentinel landscapes of the Consultative Group for International Agricultural Research (CGIAR)).

In this review of a multi-level network working on sustainability solutions, we aim to demonstrate how such multi-level networks contribute knowledge for sustainability solutions, to illustrate their preferences by categorizing the solutions, and to show how a solution scanning approach in multi-level networks can help uncover policy gaps or implications and promote sustainability solutions. The majority of the IPSI network's case studies to date are found in Asia, allowing us a representative sample of countries and cases from which to further understanding of solutions in the network. Future studies may look at solutions in Africa, Europe and North and South America.

First though, we explore the science of sustainability solutions, then we describe the solution scanning method. Next the findings of the solution scanning in the IPSI network are presented and followed by some discussion and conclusions on the broader contributions we can expect from multi-level networks to sustainability solutions, illustrated by the experiences of the IPSI network.

## Solutions-oriented science for addressing multiple sustainability threats

In this global orientation toward solutions-oriented science that can address multiple sustainability threats, it's necessary to recognize that society may value services differently from science and that various members and groups of society may value such services differently from each other [15]. Scientific reviews of solutions to managing biodiversity in the context of multiple sustainability threats have found evidence of support for a few key recommendations, but little direction in implementation among different social-ecological systems and values of different stakeholders [16]. Reviews of conservation practices for solutions to specific problems continue to be largely expert-driven processes for identifying solutions [17].

Yet there are many experience driven solutions offered by multi-level networks that have not been considered in scientific assessments, nor explicitly integrated in transdisciplinary science-policy processes oriented toward solutions at global or regional scales. This is despite the advantage of their inclusion in bringing together

disparate values and ensuring the most beneficial, informed and socially relevant knowledge base for sustainability transformations [9,18–23]. Experience-based solutions, experimentation and consolidation, integration and co-production of knowledge in all its forms among members of the network offer complementary and novel avenues for generating evidence-based and societally relevant solutions to address multiple sustainability threats through frameworks that can account for multiple ecosystems, scales and social-ecological systems [2,20••,21,23,24].

This review demonstrates how such networks can utilize methods for knowledge synthesis for environmental decision-making to facilitate knowledge integration and co-produce sustainability solutions. It spans the activities of members of the International Partnership for the Satoyama Initiative (IPSI) over the past decade 2009–2018 based on the experiences and relevant knowledge of members of the network submitted in case studies.

## Solution scanning in the International Partnership for the Satoyama Initiative (IPSI)

Science-based assessments evaluate the effects of individual solutions but do not generally account for multiple values and the inherent trade-offs and synergies in planning in a place-based social-ecological system such as SEPLS. In contrast, multi-level networks such as IPSI have garnered a plethora of solutions but have not systematically evaluated these for their effects or impacts. Multi-level networks such as IPSI have a keen niche to serve as a bridge between experiences of network actors and policy at different levels. This role requires facilitation of knowledge synthesis processes that can differentiate and integrate among stakeholders and knowledge types to capture the varying ways in which different stakeholders perceive their relationship with the landscape [15,25,26]. These knowledge synthesis processes must also increasingly take account of the greater understanding of how values in social-ecological systems such as SEPLS may shift over time at individual and group levels, and how such shifts may be used to help transform SEPLS with more sustainable use of natural resources [27,28].

Solution scanning is an approach to systematically identifying all solutions in a solution set to a given problem, and to prioritize this set by some determination of effectiveness or efficiency in a given context [29]. The method has been applied largely for environmental decision-making to support policy or practice for biodiversity conservation [17], and to narrow a broader solution (agroforestry, marine conservation) to a specific goal (mitigation and adaptation, address overfishing) [30,31], and in novel ways to identify the location and number of a particular solution (place-based networks) [32•].

In the conventional solution scanning process, scientists hold the knowledge about which solutions are effective and use their expert knowledge to sort and recommend a set of solutions to a given problem. Sustainability solutions based on sustainability science recognizes that we cannot solve complex challenges in climate, food and biodiversity without societal actions and knowledge. In our application, we extend the definition and process of solution scanning to adopt multiple values and knowledge types by using a transdisciplinary research process to identify conservation and restoration solutions to the loss of BES in social-ecological production landscapes and seascapes (SEPLS).

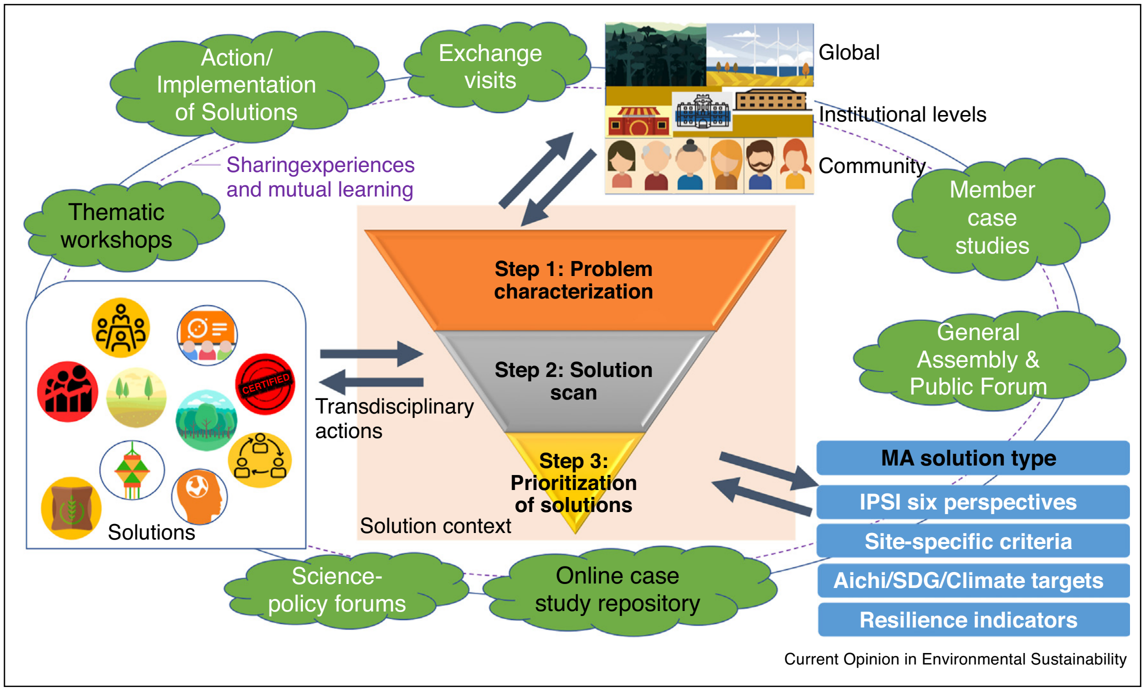
A systematic solution scan in the network is an effective method to inventory the solutions used by different actors in the network, and for the first time, to organize the solutions of a multi-level network in categories that illustrate the preferences for solution types by region, ecosystem, and scale. The typology illustrates policy gaps at different scales and levels by combining scales and ecosystems to find the gaps in local actions. Using a societal-based approach can help inform science and policy of the experiences of different actors and help integrate knowledge about sustainability solutions for the loss of BES that can address policy gaps. It can also help raise awareness and promote practices that are useful to the network when the information is co-analyzed in a transdisciplinary way and shared in collective learning processes for the consideration of the effectiveness of solutions by the network members in the future.

## Societally based sustainability solutions approach (SSSA)

We propose the Societally based Sustainability Solutions Approach (SSSA) for scanning and implementing solutions in a multi-level network for the sustainable management of SEPLS. It has three main steps (Figure 1). In the SSSA approach we can incorporate documents on local actions that include pluralistic values and additional knowledge types for a richer solution set to meet multiple sustainability challenges. SSSA applies a scientific process for systematically identifying and filtering solutions that also allows for pluralistic values in determining the usefulness of different solutions.

In step one, the problem characterization was aligned with the collective aim of the IPSI network to harmonize societies with nature through the revitalization of SEPLS. IPSI's main objectives to achieve this aim are to 1) document existing solutions, 2) draw on science and evidence-based solutions with indigenous knowledge and 3) co-design new solutions. As mentioned earlier, this problem of a loss of BES as recognized by the IPSI network is also a global concern due to the loss of BES found to be accelerating in the Asia-Pacific region from multiple drivers [1].

Figure 1




The Societal-based Sustainability Solutions Approach (SSSA). Vector diagrams for problem characterization from vecteezy.com; for solutions from Flaticon.com and Freepik.com. Solution scanning approach adapted from Ref. [24].
Step 1 occurs with the broadest scope to identify the priority problem. In our transdisciplinary application of the method the problem is informed not only by the scientific literature but by societal relevance. Actors at multiple levels of the network have different priority values of the landscape and different narratives on the problem (landscape residents, local to national institutions, global stakeholders). A collaborative framework bridges narratives and knowledges (outer network boundary). Step 2 solution scanning to identify all possible solutions to the given problem. Step 3 filtering to evaluate feasible and effective solutions for the given solution context. Two-way arrows indicate at each step that transdisciplinary processes for knowledge integration take place. Together the three steps of the SSSA approach allow for consideration of the complete solution context starting from the problem and its drivers, to the range of available solutions, and finally to consideration of their effectiveness for the given problem based on one or more filters (e.g. MA solution type; IPSI six perspectives, etc.). Clouds indicate member activities of the network. Black text indicates activities that intersect directly with the review process. Activities and processes intersect with processes and actors outside of the network. In the SSSA approach, sharing experiences and mutual learning takes place between actors at different levels, through processes and actors that connect activities and transdisciplinary actions such as solution scanning (dashed line).

During step two, the group of researchers made up of the authors surveyed accounts of network members regarding their knowledge and experiences in responding to a loss of BES in SEPLS in the Asian region[3]. These experiences were submitted by partner organizations of IPSI or published by the Initiative as case studies[4]. Among 88 cases, a total of 23 cases are located in South Asia, 29 cases in Southeast Asia and 36 cases in East Asia, representing 18 countries in these regions (See Supplementary Information Table 1).

Continuing in step two, research team members used a collective guide to data definitions in systematically recording the data from the 88 case studies. A solution was defined as any activity, intervention, innovation, practice, strategy or policy that has been proposed or applied in the case study area to address the given problem. Research team members collected data on the existence, use, scale, and ecosystem(s) associated with conservation and restoration solutions in SEPLS. We differentiated between proposed (suggested by IPSI partners) and existing solutions already implemented in the case study area.

For Step three in the solution scanning method, a filter such as those illustrated in Figure 1 (e.g. the IPSI six

[3] Central and West Asia were excluded from the Asia review because of a low number of total case studies (2 Central Asia (both in Kyrgyzstan), 6 Western Asia (2 cases in Turkey, 1 case each in Iraq, Oman, Saudi Arabia and Syria)) and also less than 50% of the countries of each region were represented in the samples, while South, Southeast and East Asia each had a minimum of 20 cases and more than 50% of the countries represented.

[4] These include published case studies of IPSI members available as of March 2018. They are found in the following sources: (1) an online case study database hosted by IPSI; A 2012 publication by the Satoyama Initiative on Asian production landscapes; Publications from the collaborative activities of IPSI with The COMDEKS Programme—Communities in Action for Landscape Resilience and Sustainability; and the flagship series of the Satoyama Initiative, its Thematic Review volumes 1–3.

perspectives, which make up the IPSI network's collective framework for action; Site-specific criteria; Aichi targets) should be used to weigh the effectiveness of various solutions and prioritize them in a specific solution context. We used a modified step to help adapt Step three for the SSSA method for use in a multi-level network with pluralistic knowledges.

In step three we held a workshop with the research team members to collectively filter solutions according to a typology of solution types derived from the Millennium Ecosystem Assessment (MA) consisting of institutional, cognitive, social and cultural, economic and technological [33]. At the workshop these five solution types were further subdivided into 26 solution subtypes through a three-phase process of deriving the framework from the MA, pre-testing a sample of solutions, and finally, collectively revising the categories for consistent application across the solutions.

For instance, for economic and incentive-based approaches, the research team adapted the MA framework to include solution subtypes relevant at the community scale, including solutions that introduce or enhance existing livelihoods in case study sites. We modified the MA framework to include cultural solutions to reflect the indigenous and community orientation of many solutions in SEPLS that reflect people's longstanding relationships to agricultural production in SEPLS that are considered cultural practices. Recently adopted frameworks for understanding BES and its contributions to nature and people such as IPBES also emphasize cultural dimensions of ecosystems services [34].

Some solution subtypes were expanded to encompass multiple meanings as the categorization progressed. For instance, the scope of the institutional and governance solution subtype for 'inclusion' was first limited to the addition of one or more stakeholders in decision-making processes, and subsequently expanded to comprise the rights of new groups to benefits (see Supplementary information Table 2 for the full list of solution types, subtypes and the scope of each category).

In a final part of step three, the research team joined a thematic workshop held in Tokyo and hosted by the IPSI Secretariat, with the Institute for Global Environmental Strategies (IGES) and United Nations University (UNU) experts and IPSI members, and shared the solution scanning and filtered outcomes for discussion with the network and feedback. The results were used to inform the Satoyama Initiative Thematic Review (SITR), Volume 4 synthesis chapter on solutions for sustainable use of resources in SEPLS. This effort in step three was intended to help inform future work of IPSI in further evaluating the effectiveness of various solutions in a transdisciplinary way, through collaboration among scientists and network members, and to help inform collective knowledge in the network and at policy levels through the synthesis chapter findings.

## The IPSI network and collaborative sustainability solutions

As an outcome of step two, a total of 489 solutions were identified from the set of 88 cases. As an outcome of step three, 485 solutions[5] were categorized according to one of the five solution types. The largest shares of both existing and proposed solutions, as well as the overall share of solutions, are institutional and governance solution types (29%), followed by economic (19%), social, cultural and behavioral (18%), technological (18%) and cognitive (16%) (Figure 2). A higher proportion of solutions were applied in SEPLS in IPSI member experiences (58% existing), while 42% were untested (proposed). Engaging additional actors or bringing them into collaborative management modes is the most frequently suggested future (proposed) solution indicated by IPSI network members.

The largest proportion of solutions by subtype was economic or incentive based through livelihood investments (13%), followed by institutional and governance-based solutions designed to increase inclusion (10%), and then technological-based solutions such as agroecological investments (9%). In four of the solution types, one solution subtype is 40% or more of the total solutions of that type. These are livelihood investments (70%, economic), agroecological practices (47%, technical), and awareness creation (46%, social, cultural and behavioral). Efforts to address knowledge gaps (for instance assessments, research) formed the largest subtype share of knowledge solutions (42%).

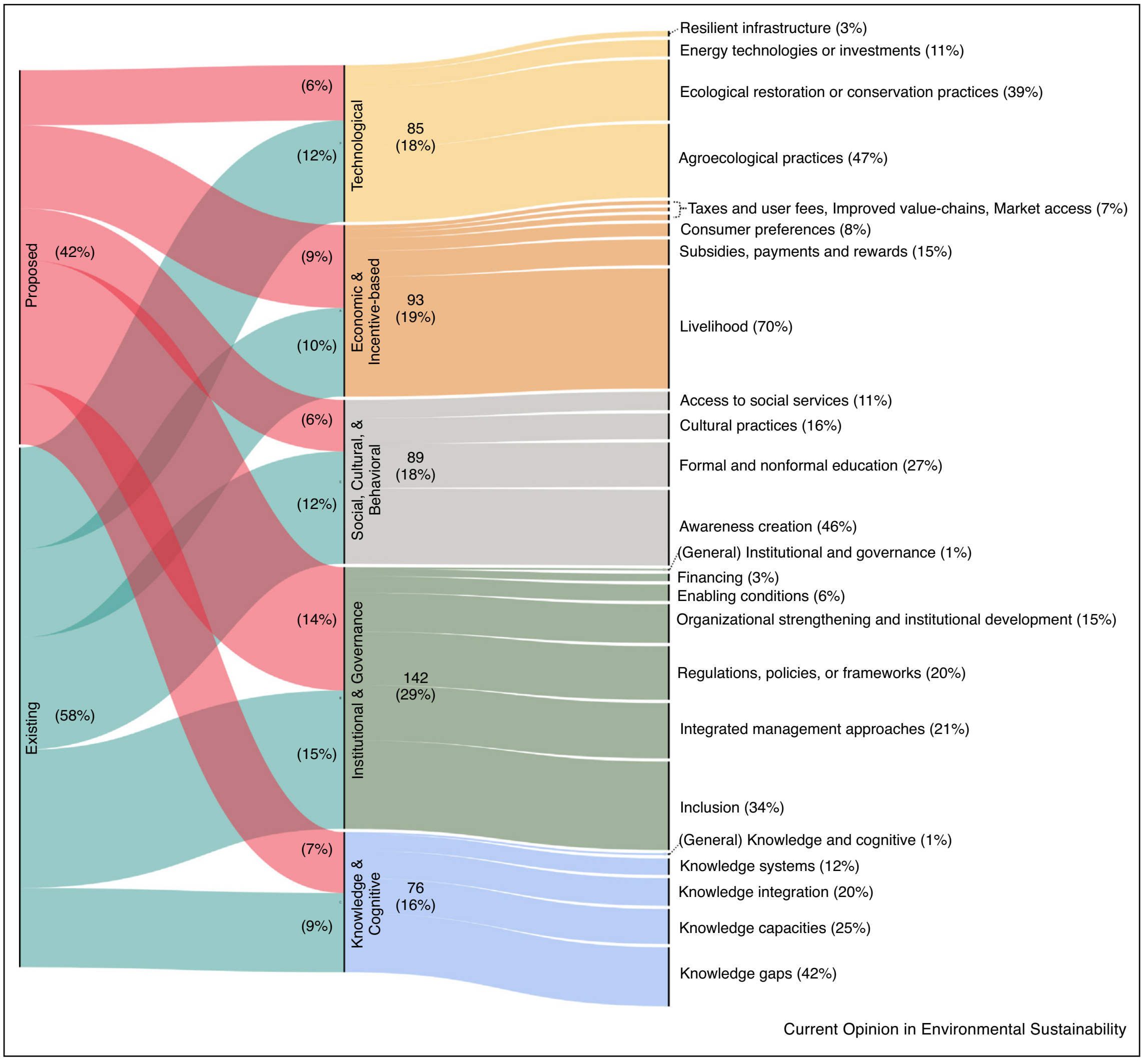
### Social learning in the SSSA approach in the IPSI network

Several tested frameworks have demonstrated that multi-level networks such as IPSI are important vehicles and social-ecological systems for social learning, and through dynamic learning iterations that build trust, they reframe multiple narratives that lead to sustainability solutions and contribute to policy processes [22,35–38]. However, it has been difficult for multi-level networks to conduct learning processes in a systematic manner or to institutionalize them [39], to ensure a conducive setting is in place for learning [40], and to sustain the collaborative learning, in particular across scales and without external facilitation [41,42].

In accordance with the authors' observations of the IPSI network's activities illustrated in Figure 1, the transdisciplinary learning processes in the SSSA approach supports horizontal exchange and knowledge reconciliation among peers that is thought to be more important for the

[5] Four solutions were categorized as multiple solution type as there was not enough information in the published data to determine whether they were proposed or implemented as economic, social, technological, cognitive, or institutional solution types.

**Figure 2**




Solutions by solution type, proposed and existing, by percent of total. Solution types and subtypes derived from MA assessment [29]. Solution subtypes by percent of each solution type.
Technical type responses comprises eco-technologies for agricultural production, conservation, energy, and infrastructure. Economic solution types largely comprises investments in improving livelihoods. Social and behavioral solution types include demand side efforts to reduce consumption such as education. Awareness creation solution subtype includes not only campaigns, but the establishment of museums and model villages. Among the solution subtypes in institutional and governance solution types are integrated management approaches that can coordinate across scales and actors and inclusion mechanisms such as participatory processes in policy-setting and implementation, or a demand for rights as well as equity in the distribution of benefits. Knowledge and cognitive solution types address insufficient knowledge and also poor use of existing knowledge. They include solutions such as monitoring and capacity building.

adoption and effectiveness of solutions [43,44]. This type of exchange is realized through several multi-directional mediums for learning such as (i) a boundary object, in this case a shared concept of SEPLS developed through a collaborative framework for the network; (ii) through the sharing or distribution of knowledge such as case studies; and (iii) collaborative learning processes where peers can share practices and experiences such as exchange visits, public forums, and workshops (Figure 1). Indeed it is the work of garnering, interpreting, and co-analyzing solutions during these types of activities in the IPSI network that supports the integration of indigenous and local knowledge in transdisciplinary processes, which is deemed vital for achieving multi-scale sustainability solutions in SEPLS [45•].

## Integrated sustainability solutions for multiple scales and ecosystems

Past expert-led assessments of existing solutions to the loss of BES in SEPLS have focused on a set of criteria relating to

effectiveness. Overall such assessments have tended to fall in either a technocratic or natural sciences framework, while there is a need for frameworks that can assess sustainability solutions from both social and environmental perspectives [46•]. The SSSA approach can aid in understanding not only what solutions were proposed or implemented in each local landscape network, but also the context of the social ecological system (e.g. the problem, the drivers, and the outcomes), to understand the effectiveness of solutions across ecosystems, scales, and governance systems [9].

The solutions of IPSI members are implemented or proposed in SEPLS composed of mosaic ecosystems and at social or ecological scales (For definitions of scales and ecosystems see supplementary information Table 3). As an outcome of step three, the research team plotted the solutions from the IPSI network by social-ecological scale, ecosystem and solution type (Figure 3). Solutions are most frequently applied or suggested in agricultural and forest ecosystems and are more distributed across social scales than ecological scales in agricultural and forest ecosystems. More than half of the solutions are targeted at the local scale where SEPLS are located. Urban and dryland ecosystems are underinvested in solution responses. Satoumi solutions are relatively underrepresented, which may reflect the number of Satoumi cases in the sample. When solutions are sought at an ecological scale, they are more often targeted at an eco-regional scale than among any other ecological scale.

Solutions targeted to in-land water ecosystems are the most evenly distributed across ecological and social scales, while the threat mentioned with the highest frequency in the case studies was to the sustainability of water sources. The frequency of this threat may be what is driving societal actors to respond with solutions spanning social-ecological scales, or could also be due to factors such as the relative ease in defining multiple uses and stakeholders for water, which creates a higher demand for collaborative governance.

Networks such as IPSI can help generate sufficient empirical evidence to show which scales, social or ecological, or a combination offer the best options for solution strategies. They can also help show potential entry points where identifying solutions at various social-ecological scales in different ecosystems can help advance the management of SEPLS in ways that balance trade-offs among scales, stakeholders and ecosystems [13,47]. In the case of the IPSI network, livelihood revitalization solutions that recognize the social and cultural relationship of local residents to the SEPLS, conducting assessments and studies to close key knowledge gaps, and engaging additional actors in institutional and governance schemes are seen as some of the best options.

Analyzing technological solutions together with economic, institutional, cognitive, and social, cultural and behavioral solutions allows for consideration of a range of solution responses and how they interact with each other to produce different desired outcomes in the landscape, including trade-offs and synergies within the context of SEPLS as a social-ecological system. This allows for consideration of the complete solution context, including its appropriateness for existing norms and values as well as ideals of justice, while helping landscape stakeholders to think of alternatives to unsustainable food systems that may be locked-in through a combination of consumer demand, input availability, private sector incentives, institutions such as farmer contracts or value chains, or government policies, and that are causing negative environmental consequences [48,49]. By thinking of this complete solution context, landscape stakeholders can then determine the most effective mix of solutions related to, for instance, agricultural production or conservation technologies, behavioral shifts, knowledge systems, or livelihood or management practices.

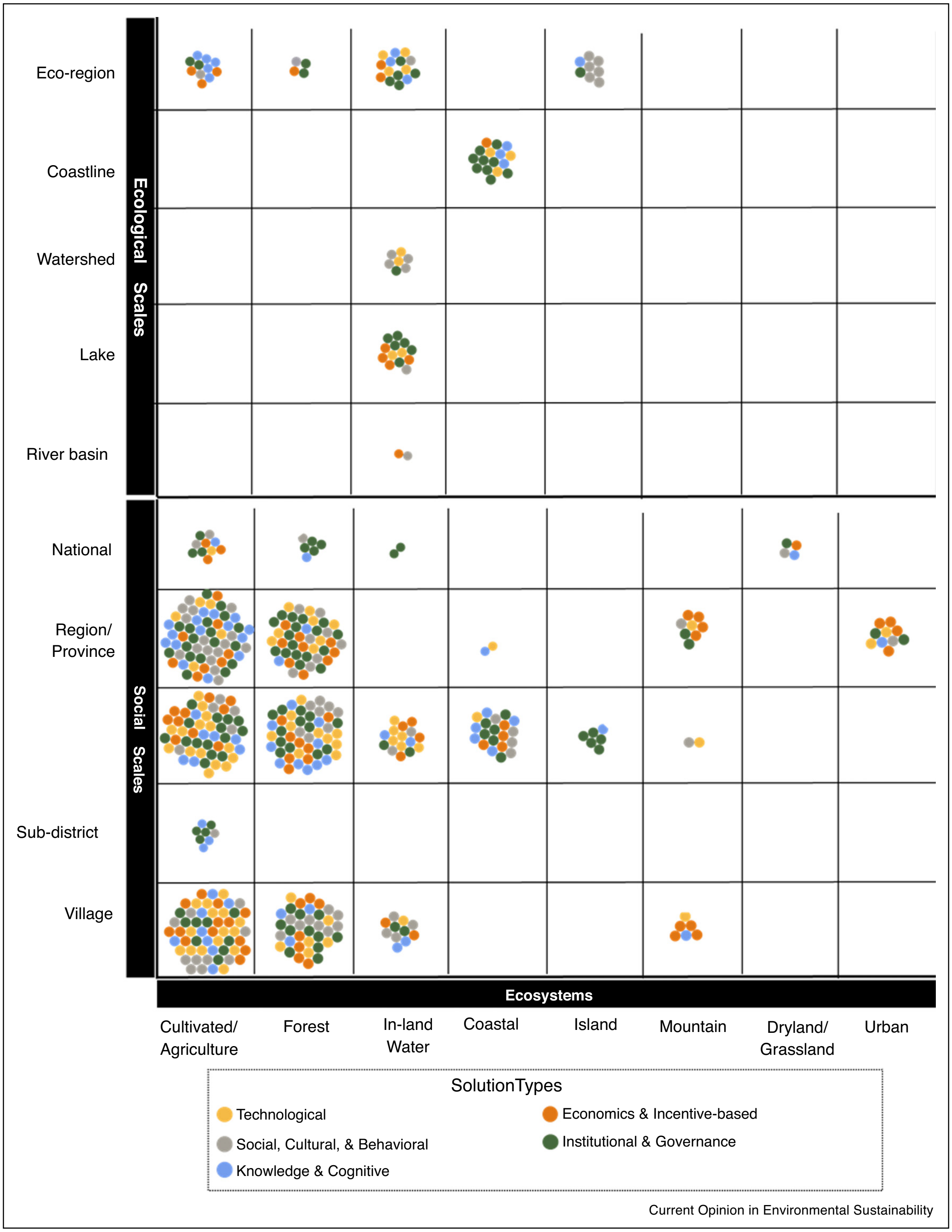
Figure 4 illustrates some of the multi-level interactions of the IPSI network. The multi-level interactions affect the local actions and selected solutions at different scales moving vertically between administration levels, horizontally among networks, and along ecological continuums from landscape to seascape. The multi-level interactions also promote shared and multi-directional learning among levels and scales, creating new opportunities for sustainability solutions informed by a wider system for knowledge and practice.

Since 2018, Suzu city in Ishikawa Prefecture, Japan has been promoting a new project called 'Noto SDGs Laboratory' to operationalize SDGs locally through technical support, collaborative experiments and matching of local needs and resources[6] (Figure 4(a)). This program is part of a larger initiative since 2010 to create a 'Noto model' of Satoyama that has present-day significance to the region, and to promote a relevant concept for sustainable use and management from local to global levels[7]. Hence, it includes numerous activities at different levels. Local revitalization and reconstruction activities are conducted through new sustainable use institutions such as Satoyama–Satoumi Resident Researchers and Satoyama Mates, which bring together community revitalization leaders such as farmers and foresters with urban dwellers, youth, and the retired population. A regional knowledge platform and eco-based agribusiness network have grown from the development of a nature school, a regional development partnership, and a Satoyama Forum and Satoyama Cheering Squad, both multi-stakeholder platforms to support local action. Engagement in the CBD and the IPSI network at a global

[6] https://noto-sdgs.jp/about-lab/.

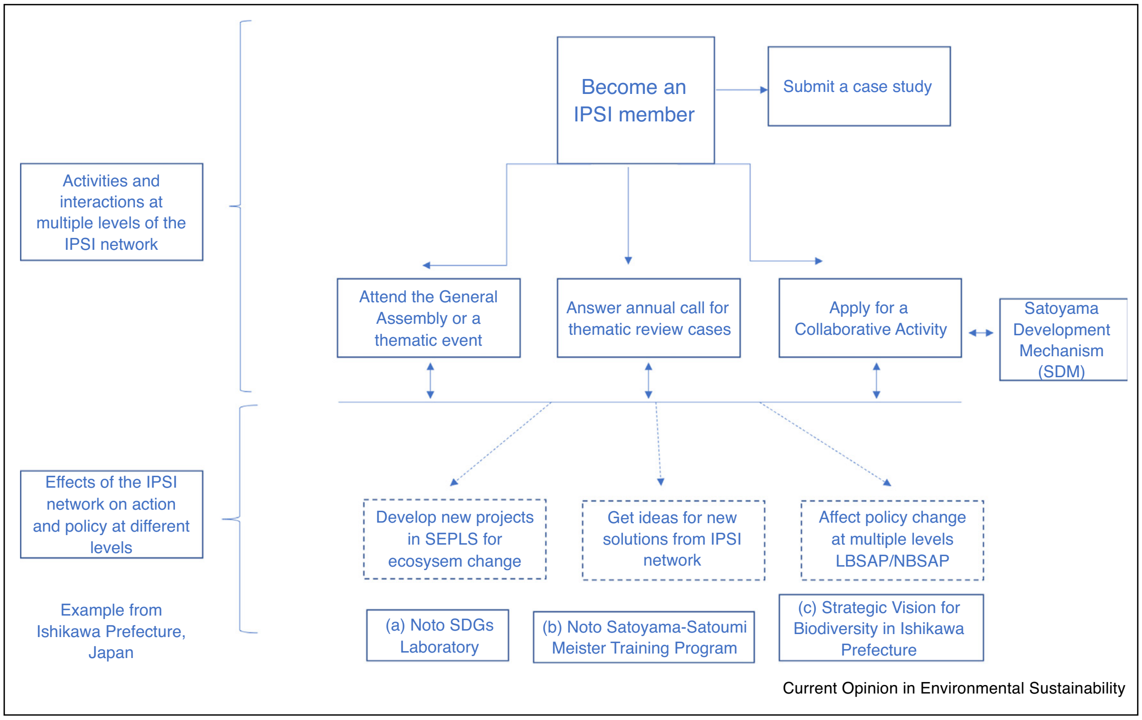
[7] Mainstreaming satoyama in research, education and regional collaboration towards the revitalization of Noto Peninsula. IPSI case study. https://satoyama-initiative.org.

**Figure 3**




Solutions by ecosystem and social or ecological scale. No cases were located in polar and marine ecosystems.
Each dot represents a solution that has been proposed or implemented in a case study area at the scale and main ecosystem of the case study area.

**Figure 4**




The IPSI multi-level network and its effects on actions and policy for sustainable use and management of SEPLS.
Acceptance as a new member to IPSI is approved by the Steering Committee (SC) and General Assembly of IPSI. Submitting a SEPLS case study is a requirement of new members. After becoming members, IPSI platform partners can (i) attend a number of forums where they may interact with other members, (ii) answer a call for thematic cases, and (iii) apply for a collaborative activity, or a mechanism that facilitates collaborative activities among member organizations, also approved by the SC. These multi-level interactions promote maintenance and revitalization of SEPLS through action and policy at multiple levels.

level has helped coordinate local biodiversity strategies and policies among regional and local levels and align them with national and global levels.

Interactions among members of the IPSI network have led to new actions at other levels in order to implement IPSI collaborative activities or to develop a thematic case study for the network (Figure 4). Some of these actions include the addition of new partners, new training and action programs, and workshops at local and national levels. Kanazawa University in Ishikawa Prefecture offers a 'Satoyama Satoumi Meister Training Program' as a post-graduate program for practitioners to learn knowledge and skills for sustainable use and management of satoyama landscapes and satoumi seascapes in collaboration with IPSI partners[8] (Figure 4(b)). This program is now also offered in the Philippines through collaboration with a Globally Important Agricultural Heritage Site (GIAHS) as part of an initiative for economic activities and conservation in the Ifugao Rice Terraces.

These interactions at multiple levels have led to the incorporation of sustainability solutions in local biodiversity strategies and action plans (LBSAP) and national biodiversity strategies and action plans (NBSAP). The 'Strategic Vision for Biodiversity in Ishikawa Prefecture' (2011) is one of the LBSAPs inspired and supported by the IPSI network (Figure 4(c)).

The Satoyama Development Mechanism (SDM) was approved as a collaborative activity of IPSI (Figure 4). The SDM provides seed funding to projects that develop replicable practices for sustainable use of SEPLS; for activities that originate or strengthen cooperation among IPSI members; and for those activities that enhance collective learning in the network. In the case of Nepal, the SDM supported an activity to localize the NBSAP through the creation of village biodiversity profiles that would inform conservation action at the local level and align local actions with national and international policies and targets. The profiles were integrated in LBSAP at village and municipality levels and Village Development Council (VDC) plans, as well as in the national level biodiversity strategy and action plan. The successful

[8] http://www.crc.kanazawa-u.ac.jp/meister/en/regular-course/outline/.

practice of incorporating conservation activities that are both aligned with and inform national policy in local level development plans was then documented in a Satoyama Initiative Thematic Review (Figure 4) through peer review by the IPSI network, and publication and dissemination among the IPSI network and wider audience. The successful practice of bringing together additional coalitions of actors led to discussions that widened the solutions menu for implementation of the NBSAP and created additional sustainability pathways for meeting biodiversity targets in LBSAP strategies at village and municipality levels.

Indeed, there is evidence that incorporating a far-reaching consideration of solutions in a systematic and transdisciplinary process such as the SSSA approach can lead to alternative sustainability pathways with wider support among diverse stakeholders in the network. Zijp *et al.* show how one such a process that gave consideration to a complete solution context led to a novel pathway for managing the resource in the case of sediment management in cultivated ecosystems [50]. Such systems could offer pathways to transformation of SEPLS and a revitalization of the balance among nature and humans through an intentional mix of solutions across ecosystems and scales in the landscape that combine to create transformative effects [51••].

## Multi-level networks and sustainability solutions

The core tenets of sustainability science: i) the bridging of scientific disciplines, ii) transdisciplinary research processes that link scientific and other knowledge forms, and iii) solutions-oriented research that links knowledge to action have shaped the agendas of international environmental science-policy forums and at the same time served as precisely the challenge for translation of research to sustainability solutions [52]. The key challenges are the development of frameworks and approaches that (i) make generalizable place-based solutions, (ii) are able to traverse and maintain linkages across scales and (iii) that encompass a comprehensive solution set that integrates social and environmental solutions.

Networks such as IPSI have an important role to play in helping to advance sustainability science research to realize evidence-based and relevant societal action. They can do this through systematic approaches that link the shifting values and problems and sustainable solutions of actors at different scales via collaborative social-ecological frameworks that are realized through transdisciplinary knowledge integration and action [53].

However, IPSI does face challenges to overcome similar to other multi-level networks, such as motivating a sustained engagement among partners, and further, to generate sufficient evidence to convince decision makers of key objectives. For instance, in IPSI's case, demonstrating to governments and members of intergovernmental processes such as the CBD that SEPLS are key to ensure implementation success of sustainability goals.

IPSI has been fairly successful in overcoming these challenges by promoting focused interactions among the partners to share, learn and collaborate with each other and by co-analyzing common issues. The network has also focused on drawing out links to policy goals on conservation and development. Lessons are synthesized from thematic reviews and public forums of the IPSI network and presented in policy-relevant academic discussions. Engaging with the academic, policy and practitioner communities (as seen from the IPSI membership that includes research organizations, government bodies and practitioner-led organizations) has further strengthened IPSI's approach. Policy recommendations for sustainable use and management of natural resources through SEPLS have been successfully mainstreamed in policy processes such as the CBD. IPSI is a major platform for 'integrated landscape and seascape approaches' of the CBD and for advocacy of the policy relevance of integrated approaches, while aiming to demonstrate the concept of Satoyama—that is supporting diverse ecosystem services for human well-being and biodiversity.

Some of IPSI's strategies to address mediating factors have been regular interactions among the members in a number of forums; opportunities to collaborate between partners to explore synergies to improve implementation actions; joint funding and seed funding opportunities; and joint refinement of methodologies to strengthen SEPLS, and for use in advocating with higher levels of decision making. IPSI has been successful in overcoming challenges through reliable core funding from the Government of Japan and through thoughtful attention to feedbacks in multi-directional learning processes to share practices and promote collaboration among network members as described in the LBSAP case in Nepal.

A recent survey of researchers and policy makers in Asia related to the loss of BES in the region and the needed agenda revealed that management of SEPLS with the use of knowledge from traditional management practices was identified as the most important science-policy agenda up until 2050 [54]. The long-term aim of the IPSI network is to help build a sustainable society in harmony with nature through, in part, the integration of indigenous knowledge. The societal-based solution scanning of the IPSI network members' experiences is a good first step in making available the knowledge for integration in science-policy agendas. Realizing additional pathways for the effective use of this network in addressing this priority science-policy agenda could be a useful aspect of the IPSI network in the coming decades.

Multi-level networks such as IPSI can strengthen their role in contributing sustainability solutions by finding opportunities to institutionalize boundary objects or activities and processes that support transdisciplinary actions across scales. For instance, in the case of IPSI, the shared concept of SEPLS and the collaborative framework developed for sustainable use of SEPLS provide a basis for co-analyzing solutions. Multi-level networks should also seek to find opportunities that increase the capacities of members to facilitate knowledge integration processes across levels to support the long-term interactions across knowledge types and scales in the network [42]. The outcome of the SSSA approach for assessing the sustainability of solutions can also be strengthened through transdisciplinary processes where actors identify their own filters for social and environmental integration of solutions across scales. A number of these are indicated in Figure 1 in white text for future application, such as the Sustainable Development Goals or Aichi Biodiversity Targets.

## Conflict of interest statement

Nothing declared.

## Acknowledgements

This research has received funding from the International Satoyama Initiative (ISI) and the Ministry of the Environment, Japan. We thank the practitioners and researchers from across the IPSI network that gathered for the Satoyama Initiative Thematic workshop in May 2018 at the United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS), organized by the Secretariat of the International Partnership for the Satoyama Initiative, The Institute for Global Environmental Strategies (IGES), The Ministry of Environment Japan, and UNU-IAS, for their discussions that informed this paper.

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.cosust.2019.09.002.

## References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest


1. M. Karki, S. Senaratna Sellamuttu, S. Okayasu, W. Suzuki, L.A. Acosta, Y. Alhafedh, J.A. Anticamara, A.G. Ausseil, K. Davies, A. Gasparatos, et al., (Eds.), Summary for Policymakers of the IPBES Regional Assessment Report on Biodiversity and Ecosystem Services for Asia and the Pacific, 2018.

2. Takeuchi K, Ichikawa K, Elmqvist T: **Satoyama landscape as social–ecological system: historical changes and future perspective**. *Curr Opin Environ Sustain* 2016, **19**:30-39.

3. Duriappah A, Nakamura K, Takeuchi K, Watanabe M, Nishi M (Eds): *Satoyama-Satoumi Ecosystems and Human Well-Being: Socio-Ecological Production Landscapes of Japan*. United Nations University Press; 2012.

4. United Nations University: *Japan Satoyama Satoumi Assessment, 2010. Satoyama-Satoumi Ecosystems and Human Well-Being: Socio-Ecological Production Landscapes of Japan - Summary for Decision Makers*. 2010.

5. Oktavia P, Salim W, Perdanahardja G: **Reinventing papadak/hoholok as a traditional management system of marine resources in Rote Ndao, Indonesia**. *Ocean Coast Manag* 2018, **161**:37-49.

6. Camacho LD, Gevaña DT, Carandang AP, Camacho SC: **Indigenous knowledge and practices for the sustainable management of Ifugao forests in Cordillera, Philippines**. *Int J Biodivers Sci Ecosyst Serv Manag* 2016, **12**:5-13.

7. Jung H-J, Ryu J-H, Jung H-J, Ryu J-H: **Sustaining a Korean traditional rural landscape in the context of cultural landscape**. *Sustainability* 2015, **7**:11213-11239.

8. Kowarsch M, Jabbour J: **Solution-oriented global environmental assessments: opportunities and challenges**. *Environ Sci Policy* 2017, **77**:187-192.

9. Leemans R: **Editorial overview: how to promote transdisciplinary, evidence-based sustainability solutions?** *Curr Opin Environ Sustain* 2017, **29**:xii-xv.

10. Ayala-Orozco B, Rosell J, Merçon J, Bueno I, Alatorre-Frenk G, Langle-Flores A, Lobato A, Ayala-Orozco B, Rosell JA, Merçon J *et al.*: **Challenges and strategies in place-based multi-stakeholder collaboration for sustainability: learning from experiences in the global south**. *Sustainability* 2018, **10**:3217.

11. Jiren TS, Bergsten A, Dorresteijn I, Collier NF, Leventon J, Fischer J: **Integrating food security and biodiversity governance: a multi-level social network analysis in Ethiopia**. *Land Use Policy* 2018, **78**:420-429.

12. • Benton T, Bailey R, Froggatt A, King R, Lee B, Wellesley L: **Designing sustainable landuse in a 1.5°C world: the complexities of projecting multiple ecosystem services from land**. *Curr Opin Environ Sustain* 2018, **31**:88-95.

How land use will account for demands for multiple services at different scales is an important question for science and management for reaching the Paris climate targets that requires more attention.

13. Opdam P: **Exploring the role of science in sustainable landscape management. An introduction to the special issue**. *Sustainability* 2018, **10**:331.

14. Takeuchi K: **Rebuilding the relationship between people and nature: the Satoyama Initiative**. *Ecol Res* 2010, **25**:891-897.

15. Pascual U, Balvanera P, Díaz S, Pataki G, Roth E, Stenseke M, Watson RT, Başak Dessane E, Islar M, Kelemen E *et al.*: **Valuing nature's contributions to people: the IPBES approach**. *Curr Opin Environ Sustain* 2017, **26–27**:7-16.

16. Heller NE, Zavaleta ES: **Biodiversity management in the face of climate change: a review of 22 years of recommendations**. *Biol Conserv* 2009, **142**:14-32.

17. Dicks LV, Wright HL, Ashpole JE, Hutchison J, McCormack CG, Livoreil B, Zulka KP, Sutherland WJ: **What works in conservation? Using expert assessment of summarised evidence to identify practices that enhance natural pest control in agriculture**. *Biodivers Conserv* 2016, **25**:1383-1399.

18. Lang DJ, Wiek A, Bergmann M, Stauffacher M, Martens P, Moll P, Swilling M, Thomas CJ: **Transdisciplinary research in sustainability science: practice, principles, and challenges**. *Sustain Sci* 2012, **7**:25-43.

19. Scholz RW, Steiner G: **The real type and ideal type of transdisciplinary processes: part I—theoretical foundations**. *Sustain Sci* 2015, **10**:527-544.

20. •• Balvanera P, Calderón-Contreras R, Castro AJ, Felipe-Lucia MR, Geijzendorffer IR, Jacobs S, Martín-López B, Arbieu U, Speranza CI, Locatelli B *et al.*: **Interconnected place-based social–ecological research can inform global sustainability**. *Curr Opin Environ Sustain* 2017, **29**:1-7.

The trends and challenges of place-based research and its use in global sustainability research offers a timely review and synthesis on the role of place-based research in garnering sustainability solutions.

21. Castro A, Quintas-Soriano C, Brandt J, Atkinson C, Baxter C, Burnham M, Egoh B, García-Llorente M, Julian J, Martín-López B *et al.*: **Applying place-based social-ecological research to address water scarcity: insights for future research**. *Sustainability* 2018, **10**:1516.

22. Manring SL: **The role of universities in developing interdisciplinary action research collaborations to understand and manage resilient social-ecological systems**. *J Clean Prod* 2014, **64**:125-135.

23. Partelow S: **Coevolving Ostrom's social–ecological systems (SES) framework and sustainability science: four key co-benefits**. *Sustain Sci* 2016, **11**:399-410.

24. Liehr S, Röhrig J, Mehring M, Kluge T: **How the social-ecological systems concept can guide transdisciplinary research and implementation: addressing water challenges in Central Northern Namibia**. *Sustainability* 2017, **9**:1109.

25. Martinez-Harms MJ, Gelcich S, Krug RM, Fleur Maseyk JF, Moersberger H, Archi Rastogi, Wambugu G, Cornelia Krug B *et al.*: **Framing natural assets for advancing sustainability research: translating different perspectives into actions**. *Sustain Sci* 2018, **13**:1519-1531.

26. Bisaro A, Swart R, Hinkel J: **Frontiers of solution-oriented adaptation research**. *Reg Environ Chang* 2016, **16**:123-136.

27. Horcea-Milcu A-I, Abson DJ, Apetrei CI, Duse IA, Freeth R, Riechers M, Lam DPM, Dorninger C, Lang DJ: **Values in transformational sustainability science: four perspectives for change**. *Sustain Sci* 2019, **14(5)**:1425-1437.

28. Kendal D, Raymond CM: **Understanding pathways to shifting people's values over time in the context of social–ecological systems**. *Sustain Sci* 2018, **14(5)**:1333-1342.

29. Sutherland WJ, Gardner T, Bogich TL, Bradbury RB, Clothier B, Jonsson M, Kapos V, Lane SN, Möller I, Schroeder M *et al.*: **Solution scanning as a key policy tool: identifying management interventions to help maintain and enhance regulating ecosystem services**. *Ecol Soc* 2014, **19**:art3.

30. Hernández-Morcillo M, Burgess P, Mirck J, Pantera A, Plieninger T: **Scanning agroforestry-based solutions for climate change mitigation and adaptation in Europe**. *Environ Sci Policy* 2018, **80**:44-52.

31. Jacquet J, Boyd I, Carlton JT, Fox H, Johnson AE, Mee L, Roman J, Spalding M, Sutherland WJ: **Scanning the oceans for solutions**. *Solutions* 2011, **2**:46-55.

32. • Plieninger T, Kohsaka R, Bieling C, Hashimoto S, Kamiyama C, Kizos T, Penker M, Kieninger P, Shaw BJ, Sioen GB *et al.*: **Fostering biocultural diversity in landscapes through place-based food networks: a "solution scan" of European and Japanese models**. *Sustain Sci* 2018, **13**:219-233.
Example of the importance of production landscapes as social-ecological systems and that the solutions embedded in place-based multi-level networks reflect local values.

33. Millennium Ecosystem Assessment: *Ecosystems and Human Well-being: Synthesis*. 2005.

34. Díaz S, Pascual U, Stenseke M, Martín-López B, Watson RT, Molnár Z, Hill R, Chan KMA, Baste IA, Brauman KA *et al.*: **Assessing nature's contributions to people**. *Science (80-)* 2018, **359**:270-272.

35. Pahl-Wostl C: **A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes**. *Global Environ Change* 2009, **19**:354-365.

36. Pahl-Wostl C, Becker G, Knieper C, Sendzimir J: **How multilevel societal learning processes facilitate transformative change: a comparative case study analysis on flood management**. *Ecol Soc* 2013, **18**:art58.

37. Sol J, Beers PJ, Wals AEJ: **Social learning in regional innovation networks: trust, commitment and reframing as emergent properties of interaction**. *J Clean Prod* 2013, **49**:35-43.

38. Campellone RM, Chouinard KM, Fisichelli NA, Gallo JA, Lujan JR, McCormick RJ, Miewald TA, Murry BA, John Pierce D, Shively DR: **The iCASS platform: nine principles for landscape conservation design**. *Landsc Urban Plan* 2018, **176**:64-74.

39. Axelsson R, Angelstam P, Myhrman L, Sädbom S, Ivarsson M, Elbakidze M, Andersson K, Cupa P, Diry C, Doyon F *et al.*: **Evaluation of multi-level social learning for sustainable landscapes: perspective of a development initiative in Bergslagen, Sweden**. *Ambio* 2013, **42**:241-253.

40. Westberg L, Polk M: **The role of learning in transdisciplinary research: moving from a normative concept to an analytical tool through a practice-based approach**. *Sustain Sci* 2016, **11**:385-397.

41. Reed MG, Godmaire H, Abernethy P, Guertin M-A: **Building a community of practice for sustainability: strengthening learning and collective action of Canadian biosphere reserves through a national partnership**. *J Environ Manage* 2014, **145**:230-239.

42. Zappa P, Robins G: **Organizational learning across multi-level networks**. *Soc Netw* 2016, **44**:295-306.

43. Tschirhart C, Mistry J, Berardi A, Bignante E, Simpson M, Haynes L, Benjamin R, Albert G, Xavier R, Robertson B *et al.*: **Learning from one another: evaluating the impact of horizontal knowledge exchange for environmental management and governance**. *Ecol Soc* 2016, **21**:art41.

44. Bolden IW, Seroy SK, Roberts EA, Schmeisser L, Koehn JZ, Rilometo CH, Odango EL, Barros C, Sachs JP, Klinger T: **Climate-related community knowledge networks as a tool to increase learning in the context of environmental change**. *Clim Risk Manag* 2018, **21**:1-6.

45. • Tengö M, Hill R, Malmer P, Raymond CM, Spierenburg M, Danielsen F, Elmqvist T, Folke C: **Weaving knowledge systems in IPBES, CBD and beyond—lessons learned for sustainability**. *Curr Opin Environ Sustain* 2017, **26–27**:17-25.
A review of how major biodiversity related science-policy processes can optimize knowledge integration processes to adopt a range of tasks important to translate multiple knowledges to sustainability actions.

46. • Schaubroeck T: **Towards a general sustainability assessment of human/industrial and nature-based solutions**. *Sustain Sci* 2018, **13**:1185-1191.
A review of key methods in sustainability assessment and suggestion of how to bridge conventional life-cycle and ecosystem service assessment tools for sustainability solutions.

47. McCormick K, Neij L, Mont O, Ryan C, Rodhe H, Orsato R: **Advancing sustainable solutions: an interdisciplinary and collaborative research agenda**. *J Clean Prod* 2016, **123(1)**:1-4.

48. Tran M: **A general framework for analyzing techno-behavioural dynamics on networks**. *Environ Model Softw* 2016, **78**:225-233.

49. Hall DM, Feldpausch-Parker A, Peterson TR, Stephens JC, Wilson EJ: **Social-ecological system resonance: a theoretical framework for brokering sustainable solutions**. *Sustain Sci* 2017, **12**:381-392.

50. Zijp MC, Posthuma L, Wintersen A, Devilee J, Swartjes FA: **Definition and use of solution-focused sustainability assessment: a novel approach to generate, explore and decide on sustainable solutions for wicked problems**. *Environ Int* 2016, **91**:319-331.

51. •• David Tàbara J, Frantzeskaki N, Hölscher K, Pedde S, Kok K, Lamperti F, Christensen JH, Jäger J, Berry P: **Positive tipping points in a rapidly warming world**. *Curr Opin Environ Sustain* 2018, **31**:120-129.
A review of climate adaptation and resilience theory on tipping points offers a useful conceptual model for understanding how transformations of social-ecological systems can occur through synergistic solutions.

52. De Pryck K, Wanneau K: **(Anti)-boundary work in global environmental change research and assessment**. *Environ Sci Policy* 2017, **77**:203-210.

53. Miller TR, Wiek A, Sarewitz D, Robinson J, Olsson L, Kriebel D, Loorbach D: **The future of sustainability science: a solutions-oriented research agenda**. *Sustain Sci* 2014, **9**:239-246.

54. Saito O: **Future science-policy agendas and partnerships for building a sustainable society in harmony with nature**. *Sustain Sci* 2017, **12**:895-899.