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Short Communication

Methodological and empirical challenges of SEEA EEA in developing contexts: Towards ecosystem service accounts in the Kyrgyz Republic

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ABSTRACT

The System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA EEA) represents a crucial approach to incorporate the assessment of the sustainable use of natural resources and ecosystems into decision- and policy-making. However, its application is constrained by challenges distinct across specific implementation contexts, including those present in developing nations. In this paper, we focus on a pilot SEEA EEA application in a local-scale case study in Kyzyl Unkur, Jalal-Abad region, the Kyrgyz Republic, characterized by a unique natural walnut forest. We summarize key methodological and empirical challenges identified through collaboration with local experts and stakeholders during the compilation of Supply and Use tables for selected ecosystem services (ES) relevant at local, national and global levels. Specifically, we focus on the methodological challenges related to a) defining and assigning benefits for own consumption; b) delineating the chain of ES flows (e.g., fodder for farm animals); c) uncovering the relevance of carbon sequestration in developing nation contexts which are often minor greenhouse gas (GHG) emitters and demand for the service lies mostly beyond their boundaries. Among empirical challenges, we highlight the issues of data collection and availability. The aim of this communication is to provide lessons learnt from building SEEA EEA accounts in a developing, data-scarce context, potentially transferable to other similar applications.

1. Introduction

Numerous initiatives aiming to tackle urgent sustainability challenges have been gaining momentum within research, policy and practice, including the United Nations framework for the System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA EEA).[1] The SEEA EEA framework was established in 2013 (United Nations et al., 2014) and has been continuously tested since then (Hein et al., 2020a), aiming to link changes in ecosystems with economic and human activities, and to assess the sustainability of the use of nature by industries and societies. Thus, SEEA EEA is a promising approach to incorporate the assessment of the sustainable use of natural resources and ecosystems into decision- and policy-making (Vardon et al., 2016) while enabling vital connection and collaboration between a range of stakeholders and experts.

SEEA EEA has been hitherto tested at multiple levels, including supranational level (e.g., Vallecillo et al., 2019a, 2018), national level (e.g., Hein et al., 2020b), and regional level (e.g., Keith et al., 2017; Schröter et al., 2014). Some experience of environmental accounting specifically within developing nations has also been shared for example

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[1] In this paper we use the term Experimental Ecosystem Accounting, whilst being aware however, that in the course of the revision process the biophysical parts of SEEA EEA (ecosystem extent, condition, physical supply and use) have lost its experimental character, while valuation part remains so. The UN Statistical Commission adopted SEEA Ecosystem Accounting as a new statistical standard on the Fifty-second session held in 1 – 3 and 5 March 2021. For most recent updates on SEEA EEA revision, please visit the website: https://seea.un.org/content/seea-experimental-ecosystem-accounting-revision.

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from efforts in Botswana (Vardon et al., 2019), Indonesia (Sumarga et al., 2015), Rwanda (Bagstad et al., 2020), Peru (Grantham et al., 2016) and some others. However, first-hand experience with piloting SEEA EEA in developing nation contexts has so far been scarce. Such contexts are characterized by unique challenges, both in transforming real-world realities into ecosystem accounts and in the implementation of SEEA EEA itself. Sharing experience of implementing SEEA EEA into such contexts is therefore crucial for further fine-tuning this initiative.

In this paper, we explore how the SEEA EEA framework can be better tailored to reflect developing nation contexts, based on an experience from piloting SEEA EEA at a local level in Kyzyl Unkur, Jalal-Abad region, the Kyrgyz Republic. We provide specific insights related to key parts of the SEEA EEA process, and bring examples of how the SEEA EEA accounting framework can be operationalised in developing nation contexts based on an iterative collaboration with local stakeholders. We focus on both the issues of conceptualisation of ecosystem services (ES), specifically at the local scale, and process-related issues of data management. We argue that our experience is valuable beyond a specific case study and we aim to share our lessons learnt and provide guidance for building SEEA EEA accounts in similar developing, data-scarce contexts.

2. Materials and methods

2.1. Case study area

The insights in this communication are based on a case study in the Kyzyl Unkur forestry unit (approximately 500 km^2), Jalal-Abad region, the Kyrgyz Republic [41.2044° N, 74.7661° E] (Fig. 1), carried out as part of a Czech-UNDP Trust Fund project held in 2016–2017. The project focused on piloting SEEA EEA in the Kyrgyz Republic with the aim of transferring experience and co-creating capacities concerning SEEA EEA. The case-study area was selected in collaboration with Kyrgyz national experts as a suitable bounded social-ecological unit, characterized by a valuable and unique ecosystem of native walnut forest (Beer et al., 2008). Forests in the Kyrgyz Republic cover less than 5% of the country's territory (Undeland, 2012), but they play a key role in sustaining the livelihoods of neighbouring communities. However, local walnut forests have been subject to unsustainable management, characterised by overgrazing and over-harvest of walnuts (Beer et al., 2008), with consequent environmental impacts, as well as those on local livelihoods and well-being.

2.2. Selection of ecosystem services

The ES within the scope of the case study were selected based on an iterative interaction (following the SEEA Diagnostic Tool (United Nations Statistics Division, 2014)) with about 30 Kyrgyz experts and stakeholders who identified walnut forests as the main ecosystem unit in the case study area and prioritized focusing on multiple provisioning, regulating and cultural ES related to this ecosystem (see Table 1).

In terms of provisioning services, provision of walnuts, fodder, timber for fuelwood and other non-timber forest products were identified as key for the area, with walnut provision being particularly important. The naturally fallen walnuts are collected once a year by locals who rent small parcels of state-owned walnut forest. They are brought to and gathered by the State Forest Farms ("leshoz" or "leskhoz"), and sold in bulk at local, national and often international markets. The second important provisioning ES is timber for fuelwood. Since logging is prohibited in the case study area, only naturally fallen trees can be legally obtained. This amounts to a yield of roughly 2 000 m^3 per year, and is mainly used at a subsistence level (estimates by local stakeholders). The third important provisioning ES are the non-timber forest products (e.g., wild apples, berries and medicinal herbs), which are dried and mostly used for own consumption (although options for their drying in bulk and selling to local and national markets as well as pharmaceutical

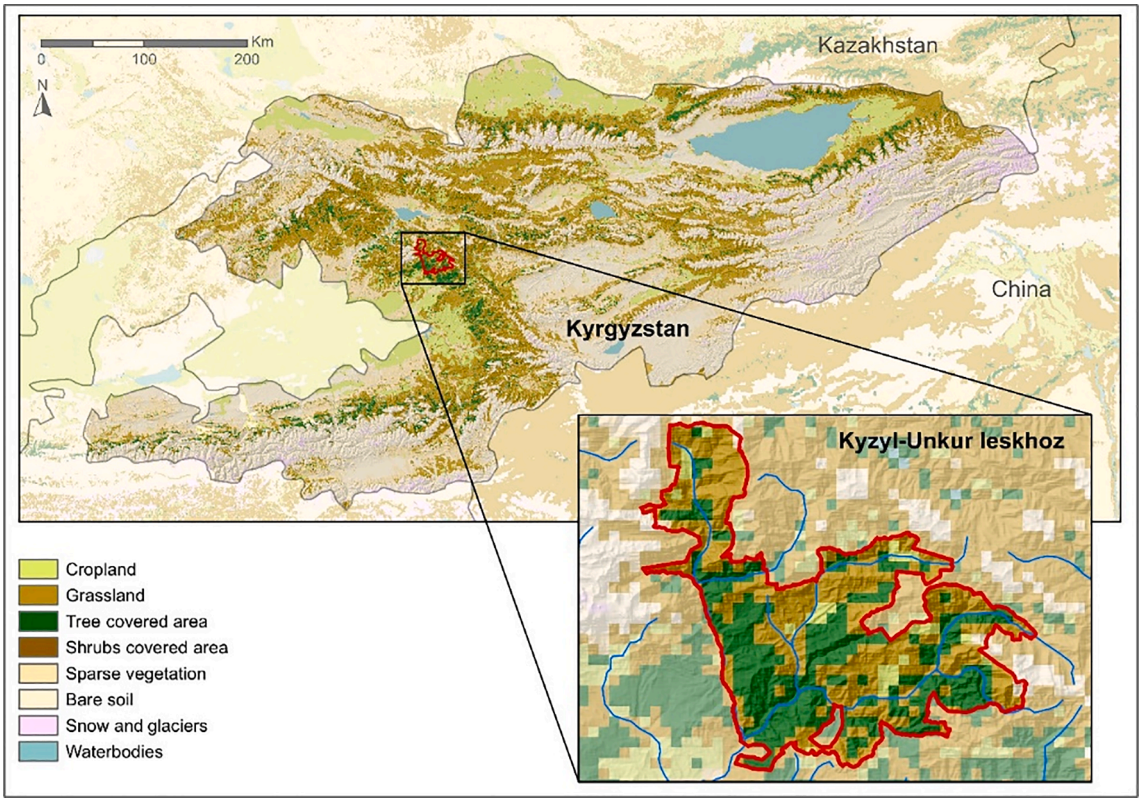

Fig. 1. The land cover map of the case study area. Total area of the Kyzyl-Unkur leskhoz is about 58 thousand ha, including about 25,5 thousand ha of forest. The Source: FAO, 2014.

Table 1
Conceptualization of ES, benefits, and users in the case study (ecosystem service classification follows CICES 5.1. (Haines-Young and Potschin, 2018)).

Ecosystem Services	Intermediate or final ES	Indicator	Related benefits	Further distinction of the benefit	SNA[a] or non-SNA benefits	Supplied by	Users (primary users)
Provision of walnuts	Final	Yield per hectare per year of walnuts to be harvested	Harvested walnuts	Walnuts sold at markets	SNA	Forest	Agricultural sector and exports
				Walnuts for own consumption	Non-SNA	Forest	Households
Provision of firewood	Final	Yield per hectare per year of wood to be harvested	Firewood	Fallen wood for firewood use	Non-SNA	Forest	Households
Provision of non-timber forest products	Final	Yield per hectare per year of wild berries	Harvested wild food	Berries sold at markets	SNA	Forest, pasture, and shrub cover areas	Agricultural sector and exports
		Yield per hectare per year of wild berries and wild apples	Harvested wild food	Berries and apples for own consumption	Non-SNA	Forest, pasture, and shrub cover areas	Households
		Yield per hectare per year of medicinal herbs	Beauty and health	Medicinal herbs to be sold at markets (still under potential)	Non-SNA (potential for SNA)	Forest, pasture, and shrub cover areas	Pharmaceutical sector
Provision of fodder	Intermediate	Yield per hectare per year of hay	Meat	Fodder provision	SNA	Forest and pasture	Agricultural sector
	Intermediate	Number of animals	Meat	Grazing animals	SNA	Forest and pasture	Agricultural sector
	Final	Kgs of meat	Meat products	Meat products	SNA	Agricultural sector	Households
Climate regulation	Final	Above and below ground carbon sequestered and storage in tons per hectare per year	Global climate regulation	Global climate regulation	Non-SNA	Forest, pasture, and shrub cover areas	Rest of the world
Recreation	Final	Hectares of land for recreation	Enjoyment	Enjoyment of nature	Non-SNA	Forest, pasture, and shrub cover areas	Tourism sector, households

Non-SNA benefits: benefits obtained by individuals which are not the result of an economic production process defined within the SNA (United Nations et al., 2014, p. 19).

[a] System of National Accounts; SNA benefit: SNA benefits are derived from products produced by economic units (e.g., food, clothing, shelter, entertainment) within the production boundary defined by the SNA.

companies are emerging). Forests and pastures are also used for cattle and horse grazing, i.e., they provide the ES of fodder provision. These ecosystems are currently substantially overgrazed with severe environmental consequences such as land degradation. In terms of regulating services, carbon sequestration is relevant due to the grassland and walnut forest land cover (Proietti et al., 2016). Among cultural ES, nature-based tourism is emerging through community initiatives but is not yet well developed.

Based on expert and stakeholder consultation and the identification of local ES priorities, the pilot Supply and Use Table (SUT) accounts focused on (1) provision of walnuts, (2) provision of fodder and (3) climate regulation (CzechGlobe, 2016).

2.3. Identification of challenges

The SEEA EEA Technical Recommendations (United Nations, 2019) propose several methodological steps to compile SEEA EEA SUT accounts. These steps can be divided into three broad groups: Identification, Measurement and Integration. Within this framework, we identify key methodological and empirical challenges of SEEA EEA implementation in this case study (Table 2). For each challenge, the potential solutions are listed in the Table 2 and described in the next section. The identification of such challenges and suggestion of the potential solutions are based on a summary of qualitative evidence from (a) three participatory stakeholder consultation workshops, (b) expert observation by the co-authors of this paper from meetings with national and local experts on national accounting and local natural-resource management (during three missions in 2016), and (c) experience of the co-authors from subsequent compilation of pilot SUTs for the Kyzyl Unkur area. During the Identification and Integration stages, our key challenge was how to conceptualise ecosystem services, benefits and their consumption relevant at the local-scale in a developing nation context. At the Measurement stage, the key challenge was the lack of data availability (Table 2).

3. Results and discussion

3.1. Compilation of supply and use tables

To facilitate the compilation of environmental-economic accounts for this case study, pilot conceptual SUTs were developed (Table 3). Economic units were divided according to sectors that constitute the users of the selected ecosystem services. Ecosystem types were divided according to the classification of ecosystems relevant for Kyzyl-Unkur leshoz, provided by the Kyrgyz Agency for Environmental Protection and Forestry (Fig. 1).

In the supply table (Table 3), the supply of ES is recorded for the selected three ecosystem units: tree-covered area, grassland and shrub-covered areas. Walnut provision is suggested to be recorded in the unit of tonnes of walnuts collected. Fodder provision is attributed to the relevant ecosystem units and assessed in tonnes of fodder gathered or directly consumed by animals. Carbon sequestration is attributed to all three ecosystem units and measured in tonnes of CO_2 sequestered.

In the use table (Table 3), walnuts were partly attributed to the agricultural sector since they are often sold at the market and contribute to the agricultural sector's total output. However, a significant share of walnut offtake is also used for own consumption, therefore this share is attributed directly to households. Fodder ES are linked to the meat products of the agricultural sector. Fodder were reported as an intermediate ES for the meat supply by the ecosystem. Tonnes of CO_2 sequestered were allocated to the global society (as in the example of Vallecillo et al., 2019b).

3.2. Methodological challenges: Conceptualisation of ecosystem services, benefits, and their consumption at a local scale, and in a developing nation context

It emerged early-on during the consultation process that the conceptualisation of ES provided by the SEEA EEA guidelines would need to

Table 2
General steps proposed by the SEEA EEA Technical Recommendations to compile supply and use accounts for ecosystem services and general and specific challenges faced at each step and potential solutions.

SEEA EEA Step	Type of challenge	General challenge	Specific challenge	General potential solutions	Specific potential solutions
Identification andIntegration	Methodological	Conceptualisation of ecosystem services, benefits and their consumption relevant at the local-scale in a developing nation context	Defining and assigning benefits for own consumption on the example of walnut provision	Using proxy of annual harvest of crops	Defining the share of walnut harvest used for own consumption
Integration	Methodological	Conceptualisation of ecosystem services, benefits and their consumption relevant at the local-scale in a developing nation context	Delineating the chain of ES flows on the example of the fodder provision	Recording as non-food crops and related to intermediate consumption linked to the agricultural industry	Estimating the areas of grazing land as well as the amount of exact fodder provision or assuming the amount of fodder that is needed per cattle and multiply this amount by the number of animals
Identification	Methodological	Conceptualisation of ecosystem services, benefits and their consumption relevant at the local-scale in a developing nation context	Uncovering the relevance of regulating ES on the example of carbon sequestration	Improving land use, land use change and forestry inventories	Improving capacity in carbon sequestration modelling
Measurement	Empirical	Managing data for SEEA EEA	Regular data updates (including digital spatial data)	Promoting inter-institutional coordination and collaboration through top-down initiatives and bottom-up initiatives	Developing the national spatial data infrastructure
Measurement	Empirical	Managing data for SEEA EEA	Temporal, spatial and unit coherence in the datasets	Promoting technological advances in machine reasoning specific for SEEA EEA purposes	Fostering capacity building on statistical reporting and data collection at all levels.
Measurement	Empirical	Managing data for SEEA EEA	Presence of rough estimates where accurate data are not available	Aligning the activities of multiple inter-agency groups linked to the SEEA EEA process	Promoting transparent data management policies by national authorities, ministries and other stakeholders relevant for SEEA EEA.

Table 3
Pilot supply and use tables[a] for walnut provision, fodder provision and carbon sequestration ecosystem services.

ES SUPPLY	Units	Type of economic unit Agriculture, forestry, and fisheries	Other economic sectors	Households	Global society	Rest of the world - Imports	Type of ecosystem unit Tree-covered areas	Grassland	Shrub covered areas	TOTAL SUPPLY
Walnuts	ton	No data filled in					tonnes of walnuts collected			
Fodder	ton						tonnes of fodder gathered or consumed by animals	tonnes of fodder gathered or consumed by animals		
Carbon sequestration	tonnes of CO_2						tonnes of CO_2 sequestered	tonnes of CO_2 sequestered	tonnes of CO_2 sequestered	

ES USE	Units	Type of economic unit Agriculture, forestry, and fisheries	Other economic sectors	Households	Global society	Rest of the world - Imports	Type of ecosystem unit Tree-covered areas	Grassland	Shrub covered areas	TOTAL USE
Walnuts	ton	tonnes of walnuts collected		tonnes of walnuts collected (own consumption)			No data filled in (unless intermediate ES)			
Fodder	ton						tonnes of fodder consumed by animals	tonnes of fodder consumed by animals		
Carbon sequestration	tonnes of CO_2				tonnes of CO_2 sequestered		No data filled in (unless intermediate ES)			

[a] Ecosystem services supply and use tables records "the actual flows of ecosystem services supplied by ecosystem types and used by economic units during an accounting period" (United Nations, 2019, p.77). There is "No data filled in" to economic units in the supply table because ecosystem services are produced by ecosystems.

be further specified to fit the compilation of the SUT in the local context. The main challenges were related to: a) defining and assigning benefits for own consumption (e.g., in the case of walnut provision) which is an issue highly relevant to the context of developing nations. Indeed, production for own consumption in households is a part of maintaining lifestyles of communities; b) delineating the chain of ES flows (e.g., fodder for farm animals). ES flows are often governed with informal agreements between beneficiaries and ES management is conducted based on local traditions and knowledge; c) uncovering the relevance of carbon sequestration in developing nation contexts which are often minor GHG emitters, and the demand for the service lies mostly beyond their boundaries.

3.2.1. *Defining and assigning benefits for own consumption when no economic sectors are involved (e.g., walnut provision)*

In terms of the provisioning service of walnut provision, SEEA EEA Technical Recommendations (United Nations, 2019) propose recording annual harvest of crops as a proxy, which means that ES equals the benefit. This approach is also taken in many studies analysing food provision ES (Grammatikopoulou et al., 2020; Maes et al., 2016; Sylla et al., 2020). In the ecosystem service accounting reports of Joint Research Centre division between ecosystem service and benefit is further developed (Vallecillo et al., 2019b). It is explained that final benefits such as food products includes nature and human inputs. In our case, we first attempted to make a clear distinction between the walnut provision ES and related benefits, but failed in the next measurement step due to data deficits (data on annual walnut growth was not available). The next best proxy was the final product (walnuts) either for own consumption or local markets. In the case of walnuts in Kyzyl Unkur, the ES of walnuts growth is linked to the final product of walnuts sold at local markets. That means that it is related to the output of the agricultural sector which is already recorded in the SNA. However, a significant share of walnuts is used for own consumption. This share could not be recorded as data on household consumption was not available.

3.2.2. *Delineating the chain of ES flows (e.g., fodder for farm animals)*

The provisioning service of fodder for meat production is now well conceptualized in the SEEA for Agriculture, Forestry and Fisheries (2020), which at the time of this project was not available. When fodder is cultivated and retained on the farm to feed animals, it can be recorded as non-food crops and related to intermediate consumption linked to the agricultural industry. If fodder is cultivated and sold at the market as a product, it should also be included in the category of non-food crops and related directly to the agricultural sector (FAO and UN, 2020, p. 51). Furthermore, it is important to track the whole value chain of meat, which is different for developed and developing countries. If the animals which consume fodder are later used for own consumption, which is very often the case for developing countries, the fodder would not be linked to the agricultural sector neither directly nor via intermediate consumption. In this case, it should be linked to households. There are already some examples in the scientific literature on how fodder could be accounted for: Remme et al. (2015), Remme et al. (2014) for instance, suggest combining grazing with harvested fodder (mainly grass and maize) for animals which spend the summer freely grazing and the rest of the year in barns being fed.

The fodder provision ES, in our case study, was challenging to be allocated within specific ecosystem units, as some grazing takes place in forested areas as well as grasslands. This also made it difficult to measure the units of the ES itself. Therefore, estimating the areas of grazing land as well as the exact amount of fodder provision, is challenging. One option is to assume the amount of fodder that is needed per cattle and multiply this amount by the number of animals.

3.2.3. *Uncovering the relevance of regulating ES in a developing-nation context (e.g., carbon sequestration)*

The ecosystem accounting model requires consideration of the ES from both supply and use sides. For climate regulation by carbon sequestration, the service is the ability of different types of ecosystems to take up greenhouse gas (GHG) emissions (in tonnes of CO_2 equivalent/year (Vallecillo et al., 2019b)) that are released to the atmosphere due to human activities. From the accounting perspective it is important to estimate the total emissions of a given country to assess the demand for carbon sequestration services provided by ecosystems. According to the World Bank, The Kyrgyz Republic is one of the world's lowest contributors to GHG emissions. Therefore, the climate regulation service accounts might have international importance due to the global relevance of the problem it is mediating. The accounting for regulating services poses an opportunity to make this type of service visible. By including such regulating and even cultural services, one may significantly extend the SNA (as shown in Obst et al., 2016). Carbon sequestration regulating ES could be defined in-line with SEEA EEA baselines, based on InVEST modelling and transfer of values (Bagstad et al., 2020).

3.3. *Empirical challenges: Managing data for SEEA EEA*

Recently, several initiatives have started to make use of publicly available remote sensing data for ecosystem accounting, for example the Earth Observation for Ecosystem Accounting initiative (Hein et al., 2020). Attempts are also being taken to use Moderate Resolution Imaging Spectroradiometer for regional land cover mapping (Klein et al., 2012; Zou et al., 2020). Finally, recent technological advances have leveraged machine reasoning specifically for SEEA EEA purposes, automatically connecting data from multiple open-access sources to best available ES models for a selected context (Capriolo et al., 2020). For the production of reliable accounts, detailed and precise data is required (as in Salminen et al., 2018).

In spite of the commitment and effort of involved local and national-level experts, local collection and reporting of multiple types of data are limited by technical and procedural constraints (Rakhmatullaev and Abdullaev, 2014). Key data-related challenges are related to (1) regular data updates (including digital spatial data), (b) temporal, spatial and unit coherence in the datasets, and (c) presence of rough estimates where accurate data are not available. The lack of economic estimates hindered the process of creating SUT in monetary terms, as has been shown above in the example of walnut provision. In this context, input from stakeholders constitutes a particularly important source of information. In our case, participatory data elicitation in collaboration with local stakeholders represented a key data source regarding the chain between ES supply, use and benefits. However, local, indigenous and household-level knowledge is rarely spatially digitalised and therefore, is not easily operational.

Based on the experience from this study, the root causes of this empirical challenge include low inter-institutional collaboration, financial and human-resources constraints in data collection at the local level and an unclear data management system. Potential solutions to these issues include (1) promoting inter-institutional coordination and collaboration through top-down initiatives (policy-driven actions) and bottom-up initiatives (through project work), (2) aligning the activities of multiple inter-agency groups linked to the SEEA EEA process (or, potentially, to unifying them); (3) fostering capacity building on statistical reporting and data collection at all levels; (4) promoting transparent data management policies by national authorities, ministries and other stakeholders relevant for SEEA EEA, and (5) developing the national spatial data infrastructure.

By applying ecosystem accounting in a developing country, the key points that need support are to structure existing knowledge, identify the shortcomings in data and data management systems, to improve networking of different partners and institutions, and to build overall capacity. The SEEA-EEA framework needs to offer flexibility, potential modifications in light of data deficits, and guidance in including and highlighting the importance of local value chains and locally produced ES.

4. Conclusion

In the process of piloting ecosystem accounts in the Kyrgyz Republic, we have encountered the following challenges as part of ES conceptualisation: a) defining and assigning benefits for own consumption, b) delineating the chain of ES flows, and c) uncovering the relevance of regulating ES in developing nation contexts. Furthermore, we also highlighted data management challenges related to data scarcity, mismatched data sources, and incomplete databases resulting with ineffective data collection and management systems.

We have outlined the specific modifications and proxies used to help address the highlighted methodological challenges in our case study. More generally however, such challenges are addressed by the global forum of experts in the process of revising SEEA EEA in order to prepare it to be adopted as a statistical standard and removing its experimental character. In our case study, we have also provided specific suggestions for how data-related challenges might be overcome. Such suggestions may be useful in other similar contexts. However, empirical challenges relate to the strategic planning of a given country and implementing aims that give reasons for preparing the ecosystem accounts themselves. One possible recommendation to overcome this challenge more generally, is to involve SEEA EEA pilot project partners and relevant stakeholders in mainstreaming SEEA EEA into national strategies and decision-making for sustainable development, and also further into statistical reporting.

Declaration of Competing Interest

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

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