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SPECIAL FEATURE: REVIEW ARTICLE

Operationalizing the Nature Futures Framework to Catalyze the Development of Nature-Future Scenarios

Exploring bioproduction systems in socio-ecological production landscapes and seascapes in Asia through solution scanning using the Nature Futures Framework

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Abstract
Social–ecological production landscapes and seascapes (SEPLS) are an essential source of livelihood for people worldwide; however, they are experiencing challenges due to climate and ecological systems' change affecting their bioproduction mechanisms. These externally influenced drivers challenge their relevance, which calls for the revitalization of these systems focusing on sustainable use and management of resources with increased socio-ecological resilience and improved economic viability. In response, this study was conducted by reviewing the literature on 90 bioproduction systems in SEPLS across three countries in Asia, Japan, Philippines and Indonesia. Through a solution scanning exercise, the study aims to identify the driver of change, the involvement of stakeholders, and the prominent response types considered during their revival. The recorded 348 policy responses are filtered using the Millennium Ecosystem Assessment-based response typology to systematically categorize the scanned solutions, and the Nature Futures Framework (NFF) to capture the linked pluralistic values. In addition to the solutions, the study captured the drivers of change and other characteristics of the bioproduction system. Overall, the stakeholder engagement, the solution type, and pathways to achieve the NFF perspectives vary across the countries. In all study countries, the change in natural, physical, and biological systems and challenges posed by land use change are the key direct driver. Indirect drivers in Japan are mainly associated with demographic change, while in the Philippines and Indonesia, they are socio-political and technological challenges, respectively. The NFF filtering indicates a stronger lean toward a 'Nature as Culture/One with Nature' perspective, achieved through solutions targeting sociocultural and behavioral change and community-based management. The solutions and the filtering allowed an understanding of the differing approaches, which can guide other bioproduction systems in enhancing their socio-economic resilience and bringing transformative change to SEPLS.

Keywords Socio-ecological production landscapes and seascapes · Bioproduction system · Solution scanning · Nature Futures Framework · Local traditional knowledge · Policy response

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Introduction

Bioproduction systems in socio-ecological production landscape and seascapes (SEPLS)

Humans' interaction with nature has led to a plethora of knowledge about effective local resource use and management, resulting in the emergence of "socio-ecological production landscapes and seascapes" (SEPLS). Bioproduction systems, which involve the production of goods and services using biological resources and processes, can be an important part of SEPLS. Through the interaction of experiences, innovations, and various types of knowledge (written, oral, visual, tacit, gendered, practical, and scientific), bioproduction systems in SEPLS showcase practices that have the potential to overcome threats imposed by climate change and other drivers. The traditional local practices that form a part of SEPLS can enhance the productivity and resilience of bio-production systems while reducing the need for chemical inputs that can harm the environment and human health. Further, SEPLS provide important ecological and social contexts for the development of sustainable bioproduction systems, which can enhance ecosystem services, support local livelihoods, and promote biodiversity conservation (SCBD 2010; UNU-IAS and IGES (eds) 2018).

Over years, stakeholders involved in the use, management, and conservation of SEPLS with different value perspectives toward nature have showcased the co-existence of humans and nature in harmony (IPBES 2022). SEPLS are referred to differently in distinct parts of the globe (e.g., the *satoyama* of Japan, the *dehesa systems* of Spain, the *pekarangans* of Indonesia, *mauel* in Korea, *muyong* in the Philippines), and their practices, including use, management, and conservation, often vary from place to place (Gu and Subramanian 2012; Buot and Buhay 2022). Some of the bioproduction systems in SEPLS are recognized and protected, while others remain unrecognized but play a crucial role in conservation efforts. Although the physical structure, management techniques, and social systems within these production landscapes vary, some of the characteristics of SEPLS are similar: for instance, the extensive use of local resources, nutrient recycling, diversity (spatial and temporal), selection of local crops, and use of traditional knowledge (Blasiak and Ichikawa 2012). A recent study suggested that SEPLS may offer experience-based insights into addressing global and local conservation goals and enhanced socio-ecological resilience (UNU-IAS and IGES (eds) 2018) as well as understanding societal transformation toward sustainability (Maiko et al. 2021); hence, bioproduction systems in SEPLS are studied.

Challenges faced by SEPLS and bioproduction systems

Changing climate and declining biodiversity and ecosystem services (BES) due to land use change and other drivers make the bioproduction mechanism of SEPLS vulnerable (Dharmarathna et al. 2012; Takeuchi et al. 2018; Hashimoto et al. 2019), thereby undermining the source of livelihood for local people across the world (Takeuchi et al. 2018). The drivers not only impact the ecological resilience and economic viability of the SEPLS, but also severely affect the sociocultural system within the SEPLS, impacting physical structure, management techniques, and governance systems. They hinder the sustainable use and management of SEPLS and affect the range of specific values (i.e., intrinsic, instrumental, and relational) linked at multiple spatial scales of the landscape with multiple stakeholders (Gu and Subramanian 2014; Duraiappah et al. 2014; IPBES 2015, 2022). Bioproduction systems in Asia are witnessing challenges due to climate change, depletion of natural resources, youth exodus from rural communities, and lower economic gain (IPSI Secretariat 2017; Reyes et al. 2020). Revitalizing bioproduction systems within SEPLS to improve their socio-ecological integrity with enhanced resilience requires understanding the system's drivers and applied adaptive mechanisms. Hence, their revival requires solutions to changing dynamics of bioproduction and sociocultural value systems (Kozar et al. 2020).

To respond to these challenges, international organizations are working toward the revival of SEPLS in a way that gives weight to food production and biodiversity conservation while emphasizing the associated sociocultural benefits, thus creating resilient ecosystems (FAO 2008; IPSI Secretariat 2017). The organizations emphasize the role of local traditional knowledge in developing a scientific approach to formulate strategies to respond to the wide-ranging challenges (FAO 2008; Diaz et al. 2015; IPBES 2019). SEPLS aspires to achieve sustainable development through rebuilding and nurturing multifunctional landscapes (Ichikawa and Yiu 2016). The IPBES Regional Assessment Report for Asia and the Pacific also accentuates the local community's involvement in addressing the accelerating loss of BES (IPBES 2018). Further, capturing multiple ecosystem services for resource management is a critical area of research while recognizing the relevance of local actions in addressing sustainability challenges (Cremades et al. 2019; Rasul and Sharma 2015).

The organizations working toward the revival of SEPLS offer locally relevant solutions and policy options to address environmental challenges. However, the knowledge gained from experience-driven solutions is often not considered in scientific assessments or integrated into transdisciplinary science-policy processes, despite its potential benefits for sustainability transformations. Previous studies highlight the need to synthesize this valuable knowledge to facilitate environmental decision-making and produce sustainable solutions (Kozar et al. 2019; Lang et al. 2012; Castro et al. 2018). This study conducts a literature review using a solution-scanning approach to shed light on evidence-based solutions and response options in bioproduction systems in Asia, specifically in Japan, the Philippines, and Indonesia, considering their unique socio-ecological contexts. Solution scanning involves collecting and analyzing information to identify potential solutions to problems and support decision-making in various fields, such as environmental science, sustainability, and biodiversity conservation. The study follows three steps: first, the identification of relevant cases in the three countries through a horizon scan; second, the capturing of each case's biophysical and socio-economic characteristics, including community and stakeholder engagement levels and key drivers of change in bioproduction systems; finally, recording the policy responses and solutions mentioned in each case.

Several case studies of SEPLS show policy responses aimed at restoring ecosystems and promoting sustainable resource use (UNU-IAS and IGES (eds) 2018). The analysis of these solutions is done using the Millennium Ecosystem Assessment (MEA)-based response typology and pluralistic value-based frameworks to filter the policy options identified in the three countries. Capturing the empirical evidence-based solutions and categorizing them using the MEA-based response typology enables us to understand how scales, ecosystems, and socio-ecological context interact to offer empirically tested options that can advance understanding of trade-offs in managing bioproduction systems in SEPLS (Opdam 2018; McCormick et al. 2016). The filtering process helps uncover the most suitable and successful combination of solutions relating to improved agricultural production, applied conservation technologies, changes in behavior, knowledge systems, and management or livelihood practices. Additionally, to capture the efforts made by local communities to revitalize SEPLS, a pluralistic value-based framework recognizes the existence of multiple values and perspectives within SEPLS. Using two filtering frameworks allows a more comprehensive and balanced approach to capture the effective combinations of response type and pathways, and perspectives that can leverage change in the bioproduction systems of SEPLS.

The following section is "Materials and methods", which explains the solution scanning approach in "Solution scanning approach" and the two frameworks to filter the solutions in "Filtering of solutions using MA response typology and Nature Futures Framework". The methodological overview describes the three steps in the solution scanning approach in "Data collection and data analysis". Each step mentions data recording details, variables, and data entry protocols. "Results" explains the outcome of data analysis of step 2 and step 3 of solution scanning under different subheadings. "Discussion" discusses the findings according to the filtering framework by providing insights into the policy response options to drivers of change and value perspectives that can leverage transformation through sustainable use and management of bioproduction systems. The section also lists some limitations and future work and the paper ends with a conclusion in the final section.

Materials and methods

Solution scanning approach

The solution scanning approach gathers, processes, and disseminates information to support decision-making (Sutherland and Woodroof 2009). It allows a rigorous literature review with an inventory of possible solutions to problems before weighing each solution's viability and benefits specific to the context (Sutherland et al. 2014). So far, its application is seen in environmental science, sustainability-related research, biodiversity conservation, and transdisciplinary studies to identify policies to support decision-making or design research agendas (Sutherland et al. 2014; Dicks et al. 2016; Sugiyama et al. 2017). Studies include cataloging agroforestry-based solutions; capturing strategies of European forest ecosystem services; and demonstrating the relevance of place-based solutions in SEPLS (Hernández-Morcillo et al. 2018, 2022; Plieninger et al. 2018; Somanje et al. 2020; Kozar et al. 2020).

As per the solution scanning approach, the three steps are horizon scan, solution scan, and filtering (Sutherland et al. 2014). The steps generally entail identifying the problems and issue that needs attention, searching for existing solutions to address them, and understanding and analyzing them to allow application (ibid). Together, the three steps allow for capturing more efficient and effective problem-solving processes by building on the experiences and knowledge of others who have faced similar challenges. The three steps are represented graphically in Fig. 1. In the 1st step (horizon scan), the study chose to focus on bioproduction systems, which are witnessing a decline of BES due to increasing threats from internal and external drivers in the subregions of Asia. The rationale behind the selection of cases is explained in "Step 1 (horizon scan)". In the 2nd step (solution scan), for the identified studies showcasing the presence of traditional, hybrid, or modern bioproduction systems, we conducted a literature review to scan for the drivers of change and the solutions applied in these bioproduction systems. In addition to listing the policy

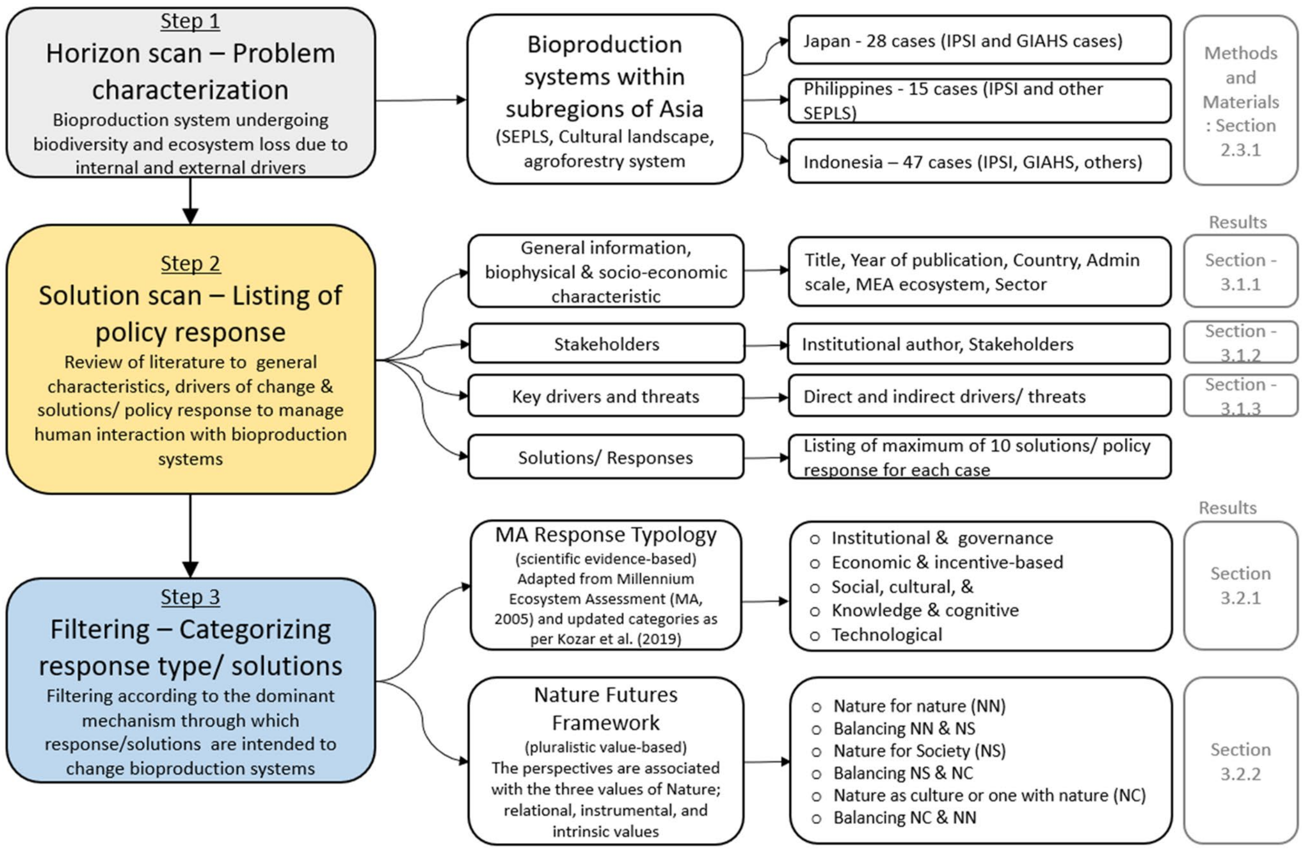

Fig. 1 Solution scanning approach: a methodological overview

responses, the study collected additional data, which includes general information, bio-physical and socio-economic characteristics, stakeholder details, identified drivers, and solutions (as in Fig. 5). Following this, filtering of the solution is done in the 3rd step (filtering) using the evidence-based and pluralistic value-based framework (as explained in the following paragraph).

Filtering of solutions using MA response typology and Nature Futures Framework

For the filtering process, the study used: (a) the response option typology adapted from Millennium Ecosystem Assessment (applied by Kozar et al. (2019)), henceforth referred to as MA response typology and (b) the Nature Futures Framework (NFF) proposed by IPBES (2022). The frameworks allow the identification of solution types and prominent pathways, followed by bioproduction systems in different socio-ecological contexts. Listing of actions and interventions through applied solutions allows for uncovering ways to improve collaboration and multi-stakeholder involvement and gathering of practical and experience-based insights to leverage transformative change (Fig. 2).

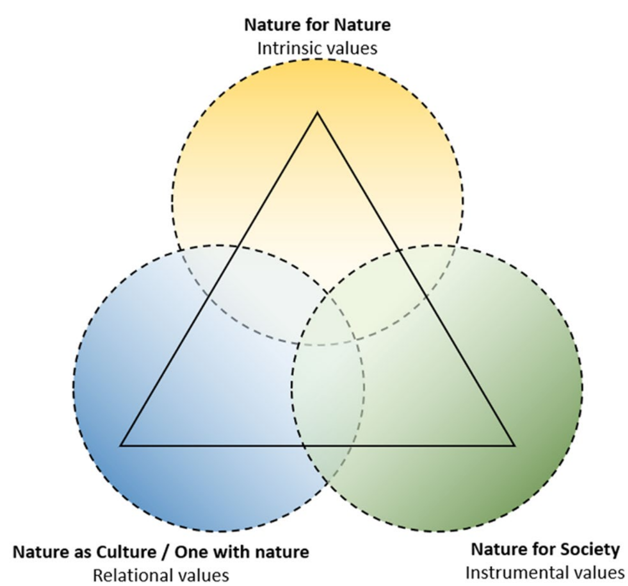

Fig. 2 Three value perspectives of the Nature Futures Framework (NFF) (adapted from Draft foundations of the Nature Futures Framework by the IPBES task force on scenarios and models)

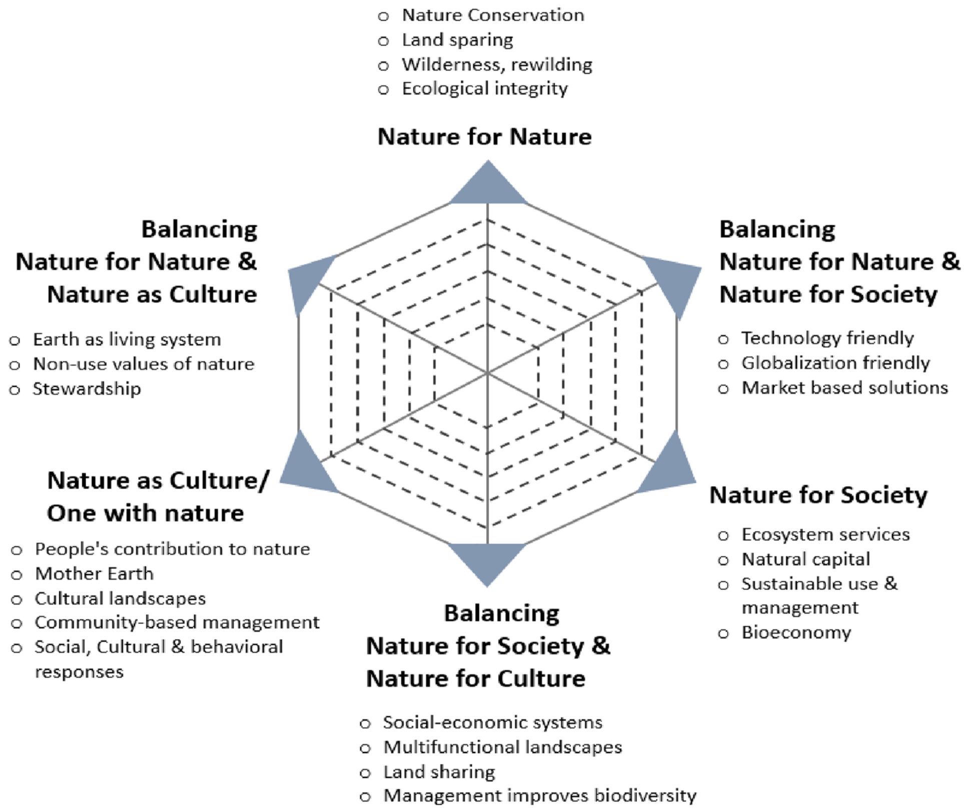

Fig. 3 Three value perspectives and their midpoints per the NFF used in the study for filtering solutions with their descriptive characteristics

The MA typology allows the capture of solutions under five response types: institutional, cognitive, social and cultural, economic, and technological (MA 2005). In addition to the five response types, we filtered the solutions as per the 26 subtypes derived by Kozar et al. (2019). We also employed the IPBES NFF to elucidate the plural value perspectives of nature embedded in various solutions. The NFF proposes and develops nature-centered scenarios to create visions and narratives for the future, in which the relationship between people and nature is the core (IPBES 2019, 2022; PBL 2018; Pereira et al. 2020; Kuiper et al. 2022). A recent study demonstrated that the NFF could be used as an archetype and template to synthesize pluralistic perspectives of nature (Quintero-Uribe et al. 2022). Further, the framework captures direct and indirect use, non-use (intrinsic), and relational values (Kim et al. 2021; Mansur et al. 2022). As highlighted by the IPBES assessments, capturing diverse values and embedding them into decision and policy-making is essential to achieve the 2050 Vision for Biodiversity and the 2030 Agenda of SDG (IPBES 2022). Hence, NFF is used to capture the specific values linked with the solution to understanding value perspectives that encompass local people's relationship with nature. The three broad categories of value perspectives in the NFF are (1) nature for nature (NN), (2) nature for society (NS), and (3) nature as culture/one with nature (NC) (Pereira et al. 2020; IPBES 2021), which are associated with the three values of nature: intrinsic, instrumental, and relational values. Per se, intrinsic values are independent of people as a value; instrumental values are generally associated with "ecosystem services"; and relational values represent meaningful human–nature interactions. The NFF value perspectives capture a multi-dimensional space within these three values; however, the preference varies (Lundquist et al. 2017; PBL 2018; Kim et al. 2021). Accordingly, the intermediate spaces are identified by Kim et al. (2021) with three more narratives balancing the core values and their distinctive descriptive characteristics. Following this, the study used six value perspectives to filter the recorded solutions (as in Fig. 3). As the NFF has been proposed recently, its application in case studies is limited, which makes use of NFF for solution scanning a novel attempt to evaluate the trajectories followed by bioproduction systems in Asia in response to current global challenges.

Data collection and data analysis

The study involves systematically organizing and categorizing data for bioproduction systems in SEPLS, with different variables across scales and regions, covering over 90 cases. The data collection and analysis were guided by the three steps of the solution scanning approach (as in Fig. 1) and explained in detail in the following section under each step. Descriptive statistics were used to prepare the dataset, which was then analyzed to gain a clearer understanding of patterns and trends and identify potential relationships or correlations between variables. By analyzing the recorded solution and response options, the study recognized preferences for solution types by region, ecosystem, and scale. This provided valuable insights that could guide decision-making and facilitate the co-production of sustainability solutions. The approach provides a valuable starting point for further investigation and analysis.

Step 1 (horizon scan)

For the study, the cases identified by the International Partnership of the Satoyama Initiative (IPSI) networks, the Globally Important Agricultural Heritage Systems (GIAHS), and other bioproduction systems showcasing revitalization efforts at the local level are considered for review, since they share similar concepts and objectives though branded and/or institutionalized by different organizations (Uetake et al. 2019). To be more precise, the IPSI cases aim to realize "societies in harmony with nature" through collaboration with local stakeholders. The GIAHS approach encompasses, 'dynamic conservation,' and the IPSI approach 'integrates traditional ecological knowledge and modern science to promote innovative management' (Ichikawa and Yiu 2016). Similarly, the GIAHS-designated sites showcase diverse traditional agriculture systems aiming to embody the concepts of sustainable development, socio-economic progress, and environmental conservation through the co-adaptation of the community with the environment (FAO 2018). In total, 90 case studies were reviewed in this study, of which 28 were from Japan, 15 from the Philippines, and 47 from Indonesia.

In Japan, the cases identified by these networks showcase multifunctional landscapes, where the networks work with the local community to enhance biodiversity while sustaining the community's well-being in response to the observed threats. As the number of cases cover many regions of Japan with different ecosystems, the study is restricted to the network-identified cases only. In the case of the Philippines, a combination of IPSI and other case studies that delve into human–nature interactions on different traditional and modern bioproduction systems were scrutinized. As the country's rich biodiversity faces numerous threats and risks from climate change and anthropogenic factors, the selected local case studies dig into solutions that align with the vision and perspectives of IPSI. It encompasses those cases ranging from multi-stakeholder collaborations and participation to those realizing the importance of indigenous or traditional ecological knowledge in sustainable management of SEPLS. In Indonesia, IPSI cases and bioproduction systems from the Sumedang regency in West Java are selected for study. The Sumedang regency is a potential site for piloting GIAHS studies in Indonesia. The area has various traditional agricultural bioproduction systems that embody the concept of sustainable development; however, they face challenges due to a changing climate. As the bioproduction system maintains the region's economy, it must increase its adaptive capacity to meet these challenges through innovative solutions. Accordingly, the cases are selected to record the effort made by the community and government to meet the challenges. Appendix A lists the title of the studied cases, code number of cases, data collection sources, and publication year of cases, and Fig. 4 indicates the geographic locations of the cases.

Step 2 (solution scan)

Data collection, data source, and data variable For the selected cases, the data were collected from various sources; for IPSI cases, the referred data includes the online database hosted by the Secretariat of IPSI and publications by the Satoyama initiative. The literature review of the GIAHS cases is done by procuring a proposal document from the FAO website (http://www.fao.org/giahs/en/). For additional Philippines and Indonesia cases, project reports, publications, and gray literature are included (Appendix A).

To guide data collection, a document was prepared with variables, their pre-defined values, and data entry instruction (Appendix B) to allow systematic data entry in Microsoft Excel by the project members from different countries (Appendix D). Both Appendix B and Appendix D were adapted from Kozar et al. (2019, 2020). Further online workshops (March 11th, 2021, and May 13th, 2021) and monthly meetings were held to arrive at a common understanding of variables, terminologies, and the identification of solutions. The listing and filtering did not consider the effectiveness or stage of solution implementation.

General information and biophysical and socio-economic characteristics Under general information, the study recorded publication year, title, and country details (Appendix A). Further, the administrative scale is recorded under six values (from national to sub-village scale). Biophysical and socio-economic characteristics include the most significant land use area of the bioproduction system under 'ecosystems,' activities implemented under 'sector' and activities performed for living in the form of 'livelihood' was collected. The ecosystems are recorded per the ten classification types of the MA ecosystems (MA 2005; Kozar et al. 2020), which characterize the area's land use. For each case, four values are recorded, reflecting the case study's focal ecosystems. The sectors indicate activities carried out, and a maximum of five values are recorded from the pre-defined

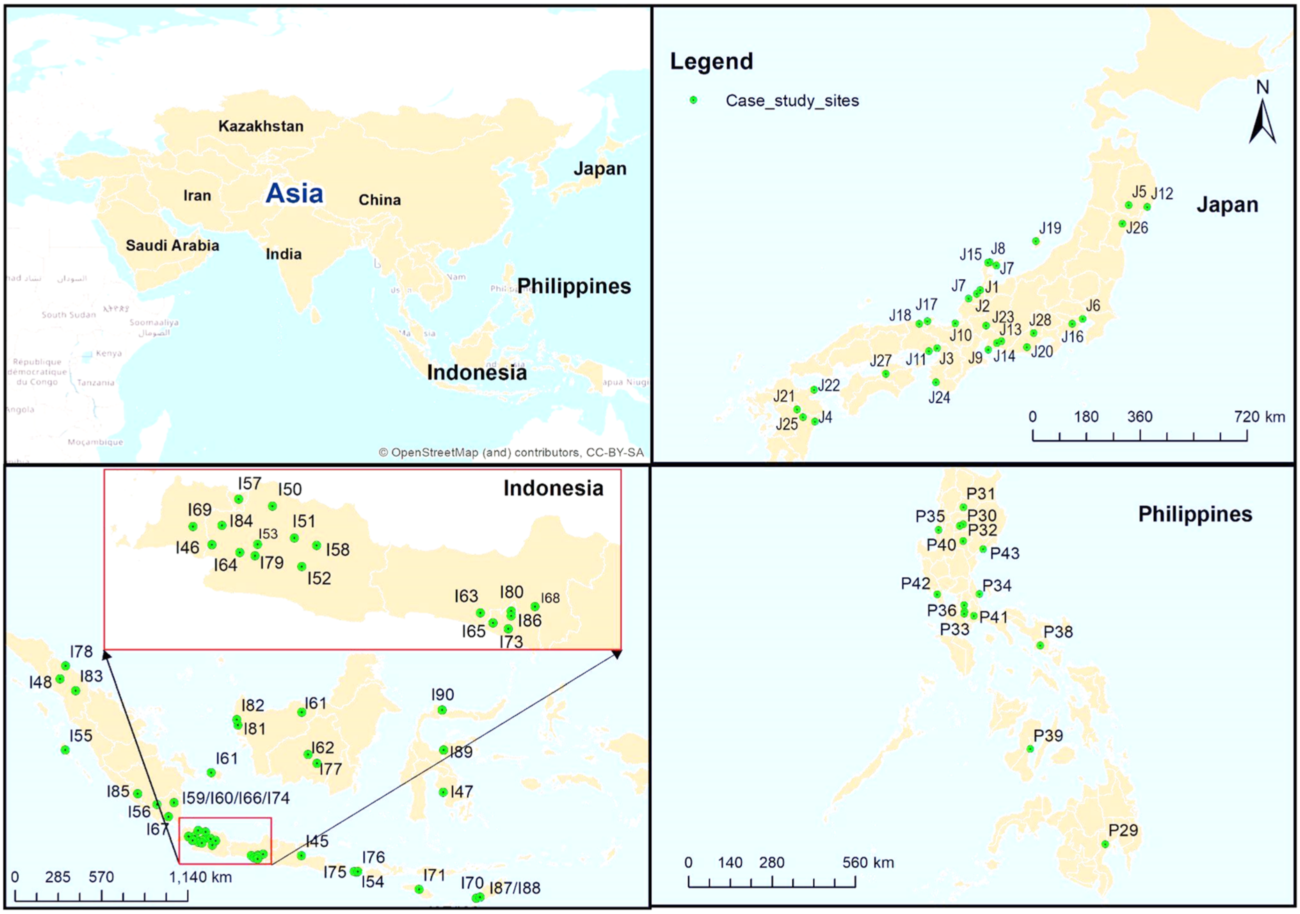

Fig. 4 Map showing the locations of the selected case studies in Japan (case code number starts with J), Philippines (case code number starts with P), and Indonesia (case code number starts with I)

values (Fig. 5 and Appendix B). Through open response, livelihood and socio-economic activities were recorded; their statistical analysis was not performed, but it allowed us to capture significant products and activities within the areas.

Stakeholder details and identified drivers Further, to capture the level of involvement of different actors and the collaboration between stakeholders, the details of key institutions and stakeholders are recorded in each case. For stakeholders, a maximum of eight and a minimum of one value were listed from the 20 pre-defined values (Table G in Appendix B). They were subdivided into public, nongovernmental, research, and community. The identification of the organization of the authoring institution or the affiliations of individual authors is listed from the eight pre-defined values (Table D in Appendix B).

Identified drivers The problem, events, and processes affecting these bioproduction systems are drivers and threats. Following the MA response typology, drivers are 'natural or human-induced factors that cause a change in ecosystems' (MA 2003). Using the categorization of direct and indirect drivers defined by the MA response typology, the threats identified for each case are categorized as direct and indirect and further classified as per the subtypes.

Solutions and responses In the case study area, any activity, intervention, innovation, practice, strategy, or policy suggested or implemented to address a given problem is regarded as a solution or policy response (Kozar et al. 2019, 2020). The case study lists a maximum of ten solutions for each case, and if the implemented solutions/responses are less than ten, the corresponding cell is marked as 'not indicated'.

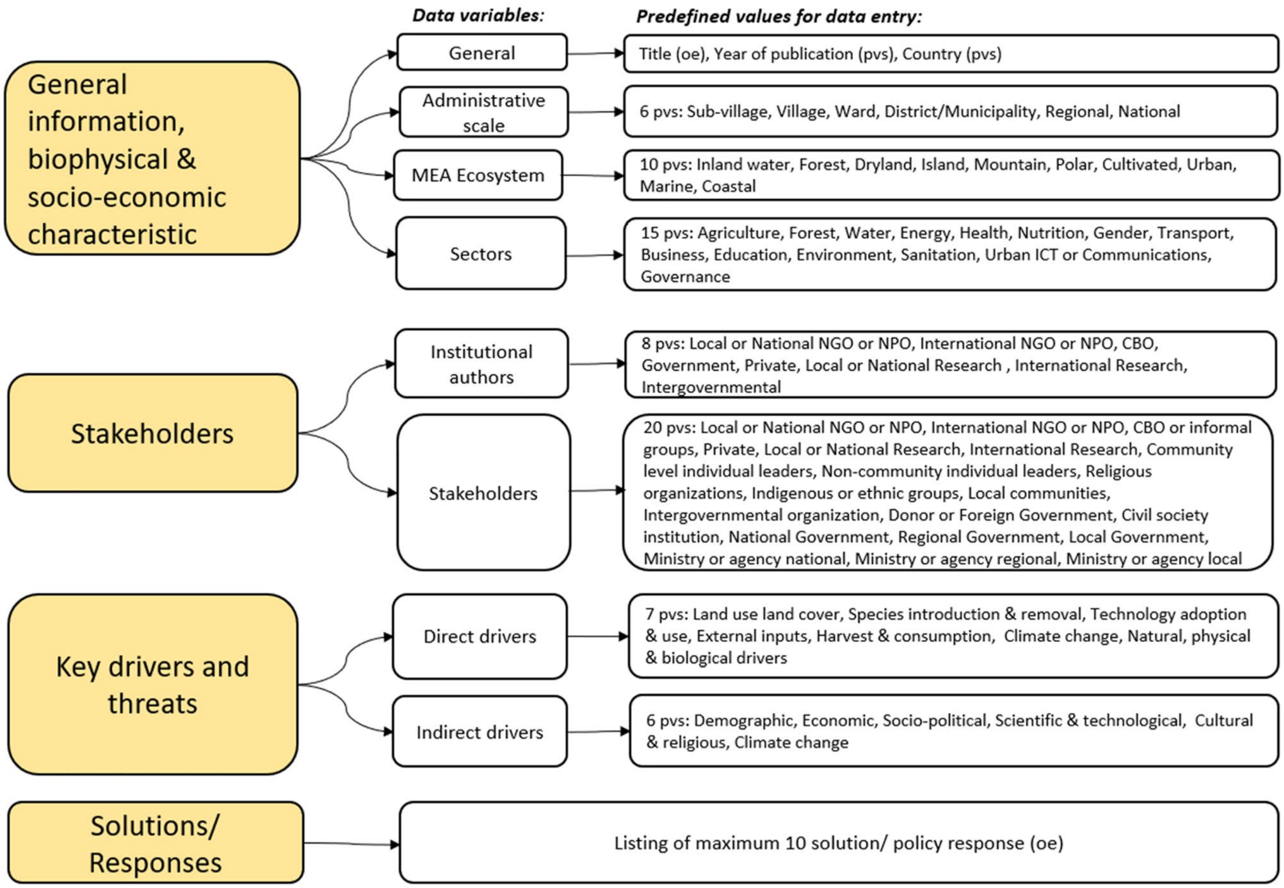

Fig. 5 Details of step 2 (solution scan), showing the data variables under the collected data with their pre-defined values used during data entry (under the data variable, pvs refers to pre-defined values, and oe refers to open-ended response). A comma separates the pvs. The definition used for each data variable and instruction guide for data entry are explained in Appendix B, and adapted from Kozar et al. 2019

Step 3 (filtering)

Filtering and classification of MA response type First, the solutions recorded under the cases were sorted into the MA's five response types and 26 subtypes, adapted from the Millennium Ecosystem Assessment and later modified by Kozar et al. (2020) 2005—a further explanation is given in Appendix C.

The interactions between the five broader MA response types (institutional and governance; economics and incentive-based; social, cultural, and behavioral; knowledge and cognitive; and technological) were examined. For each case, the number of MA response types present was identified. A case with three MA response types was considered a 3-way connection. If it had four, it was considered a 4-way connection. An example of a 3-way connection is policy options related to institutional and governance, economics and incentive-based, and knowledge and cognitive. Overall, identifying the interactions between the MA response types helped to determine whether the identified cases followed an integrated and coordinated approach to ecosystem management and decision-making.

Interpretation of value perspectives embedded in response options as per NFF Application of ecosystem service-based assessments is widespread, with diverse approaches including social–cultural values of nature (Pascual et al. 2021; Chan et al. 2016, 2018). However, engagement of a broader range of values, notably relational values, has been highlighted by Chan et al. (ibid). Hence, to assess the solutions through the lens of the human–nature relationship, NFF was used to filter the solutions (as shown in Fig. 3). Each solution was associated with the closest descriptive characteristics of different NFF perspectives for filtering. As many solutions were not limited to one character and indicated interactions, three descriptive characteristics were listed for each solution. The perspective was assigned to the solution based on the prominence of characteristics. A balancing perspective between the two core perspectives was assigned

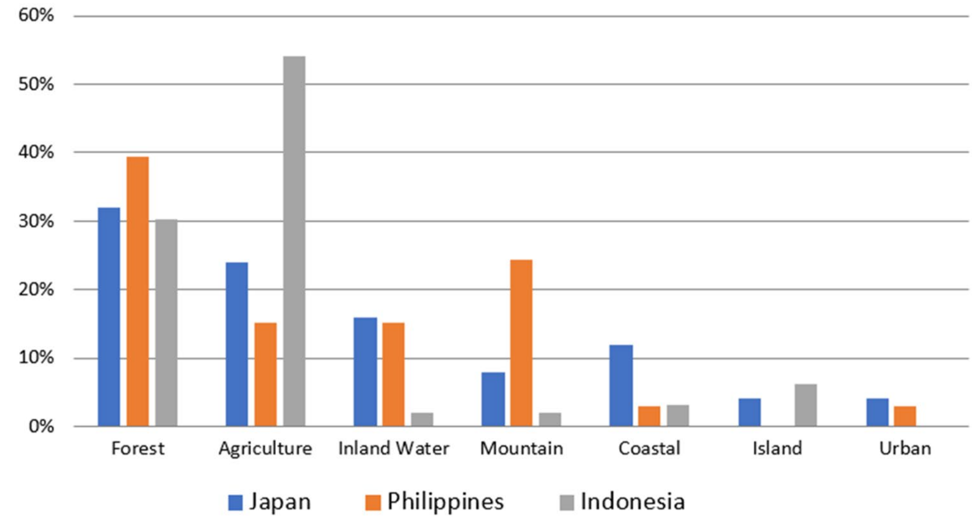

Fig. 6 The ecosystems represented by the studied cases in Japan, Philippines, and Indonesia

if the solution combined mixed characteristics from two different perspectives. Otherwise, predominant characteristics allowed us to identify the perspective. In the case of some solutions, a consultation meeting was held to arrive at the agreed categorization. Further, to avoid ambiguity, a counter-check activity was conducted by team members who reviewed all the solutions and their categorization. As some of the response options were generic with implications over the multidimensional space of NFF, they were considered crosscutting. Overall, the crosscutting policies were below 1%; hence, they are not plotted separately in the NFF perspective web diagram.

Results

The section discusses the findings from step 2 and step 3 of the study. The first step of the solution scanning process, which involves the identification of cases through a horizon scan, is included in "Materials and methods".

Data scanning of bioproduction systems: step 2

Characteristics of the studied bioproduction systems

The cases studied were published between 2007 and 2021. The administrative scale of the cases in Japan is primarily regional (57%), followed by village (21%) and municipality scale (18%). The Philippines cases represent the village scale (40%) and municipality scale (33%) cases toward the higher side, and the reverse for Indonesia municipality scale (36%) and village scale (28%). Overall, the representation of national and sub-village scales cases is low, with no ward-level study.

None of the cases are located in dryland and polar ecosystems, while overall, most are part of agriculture (39%) and forest (32%) ecosystems. In Indonesia, over 50% of cases correspond to agriculture ecosystems, followed by forest ecosystems. In addition, the Philippines has some cases from the mountain and inland ecosystems (refer to Fig. 6).

Collaborations and engagement

The institutional author indicates either the authoring organization or institutional affiliation in the case of the individual author. As for Japan, for 57% of cases, the institutional authors are a government organization, followed by local/national research (21%), and NGO/NPO (14%) of published cases. In the case of Philippines and Indonesia, over 50% of cases were reported by local/national research. Following this, in the Philippines, local/national NGO/NPO and international research are active, while in Indonesia international NGO/NPO are active along with international research. Civil society organizations and international organizations are not involved as institutional authors.

Overall, stakeholders from the community and public sector were highly involved, while the involvement of research sectors was lowest. However, it varies dramatically within the three countries (Fig. 7). In Japan, having cases from the IPSI network and GIAHS sites, high involvement of stakeholders from the public sector (35%) and non-government organizations (31%) is seen, and relatively lower participation by the community (15%). On the contrary, local communities play an active role in the Philippines and Indonesia with 46% and 43% participation rates, respectively, and among communities; particularly local communities are highly involved. Under the subhead of the public sector, which showed the highest

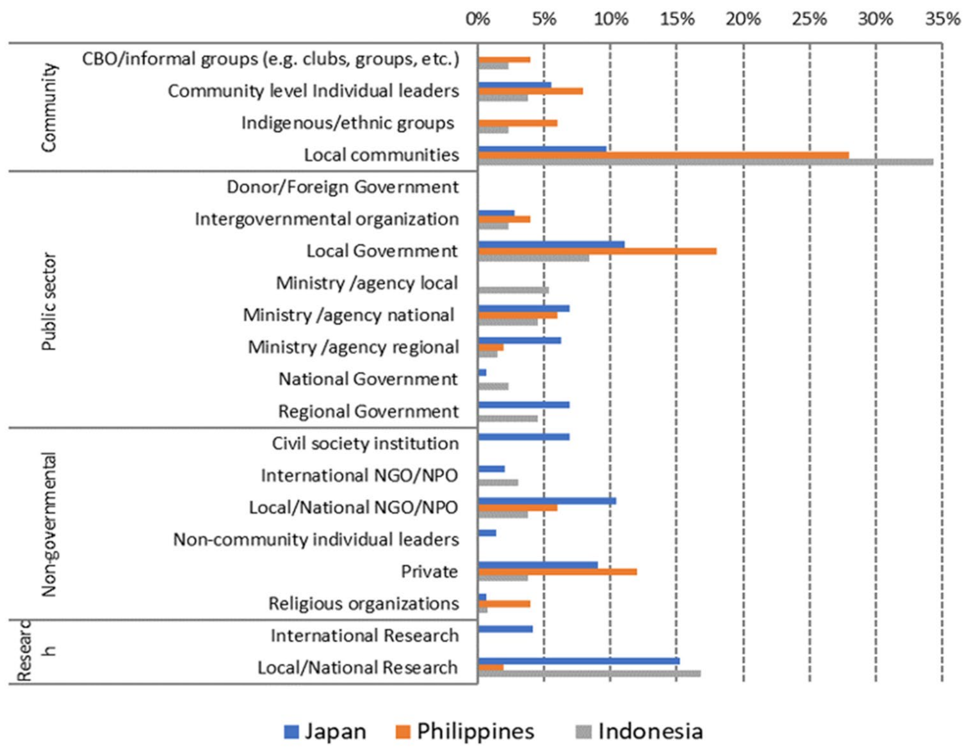

Fig. 7 Stakeholder involvement indicating the level of engagement identified in the studied bioproduction systems (CBO—civil society organizations, NGO—non-governmental organization, NPO—not for profit organization)

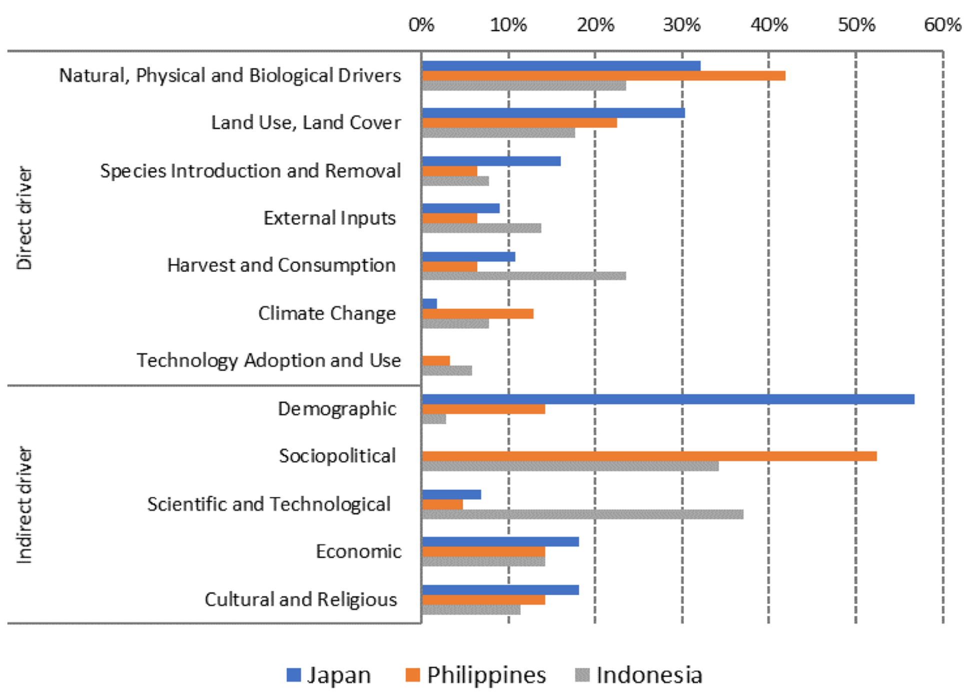

Fig. 8 Drivers and threats impacting the bioproduction systems

participation in Japan, a firmer hold of local government (11%), with equal involvement of regional government and ministries per the administrative scale, is seen. Overall, multi-level stakeholder engagement is prevalent in Japan (16 values identified out of 19), while in the Philippines and Indonesia, the involvement of 50% of stakeholders is identified from the listed stakeholder groups. In the Philippines, local governments (18%) are highly involved in supporting the local communities (28%), followed by participation of the private sector (12%) from the non-government group. However, a complete absence of an international research community is seen. Overall, the composition and involvement of stakeholders varied depending on the socio-ecological context. In Japan and Indonesia,

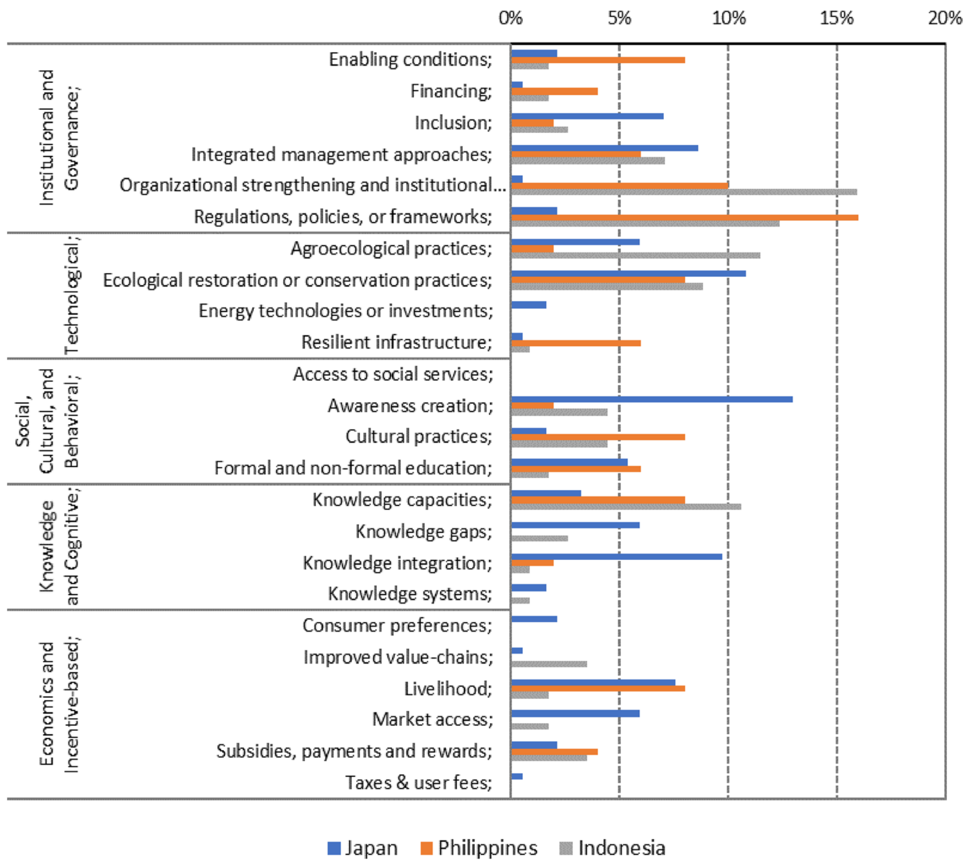

Fig. 9 Solutions and subcategory of solutions as per subregions (in %)

for instance, local and national research institutions (over 15%) participate in realizing the vision of restoration and conservation, while in the Philippines, these stakeholders are less engaged (2%). In Indonesia, an alliance of non-government stakeholders is missing compared to higher participation recorded for Japan (31%) and the Philippines (22%).

Challenges faced by the bioproduction systems

In all, 238 threats were recorded, with direct drivers slightly higher than indirect drivers (rough ratio of 60–40), as in Fig. 8. The main subtypes identified under the direct drivers are 'natural, physical, and biological drivers' and 'land use and land cover change'. In Indonesia, 'harvest and consumption' are equally prominent drivers of change. Under the 'natural, physical, and biological drivers,' pollution and contamination, biodiversity loss, ecosystem degradation, disasters, and soil erosion are the main reasons for the challenges to the bioproduction mechanism. Abandonment, underuse, deforestation, land use conversion, degradation, and expansion of built-up areas are prominent reasons for land use change. Species extinction and expansion of non-native species have occurred in Japan as a result of species introduction and removal. 'Climate change' is ranked third among direct drivers in the Philippines, owing primarily to the severe post-disaster implications. In Japan, demographic change is a critical threat, followed by economic, cultural, and religious threats. However, in the Philippines, the indirect threats are primarily driven by socio-political factors. Scientific and technological challenges, as well as socio-political threats, are identified as key indirect drivers in Indonesia.

Filtering of policy responses and solutions: step 3

Response type in different social–ecological contexts

For the 348 solutions (Japan:185, Philippines:50, Indonesia:113), 'institutional and governance' related solutions are recorded on the higher side (41–46%) (Fig. 9), followed by 'technological' solutions. In the Philippines, the response through 'knowledge and cognitive' solutions is the least prioritized, and the 'social, cultural, and behavioral'-related responses are recorded less in Indonesia. However, they are high in Japan following 'institutional and governance'-related responses.

The subtype indicates high 'institutional and governance' response implementation through 'integrated management approaches' and 'inclusion' in Japan. Of course, the network

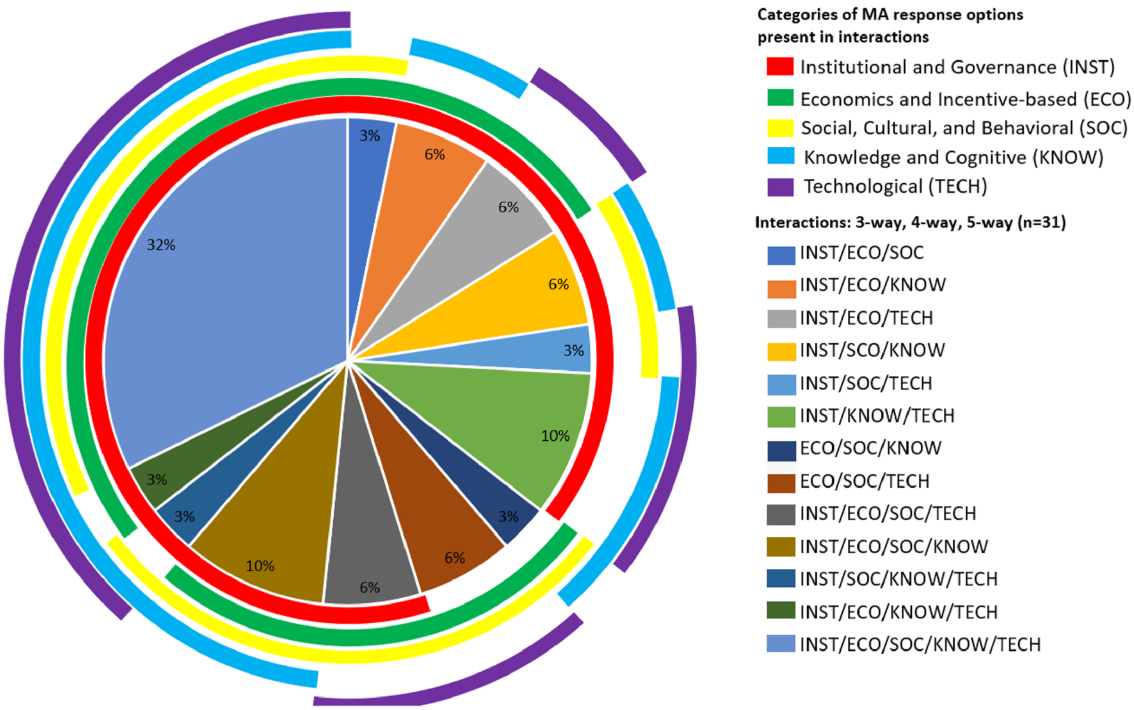

Fig. 10 Interactions between the five broad MA responses (above 3-way connections)

facilitates increased coordination across sectors, actors, and scales in managing these systems, leading to higher inclusion and increased stakeholder engagement. However, for the same response type, the approach followed by the Philippines and Indonesia varies; they mainly focus on enhancing institutional performance, laws, and mandates to put strategies in place. For 'technological' responses, all the countries focus on 'ecological restoration or conservation' practice; however, in Indonesia, 'agroecological practice' by promoting eco-technologies to improve productivity while conserving nature is prioritized. Following 'restoration and conservation' practices in the Philippines, the 'technological' response focuses on building 'resilient infrastructure' through technology-driven solutions to address disaster-related risks.

In Japan, the bioproduction system's cultural importance is well recognized. Accordingly, the responses focus on propagating 'cultural practice' through awareness creation and incorporating the practices into the education system through 'formal and non-formal education'. On the contrary, in the Philippines, the focus is on establishing new systems incorporating the 'cultural practices' with a scientific approach to revive these bioproduction systems. In Indonesia, awareness creation and cultural practices are equally considered. Economy-based responses are achieved through market-based approaches, such as taxes, consumer preference, subsidies, livelihood options, and market creation. Solutions addressing the alternative livelihood options are the highest in Japan and the Philippines, while taxes, user fees, and value chains are not recognized much. Further, interventions to create new local businesses for local produce are included in Japan, but not in the Philippines. Indonesia follows a different path here, with little focus on economic-based responses, but some efforts in subsidies, payments, and rewards and to improve value chains. Regarding knowledge-related responses, Japan focuses on knowledge integration and addressing the gaps, while the Philippines and Indonesia prioritize strengthening capacities to apply or use knowledge through training or learning systems. This aligns with the focus on agroecological practices prioritized in Indonesia and local ecological knowledge included in practical learning experiences in the Philippines.

Overall, the 3-way, 4-way, and 5-way connections between the five broader MA response options reveal prominent and weaker interactions (Fig. 10). Of the 90 cases, only 31 show above 3-way connections between response option categories, with 13 types of interactions (3-way = 8; 4-way = 4; 5-way = 1). The data provides insights into prominent response options and underutilized interactions. The information indicates the degree of association between the response options, a more detailed analysis of which could lead toward a more integrated approach for sustainable outcomes.

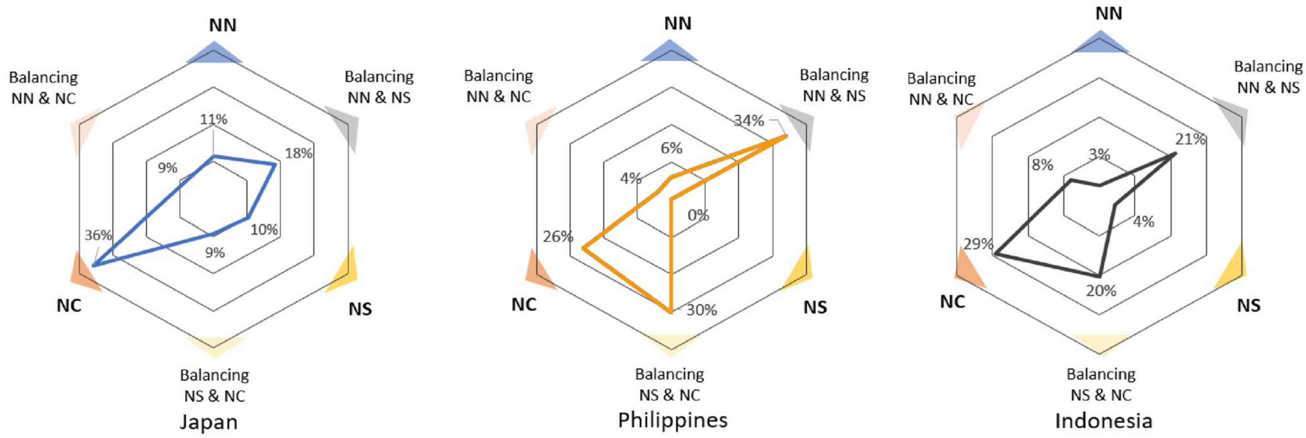

Fig. 11 Solutions indicating evident NFF perspectives in Japan, Philippines, and Indonesia (in %)

Prominent value perspectives and associated characteristics

Solution scanning using a filter of NFF indicates a strong lean toward the NC perspective in Japan and Indonesia (36% and 29%, respectively), followed by a preference toward balancing the NN and NS perspective (18% and 21%, respectively) (Fig. 11). A closer look at the descriptive characteristics shows that policies aiming toward 'sociocultural and behavioral' response and 'community-based management' approach have led to the prominence of NC perspectives in both the countries. In Japan, the cases being part of the cultural landscape with higher involvement of public stakeholders and government tend to promote solutions aiming toward the NC perspective. However, the same is seen in Indonesia, where responses identifying 'people's contribution to nature' are equally important, in addition to behavioral and community-based solutions. Similarly, solutions underpinning 'technology-friendly' and 'market-based' approaches are crucial for balancing the NN and NS perspective in these countries. Japan and the Philippines's solutions addressing 'nature conservation' and 'ecological integrity' are pivotal. However, since abandonment is a concern in the cultural landscape of Japan, solutions considering 'land sparing' or 'wilderness' options to conserve these landscapes are less popular. Instead, the solutions aim toward revival by boosting the local economy through 'sustainable use, management', and 'bio-economy' under the NS perspective in Japan (10%). In Indonesia, the 'management improves biodiversity' characteristic is key to achieving a balance between NS and NC.

In the Philippines, the NC perspective is third in priority, and solutions are inclined toward balancing the NN and NS perspective and the NS and NC perspective. This might be in response to higher community involvement and the prevalence of more community-driven solutions that the local government and private sector support. The solutions are more unified by combining characteristics from NN (nature conservation) and NS (sustainable use and management) in addition to the characteristic of balancing NN and NS, which makes this perspective more apparent in the Philippines. Among the bioproduction system of the Philippines, solutions aiming toward conservation efforts are not visible; hence, the NN perspective holds the lowest value, following the NS perspective. Overall, 'social, cultural, and behavioral responses (NC),' 'community-based management (NC),' and 'sustainable use and management (NS)' descriptive characteristics are highly recorded for solutions in all three countries.

Discussion

The study reviews the literature to capture adaptive and innovative practices that evolved from local knowledge and cultural and community practices in response to the evolving threats due to ecosystem change and other external influences. The cases show the prominence of agriculture and forest ecosystems with varying administrative scales (regional, village, and municipality). The stakeholder engagement and solution preferences vary across countries (Figs. 8 and 10). The prominence of the NC perspective indicates the importance of relational values. The scanning exercise through document review allowed the capture of solutions applied in different ecosystems across scales, with varying socio-ecological contexts, drivers, and threats. The findings showcase different levels of interaction and approaches, thus increasing understanding to address the much-needed transformation to balance nature and human needs in SEPLS.

Response type and solutions to the drivers of change

In Japan, the direct drivers impacting the bioproduction system are changing ecosystems and land use which are mainly triggered by the indirect driver of demographic change. The population is declining or migrating, causing a severe labor shortage, land abandonment, management of bioproduction systems, and loss of traditional cultural values (Haribar et al. 2023; Hori et al. 2021; Oono et al. 2020; Haga et al. 2020). Accordingly, the MA's response type showcases a good mix with relatively higher multi-level stakeholder engagement, facilitating collaboration and community involvement. Higher interactions among the public sector and non-government organizations with support from research organizations have led to these multi-level collaborations needed to develop local place-based solutions. The identified equal weightage in response type highlights a synergetic approach to balance BES and production benefits, also attested by Kozar et al. (2020). Some examples include: the revival of 'the ibis-friendly farming method' in Sado, 'reintroduction of white stork' in Toyooka City, and 'the traditional system of Shiitake cultivation' in Usa area of the Kunisaki Peninsula (GIAHS 2011; IPSI Secretariat 2012; GIAHS 2013). The mixed responses are aimed toward increasing production, implementing restoration and conservation efforts, integrating knowledge systems by incorporating traditional knowledge and cultural practices, focusing on behavioral shift, and coalition among multi-level stakeholders. This illustrates that mixed responses could result from multi-level stakeholder collaborations delivering multiple solutions to gain multiple benefits from SEPLS, substantiated by existing studies (Cockburn et al. 2018; Freeman et al. 2015). Such collaborations are identified as needed interventions to allow transformative change (Maiko et al. 2021). Other cases studied across Japan also attest to the relevance of inclusion and collaborative decision-making in realizing solutions for equitable benefits by sharing ecosystem services (Plieninger et al. 2018; Duraiappah et al. 2014; Takeuchi et al. 2016; UNU-IAS and IGES (eds) 2018; Saito (eds) 2019; Gu and Subramanian 2012; Kozar et al. 2020).

The direct drivers affecting the SEPLS in the Philippines are similar to Japan. However, they are mainly driven by the indirect driver relating to socio-political challenges, mostly observed within the jurisdiction of local government units (LGUs). Several factors impeded better outcomes in the conservation development of LGUs, such as ambiguous institutional mandates, insufficient funds, absence of tenurial instruments, bureaucratic hurdles, and scant transparency, accountability, and capacity among government and private offices in charge of managing natural resources (World Bank 2003). Hence to address the sustainability of community-based initiatives in LGUs (Tanguilig and Tanguilig 2009), the focus is on responses reviving institutional capacities through reforms and reinforcing the action plans and strategies involving local communities. For example, the conservation farming village program focuses on local farmer empowerment, conservation farming techniques (i.e., agroforestry), and partnering with state universities and colleges to develop the sites as research field laboratories (Cruz et al. 2013). The community-based forest management (CBFM) program was formulated to integrate people/community-oriented policies and programs (Aquino and Daquio 2014). Although these policies and programs recognize the role of local forest communities as partner stakeholders, their realization on the ground requires 'radical structural and institutional reforms' (Pulhin et al. 2013). An initiative like ridge to reef aims to reduce the exposure and vulnerability of communities to hazards, where local stakeholders are immediate beneficiaries of livelihood opportunities (PANORAMA 2017; Hapinat 2019). In the Philippines, to respond to climate change, the updated Development Plan (2017–2022) mentions an enhanced focus on building resilient infrastructure and conducting risk assessment and modeling for infrastructure planning (Asian Development Bank 2022). Nevertheless, nature-based solutions are recognized as a potential way to attain environmental and economic benefits for local communities, such as mangrove ecosystems as a protective barrier during storm surges in coastal communities while helping in carbon sequestration, improving marine biodiversity, and sustaining their fishing livelihoods (Gevana et al. 2021). Other examples include reforestation/afforestation, urban gardens, green spaces, and soil and water conservation techniques to alleviate the impacts of natural disasters (Asian Development Bank 2022).

In Indonesia, the prominent direct drivers are ecosystem change and change in harvest and consumption patterns, mainly due to socio-political and technological inefficiency. Similar to the Philippines, the approach is organization strengthening, policy reforms, and action plans. Hence, the Indonesian Biodiversity Strategy and Action Plan (IBSAP 2015–2020) issued by the Indonesian Ministry of National Development Board (*Bappenas*) is working with a detailed action plan and program (Bappenas 2016). Further, the Forest Investment Program II aims "to promote sustainable community-based natural resource management and institutional development," supported by the Ministry of Environment and Forestry (Rahmadani et al. 2018). Following the reforms, the efforts focus on incorporating technology to increase resource efficiency through enhanced restoration and conservation practices. Particularly in Indonesia, agroecological practices are promoted to increase the efficiency of bioproduction systems, for example, the introduction of stingless beekeeping in the mixed garden systems of Sumedang. Studies on stingless bees have indicated the multidimensional roles and functions of stingless bees in cultivation (Elpawati 2017).

Additionally, in both countries, the focus is on strengthening the capacity to use knowledge through learning or training, as identified by previous studies (Kozar et al. 2020; Amurazaman et al. 2018). In the Philippines, the government provides capacity building, knowledge training, farm or business assistance, demonstration or techniques, and communication and support services in the agriculture, aquatic, and natural resources sectors (Ani and Correa 2016). Furthermore, climate smart agriculture knowledge and strategies are made accessible through distance learning (i.e., radio broadcasting and online applications) (Perlas 2020), and the state universities are mandated to provide diverse technical assistance, research, and extension, and information and education campaigns (The University of the Philippines Charter Act of 2008 2007). In Indonesia, training focuses on introducing ways to respond to the threats and challenges, for example, (1) creating agricultural management training groups to equip farmers with new skills (Amurazaman et al. 2018); (2) introducing diversified forage composition through participatory learning groups to introduce complementary feeds (Setiawan and Khumairah 2014); (3) organizing workshops for coffee farmers to increase their market access (ICRAF 2018); and (4) introducing place specific technology to increase productivity in the paddy field (Sulakhudin and Hatta 2018).

Characteristics of value perspectives that can leverage transformation

In SEPLS, human–nature interactions are not just for economic gains; studies have shown that other ecological, social, and cultural values are equally essential in sustaining the livelihoods in these rural communities (Ichikawa and Yiu 2016). Hence, capturing the diverse values associated with a solution using NFF allowed for exploring solutions that enhance people's connection to nature. The NFF allowed for identifying the determinants and pathways to achieve transformative change and understanding solutions that could stimulate deep leverage points in response to sustainability challenges (Quintero-Uribe et al. 2022). People relate to nature in multiple ways; the prominence of the NC perspective in the bioproduction systems indicates the importance of relational values and human beings as an integral part of nature. The dominance of relational values, while mobilizing intrinsic and instrumental values through a balanced approach, reflects how these SEPLS are reviewing and following pathways nurturing sustainability-aligned values. The solutions relating to relational values highlight two critical characteristics: sociocultural and behavioral changes and community-based management. In Japan, this is achieved through reforms in the education system; promotion of local techniques through training, exchange programs, and youth engagement programs; incorporation of ILK in managing natural resources; awareness creation; and preservation of local cultural practices. For example, the revival of the Kanakura community as an eco-museum that links the landscape with local history and culture attracts the urban population (refer case-J15). Another example is awareness raising through Satoyama training programs in the Noto, Kaga, and Hyogo areas (refer case J3, J7, J8). In Aso grasslands, Akaushi's value and its consumption are promoted (refer case-J21). Further, strong support from institutions enables the recognition and integration of diverse values to enable decision-making aligned with sustainability and biodiversity targets.

In the Philippines and Indonesia, at present, the focus is on community involvement over behavioral changes. In the Philippines, the local community organizations and tribal communities are part of a protected management board. Likewise, the indigenous community of Ivatans in the Batanes protected landscape and seascape performs the community-based fishing ritual called '*mayvanuvanua*' during '*mataw*' season to 'regulate gear entry and seasonal use rights in certain fish grounds' (Biodiversity Management Bureau 2015). Additionally, local communities have been actively participating in preserving and observing biodiversity in their respective areas. Currently, community resource protection volunteer organizations, totaling close to a thousand, are on the front lines of enforcing park rules with park rangers in Mount Kanlaon, Mount Kitanglad, Bataan, Apo Reef, and Batanes in the Philippines (Senga 2001). Similarly, in Indonesia conservation and eco-tourism activities in Mount Leuseur National Park in Sumatra involve the local community. The locals protect the national park from poachers and illegal loggers and avail their livelihood from tourism activities (Wiratno et al. 2022). Pasir Eurih Village promotes community-based tourism through community-led tourism programs that have increased the community's social resilience (Rais 2021). Further, the prominence of community-based management approaches is due to a high level of community engagement, in synch with the MA response type. In Japan, this is due to the vital role played by the networks (IPSI and GIAHS) in realizing the collaborative decision-making process through multi-level stakeholder engagement, also corroborated by IPBES regional assessments for BES in Asia (IPBES 2018). Moreover, other prominent perspectives in the Philippines and Indonesia are balancing nature for nature and nature for society through different approaches. For example, in the Banaue rice terraces, the government and local communities' collaborative action is implemented to protect the biodiversity and sustain the essential ecosystem services for future generations (UNESCO 2016). In Indonesia, coffee agroforestry is one such effort toward environmental conservation, wherein the local communities are participating in managing the forest conservation areas (Sustainable Landscape 2017).

Limitations and future research

The sustainability of bioproduction systems depends on integrating knowledge systems and adaptive collaborative management approaches that involve multiple stakeholders and are effective across scales (Takeuchi et al. 2018, 2016). Several studies have highlighted the role of these approaches in achieving long-term resilience by enhancing productivity and improving economic and social benefits (Takeuchi et al. 2018; FAO 2008; De Schutter 2010; Zhu et al. 2011). Kozar et al. (2019) recommend the involvement of societal actors and place-based solutions as crucial to respond to the pressing sustainability challenges in Asia. This study used the MA response typology to understand the effective combination of response options and leveraged NFF perspectives to gain insights into how knowledge integration, coalitions of actors, and place-based solutions can guide future strategies to enhance the resilience of bioproduction systems. These approaches make it possible to apply solution scanning not only to the three Asian countries studied in this study but also to other regions and countries. However, the study has several limitations; firstly, it is limited geographically to Asia, it only focuses on bioproduction systems within countries identified by the ITMoB project[1], and represents a limited number of cases available for many ecosystems. Secondly, the study needs to evaluate the recorded solutions' effectiveness. Also, the performance and impact of the recorded solutions needs attention. In response to the limitations, future research should include other regions with different socio-ecological and economic contexts and more diverse ecosystems to provide a more comprehensive dataset of solutions. The analysis should capture the status of solutions (existing or proposed) and their effectiveness. Evaluating the performance and impact of solutions is recommended for future research. In terms of analysis, future studies should investigate how response types can contribute to achieving specific SDGs, such as SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land). Additionally, research should explore the potential trade-offs and synergies between different SDGs and response types and their impact on the resilience and sustainability of bioproduction systems. The listed solutions could also guide toward arriving at hybrid solutions and responses needed to address challenges.

Moreover, it is essential to capture and evaluate the status, performance, and impact of the response types and solutions, as well as their potential benefits and barriers to implementation through stakeholder evaluation or expert opinions, as well as the development of appropriate indicators and metrics to assess their effectiveness and sustainability. Finally, as highlighted by other studies, the study highly recommends stakeholder evaluation or expert opinions to understand the potential benefits and barriers to implementing the recorded solutions (Hernández-Morcillo et al. 2018, 2022).

Conclusion

In conclusion, recognizing the interconnection between culture and nature is crucial for a comprehensive understanding of bioproduction systems in SEPLS. This study examines solutions and policy responses related to bioproduction systems in Japan, the Philippines, and Indonesia to understand better how local communities revitalize SEPLS through sustainable management practices. To achieve this, the study employs a solution scanning approach to record the data systematically and uses MA response typology and Nature Futures Framework (NFF) to categorize response options and solutions. Using two frameworks to filter the solutions allows a clear understanding of the relationships between drivers of change, potential solutions, and the value perspectives considered in SEPLS. The different response types and diverse values captured by filtering through the MA response typology highlight the much-needed multi-level interactions, multi-directional learning, and mix of solutions and response options with the wider community and stakeholders' support to facilitate the overall solution context. The NFF filtering process provided a clear understanding of the relationships between people and nature; the importance of the NC (Nature as culture/One with Nature) perspective emphasizes the valuable relationships shared between them in the bioproduction systems of SEPLS. The NC perspective mobilizes intrinsic and instrumental values through a balanced approach to nurture sustainability-aligned values. The solutions emphasizing relational values highlight the need for sociocultural and behavioral changes and community-based management to achieve sustainability. The dataset

[1] Integration of Traditional and Modern Bioproduction System for a Sustainable and Resilient Future under Climate and Ecosystem Changes (ITMoB). ITMoB project by the East Asia Joint Research Program (e-ASIA JRP) is a 3-year cooperative research project that aims to fill this gap by exploring scenarios/pathways for a sustainable and resilient future under climate and ecosystem changes.

and findings support visioning and scenario framing toward a transformative change of SEPLS. The study highlights the importance of considering multidimensional values in decision-making to bridge knowledge–action gaps and create a sustainable future for SEPLS in these three countries and beyond.

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Data availability The data that support the findings of this study are available on request from the corresponding author.

Declarations

Conflict of interest The authors declare no conflicts of interest or competing interests.

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