Chapter 13
Synthesis: Concept, Methodologies, and Strategies to Address the Nexus in SEPLS

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Abstract This chapter synthesises major findings from the eleven case studies presented in the previous chapters, offering policy recommendations arising from the synthesis. It distills key messages to address questions on the following issues: (1) how to conceptualise the nexus between biodiversity, health, and sustainable development in the context of SEPLS management; (2) how to measure, evaluate, and monitor the effectiveness of SEPLS management in regard to securing and improving both ecosystem and human health; and (3) how to address the challenges and seize the opportunities of SEPLS management in minimising trade-offs and maximising synergies between different efforts augmenting both ecosystem and human health, as well as well-being, so as to move towards more sustainable futures. The chapter identifies several policy recommendations to better manage the biodiversity-health-sustainability nexus in SEPLS and facilitate transformative change for sustainable development. It also revisits the concept of the biodiversity-health-sustainability nexus to offer perspectives on the complex interlinkages in the context of managing SEPLS on the ground.

Keywords Socio-ecological production landscapes and seascapes · Nexus · Trade-offs · Synergies · One Health · Integrated approaches · Sustainable development

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1 How Can We Conceptualise the Nexus Between Biodiversity, Health, and Sustainable Development in the Context of SEPLS Management?

The **nexus between biodiversity, health, and sustainable development** can be seen as the interdependent connections between the ecological and human dimensions of a social-ecological system that together contribute to the well-being and resilience of the human-nature system (see Chap. 1). Such a conceptualisation furthers a recognition of the links between biodiversity and health in the sense of physical, mental, and spiritual health. Furthermore, human health and well-being are dependent on environmental health that provides various ecosystem benefits we derive including clean air, water, regulation of floods, food security, nutritional security, medicinal resource diversity, and access to various cultural benefits, among others. The understanding of this dependence of human health on the environment has become more vivid during the COVID-19 outbreak, when multiple challenges arising from the viral disease, including those relating to access to medical facilities, conventional food markets, employment opportunities, and the like, came to the fore especially in the context of local communities. We examine in this volume (and specifically this chapter) how communities cope and find solutions to address these multiple challenges within the context of socio-ecological production landscapes and seascapes (SEPLS). Specifically in the context of SEPLS, biodiversity acts like insurance to ensure security of food, health, energy, water, livelihoods, and income, among others. This is because a diversity of resources (and by implication well-functioning ecosystems) enhance options to mitigate or adapt to various perturbances (natural or human-induced) through regulating natural processes (such as floods and soil fertility), providing varieties that can adapt to climatic change, and opening economic opportunities that allow diversifying risks from economic or natural shocks, leading to better health outcomes. It is important to note that securing these benefits is dependent on the wise use of both traditional and modern knowledge relating to use, maintenance, and marketing of products and services from the SEPLS.

1.1 Human Health and Healthy Environment

Health and Sustainable Development

Health is defined as physical, mental, and social well-being (WHO, 2006), implying a deep and wide correlation that connects the environment with social relations and economic activities. What this means is that ensuring good health is a pathway towards achieving the Sustainable Development Goals (SDGs). For example, unravelling the various constituents of good health at the local level has been well highlighted in connection to food security and sovereignty brought about by dietary

diversity (for instance, see Chaps. 9 and 11). Also well understood are access to medicinal resources and spaces of cultural and aesthetic significance that are also important for mental well-being (in addition to physical health). This implies that ensuring good health at the community level strongly contributes to a high level of social-ecological resilience. In this context, the following components, in no specific order, have been identified as relevant parts of the nexus between biodiversity, health, and sustainable development:

- *Ensuring food security and sovereignty,*[1] *dietary diversity, and nutritional security:* To achieve this, ensuring a high degree of agro-biodiversity, furthering healthy soils, and "no-harm" agronomic practices (such as rational or low use of chemical pesticides and increase in ecologically friendly organic pesticides) are required. These have consequent benefits for the health of water systems (including coastal and marine ecosystems), other biological life forms, and human health (e.g. Chaps. 3–5, 10–12).
- *Ensuring the integrity of ecosystems especially relating to the regulation of natural cycles such as of water, soil fertility, carbon, nitrogen, and phosphorus:* Achieving this requires management of water, plant, and soil resources in a sustainable fashion and may involve regeneration activities. These activities have a direct impact on agricultural productivity, availability of clean air and water, as well as psychological health, in addition to enhancing biocultural linkages (e.g. Chaps. 4, 6, 7, and 11).
- *Ensuring One Health that includes the health of people, environment, and animals:* This requires interdisciplinary expertise from modern sciences and local knowledge to establish good practices for the integrated management of the health-for-all-linked components of human society and nature. This would require negotiating prejudices between disciplines, knowledge systems, and power hierarchies among different decision-making institutions. This nexus approach would enable policy coherence and a strong alignment of local-level priorities and policy goals on ensuring health and sustainability using a systems approach (e.g. Chaps. 2, 4, 9, and 12).
- *Ensuring that different stakeholders in the community are engaged proactively in the decision-making and management of SEPLS:* This ensures inclusion of various priorities related to well-being and bridges potential areas of conflict that could arise due to decisions related to the individual use and management of landscapes and seascapes. This would require an explicit acknowledgement of the rights and obligations of different stakeholders to the landscape and resources, including both primary and secondary stakeholders (e.g. Chaps. 4, 8, 10, and 12).
- *Ensuring connectivity between adjoining landscapes under different governance regimes:* This requires an explicit recognition of the heterogeneity of ecosystems that is to be factored in to planning and governance systems in landscapes and seascapes, including national and regional government reserves, production

[1] Sovereignty refers to control over types and supply of food.

areas, private lands, indigenous reservations, and other effective area-based conservation measures (OECMs). This will ensure conservation of biodiversity and ecosystems and their sustainable use, and will further ensure that the norms for access and management are fair, just, and equitable to all stakeholders (e.g. Chaps. 3, 4, and 5).

In summary, the nexus at the SEPLS level constitutes a combination of access to food, medicines, various ecosystem types and benefits, autonomy and co-management, and cultural and political rights.

1.2 What Does the Nexus Approach Mean in the SEPLS Context?

Based on the priorities identified in the nexus between biodiversity, health, and sustainability, we can further identify some clear scalar level guidance to the management and governance of SEPLS to strengthen these interconnections. These include the following:

- At the resource level:
  - Focus on promoting spatial connectivity (within and between landscape and seascape) that is crucial to the linkages between production practices and impacts on biodiversity and health of humans and other life forms.
  - Given the direct dependence of populations in SEPLS on biodiversity, for example for food, health, and nutrition, promote activities that enhance diversity of species and improve mediums that support life (such as soil, water), and encourage cultural practices that promote this diversity (e.g. endemic food, local food concepts, traditional medicine practices, sustainable production and consumption that are linked to cultural knowledge).
  - Enhance livelihood security based on the connectivity of traditional knowledge and modern sustainable customary practices such as aquaculture, small-scale fishing, crab culture, honey and wax culture, and traditional arts and crafts, as both alternative and additional livelihood options.
- At the governance level:
  - Focus on promoting inclusive planning among different stakeholder groups including women, youth, and other marginalised groups.
  - Promote cooperation and strategic alliances between public, private, and academic sectors with convergent goals and co-management scenarios.
  - Integrate traditional and modern knowledge for endogenous development, which works on the principle that all available knowledge and experience are leveraged to address well-being priorities on the ground for sustainable, regenerative development.

  - Promote intergenerational transfer and documentation of traditional knowledge and sustainable customary practices and sharing of experiences with other SEPLS and a wider set of communities that would foster relevant innovations.

- At the macro policy decision-making level:
  - Focus on initiatives that promote sustainability including "green" energy use; address issues of biodiversity loss, climate change, and livelihood security together; promote adaptive capacity; and reduce vulnerabilities to natural and socio-economic shocks (such as the pandemic, and other disasters from natural and economic or policy shocks).
  - Promote community-based approaches in national policymaking to encourage local solutions within larger Global North-Global South scenarios in observance of the United Nations Decade on Ecosystem Restoration.
  - Expand recognition of communities' rights, appreciation of their knowledge and values, and protection of their lands in relevant policy processes at international, regional, and national levels with a particular focus on the Post-2020 Global Biodiversity Framework (GBF) phase.

2 Measuring, Evaluating, and Monitoring the Effectiveness of SEPLS Management with Regard to Ecosystem and Human Health

The health-biodiversity-sustainability nexus is distinctive when it comes to SEPLS because of inherent human-nature interactions and scalar linkages. Although conventional methods and approaches for project monitoring and evaluation (M&E) are well known (Bours et al., 2014; GIZ, UNEP-WCMC, and FEBA, 2020), monitoring implementation of the interventions, particularly from the nexus lens, demands more tailored approaches for SEPLS, based on the specific conditions of the multiple ecosystems they represent, including their sociocultural diversity and well-being parameters. In this section, we discuss the approaches, tools, challenges, and opportunities with regard to monitoring and evaluating the effectiveness of interventions in SEPLS. The approaches and tools captured here emerge from the experience of the practitioners of on-the-ground projects and initiatives. Figure 13.1 shows the main keywords emerging out of these case studies with reference to M&E.

2.1 Approaches for Monitoring the Biodiversity-Health-Sustainability Nexus in SEPLS

The previous volumes of SITR highlighted the need for M&E in SEPLS and various M&E methods, focusing on SEPLS' multifaceted and multidimensional nature that

Fig. 13.1 Top keywords on relevance and methods of M&E approaches in SEPLS presented in this book

makes the need for integrated approaches much more essential (UNU-IAS & IGES, 2019; Nishi et al., 2021). In this volume, we discuss below such integrated approaches used by and mentioned in various case studies, namely:

Community engagement approaches: These include operationalising traditional knowledge systems, and building capacities of the community through facilitation, training, and engagement in localising global, regional, or national indicators. Communities need to be given greater ownership of the interventions, including the situational enhancement of the role of indigenous peoples and local communities (IPLCs), women, youth, and other marginalised groups in monitoring and documentation based on localised indicators.

Mixed approaches using both quantitative and qualitative methods: Although community engagement is deemed important, it is also useful to do economic valuation of biodiversity and ecosystem services to have quantitative estimates. To effectively use mixed approaches, studies on human-nature interactions must include social analyses to obtain a holistic picture, including qualitative aspects perceived from the ground. This transdisciplinary effort will help combine biophysical and social knowledge.

Interdisciplinary and multidisciplinary approaches: These approaches integrate expertise across different levels and sectors. For this to happen, there is a need to develop indicators that are locally sensitive and comprehensible to all involved stakeholders while taking into consideration the diversity of sectors and metrics involved in human-nature linkages that may need evaluation in terms of ecosystem and human health. The different stakeholders include the public sector (various ministries including health, agriculture, nature conservation, and environment), private sector, and local community. In the SEPLS context, we may mention this as a "whole-of-the-society" approach or an "interagency" approach.

Table 13.1 Synthesis of various approaches and tools used and suggested by the case studies

Approaches	Methods and tools
• Community empowerment and engagement of youth and women	• Use of indigenous and local knowledge • Revitalisation of traditional practices • Monitoring and documentation by the community • Participatory planning
• Resource mapping	• Local survey • Ecosystem service valuation
• Remote sensing	• Use of aerial imageries • Use of GIS data available at other platforms
• Localisation of indicators	• Selection of locally adapted indicators • Engagement or creation of local self-help groups to generate awareness on global indicators
• Networking	• Long-term ecological network • Engagement of multiple stakeholders

2.2 Tools and Indicators for M&E

Implementation of the above-mentioned approaches requires appropriate and need-based tools and indicators well suited to the SEPLS context. While no one tool or indicator alone would suffice for M&E in SEPLS, there are various options tried and tested by practitioners. Table 13.1 shows the various approaches and tools used in the case studies presented in this book. Some of them include the following:

SEPLS resilience indicators toolkit: This toolkit is unique in terms of its suitability and flexibility for a SEPLS as it offers a set of indicators that are designed for monitoring both ecosystem and human health and their linkages, but can be flexibly chosen and adapted through local consultation to accord with local conditions and circumstances.

Use of other available indexes: Other indexes, if well suited to the SEPLS condition, can be used, such as the Livelihood Vulnerability Index (LVI),[2] Social Vulnerability Index,[3] and other tools that include biodiversity mapping. Some of these already include multiple sectors or can be tweaked appropriately to include more indicators related to the ecosystem and human health nexus.

Setting benchmarks: For very specific local conditions, it is better to set appropriate benchmarks for the evaluation of ecosystem and human health including qualitative and quantitative changes in biodiversity and air, water, and soil quality.

[2]The LVI uses multiple indicators to assess exposure to natural disasters and climate variability, social and economic characteristics of households that affect their adaptive capacity, and current health, food, and water resource characteristics that determine their sensitivity to climate change (Hahn et al., 2009).

[3]Developed by the Agency for Toxic Substances and Disease Registry (USA), it was meant to create databases to help emergency response by planners and public health officials to facilitate identification and mapping of communities that will most likely need support before, during, and after a hazardous event. It is increasingly used as a part of a climate resilience toolkit.

This can also help in long-term resource mapping including degradation in ecosystem or human health, and effectiveness of SEPLS management and conservation.

Adapting global indicators: Although several global indicators are available from the SDGs, biodiversity, and health targets, many of them may not be well suited for local conditions. Such indicators can be tweaked or downscaled based on local parameters and needs, or more preference could be given to indicators that are already localised and well understood by the community.

To use these tools and indicators, quality data needs to be collected from the SEPLS, which can be done using the following:

Citizen science: Through citizen science, people share their knowledge and contribute to data collection and monitoring, thus enhancing their participation and collaboration in scientific research (National Geographic, 2012). In the context of SEPLS, this could be seen as one of the most preferred methods for collecting local-level data, as it can directly engage the local community. It helps develop networks for ground monitoring, provided that it considers ecological knowledge, local use practices, tradition and heirlooms, and other socio-demographic heritage indicators.

Secondary data: Secondary data or outcomes can be examined, for example, from remote sensing data related to land use, mountainscape transformation, or climate change.

Established methodological frameworks and networks: Available frameworks and networks can provide data that help to provide basic ground information of the SEPLS. These include networks like long-term ecological monitoring networks.

2.3 What Are the Major Challenges in SEPLS M&E?

Despite the availability of different tools and data, practitioners face challenges in various contexts and levels. Some of the challenges are physical barriers and others are social or capacity barriers. A few of these are discussed below:

Developing linkages between various indicators and frameworks: Although various global indicators are available for sustainability, biodiversity, and health, they often suffer from various trade-offs among them. There could be a trade-off between the objectives of SEPLS and other objectives, such as the SDGs. For instance, the SDGs' "zero hunger" goal promotes free food distribution, affecting people's capacity and ability to grow local foods and develop local markets. This makes M&E a tough task from the nexus perspective, as while one goal is achieved, another is compromised. Therefore, there is a need to develop a global framework of indicators that allows for minimising trade-offs and maximising synergies to address the biodiversity-health-sustainability nexus and achieve multiple sustainability goals. Such a framework is currently lacking. Further, there is a lack of a system of global indicators that fully considers the nexus, which may lead to gaps between global indicators and local ones.

Lack of data and robustness: There is a lack of scientific data for M&E, and when available, they are often not scientifically robust. Quantitative data do not

always address some socially relevant questions well, such as "why" a certain change happened. There is also a lack of knowledge on policy decisions that impact the lives of locals.

Monitoring after funding ends: There is often no monitoring after a project ends, as most donor-funded projects are output-focused and do not give much attention to long-term outcomes. For this reason, the actual effectiveness of the interventions is not measured over the long term.

Responsibility distribution for M&E: When multiple stakeholders are involved, the party responsible for M&E can remain unclear, and may depend on who owns the land, may it be private, government, or locals.

Quantitative nature of M&E: It is difficult to measure the benefits to a community, as they purely depend on what value community members put on the local resources, which broader quantitative estimates cannot measure.

2.4 What Are the Opportunities that Can Be Galvanised?

With challenges also come opportunities that can help overcome many barriers to effective M&E. These may include, but are not limited to:

Traditional knowledge and IPLCs: Local traditional knowledge and community-based monitoring can help with some of the listed challenges above, especially those pertaining to the lack of qualitative and on-the-ground data and responsibility for monitoring. Further, IPLCs also bring together years of accumulated knowledge and experience for better conservation and management. Thus, promotion of traditional knowledge in modern systems through participatory planning could be a way forward (e.g. Chaps. 2 and 3).

Mainstreaming of biodiversity and health: It is also worthwhile and relevant to mainstream health-biodiversity-sustainability indicators in other relevant indicators or approaches, to make them an integral part of ecosystem management and conservation (e.g. Chaps. 9 and 10).

Communication of M&E objectives and bridging stakeholders: In cases where the need for M&E and its implications to SEPLS management are clearly explained and well understood by the community and other stakeholders, the quality of the assessment process and its implementation can be enhanced (e.g. Chaps. 2 and 9). It is also desirable to bridge stakeholders including academic institutions, non-governmental organisations (NGOs), private companies, and other actors involved in facilitating SEPLS initiatives and fostering communication between primary (e.g. IPLCs) and secondary (e.g. government organisations) stakeholders in SEPLS. In many cases, these stakeholders play an essential role in conducting initial and follow-up M&E activities, in communication of M&E results and their management implications, and in capacity development of other SEPLS stakeholders (e.g. resilience assessment workshops in Xinshe SEPLS in Chap. 4).

3 How Can We Address the Challenges and Seize the Opportunities to Manage the Nexus in SEPLS?

To explore ways forward, the nexus approach helps to elucidate trade-offs associated with different pathways towards sustainability and to identify synergies that can build on the inherently coupled and mutually interdependent elements of SEPLS. This section first clarifies different types of trade-offs and then discusses the processes and steps to simultaneously attain multiple sustainability goals of SEPLS management through the nexus approach.

3.1 Types of Trade-Offs

Trade-offs are inevitable given the constraints in natural resources and multiple values attributed to them differently by different actors. The case studies show four types of trade-offs, including those between (1) ecosystem services, (2) stakeholders, (3) human well-being components, and (4) management goals. Due to the complex interlinkages between various elements of SEPLS, these types are not always clear-cut, but rather reciprocally influence each other. Furthermore, many of these trade-offs cut across sectors and scales, making varied impacts on different sectors, geographic and temporal scales, and governance levels. This typology is applicable to a wide range of multifunctional social-ecological systems (Lu et al., 2021; eds. Sarmiento & Frolich, 2020; Manning et al., 2018), but the case studies in this volume highlight the trade-offs in seeking for both ecosystem and human health and sustainability that can result from human-nature interactions within SEPLS.

Ecosystem Services

SEPLS, involving a variety of ecosystem functions and processes, provide multiple ecosystem services between which trade-offs can occur across sectors and scales. For instance, the case of the Angkorian landscape in Cambodia explicates the trade-offs between provisioning, regulating, and cultural services. The exploitation of forest resources (along with other drivers such as forest fire) has led to the reduction in water storage capacity and availability, affecting the quality and quantity of water in the upper catchment and threatening the downstream system of water management, which is also linked to agricultural production (e.g. through irrigation) and tourism (e.g. through flood control) (Chap. 7). In this case where tourism is highly dependent on natural and human-made water management networks, recent trends demonstrate that the excessively flourishing tourism (e.g. too many inbound tourists) contributes to the increase in demand for water that can put pressure on groundwater resources, not only affecting the water supply but also fragilising the structural base of the temples as cultural assets. More recently, the COVID-19 pandemic has

adversely affected tourism (through decreased tourists) and has in turn reduced the revenue available for the water sector, constraining the water management administration despite the lessened pressure on water resources.

Trade-offs also arise between quantity and quality of the same kind of ecosystem services. The case of Indian peri-urban wetlands accounts for experiences in which curbing the use of chemical fertilisers and pesticides has improved the quality of food provisioning services and redressed negative health impacts on humans, but reduced the quantity of food provision in terms of crop production (Chap. 6). Similar trade-offs are found in the case of the Ghanaian cocoa farms, where government intervention to control cocoa pests and diseases has significantly increased the cocoa output nationwide but undermined the quality of cocoa production, imposing negative impacts on ecosystem and human health particularly for those within and around the local cocoa farms (Chap. 12).

Stakeholders

Given the varied ecosystem services derived from SEPLS, trade-offs arise likewise among the stakeholders who receive those ecosystem services that contribute to human well-being. The Angkorian case, where upstream forest degradation has lowered downstream groundwater levels, illustrates that the material gain by the population in the upper catchment (e.g. forest products) is traded off with the well-being of those in the lower catchment (e.g. access to groundwater) (Chap. 7). This raises a question about who should pay for the benefits from water management (including forest management), considering that efforts in forest conservation in the upper catchment, as well as water-efficient agriculture in the mid-catchment, would contribute to downstream water conservation.

These trade-offs also involve political dimensions in regard to the distribution of benefits from SEPLS management. The case of Alpine landscapes in Austria shows that ski tourism development has definitely benefited the international enterprises and their customers (e.g. through sports, wellness, and health), who can largely control the business with their monetary power, but has mixed effects on human and ecosystem health at the local level (Chap. 8). The regular tourism-based income has helped to stabilise the livelihoods of the locals and keep traditional sustainable practices alive (e.g. traditional gentian use contributing to biodiversity conservation) while limiting opportunities for alternative land uses (e.g. through the construction of large wellness hotels) and for earning decent subsistence from farming alone.

The case of local vegetable promotion in Africa also suggests that the gender gap in power raises trade-offs in regard to the benefits from the vegetable production: the women's contribution to growing the underutilised vegetables is not socially well recognised but instead, men take a central role particularly once the initiative becomes economically profitable (Chap. 10). This alludes to the gendered trade-offs in equitable sharing of benefits from the initiative (e.g. economic profits, social recognition). The same case also points to possible trade-offs between holders and users of traditional knowledge concerning local species and associated cultivation

and utilisation practices. As the political and economic power of knowledge users mostly outweighs that of holders, particularly for traditional knowledge use, the rights of knowledge holders are often undermined without any regulations and their shared benefits from knowledge use could be compromised.

Human Well-Being Components

Related to the above trade-offs, different value preferences bring on trade-offs between human well-being components—including material, relational, and subjective dimensions of well-being. This kind of trade-off often happens between different stakeholders, and even within the same community and individual. The case study of the "ridge-to-reef" watershed in Chinese Taipei, for instance, signals the trade-offs incurred by the return of migrated youths to the community (Chap. 4). Some of the returned youths valuing quality of life surrounded by a wealth of nature (i.e. subjective well-being) became disillusioned with the rural living standard and fewer income-generating opportunities (i.e. material well-being) and went back to the city. Their continued urban lifestyle associated with wasteful consumption (i.e. material well-being of the returned youths) could be perceived by the locals as being against their cultural and traditional values (i.e. subjective well-being of the locals), leading to conflicts or undermining the social cohesion (i.e. relational well-being of both ends).

Another example is the Cambodian case of the Angkorian landscape where migration under the pandemic is leading to emerging trade-offs between food security and food sovereignty (Chap. 7). Food security of the locals (i.e. material well-being)—in addition to the security of land, water, and jobs—has declined due to the increased demand resulting from returned migrants in the aftermath of the COVID-19 outbreak. In combination with border closures and raised awareness of health, however, this challenge has turned their attention to local food and associated cultural practices, creating opportunities for food sovereignty through local food promotion and cultural preservation (i.e. subjective well-being). Nevertheless, achieving local sustainability may depend on whether the cost for local food production can be paid (i.e. material well-being) and whether the ownership of food, knowledge, and culture can be secured (i.e. subjective well-being). In this connection, the conflict between cocoa production and conservation in the Ghana case points to the importance of trade-off analysis that could evidence the ecological and health benefits from the integrated pest management (IPM) with biopesticide use compared to those from chemical pesticide use (i.e. material well-being) (Chap. 12). Such evidence helped increase the awareness among the farmers (i.e. subjective well-being), resulting in the increased adoption of IPM.

Management Goals

The sustainability goals of SEPLS management are indeed in multiples as similarly manifested in the SDGs. It is often the case that some goals could be compromised or even sacrificed to pursue other goals if it is not feasible to attain multiple goals at the same time. These trade-offs cut across economic, environmental, and social pillars of sustainability. For instance, conservation measures such as the mandatory ban of fishing during the spawning seasons of certain fish species (i.e. environmental) distress the livelihoods of those economically dependent on local natural resources such as traditional resource users (i.e. economic) (Chap. 2). The introduction of alternative livelihood means to them (e.g. aquaculture), however, could help to meet the original conservation goal (i.e. environment) without jeopardising their livelihoods (i.e. economic).

Even once a win-win situation is attained, economic betterment through natural resource use again requires caution for further trade-offs. The initiative to promote underutilised crops in Africa, for example, involves the threats of overharvesting and genetic erosion (i.e. environmental), particularly when it becomes economically profitable (i.e. economic) (Chap. 10). This threat could be furthered by attracting outsiders with different motivations or priorities, who may not only exploit natural resources for economic gain (i.e. environment vs. economic) but also undermine the social cohesion of the local communities (i.e. social). Similar trade-offs are suggested in the Indian case of peri-urban wetlands (Chap. 6). Some of those initially motivated in wetland conservation to develop ecotourism as an alternative livelihood activity could become further committed to tourism development (i.e. economic) but less attentive to conservation (i.e. environmental), especially once they are economically better off. Such a shift in mindset could divide stakeholders who were once more united to start up ecotourism with wetland conservation but started to seek different priorities and interests (i.e. social).

3.2 Ways Forward

To achieve multiple sustainability goals simultaneously, strategies for SEPLS management should essentially minimise inevitable trade-offs. Yet, solutions could be found not necessarily within the zero-sum game in resource allocation, but can build on synergies between multiple resources of SEPLS (Mohtar & Daher, 2017). The nexus approach helps address both trade-offs and synergies to seek for sustainability. Indeed, materialising the nexus approach in action allows us to pursue sustainable pathways. This process entails three steps: (1) identifying problems and solutions, (2) motivating multiple actors, and (3) governing multiple actions.

Identifying Problems and Solutions

To search pathways towards sustainability, it is highly critical to identify a "nexus hotspot". The hotspot is a vulnerable area of the "nexus" (i.e. wherein trade-offs are established) at a given scale, which faces stresses resulting from resource allocation that is at odds with harmonious human-nature relationships (Mohtar & Daher, 2016). Due to the multiscale nature of trade-offs, attention needs to be geared towards existing and potential nexus hotspots at multiple scales so as to minimise trade-offs and strengthen the weakest links to secure positive connectivity. This process requires attention to synergistic links between multiple resources so as to move beyond the zero-sum game for allocating fixed resources (Mohtar & Daher, 2017). The pathways could thus be better identified through dialogues and communications among multiple actors who value and bring together different resources and develop their own capacities for the nexus analysis (also see Chap 1).

Challenges and opportunities in drawing on the nexus analysis of problems and solutions lie in two levels: knowledge and information, and communications. First, knowledge and information concerning the nexus in SEPLS involve a high level of complexity, ambiguity, and uncertainties, giving rise to challenges. For instance, transition to a decarbonised society would require a major transformation, at least in tourism, energy, and water sectors in the Austrian context, but efforts to bring about such an unprecedented transformation may have unintended consequences, leaving equity-related questions about who will be benefited and who should be compensated for the costs for transition. Even in ongoing initiatives, challenges also exist. Adverse effects of pesticide use on human and ecosystem health and the productivity of cocoa farming have been felt and observed by local communities, and then their enhanced awareness has helped improve both ecosystem and human health synergistically at the local level (Chap. 12). Yet, these effects are not well recognised by policymakers, whereas fake or inaccurate information through media could mislead the stakeholders to take action. Also, transnational and multinational projects ignorant of local environmental conditions have made a huge investment in fossil fuel-based power plants in an ecologically critical area in Bangladesh.

Opportunities to overcome these challenges and forge synergies lie in the co-production of knowledge among multiple actors and making information more communicable to them (e.g. Sarmiento et al., 2013). Knowledge co-production among a variety of stakeholders—including local communities, government officials, enterprises, scientists, youths, the elderly, men, and women—allows for learning from their diverse experiences (including trial and error), bringing in new skills and different expertise, transferring knowledge within and across generations, and empowering stakeholders for their sound decisions and actions (e.g. Chap. 4). Among others, experiential knowledge held by local communities is essential for knowledge co-production in SEPLS, where trade-off impacts on ecosystem and human health are directly felt and seen. However, such knowledge is not always easily understandable and available in a communicable form to other stakeholders, including decision makers on the SEPLS management (e.g. policymakers). Some cases provide examples of efforts that have been made in this regard, such as the methodological development for documentation, synthesis, and visualisation of

knowledge and information on foodways for better recognition and communication among different stakeholders including knowledge holders (e.g. Chap. 10).

Second, communication of knowledge and information is an important process for the nexus analysis. Bringing together a wide range of stakeholders in the communication process (e.g. the "whole-of-the-society" approach) to avoid negative consequences for a certain SEPLS segment, particularly those vulnerable to environmental change (e.g. IPLCs), and build synergies is indeed a high road. Yet, it is not always easy to create new communication channels between different groups. The case of a biocultural hotspot in India illustrates the distinctions between the four sectors—food, health, culture, and biodiversity—which have posed a challenge in communication and collaboration to promote the combined efforts on local health traditions and local food baskets, but which if integrated could offer opportunities for synergies (Chap. 9). The case of forest and milpa landscape (FML) in Mexico also shows the challenges in involving external actors with very different interests and values (e.g. pig firms and mega-projects) in the process of local SEPLS management (Chap. 5). This is even tougher in situations of conflict and uprising. The case of Sundarbans in Bangladesh alludes to the transboundary conflicts of water allocation, which heighten competition rather than cooperation for transborder watershed management (Chap. 2). In the case of the Colombian Pacific ecoregion, where some civil unrest has amounted to uprising and violence, even those who are committed to collaboration (e.g. scientists, NGO workers) can hardly reach out to local and indigenous communities for interventions in livelihood support and cultural preservation due to security issues (Chap. 3).

Even when all stakeholders cannot be brought in, it is worthwhile to create or join a platform for communication, dialogue, and learning so as to start converging the interests of different stakeholders. The FML case of Mexico illustrates the workshop-based peer learning through which multiple local communities within a wider landscape came to better understand broader perspectives on socio-economic conditions and collectively developed integrative bottom-up action plans for SEPLS sustainability (Chap. 5). Likewise, in the case of Chinese Taipei, regional efforts have in fact progressed to facilitate dialogue across a wider land/seascape, as part of a nationwide initiative, called the Taiwan Partnership for the Satoyama Initiative (TPSI), to identify common issues across different SEPLS communities and systematically develop locally sensitive management strategies. The TPSI and Taiwan Ecological Network—and the national policy that supports them—operate with three types of nexuses including the "green nexus" (terrestrial ecosystems), "blue nexus" (freshwater and marine ecosystems), and "human nexus" (multiple SEPLS stakeholders nationwide).[4] In addition, as suggested by the Colombian case, even in the case where local- or regional-level communications are difficult, global sharing

[4]For further information, please see (1) Taiwan Partnership for the Satoyama Initiative (TPSI), Forestry Bureau, Council of Agriculture official website (https://conservation.forest.gov.tw/EN/0002040) and (2) 2018–2021 Taiwan Ecological Network, Forestry Bureau, Council of Agriculture official website (https://www.forest.gov.tw/0002812) (in Chinese).

of information and experiences would offer opportunities to facilitate global knowledge co-production, replication of good practices elsewhere, and international collaboration to overcome challenges (Chap. 3).

Motivating Multiple Actors

The process of knowledge co-production through communication, dialogue, and learning helps motivate people to act on the findings from nexus analyses. It facilitates awareness raising, capacity development, and community empowerment so that stakeholders can better understand existing and potential trade-offs, recognise their rights and responsibilities, and appreciate their capacities and resources in managing SEPLS. This process can have positive effects particularly on the subjective and relational well-being of stakeholders as members of society moving towards sustainability, possibly leading to a shift in mindset and behavioural change from unsustainable to sustainable practices.

However, material well-being is no less important to motivate people to take action for sustainability. The case of Kampong Cham in Cambodia clearly shows that farmers' uptake and continuation of sustainable agricultural practices (e.g. composting and use of organic fertilisers) fundamentally rely on their cost-benefit analyses to sustain their livelihoods (Chap. 11). If additional costs are incurred through the introduction of alternative practices to livelihood means, such costs need to be sufficiently compensated; otherwise community members can hardly be motivated to engage in such practices. Indeed, economic incentives would work for garnering interest and getting key stakeholders engaged in new sustainability projects. The Indian biocultural hotspot case offers evidence that the premium price for medicinal rice with value addition, which was achieved through marketing development supported by the local government, helped to compensate for the crop loss caused by switching from the previous chemical use to organic farming (Chap. 9). This intervention has economically incentivised farmers and other stakeholders to support and engage in practices that synergistically enhance ecosystem and human health. As a result, it has been replicated beyond the state in the country.

Economic viability of interventions is needed for the long term, but the sustainable practices supported through subsidised projects often cease once the project terms end. Economic viability, however, cannot be built overnight. It is rather susceptible to market conditions and difficult to ensure over the long run. The Cambodian case of sustainable farming practices exhibits the challenge that even the markets, which were once viable for organic products, have become threatened by changes under the COVID-19 pandemic (e.g. the loss of access to major markets as well as the loss of tourists as consumers resulting from border closures, and increased demand for quantity of food due to the returned migrants) (Chap. 11). To make SEPLS more economically viable and more resilient to shocks and stresses, cautious approaches could be taken. One way is to put safety-net measures in place to limit the liability of negative trade-off impacts on local communities (e.g. a

universal social security system to ensure access to health, education, and food security, microinsurance coverage for economic security) (e.g. Chaps. 2 and 6). Another is to build short-term measures within a SEPLS management programme (e.g. immediate income compensation, managerial and financial support) in consideration of a transition period for capacity development, which often takes time (e.g. Chaps. 5 and 6).

Governing Multiple Actions

As mentioned above, trade-offs occur across sectors, levels (governance), and scales (temporal and spatial). Governing different actions at smaller scales could be more feasible given that actors may identify trade-offs that are more visible at hand and could be motivated to develop synergistic solutions through more intimate communications and dialogues at the local level. However, managing the nexus that cuts across levels and scales requires coordination and implementation of activities at the large scale. This in turn provides opportunities to tap into diverse knowledge, expertise, and resources of a wider range of stakeholders while giving rise to challenges in mobilising and accommodating them and steering all of them towards sustainability. In this regard, governments fulfil an important role in enhancing policy coherence and ensuring fair and equitable incentive mechanisms across sectors and scales (Mohtar & Daher, 2017). The case of foodways documentation in Kenya alludes to the significance of policies, regulations, and protocols to prevent local natural resources from being exploited by outsiders and to protect the rights of traditional knowledge holders to be equitably benefited from knowledge use (Chap. 10).

Governments alone cannot manage the nexus. Their knowledge and information could be partial and might even be incorrect given the complexity, ambiguity, and uncertainties associated with the nexus, possibly misleading the governmental policies (e.g. Chap. 12). The "whole-of-the-government" approach may work to some extent to mobilise knowledge and resources from different sectors for more synergistic policymaking (e.g. cooperation between various agencies subordinate to the Council of Agriculture in Xinshe SEPLS, Chinese Taipei (Chap. 4)). Yet, knowledge and expertise at the government level can be insufficient to fully address existing and potential trade-offs and create synergies. Likewise, the media can serve as a major communication channel to cover and disseminate information, mobilise public opinion, and influence policies. Yet, their information could again be partial, biased, or wrong. If so, it may erroneously or even contradictorily influence policies, while the advancement of information and communication technology (e.g. social media) may offer opportunities to better inform policymaking and implementation.

Given that full-blown knowledge on the nexus cannot be produced instantly at a certain point of time and area, the governing process needs to be repetitive, cyclic, and gradual. Several case studies suggest that integrated and inclusive approaches to SEPLS management at the local level (e.g. the One Health approach) should be scaled up to address the issues of SEPLS that are interconnected and interdependent

at higher levels and scales (e.g. biodiversity, climate change, livelihoods, pollution, gender, employment, and health) (e.g. Chaps. 2 and 9). As a first step to do so, it is again crucial to support and, if needed, strengthen community-based governance institutions to facilitate endogenous development and make the interventions more sustainable. For instance, the case from Colombia points to the significance of safeguarding the livelihoods and knowledge of indigenous peoples in reducing their vulnerabilities and leading to betterment of both human and ecosystem health through their enhanced ecosystem stewardship (Chap. 3). In this connection, the Indian case of peri-urban wetlands suggests that a phased approach should help to mainstream local institutions into higher level policy, comprising step-by-step interventions in SEPLS management (Chap. 6). The approach included introduction of microinsurance coverage to local communities, provision of alternative economic opportunities along with capacity development, consultation among different stakeholders with administrative and financial support, and awareness raising at the broader scale.

These governing processes can facilitate identifying and acting on synergistic solutions that build on local experiences and lessons but mobilise a broader range of knowledge, expertise, and resources to minimise trade-offs and create synergies. Synergistic examples at the relatively small scale include job creation based on traditional practices (e.g. food production and cultivation), which has led to sustainable use of biodiversity, cultural preservation, land security, and income generation for the locales (e.g. Chaps. 2 and 7). Another example at the larger scale is the "ridge-to-reef" synergy where eco-agricultural practices in SEPLS have contributed to (1) improved health of the coral reef coastal ecosystem, (2) reintroduction of native species leading to revitalisation of indigenous and local knowledge, (3) creation of new income-generating opportunities based on local natural resources and return of migrant youths, and (4) enhanced social capital of the communities allowing for more marketing opportunities and more resilient livelihoods (Chap. 4).

4 Conclusion

The interconnections between biodiversity, health, and sustainable development in the SEPLS context could be considered fundamental to ensure the well-being of the social-ecological system. A well-functioning and biodiverse ecosystem ensures attainment of various material benefits (e.g. food, medicine, clean water), regulating benefits of natural processes such as water cycles and nutrient cycles, and intangible and non-material benefits (e.g. cultural and educational values). These in turn provide a base for productive livelihoods and attainment of different components of good quality of life, which range across security of food, health, income, livelihoods, and identity, to name a few. Factors that enable achieving a good quality of life include access to biodiverse resources; knowledge related to their use, management, and value addition; adaptive capacity to economic and environmental shocks; and equitable and respectful interactions between different stakeholders in the

governance and management of the SEPLS. That said, in practice, as the case studies highlight, several trade-offs arise owing to non-alignment or mismatches between sectoral goals, stakeholder priorities, and institutional mandates.

At the same time, opportunities to synergise resources can be leveraged across the phases of decision-making (i.e. planning, implementation, assessment, monitoring, and review) through participatory and inclusive approaches involving all stakeholder groups. The importance of peer learning, co-production of knowledge, promoting co-management and co-responsibility over resources and sectoral priorities, fostering bridging of institutions to negotiate and reduce conflicts, and engaging citizens to ensure "whole-of-society" commitment comes across quite clearly in this regard.

Given the high relevance of local actions to meeting national and global policy goals on sustainable development, evaluation, monitoring, and reporting on such activities to high-level planning forums are essential. This also needs to be done in a manner that ensures the richness of the contexts but speaks to the generalised language of policy forums. What is noteworthy, though, is that multiple synergies and trade-offs arising from the complex socioal-ecological connections in SEPLS challenge the monitoring of progress in the nexus context. This could be resolved through globally accepted indicators harmonised in the manner of minimising trade-offs and maximising synergies, and localised based on community needs and adaptability. It means that even while there exist no single methodology or standardised indicators to measure or assess the strength of the nexus between biodiversity, health, and broader sustainability goals, the case studies demonstrate that it is possible to do so by contextualising accepted indicators and engaging in more inclusive and participatory approaches to planning, managing, and governing SEPLS. However, these also require investments in data collection, mainstreaming activities, and capacity-building of different stakeholder groups to sensitively conceive of and implement SEPLS management plans taking into consideration multiple sectors and their overlapping agendas.

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