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Including diverse knowledges and worldviews in environmental assessment and planning: the Brazilian Amazon Kaxinawá Nova Olinda Indigenous Land case

Fernanda Ayaviri Matuk ^{a,b}, Jelle Hendrik Behagel ^a, Felipe Nogueira Bello Simas^c,
Eufan Ferreira Do Amaral^d, Moacir Haverroth^d and Esther Turnhout ^a

^aForest & Nature Conservation Policy Group, Wageningen University, Wageningen, The Netherlands; ^bGeography and Rural Extension, Federal Institute of Minas Gerais, São João Evangelista, Brazil; ^cEducação do Campo (Education Department), Federal University of Viçosa, Viçosa, Brazil; ^dBotanics and Soil Science, Embrapa-Acre, Rio Branco, Brazil

ABSTRACT

The concepts of ‘ecosystem services’ (ES) and ‘nature’s contributions to people’ (NCP) inform environmental frameworks that set out to include Indigenous and Local Knowledge systems (ILK) and worldviews in policy and planning processes. These frameworks aim to enhance biodiversity conservation and human well-being in a legitimate and effective way. In this article, we explore how the concept of People’s Contributions to Nature (PCN) is complementary to NCP. We use it to investigate challenges that planners and locals face in realizing the legitimate inclusion of diverse knowledges and worldviews that account for people and ecosystems in a relational way. We introduce a case study where planners drew on ES and NCP and used participatory methods to implement a REDD+ policy in the Kaxinawá Nova Olinda Indigenous Land (Acre-Brazil). We find that both Kaxinawás and planners emphasize both NCP and PCN in their discourses. Nevertheless, differences between knowledge systems and disciplines, uneven power relations between Kaxinawás and planners, and an under-consideration of PCN by global frameworks challenge the legitimate inclusion of the Kaxinawá knowledge and worldviews to craft assessment and planning. We conclude that by explicitly addressing these challenges, science-policy interfaces can further advance knowledge legitimacy and policy effectiveness.

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1. Introduction

Scholars have advocated the use of frameworks based on the concepts of ecosystem services (ES) and nature’s contributions to people (NCP) (Díaz et al. 2018; Pascual et al. 2018) for global environmental policies to better account for the mutual dependencies between people and nature, to enhance human well-being, and to further biodiversity and nature conservation. ES are conceived as all benefits that people obtain from ecosystems (MA 2005) whereas NCP build on this concept to stress the central role that culture plays in underpinning the relations between people and nature (Díaz et al. 2018). These ES and NCP frameworks are largely used in environmental assessments that inform the resource management planning of Indigenous Peoples and Local Communities’ (IPLC). IPLC include a wide variety of communities (Skutumpah and Turnhout 2018), most of whom depend on local natural resources for their livelihoods (Turnbull 2009). IPLC also contribute to the management of up to 80% biodiversity of the planet (FAO 2017). Many IPLC are recognized for holding Indigenous and Local Knowledge (ILK) systems that are considered valuable for the conservation of biodiversity and sustainable land use, among others (Barrera-Bassols and Zinck 2003; Barrios et al. 2012).

The Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services’ (IPBES) proposed the NCP framework to be inclusive of ILK and IPLC. At the same time, the NCP framework maintains the concept of ES in terms of the ecological, economic, and socio-cultural values on nature (MA 2005). The NCP framework thus emphasizes the inclusion of context-based ILK and worldviews in policies, as they co-produce biodiversity and human well-being together with nature. The NCP framework is also careful not to prioritize scientific knowledge on ecological functions and economic values over diverse knowledges, worldviews, and values, as the previous iterations of the ES framework tended to do (Martín-López et al. 2014). With the adoption of the concept of NCP, IPBES thus stresses the need of science-policy interfaces to advance the legitimate inclusion of diverse knowledge systems in assessments and planning, to achieve well-being, conservation, and sustainable use (Pascual et al. 2018).

An important criterion for legitimate knowledge is that it is inclusive of diverse worldviews and knowledge systems of different stakeholders, including their different aspirations, values, and classification systems (Tengö et al. 2017). This understanding has led to the adoption of participatory methods where

planners and IPLC bridge and co-produce knowledge and worldviews on nature that include both scientific knowledge and ILK systems (Irvine et al. 2016). It has also informed the development of interdisciplinary approaches to understand the social and ecological interplays involved in resource management (van Oudenhoven et al. 2012). Participation and interdisciplinarity are especially necessary to include ILK systems that are shaped by cosmovisions – holistic worldviews that integrate biophysical and cultural phenomena (Toledo and Barrera-Bassols 2009).

For instance, Fairhead and Leach (1996) show that planners who did not account for the relations between African IPLC and their forests misinterpreted forest mosaics as the result of unsustainable practices of these communities. A later interdisciplinary understanding of the practices of these IPLC led planners to comprehend that these mosaics resulted from conservation practices of these IPLC.

In practice, the integration of ILK in knowledge production has faced challenges (Chan et al. 2012; Fagerholm et al. 2012; Díaz et al. 2018). First, there is a tendency of scientists to consider science as superior to ILK (Agrawal 1995). This tendency leads planners who use scientific frameworks to resist making shared decisions with IPLC. It also leads to the extraction of decontextualized bits of knowledge from ILK to fit scientific frameworks, rather than to the bridging of knowledge systems (Klenk et al. 2017). Second, different disciplinary backgrounds make it difficult to establish common knowledge about the various social-ecological interplays that make up and affect biodiversity (Carpenter et al. 2009). This difficulty obscures insight in the mutual interactions and relations between people and nature. Third, ES and NCP frameworks tend to emphasize how humans depend on and benefit from nature, that is, NCP (Kenter 2018; Peterson et al. 2018) and focus less on PCN.

The concept of PCN stresses that people interact with natural processes and together with these processes condition the state of ecosystems and biodiversity (cf. Díaz et al. 2015; Peterson et al. 2018). This literature mostly highlights people's values and classifications of ES or NCP as impacting nature in this way (Chan et al. 2012; Kenter 2018). We emphasize that both people's knowledge, worldviews, and practices are important dimensions of PCN, and that these dimensions can be explored further (cf. Toledo and Barrera-Bassols 2009; Matuk et al. 2019). Moreover, accounting more explicitly for both PCN and NCP in environmental assessment frameworks can help policies advance a legitimate and relational understanding of how ecosystems and people affect and co-produce each other and offer better insight into local social-ecological contexts to inform planning in practice.

This article explores the challenges that environmental planners and IPLC face to include legitimate

knowledge and worldviews that account for people and ecosystems in a relational way in assessment and planning. We use a case study in Acre state (Brazilian Amazon) that was part of the implementation of the regional REDD+ policy called System of Incentives for ES (SISA, acronym in Portuguese). The case illustrates an attempt to include ILK and cosmovisions in assessment and planning by drawing on both the ES and NCP frameworks. Our analysis shows how knowledge and worldviews on nature include aspirations, classification systems, and values that are manifested in global to local discourses, as well as how these discourses come together in participatory processes. The discussion explores the extent to which the SISA assessment and planning processes resulted in legitimate and relational knowledge and other outcomes. We conclude by reflecting on the challenges that planners and Kaxinawás faced to include ILK in assessment and planning and draw lessons for other contexts.

2. Conceptual framework

2.1. Knowledge and worldviews

In the 19th century, modern 'Western' science established that the world should be explained by 'universal' and value-neutral scientific truths, and that natural and social disciplines should address material and non-material phenomena separately (Lévi-Strauss 1966). This conceptualization relies on and reproduces two dichotomies: one between scientific and ILK knowledge systems, and another between social science and natural science disciplines. Post-structuralist, post-humanist, and post-colonial schools of thought have argued against these dichotomies. They argue that reality is multiple and that it can be understood by 'pluriverses' of knowledge (Escobar 2016, p. 13). In this article, we adopt the perspective that knowledge is entwined with worldviews and is derived from dialectical interactions between people and nature (Latour 2004).

The entwinement of knowledges and worldviews can be studied via the discourses of knowledge holders of different knowledge systems and disciplines. These discourses include different elements of meaning that comprise classifications, values, and aspirations, and that form a coherent whole (Foucault 1972). Classification systems consist of categories that reflect those items that people value and that they identify with (for example nature as ecosystem or as commodity), which influence what knowledge is considered valid or legitimate (Fisher et al. 2009). Values include qualifications that people use to signify phenomena and to guide actions. Aspirations include ideal images associated with needs and objectives that people and policies prioritize such as the conservation of nature (cf. Díaz et al. 2015). Analysis of

the discourses of actor groups can thus reveal resonances and incongruences between these classification systems, values, and aspirations. It can also show how specific discourses affect policies and their outcomes (Hajer and Versteeg 2005).

Discourses are found to be performative and tend towards the reproduction of themselves in practice, while resisting other discourses (Law 2009; Behagel et al. 2017). This leads to challenges to accommodate and include diverse knowledges and worldviews. Those challenges may persist even despite intentions otherwise or the use of participatory methods to integrate knowledge. Thus, the performativity of discourse affects the inclusiveness, legitimacy, and effectiveness of knowledge (Behagel et al. 2017). An example is when local knowledge is either excluded or extracted from its meanings to fit ‘universal’ classification schemes (Turnhout et al. 2016; Klenk et al. 2017).

The tendency of discourses to reproduce themselves calls for sensitivity to power dynamics in environmental assessment and planning during the bridging and co-production of knowledge (Turnhout et al. 2019a, 2019b). This sensitivity should lead to the creation of shared understandings of both the social and ecological dimensions of resource management contexts and to the inclusion of a legitimate and relational understanding of NCP and PCN (Chan et al. 2012). In this paper, we explore the role of an intercultural approach (Rist and Dahdouh-Guebas 2006) in achieving this purpose. This approach is based on an attitude of humility to recognize that knowledge systems and disciplines can enrich each other (Jasanoff 2003). This attitude is exercised by respecting the integrity of meanings and terms communicated in discourses of different knowledge holders (Haraway 2016; Tengö et al. 2017; Díaz-Reviriego et al. 2019) and by being flexible to reflect on and adapt scientific frameworks and worldviews to include ILK (Kincheloe 2008; Toledo and Barrera-Bassols 2009).

2.2. ES and NCP discourses

When analyzing the discourses of the ES and NCP frameworks from the perspective outlined above, we find that they represent distinct discourses that differ in terms of classifications, values, and aspirations. Still, both discourses are part of one overarching discourse that aims to enhance human well-being, nature conservation, and biodiversity. Moreover, both discourses seem to offer compromises for the inclusion of diverse and relational knowledge and worldviews. The ES and NCP discourses are schematically presented in Table 1 and discussed below.

The ES discourse is strongly expressed in the Millennium Ecosystem Assessment (MA 2005), The Economics of Ecosystems and Biodiversity, and the

Common International Classification of Ecosystems (CICES) (Haines-Young and Potschin 2017). These frameworks aim to offer guidance for policy and planning processes to foster multifunctional landscapes and ensure that ecological processes and functions as well as their economic, socio-cultural benefits and values are accounted for (Levin et al. 2009). The ES discourse is based on a classification that includes different categories of ES: 1) support services that provide the conditions of life and (re)production (e.g. genetic diversity); 2) regulation services that regulate ecological processes (e.g. soil quality); 3) provision services that include the products and benefits that address human needs more directly (e.g. ‘food’); and 4) cultural services such as spirituality, art, and recreation. The ES classification is recommended because of its presumed ability to elucidate synergies and trade-offs between land use options and decisions on priority ES to be targeted in planning. Yet, while some articulations of the ES discourse highlight both ecological processes and functions and their economic and socio-cultural benefits and values (de Groot et al. 2002; Costanza et al. 2014), many ES assessments in the past have given more emphasis to monetary values (de Groot et al. 2010; Peterson et al. 2018). Critiques of the ES discourse thus argue that the term ‘service’ inevitably holds an explicit utilitarian economic interpretation and that in practice economic values continue to dominate ES debates, among others because they are easy to quantify (Turnhout et al. 2014; Martín-López et al. 2014). Cultural ecosystem services have often been excluded because they are not ‘associated with the production and valuation of tangible things or conditions [...] involve the production of experiences that occur in the valuer’s mind’ (Pascual and Muradian (2010, p. 7). The economic and monetary associations of the ES concept and its shortcomings in incorporating cultural or non-material values were important factors in the emergence of the NCP discourse.

The NCP discourse is expressed in the IPBES framework (Díaz et al. 2018; Pascual et al. 2018) and recognizes that different NCP and values are interrelated according to the specifics of each context. Díaz et al. (2018, p. 270) explain that ‘the NCP approach recognizes the central and pervasive role that culture plays in defining all links between people and nature’. This role refers to the influence of people on biodiversity and the way in which biodiversity is co-produced by people and nature, for instance, under the influence of IPLC and policy aspirations. To address people and nature in their relationship, Díaz et al. (2018, see also Supplementary materials) propose a general classification that includes 18 subcategories of NCP. These subcategories are associated with three central categories of NCP which are: 1) ‘regulation’ (e.g. habitat maintenance and pollination); 2) ‘material’ (e.g. food); and 3) and ‘non-



Table 1. Categories of aspirations, classification, and values presented in the discourses of ES and NCP frameworks.

Aspiration Categories	Classification Categories – subcategories (examples)		Values Categories (criteria) – subcategories (examples)	
	ES	NCP	ES	NCP
Enhance ES; biodiversity; human well-being; ecological resilience	Enhance ES; biodiversity; human-well-being; cultural and ecological resilience	Support and habitat – Soil formation; Maintenance of biodiversity and nursery-services (gene pool protection); Lifecycle maintenance (photosynthesis); Primary production; Nutrient cycling	Regulating – Habitat creation and maintenance; Pollination, dispersal of seeds, and other propagules; Regulation of air quality; Regulation of climate; Regulation of ocean acidification; Regulation of freshwater quantity; Location, and timing; Regulation of freshwater and coastal water quality; Formation, protection, and decontamination of soils and sediments; Regulation of hazards and extreme events; Regulation of organisms and biological processes	Ecological (sustainability and intrinsic related) – Carrying capacity of ecosystems; Plants and animals have value for themselves and non-use value for people; Integrity and resilience of nature to maintain production; habitat functions (complexity, diversity, and rarity)
Promote environmental sustainability; conservation by highlighting the economic value of nature and relying on scientific knowledge	Weave and bridge ILK based NCP classifications with scientific NCP classifications	Regulating – Air quality (air purification); Climate (carbon sequestration); Clean water (water treatment and natural purification); Water flows (drought mitigation); Geo-chemical cycles (of carbon, nitrogen, and oxygen); Disturbance prevention (flood mitigation); Clean soil (soil regeneration); Soil regulation (erosion and fertility); Pollination (bees); Biological control (pest regulation, seeds dispersal); Human disease control	Material – Energy; Food and feed; Materials; companionship, and labor; medicinal, biochemical, and genetic resources	Intrinsic (Non-anthropocentric or focused on nature) – Animal welfare and rights; Gaia and Mother Earth, Evolutionary and ecological processes; Genetic and species diversity
Include diverse worldviews and address diverse needs	Include diverse knowledge and worldviews in assessment	Provisioning – Food (seafood, fruits) Water (fresh water, presence of water resources); Raw materials (timber, fibers); Genetic material (or resources); Fuel and energy (biomass fuels); Drugs and pharmaceutical (medicinal resources); Ornamental resources (decorative and handicraft use)	Economic (anthropocentric, monetary and instrumental values) – Direct market valuation of goods' prices associated with carrier functions of landscapes for markets and human land use practices of cropping among others; Indirect market valuation based on a willingness to pay or to accept compensation for the availability or loss of ES; Contingent valuation based on a willingness to pay before hypothetical scenarios; Group valuation to deliberate around monetary values and shared priorities	Instrumental values (anthropocentric or focused on NCP) – Habitat creation and maintenance, pollination and propagule dispersal, and regulation of climate; Food and feed, energy, and materials; Physical and experiential interactions with nature, symbolic meaning, and inspiration
		Cultural – Cultural diversity (heritage and inspiration for culture, art, and design); Knowledge systems (information for cognitive development and stimulation); Spiritual and religious value and experience; Aesthetic values and information (beauty); Recreation and eco-tourism	Non-material – Learning and inspiration; Physical and psychological experiences; Supporting identities; Maintenance of options	Relational values (anthropocentric and focused on the quality of life) – Physical, mental, and emotional health; Way of life; Cultural identity and sense of place; Social cohesion

material' (e.g. learning experience). Here, the NCP regulation category resonates with the ES support and regulation categories, the NCP material category with provisioning ES, and the NCP non-material with cultural ES. In contrast with the ES discourse, NCP includes a subcategory called 'maintenance of options' which gives space for a more anticipatory and precautionary approach and allows for the inclusion of other categories indicated by IPLC that do not fit its general categories. IPBES moreover calls for the bridging of ILK and scientific knowledge on NCP and proposes a diverse valuation approach to prioritize NCP that elucidates and includes plural values that are relevant for different stakeholders – i.e. economic; biophysical; health; socio-cultural; and holistic values (Pascual et al. 2018). The NCP framework thus invites policy assessment to link these plural values to NCP categories and to explicitly recognize 'intrinsic' and 'relational' values (which can include animal welfare and rights, and Mother Earth). Moreover, IPBES aims to be inclusive of IPLC cosmologies that consider Mother Earth as a self-regulating system that is simultaneously an extension of people and an entity that integrates people and (non)living beings.

2.3. PCN further explored

Scholars have criticized how the NCP framework (Díaz et al. 2018) gives limited space to the role of people in shaping nature (which we refer to here as PCN) (Peterson et al. 2018). This may compromise the IPBES's ability to advance the inclusion of diverse knowledges and worldviews in policy assessment and to give centrality to culture as a key factor in defining and conceptualizing nature, and the linkages between people and nature (Kenter 2018). Díaz et al. (2018) recognize that NCP are co-produced by nature and people, and this shows that the NCP framework includes PCN to a certain extent. Nonetheless, the term 'contributions' in NCP may give the suggestion that nature provides people with 'gifts' without people having a role to play in the provision of those gifts (Kenter 2018, p. 41). Furthermore, despite the central emphasis of the NCP discourse on culture, only a few subcategories of NCP are directly associated with it (e.g. labor). Moreover, the relation between those NCP subcategories that have a cultural content and those that have an ecological content is difficult to make concrete in certain contexts. For instance, Díaz et al. (2018, p. 271) stress that '*the non-material dimension of regulating NCP is not as widely recognized across cultures*'. Failing to sufficiently account for the role of people in supporting (or undermining) services or contributions from nature can prevent a political discussion of the role of different actors in resource management and nature conservation. This specifically applies to the knowledges and

worldviews that various actors introduce to environmental assessments and are used to inform the planning of resource management.

With our conceptualization of PCN, we look beyond knowledge and worldviews to also include practices. These three forms of PCN affect the state and regulation of ecosystems and can both support and undermine specific NCP or ES (cf. Raymond et al. 2017). Practices correspond to the material dimensions of people's culture entangled with non-material values and knowledge, which are all important for assessments to address the diversity comprised in social-ecological contexts in a relational way (Matuk et al. 2019). This broad conceptualization of PCN is suggested to advance assessment frameworks in linking these material and non-material PCN to nature's provisions (cf. Chan et al. 2012) and to further feasible planning strategies towards nature conservation.

3. Material and methods

3.1. Study area

The Kaxinawá Nova Olinda Indigenous Land (KNOIL) is located in Feijó, in the Brazilian State of Acre (Figure 1). Acre has an area of 157,490 km² (approximately the size of Bangladesh), of which 88% is covered by Amazon rain forest (Sills et al. 2014). Several governmental and non-governmental entities cooperate to address the various Acrean IPLC, including Indigenous ethnicities, fish farmers, and others. These entities employ participatory methods to co-design and implement policies that aim to enhance the biological and cultural (bio-cultural) diversity of their territories (Iglesias 2008). KNOIL covers 27,000 ha and is home to 492 people who speak Portuguese and the Kaxinawá language *Hátxa Kuin*. Similar to about 6,000 Kaxinawás and other Amazonian ethnicities that live close to the Brazil-Peru border, the Kaxinawás of KNOIL have animist holistic worldviews that consider all biophysical entities, including humans, to be linked and sacred (Maná Kaxinawá 2002). Kaxinawás have lived in KNOIL since remote times that are not registered in the literature. They practice a traditional form of resource management that includes practices such as shifting cultivation, collecting, hunting, fishing, and handcrafting, which do not rely on external chemical inputs or machinery and aim mainly at subsistence (Do Amaral et al. 2015).

Planners of the Brazilian Agricultural Research Corporation (EMBRAPA, acronym in Portuguese) started implementing the SISA policy in KNOIL in 2011 as a pilot project to further the participatory implementation of this policy. This project comprised a broad participatory assessment of the social and

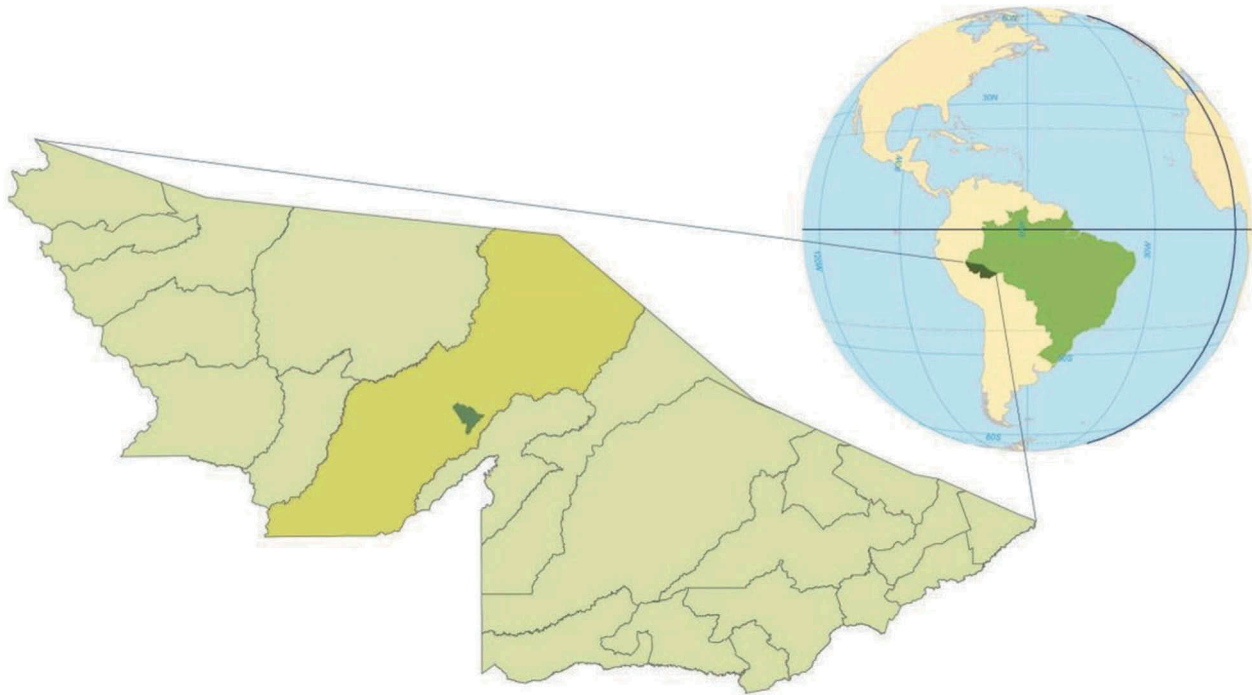


Figure 1. Location of KNOIL in the municipality of Feijó, in the Acre state, and in Brazil. (Do Amaral et al. 2014).

ecological characteristics of the KNOIL territory, which informed adaptive collaborative management planning with Kaxinawás. While SISA was mainly designed as a REDD+ policy that targets ES, the assessment and planning processes of SISA included both scientific knowledge on ES and explored the concept of NCP with Kaxinawás to assess and include their aspirations, classification systems, and values on nature. To this end, the planners used an intercultural and interdisciplinary approach (Do Amaral et al. 2015).

3.2. Data collection and analysis

Data collection took place in KNOIL and in the city of Rio Branco (SISA headquarters, capital of Acre state). The first author collected data in collaboration with the fourth and fifth co-authors (who had previously implemented SISA in KNOIL) and analyzed data with the other co-authors. Data was collected in Portuguese and co-validated with participants at the end of the fieldwork. Free and prior informed consent was obtained from the Kaxinawás of KNOIL (Brazilian Law n° 13.123, 20/05/2015). We stress that while the Kaxinawás of KNOIL are not co-authors of this article, they are co-producers of this research, as an ethnoecological research accounts for participants as research partners in data collection, analysis, and validation (see Albuquerque et al. 2014).

Data for the discourse analysis included: publications on ES (de Groot et al. 2002, 2010; MA 2005; Haines-Young and Potschin 2017) and on NCP (Díaz et al. 2018; Pascual et al. 2018); planners' reports (Do Amaral

et al. 2014, 2015); the SISA framework described in the state Law n° 2.308 (Government of Acre 2010); and interviews. Interviewees included 20 SISA practitioners – policy makers and planners of (non)governmental organizations who participated in the design of SISA or in its implementation in KNOIL; and 40 Kaxinawás from KNOIL of varied ages and gender who participated in the local SISA assessment and planning processes. In the interviews, we probed both planners and Kaxinawás on their aspirations, values, and classification systems and we asked them how they perceived the participatory processes to implement SISA and how they were able to influence the inclusion of knowledge and worldviews. Thus, interviews also provided data to analyze how discourses of planners and locals interacted, and how they resonated with discourses of ES and NCP.

Data from interviews was cross-checked with data from participant observation of a four-day workshop (including 35 Kaxinawás and two planners who implemented SISA in KNOIL). In the workshop, we traced back the contents that were prioritized during the SISA assessment and planning and how decisions were made during these processes. During the workshop, we conducted circles of dialogue (Freire 2000) where we conceptually mapped Kaxinawás' knowledge and worldviews by inquiring on their values, aspirations, and classification of NCP. We also conducted a participatory mapping (Albuquerque et al. 2014) where Kaxinawás presented to us (in drawings and in the field) the spatial distribution of NCP and PCN categories in landscape units that they recognize

as having different land uses, relief, and soils and that they used to plan resource management with planners. Finally, we problematized the contrast between our findings with findings reported by Kaxinawás and planners in interviews and SISA reports, and the challenges and achievements found by them when bridging and co-producing knowledge and worldviews to implement SISA. All data was registered in notes, recordings, and transcriptions.

To support the discourse analysis, we used qualitative coding of the documents and interview data to analyze expressions of aspirations, values and classifications systems. We analyzed the way in which different forms of knowledge were articulated in relation to each other in order to identify knowledge dichotomies and uneven power relations. Finally, we contrasted the discourses we found with one another to highlight differences and similarities. We also analyzed how discourses shaped assessment and planning processes by contrasting how different interview respondents and participants in the workshop reported about the extent to which they were able to influence the participatory processes and its outcomes. This enabled us to identify whether and how knowledge differences present in different discourses influenced power dynamics and affected the inclusion of diverse and relational knowledge and worldviews.

4. Results

In this section, we present the discourses of SISA planners and Kaxinawás in relation to discourses of ES and NCP, and the implications of the encounter of these discourses during participatory processes for the inclusion of diverse and relational knowledge in the SISA assessment and planning.

4.1. SISA discourse

The SISA discourse expresses aspirations to enhance bio-cultural diversity and reduce deforestation and forest degradation in alignment with the knowledge, aspirations, and worldviews of IPLC (see Table 2).

The discourse also expresses the idea that IPLC are ‘forest guardians’ and the aim to reimburse IPLC for their past contributions to maintain the rain forest cover at 88% of the territory of Acre. The commitment of SISA policymakers to the REDD+ donor German Bank KfW involving IPLC is thus to provide shared benefits for IPLC that strengthen the conservation of their culture, livelihoods, and territory as well as the sustainability of their resource management (Government of Acre 2010). Therefore, SISA builds upon IPLC’s worldviews, ILK, and resource management:

... We know that the cultures of the indigenous people and other Acrean communities are dynamic, and they wish to maintain their traditional knowledge and practices ... We know also that their resource management is usually more sustainable than that of other stakeholders. Thus, we build on their knowledge and needs to help them adapting resource management (Interview 3).

SISA practitioners hold that if environmental assessment is to inform adaptive collaborative planning with IPLC, it must be adapted to the Acrean context and enable the bridging of scientific and local knowledge and worldviews. Accordingly, these practitioners have relied on global frameworks (MA 2005; Díaz et al. 2018; among others) and on several workshops with IPLC from Acre to select the ES categories that SISA addresses (see Table 2). SISA’s classification of ES was designed with the participation of IPLC and is inclusive of ILK, culture, and sociocultural diversity (Table 2). It emphasizes the contributions of PCN represented by both ILK, worldviews, and practices of IPLC’s for ecosystems. The quote below expresses this idea:

We assess ES, but also the influences of Indigenous and local communities on nature ... We consider for instance their cultural worldviews, knowledge, and practices for the regulation and provision of ES and vice-versa ... When we assess ILK classifications of ecosystems we use the concept of NCP because this is easier for the communities to connect with. This approach has enabled us to develop a holistic understanding of ES (Interview 7).

Table 2. Categories of aspirations, classification of ES, and values manifested in the discourse of SISA policy makers and planners.

Aspirations	ES classification categories	Values
Maintain the rain forest cover at 88% of the territory of Acre and reduce forest degradation	Carbon services	Stewardship with locals to understand their social-ecological context and to plan resource management and governance via interdisciplinary and participatory approaches
Enhance and strengthen ES, human well-being, bio-cultural diversity and social-ecological resilience	Water resources services	
Craft global and SISA frameworks to align with IPLC knowledge, worldviews, practices, and contexts, and needs	Climate regulation services	Humility to respect diverse cultures and related knowledge and worldviews of IPLC via an intercultural approach
Provide shared benefits for IPLC (i.e. infra-structures; seeds, cultural rescue, and capacity building of indigenous knowledge leaderships to become SISA ‘agroforestry’ knowledge agent officials)	Soil services	
	Natural beauty patrimony	Ethics and solidarity with IPLC’s well-being, aspirations, cultural diversity, and needs
	Culture and ILK	
	Sociocultural (bio-cultural) diversity	

SISA practitioners stressed that they became aware of the importance of assuming an intercultural approach to reflect on their own values and respect IPLC's culture, values, and knowledge after having worked on policies that address these communities since the 1990s (see Sills et al. 2014). They also consider interdisciplinary collaborations between planners with backgrounds in social as well as natural sciences indispensable to address NCP and PCN to biodiversity simultaneously and to include ILK and cosmovisions holistically. IPLC's multiple knowledges and values on nature, as well their livelihood needs are conceived to both influence and to be influenced by ES, as explained in the following quote:

Communities develop their culture via social learning with nature ... This influences how they decide practices. These practices affect the regulation of ecosystems and biodiversity, and also support the provision of ES ... For instance, the Indigenous people management of hunting aims to maintain hunting species available for their descendants (Interview 1).

The SISA discourse shows that planners prioritize knowledge and worldviews in assessments that are relevant to plan management. This requires reflection with IPLC on the prioritization of ES and values that can be addressed in practice to enhance bio-cultural diversity in alignment with local aspirations. Planners hold that ILK and worldviews are usually oriented to sustainable practices. Moreover, cultural values underlie the creation of ecological and economic value:

... The cultural values of Indigenous and local communities are usually concerned with generating income with resource management that complements their subsistence and that also maintains natural resources available both for future generations and natural entities ... Thus, cultural values inform decisions on practices and labor of these communities and they determine what economic and ecological values are generated in their territories ... SISA aims to embrace local values and knowledge that support the continuation and improvement of community sustainable practices. This goes far beyond prioritizing economically-oriented decision-making ... (Interview 15).

4.2. *Kaxinawá discourse*

The Kaxinawá discourse articulates aspirations that link cultural and biological diversity. Accordingly, the central Kaxinawá aspirations (food and livelihood security and territorial sovereignty) (Table 3) are considered in resonance with the needs of natural entities:

Our culture is our spirituality and is centered on our food. We have learned with nature and with the ancestors that all beings, people, soil, and plants are

sacred and must have their needs respected ... (Interview 47).

Kaxinawás explain that, to understand their knowledge and worldviews, we need to know their history and social-ecological context. Kaxinawás reported that by maintaining collective land use, food traditions, the *Huni Kuin* language, and spiritual values, they have been able to safeguard their social-ecological heritage. However, changes have threatened this heritage. These changes date back to the development of the Amazon region via Brazilian government projects which introduced slavery for rubber-tapping and alcoholism in KNOIL in the 19th century. Kaxinawás became visible to the government and had their identity and land rights recognized in the 1980s by engaging in grassroots movements (see Iglesias 2008). However, the fixed boundaries of their territories, combined with population growth, have required them to adapt their traditional resource management. Moreover, some Kaxinawás have found support in a protestant religion to fight alcoholism since 2010. This created political and cultural fragmentation from other Kaxinawás who maintained their traditional spirituality. Kaxinawás emphasize that this spirituality involves the shamanist ritual use of *Ayahuasca*, a forest brew prepared by shamans that mediates spiritual awareness to steward self-existence and resource management with nature. Simultaneously, more intense contact with urban spaces has stimulated Kaxinawás to migrate in search for study and health care. Kaxinawás highlight that these changes make the support by scientific knowledge via policies relevant for them to adapt their knowledge and practices in such a way to conserve their socio-cultural legacy and ecological sustainability.

Kaxinawás indicated diverse NCP and PCN categories during our interviews (Table 3). For instance, the linked subcategories of soil – and forest – related NCP to livelihoods subcategories (i.e. raw materials and fibers used in boats, and clothing that integrate their cultural identity). Figure 2 visually illustrates part of the diversity comprised in the Kaxinawá knowledge and cosmovisions on NCP and its relational consideration of people and ecosystems. Although Kaxinawás consider all NCP categories to be important, we organized them in (sub)categories to facilitate their representation. Therefore, we relied on the emphasis given in Kaxinawá discourses to link specific subcategories with specific social and natural resources (e.g. knowledge and soils). Likewise, although Kaxinawás mentioned several indicators they use to manage resources and adapt knowledge and practices, we presented in Table 3 the indicators they mentioned most – e.g. the thickness and height of secondary forest trees indicates when fallows can be cleared and crops can be planted in shifting cultivation areas. Moreover, these (sub)categories are all

Table 3. Aspirations, classification of NCP and PCN, and values manifested in the Kaxinawá discourse (KNOIL, Acre – Brazil).

Aspirations (PCN linked with NCP)	Classification of NCP and entwined PCN Categories – Subcategory (examples)	Values (PCN entwined with NCP) Categories – Subcategory (examples)
Food and livelihood security and territorial sovereignty	<p>Forests – Life pool; identity; homeland; sense of belonging; collecting; shadow to soften the warmth in the houses; food; medicinal plants; palm leaves to make the ceiling of boats, ink for body and handicraft; fiber for clothing fuel; wood (houses, rowing, bow and arrow); source of learning indicators for using and managing resources (thickness and height of secondary forest trees indicates when fallows can be cleared and crops can be planted in pre-existent shifting cultivation areas);</p> <p>Soil – Shifting cultivation (cassava, banana, corn, yam, taioba, peanuts, agroforestry with fruit trees); clay for ceramics; associated to landscape units with specific vegetation, relief, and land uses; shelter; habitat for (non)human species; clay (ceramics); water spring source (regulation of clean water); Kaxinawá land; territory; homeland; indicator (when soil fertility and crop's yields decline indicates that shifting cultivation areas must be left to become fallows and soil quality auto-regulation can take place; several indicators for land suitability for crops such as texture, consistency, taste, and humidity)</p> <p>Water – Learning experience to contribute to the nature regulation of the river life pool; landscape builder (water causing soil erosion and crating river arms, referred regionally as <i>igarapés</i>); food provision via soil humidity and fertility; softening of the warmth; domestic consumption; fishing; means of transport (KNOIL is surrounded by river and dense forest); leisure; rituals; contemplation; territory; indicators (regulation of soil fertility and humidity indicates the suitability of lands for crops; water regulates forest growth)</p> <p>Fauna – Presence of species suitable for hunting and fishing; flora and fauna medicine; companionship; chicken; pork; and cattle production (this later was introduced by colonizers and has been abandoned by most Kaxinawás); feathers for <i>coçar</i> that are part of the Kaxinawá cultural identity (headdress); means of communication via a bugle made of horn (only used by the cacique chief)</p>	<p>“Mother Earth” – Kaxinawás and nature are an indivisible and self-regulating interdependent unit that links sacred biophysical entities, including man (animist worldview)</p> <p>Spiritual – Respect for biophysical Earth's entities; indicator (reduction of crops and hunting provision indicates need to rethink practices and values); medicinal healing; social learning; enlightenment; and adaptation of cosmovisions; knowledge; and practices; the protestant religion is perceived as not conflicting with the Kaxinawá animism but as conflicting with the use of <i>Ayahwasca</i></p> <p>Informational and educational – Nature orients social learning and adaptive management and governance (guiding the access to resources)</p> <p>Ethical – Humility and moral responsibility, and solidarity towards all (non)human entities; co-existence with nature</p> <p>Economic – Subsistence non-capitalist values (subsistence) and monetary values (not yet quantified income generated with agricultural surplus and handicraft)</p> <p>Stewardship – Agency of nature and people; people-ecosystems governance; compassion between people and nature</p> <p>Individuality and community – Self-identity; sense of interdependence with others; gender and age differences; social roles; marriage (s made early to ensure that family members obtain their subsistence together); family (labor, share of duties, care)</p> <p>Cultural identity – Kinship with nature and people (identity relation with jaguar); sense of belonging to the <i>Huni Kuin</i> (“true people”) ethnicity and to the Amazon forest and landscape (Kaxinawás see themselves as “forest and water people”); territory; community; Recreational – Leisure; relaxation; contemplation of the natural aesthetic beauty</p>
Social-ecological sustainability and resilience	<p>Climate – Rain and humidity to soften the heat; regulation of humidity; seasons; indicators (weather and seasons are forecasted by species); seasonal distribution of land use practices</p> <p>Geographical reference – Time (birds and moon indicate respectively times of the day and time for cropping); weather (nature signs indicating rain, location (rivers and landscape features); space (historical social-ecological heritage, availability of resources, cultural legacy)</p> <p>Knowledge – Social and transformative learning via experimentation with nature; knowledge sharing and co-production with (non) governmental entities; and IPLC; nature is a teaching entity; resource management wisdom/knowledge; emphasis is put on medicinal shamanic wisdom and food production knowledge (both linked with health; spiritual balance; survival; respect for nature; learning; social-ecological reproduction and survival)</p> <p>Governance – Political ecology formed by reciprocity via a co-stewardship with nature, where (non)human agents influence decisions via their response to Kaxinawá practices; traditional and legal territory; defense of territorial boundaries from eventual hunters; male domination but recent women leadership to support cultural rescue; marriages soon after puberty ensure a familiar labor basis and interdependency between children and elders; political attitude of maintain traditional culture (knowledge, practices, values); the spiritual and medicinal shaman chief and the political and educational cacique chief maintain and adapt this culture; rules to use and manage common use resources and lands, including time, place in the landscape, and technique used (Kaxinawás know that their rare use of electricity implies in less need to exploit nature to obtain income to pay for it as well as avoids deforestation which affects the regulation of soil humidity, fertility, and fauna habitat)</p> <p>Economy – Subsistence (sovereignty, self-consumption); maintenance of nature regulation processes and enhancement/maintenance of sustainable practices; capitalist relations and trade (of crop surplus and handicraft)</p>	<p>Interdependence with others; gender and age differences; social roles; marriage (s made early to ensure that family members obtain their subsistence together); family (labor, share of duties, care)</p> <p>Cultural identity – Kinship with nature and people (identity relation with jaguar); sense of belonging to the <i>Huni Kuin</i> (“true people”) ethnicity and to the Amazon forest and landscape (Kaxinawás see themselves as “forest and water people”); territory; community; Recreational – Leisure; relaxation; contemplation of the natural aesthetic beauty</p>
Creation and strengthening of partnerships with (non)governmental entities to find support of scientific knowledge and policy fund' and adapt practices in face of social-ecological changes	<p>Spirituality – Rituals to practice agriculture, handicrafting, among others; consumption of healthy food and of diverse substances from the forest to raise personal balance and strength to work; ethical habits; medicine from the forests; friendly co-existence with nature; sacred plants that enlighten people with perception and wisdom and that protect (non)human and non-living beings) such as <i>Banisteriopsis</i> sp. and <i>Psychotria</i> sp. (used to produce <i>Ayahwasca</i>); and <i>samauma</i> or <i>Ceiba pentandra</i> (giant tree used to produce rape and considered a spiritual authority that contributes to the ancestral wisdom of shamans on traditional medicine);</p> <p>Cultural identity – Kaxinawá identity; affective bonds with forest/river landscape (nature is a caring entity but gives lessons to correct Kaxinawás when they do not respect its limits of renewability of soil quality and forest regeneration; nature's entities represented in body-painting and handicrafts; Kaxinawá ancestry from animals including their traits and skills that ancestors perceived (jaguar, tapir)</p> <p>Folklore tradition – artistic representations that teach ethical social interactions; recreation; <i>Kaixanawa</i> where Kaxinawás thank nature for harvesting; <i>nixi pae</i> ritual where Kaxinawás drink <i>Ayahwasca</i> to find spiritual wisdom and envisions personal and political learning to govern nature.</p> <p>Art and handicraft – Cotton for clothing; feathers and jaguar teeth for jewelry; latex from <i>Hevea brasiliensis</i> trees to produce the regionally important rubber “vegetal leather” (“encauchados”); musical instruments; inspiration (nature informs art and provide raw materials for handicraft, people's handicrafts transmit values of nature)</p>	<p>Artistic – Music; clothing; poetry; tales; education</p>



Figure 2. Examples of NCP and PCN identified by Kaxinawás: (a) feathers of birds used to produce ‘cocares’ (headdresses) that symbolize the Kaxinawá cultural identity and political hierarchy); (b) palm leaves used to produce a boat ceiling; (c) handicraft made of latex made with technology adapted from rubber-tapping introduced in the past of slavery; (d) agrobiodiversity of corn species associated with the Kaxinawá land use heritage; (e) (rattle) instruments produced with different wood and raw materials; (f) Kaxinawá knowledge agents (SISA officials) responsible for maintaining and supporting KNOIL in adapting the Kaxinawá knowledge legacy; (g) bridge and house made of wood; (h) shifting cultivation with banana and cassava; (i) ceramics produced by women using Kaxinawá spiritual rituals and knowledge.

referred to as intertwined with PCN and linked with each other. As such, forests are considered simultaneously as a pool of life; as identity; as homeland; as source of medicinal plants; and so on.

The Kaxinawá discourse is based on an understanding that people, ecosystems, and biodiversity are entwined, as this Kaxinawá expresses: *‘It is not only nature that works for us. We work together with nature’* (Interview 24). Kaxinawás stress that this is why they have adapted their resource management so that it is not only in accordance with their culture but also responsive to ecological processes and functions. For instance, the Kaxinawá management of hunting and fishing is both associated with Kaxinawá food culture and aims to contribute to fauna reproduction cycles (Table 3). Thus, according to the Kaxinawás, the different subcategories of NCP are not only interdependent but also inseparable from each other. The following quote illustrates how the Kaxinawás use their knowledge of how their practices affect and are affected by the support, provision, and regulation of biodiversity in the temporal and spatial distribution of their resource management:

When we notice that the birds are disappearing in an area, we know we are clearing forest for cropping too much there and not leaving enough food for the birds. Then, we leave at least part of that area to remain as a fallow ... In turn, the birds come back and keep cheering us with their singing (Interview 22).

The Kaxinawá discourse is based on an animist world-view of ‘Mother Earth’, which means that all Kaxinawá values are formed in relation to nature and its intrinsic values, and in relation to their knowledge, practices, and aspirations (see also Maná Kaxinawá 2002). For instance, stewardship values are expressed in tales used by Kaxinawás to register and transmit their knowledge – e.g. rats have taught women to give birth and squirrels have taught man how to grow crops). Co-existence with nature thus includes values of reciprocity, ethics, and solidarity towards all (non)human entities. This quote shows how Kaxinawá socio-cultural, intrinsic, and economic values are interconnected:

We do as the ancestors did. We sing sacred songs to ask permission and bless the nature entities before fishing, hunting, clearing forests, and harvesting. We also prepare our minds and body, by watching our thoughts, food, and sexual behavior ... If we do not respect the care that nature requires and the needs it has for its own sake, we can feel unwell and not get the livelihoods we need (Interview 33).

Finally, the Kaxinawá values inform Kaxinawá’s governance and resource management decisions via an understanding of the world that considers nature to have agency. Accordingly, the Kaxinawás’ understanding of the impacts of their practices on nature informs changes in their resource management towards a co-stewardship with nature where people

and ecosystems play a role in shaping management strategies and biodiversity. The spiritual and medicinal chief (shaman) and the political and educational chief (cacique) ensure that the use and access to resources follows this co-stewardship.

4.3. The shaping of policy processes by different discourses

The SISA and Kaxinawá discourses interconnected during the SISA implementation process and particularly during the dialogues between planners and Kaxinawás to assess local needs, values, and classification systems and gain insight on how they could be accounted for in the planning of resource management related practices. This dialogue was initiated by planners participating in Kaxinawá practices to interconnect with their culture. These included: harvesting, meals, and spiritualistic rituals through which Kaxinawá women extract clay to produce ceramics and Kaxinawás do the *katchanawa* (see Table 3 for an explanation). For a proper interdisciplinary dialogue with Kaxinawás and an appropriate interpretation of their interactions with nature, the planners of EMBRAPA with a background in soil science also relied on input of planners who have a social science background. Kaxinawás reported that the engagement of planners in their practices demonstrated that planners considered their knowledge and culture as relevant. This was very important to establish mutual trust and provided a solid basis to proceed with the joint planning of resource management.

The intercultural approach adopted by planners mediated a respect for the diversity and relational thinking comprised in the Kaxinawá knowledge and worldviews during both assessment and planning. Kaxinawá and SISA discourses resonated insofar that planners gave Kaxinawás voice to express their knowledge and worldviews and to make decisions. During the SISA assessment of the KNOIL territory, Kaxinawás contributed by eliciting priority categories of aspirations, of NCP, and of values; and by helping planners to find common objectives involving Kaxinawá aspirations and SISA aspirations (both of which focused on enhancing bio-cultural diversity). To include these categories in their diversity, planners asked Kaxinawás to indicate associations among aspirations, NCP, and values. These associations were made via a reflection on management options that benefit all Kaxinawás. Planners thereafter weaved these categories with their own respective categories without the participation of Kaxinawás in an identification-key containing the SISA and Kaxinawá aspirations, classification systems, and values assessed (Table 4). Besides this result of the assessment, planners also generated with Kaxinawás a participatory mapping in which Kaxinawás elicited the distribution

of the most representative NCP and PCN in each landscape unit they recognize in KNOIL. Planners also represented this mapping graphically without including the Kaxinawás (Figure 3). During the subsequent planning of resource management, planners facilitated Kaxinawás to decide on management options that addressed both SISA and Kaxinawás objectives. This part of the process was not focused on values anymore, as planners argued that these management options had already been designed while taking account of Kaxinawá values. Finally, planners systematized the resultant planning of strategies for adaptive collaborative management (Table 5).

The SISA implementation processes showed strong efforts to include both scientific and local knowledge and worldviews in the outcomes of the assessment and planning processes that account for NCP and PCN in a relational way. However, there were also challenges. While both Kaxinawás and planners, including those with a background in soil sciences and in social sciences, participated in decisions on what knowledge should be prioritized during the assessment and planning; only the planners with a background in soil sciences participated in the elaboration and validation of the graphical outcomes presented in the SISA reports. This happened because most of the EMBRAPA planners had a background in soil science and preferred to weave correspondences and complementarities between their and the Kaxinawá knowledge and worldviews to compose the SISA outcomes on their own. Planners explained that they decided not to include Kaxinawás in this part of the process because they considered that scientific classifications involve complexities and particularities that are not relevant and that do not need be taught to Kaxinawás, who rely on their oral and contextualized knowledge to manage resources. Moreover, the inclusion of the planners with a background on social science in the creation of SISA outcomes was considered unnecessary and challenging, as these outcomes were mainly produced to be shared with practitioners of EMBRAPA who are mostly not acquainted with the terms and methods of social sciences. These challenges resulted in a reduced representation of the content of the Kaxinawá knowledge and worldviews. This reduction becomes clear when we compare Table 3 (which includes our assessment of the Kaxinawá discourses on those contents) with the outcomes of SISA (Tables 4 and 5, and Figure 3). Nevertheless, the contents included in the SISA outcomes do account for interplays between NCP and PCN in a relational way.

Both Kaxinawás and planners considered the process to be legitimate, despite the challenges to include knowledge and worldviews associated with different knowledge systems and disciplines. There are

Table 4. Correspondences and complementarities between the aspirations, classifications, and values of Kaxinawá and planners that were prioritized in the SISA assessment (KNOIL, Acre – Brazil).

Aspirations		Classifications		Values	
Kaxinawás	SISA	Kaxinawá NCP and PCN categories (considered linked)	SISA ES categories (intertwined)	Kaxinawá categories (intertwined)	SISA categories (intertwined)
Social-ecological sustainability and resilience with a focus on strengthening food and other livelihoods security, and on territorial sovereignty	Enhance ES, bio-cultural diversity; social-ecological resilience and the Kaxinawá resource management sustainability with a focus on reducing deforestation and forest degradation, mitigating climate change, enhancing soil and water conservation and human well-being	Forests, soil, water, fauna, and climate geographical reference, knowledge, cultural identity, folklore tradition, art and handicraft (all related with the support to the provision of natural resource, biodiversity and cultural diversity, of habitat, of the regulation of their provision, and livelihoods); emphasis on food, medicine, and other livelihoods that are part of the Kaxinawá culture, resource management, and governance, and that mediate the Kaxinawá economy (subsistence and trade)	Carbon, soil regulation; water resources; climate services; and natural beauty patrimony	'Mother Earth', political ecology of stewardship with nature, governance, economic (subsistence and trade – not quantified yet), recreational, and economic subsistence	Stewardship with locals to assess their social-ecological context as well as knowledge, practices, and values; and to plan resource management and governance that addresses Kaxinawá needs and nature conservation in KNOIL
Cultural conservation (traditional medicine, land use, resource management), and governance, prevent migration, political attitude to maintain subsistence and culture, strengthen partnership with (non)governmental institutions	Conserve and strengthen the local bio-cultural diversity, and provide shared benefits for Kaxinawás	Social-ecological heritage, cultural identity, territory and habitat for flora and fauna, folklore, traded handicraft, art	Bio-cultural diversity (including cultural local knowledge, worldviews, practices, and needs as well as ES and related livelihoods)	Cultural identity, community, family, Gender and age values, spiritual, art	Ethics and solidarity with the Kaxinawá well-being, aspirations, cultural diversity, and needs
Bridge and co-produce knowledge with (non) governmental entities in tune with the local social-ecological context, existent Kaxinawá knowledge, cultural legacy, and resource management and governance top face social-ecological changes	Craft the SISA framework to embrace the Kaxinawá knowledge, worldviews, practices, and context; via participatory assessment and planning, and by funding benefits that can be shared by all Kaxinawás (i.e. activities, infra-structures, and capacity building) as part of the planning of resource management and governance with Kaxinawás	Traditional knowledge, spirituality, and ancestral wisdom	Culture and ILK services	Informational; educational; ethical	Humility to respect the Kaxinawá culture, including knowledge, worldviews, and practices

Table 5. Planning strategies based on the bridging of aspirations and classifications of Kaxinawás and SISA planners (KNOIL, Acre – Brazil).

Aspirations	ES (including NCP and PCN)	Planning strategy
Social-ecological resilience; Kaxinawá well-being, with a focus on food and other livelihoods security, and on territorial sovereignty	Forests; water; soil; climate regulation; habitat, with a focus on the provision of food and other livelihoods, land use, and on resource management and governance	Optimize the sustainability and productivity of the shifting cultivation to increase the food productivity in fallows by: reducing deforestation in pristine forest areas to enhance in combination the intertwined forest, soil, water, and climate services; using cropping areas as more robust agroforestry systems to continuously provide litter and nutrients for soils (i.e. intensifying the use of legumes which fixate nutrients in the soils and benefit other cropping species with soil fertility); and allocating precisely cropping species in soil and landscape units that better attend their nutritional demands; Reduce the pressure of fishing on NCP, by increasing the hunting activity in different areas of KNOIL over the year to mitigate their impact; and by installing fish farming ponds Rely on the SISA provision of shared benefits by providing seeds for the installation of a seed banking for agroforestry systems – the installation of ponds will be considered as possibility in the future as it is hard to transport machinery to by boat KNOIL and it is surrounded by the river Rescue and conserve the Kaxinawá cultural knowledge, practices, and values, to prevent migration and maintain the social-ecological legacy
Biophysical and cultural diversity with a focus on the Kaxinawá culture and economy (including subsistence and complementary trade practices)	Social-ecological heritage, cultural identity, territory; folklore; cultural and natural patrimony Handicraft and agricultural self-consumption and trade; economy (subsistence and trade)	Rely on the SISA provision of shared benefits via the funding of expeditions for knowledge interexchange with other Kaxinawás on painting, handicrafts, and resource management practices Quantify the income obtained with the trade of agricultural surplus and handicraft, and the agricultural goods needed to supply the Kaxinawá self-consumption; expand the production of handicraft for a better economic organization towards well-being and sustainability – with support of Embrapa (via the continuation of projects with Kaxinawás) and of the resorted Acrean (non)governmental entities Apply the knowledge on soils and ecosystems co-produced by planners and Kaxinawás to adapt the Kaxinawá resource management and governance in KNOIL – with the support of Indigenous agroforestry knowledge agents capacitated as SISA officials along the implementation of the policy as well as of the caciQue and shaman local leaderships
Bridge and co-produce knowledge via SISA knowledge agents and via partnership with (non)governmental entities of Acre in tune with the cultural legacy	Knowledge; spirituality; ancestral wisdom; political ecology of a governance in stewardship with nature	Rely on the SISA provision of shared benefits via the funding of Indigenous agroforestry knowledge agents as disseminators of knowledge and practices agreed during the SISA planning Resort to diverse Acrean (non)governmental institutions – specially the Commission Pro-Indigenous peoples of Acre (CPA-Acre, acronym in Portuguese), and the Secretary of Familiar Production (SEAPROF, acronym in Portuguese) – to quantify the income obtained with the trading of agricultural surplus and handicraft; potentiate the handicraft trading; and raise awareness of young Kaxinawás on cultural values and maintenance of the <i>Huni Kuin</i> language via dialogues with the KNOIL community and formal lectures in schooling spaces

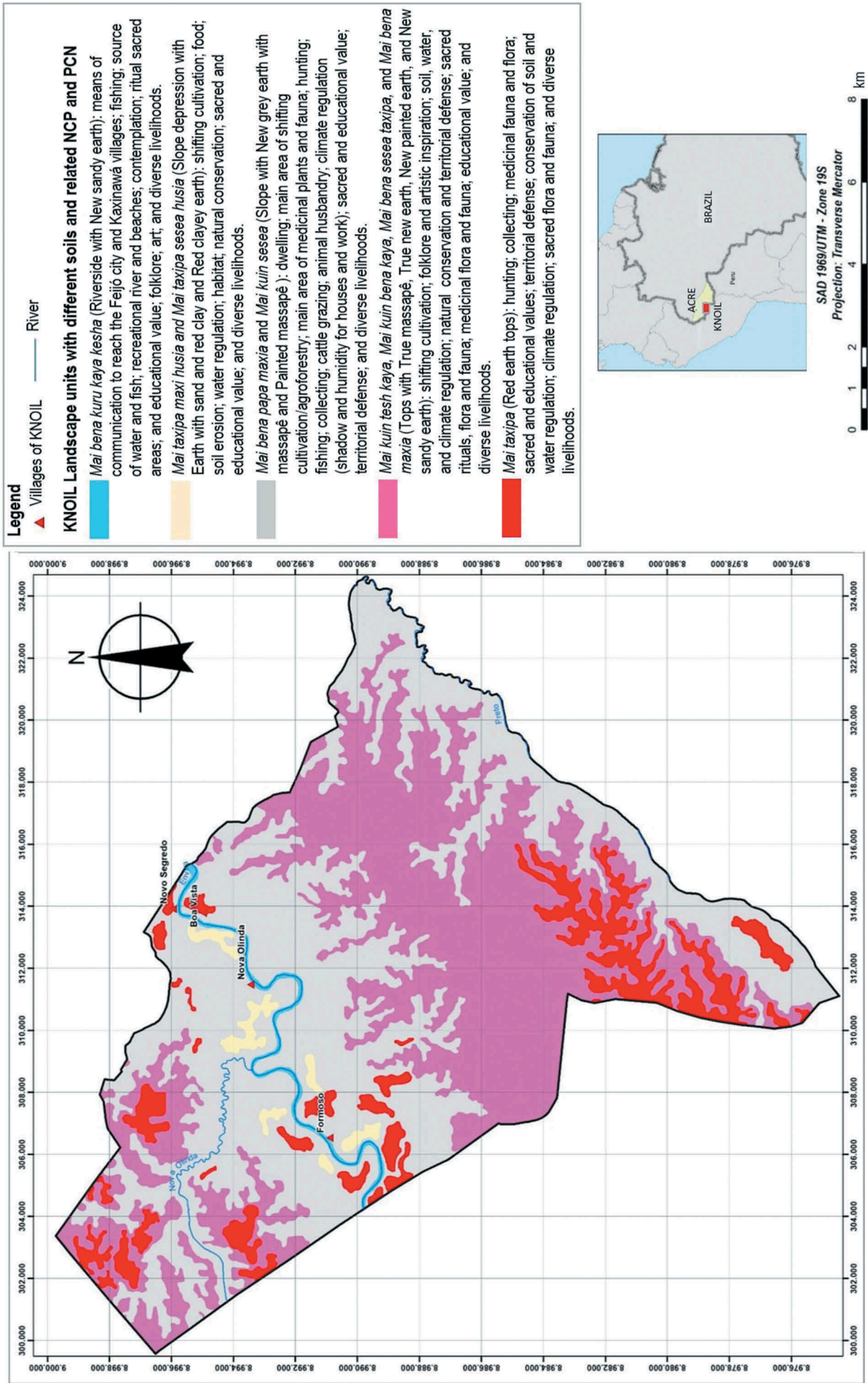


Figure 3. Distribution of the main NCP and PCN categories that occur in each landscape unit and respective soil type of KNOIL (in Huni Kuin and translated to Portuguese), presented in accordance with the Kaxinawás knowledge.

a number of reasons for this assessment. First, the planners with a background in soil science based their work on previous processes of co-production which resulted in shared understandings of local aspirations, classifications, and values. Second, the Kaxinawás considered the outcomes to be in accordance with their decisions on what information was to be prioritized during the SISA assessment and planning. Kaxinawás explained for instance that they had a dialogue with planners about the landscape unit *Mai bena kuru kaia kesha* (Figure 3), to think of several NCP and PCN under influence of the river Envira (i.e. ‘means of transport’ and ‘fishing’) during planning. Kaxinawás did make the reservation that they wish they had had access to the outcomes reported by planners and more awareness of the greater picture of the inclusion of their knowledge in these outcomes, so that they could for instance use these outcomes.

In addition to the above, we also identified challenges in the knowledge co-production processes that nonetheless do not appear to have led to the exclusion of diverse knowledges and worldviews. First, planners explained that no emphasis was given to the ES discourse when interacting with Kaxinawás, as SISA was implemented by departing from the Kaxinawá knowledge and cosmovisions on people and ecosystems which resembled more the NCP concept. However, planners did recognize that the focus of ES on ecological processes incorporated in the SISA discourse helped them to assess NCP with Kaxinawás with an orientation to think of planning practices to address both SISA and Kaxinawá aspirations. Second, planners stressed that it was difficult for Kaxinawás to clearly express socio-cultural values and regulation services. Rather, values were found to be tacit and deeply rooted in identity, and regulation services involved causalities and explanations that are not directly assessable. Data on these values and services was then made via inquiries about reasons and criteria (it means, indicators) that drive locals to adopt and adapt practices. Moreover, planners stressed their concern with avoiding relabeling Kaxinawá values. An example was that while Kaxinawás do not use the term ‘Mother Earth’ to refer to their animist values, these are implicit in their discourse and were treated as ‘the Kaxinawá belonging to and having respect for nature’.

Finally, the interconnection of the Kaxinawá and SISA discourses involved a co-production of new knowledge and worldviews to plan resource management. Planners and Kaxinawás stressed that, in some cases, planning was easily constructed by linking an aspiration with a planning strategy – e.g. ‘to resort to (non)governmental entities to access policies’ (Table 5) ‘to find support of scientific knowledge and policy funds’ (Table 4). In other cases, planning required

additional knowledge and transformation of worldviews to adapt practices. For instance, planners suggested to Kaxinawás that addressing food/livelihood security and nature conservation would require adapting their shifting cultivation practices. The Kaxinawás’ shifting cultivation relies on the use of fire to clear pristine forests, and on a manual clearing of fallows (secondary forests) previously cleared. While pristine forests maintain the soil fertility to produce food for 4 years, fallows maintain it usually for 2 years. Kaxinawás had noticed that the continued deforestation of pristine forests impacts more NCP (i.e. habitat and presence of species for hunting) in comparison with the re-use of fallows. However, only with the support of planners did Kaxinawás decide to give preference to fallows instead of pristine forests and to turn fallows into more productive agroforestry systems. This and other strategies (Table 5) have been effectively adopted in KNOIL and are considered by planners and locals to be enhancing nature conservation and both biophysical and cultural diversity. There was also a case in which different aspirations of Kaxinawás compromised the inclusion of diverse worldviews in planning and consequently the adoption of change in the local resource management. When planning the management of hunting to mitigate its impacts on biodiversity, planners suggested to redistribute hunting in different areas of KNOIL (Table 5). Different community members disagreed on possible hunting areas to be adopted when these were distant from their houses. This example illustrates that despite transparent negotiation to respect diverse worldviews, the inclusion of such diversity can be constrained by trade-offs and different aspirations of participants in decisions.

5. Discussion

Our case study offers an example of how policymakers and planners aligned global discourses of ES and NCP with those of the Kaxinawá Indigenous community in the context of the implementation of the SISA policy. Particularly important was the way in which these practitioners were able to recognize and incorporate Indigenous knowledge and worldviews which are based on a relational understanding of NCP and PCN. This approach was mediated by a joint negotiation of aspirations and values and a co-production of shared understandings that supported planners and Kaxinawás to consider the SISA outcomes as legitimate (cf. Irvine et al. 2016; Turnhout et al. 2016). For these reasons, we understand that the SISA assessment and planning processes showed signs of overcoming dichotomist thinking between science and local knowledge and between social and natural disciplines, which resulted in legitimate outcomes (Tengö et al. 2017). This was possible because

practitioners adopted an intercultural approach that was sufficiently flexible and open to link correspondences and complementarities between the knowledge and worldviews of Kaxinawás and of planners and to respect different classification systems (Kincheloe 2008; Albuquerque et al. 2014). This flexibility enabled planners to pay attention to the meanings and structure of interrelation among categories of aspirations, classification systems, and values as elicited by Kaxinawás.

Analyzing the resonances and contrasts between discourses, we found that the ES and NCP discourses resonated with the SISA and Kaxinawá discourses because they both address human well-being and biodiversity simultaneously and give space for PCN, which affect the nature's benefits for Kaxinawás. We also found differences. The ES discourse ended up being more dominant in the SISA implementation during the prioritization and assessment of ecological process and functions to be targeted in planning. However, the ES discourse did not resonate with the SISA and Kaxinawá discourses when it emphasized universal types of economic values or material benefits in detriment of socio-cultural, ecological, and economic values that are relevant for Kaxinawás. In that sense, the discourses of SISA and Kaxinawás resonated more strongly with the NCP discourse which recognizes the multiple values and benefits of nature and their context-dependency. Moreover, the ES and NCP discourses list categories and values that have mainly an ecological or a cultural content separately instead of linking and listing them side-by-side as Kaxinawás and SISA practitioners did. The ES and NCP discourses are not directly aimed at management and planning and therefore do not link these categories and values to aspirations and practices as strongly as SISA did (cf. Chan et al. 2016; Kenter 2018; Matuk et al. 2019).

We stress that the SISA discourse moved closer to the Kaxinawá discourse by explicitly recognizing the relationality between people and ecosystems, and by acknowledging that people not only benefit from but also contribute to nature and biodiversity. SISA did so by including not just NCP but also PCN and the linkages between these. This entailed envisioning that culture comprises non-material and material contributions that people provide to nature respectively via their knowledge, values, aspirations, and their practices. This matched the Kaxinawá discourse on how they account for both their cultural values and ecosystems to manage the provision and regulation of NCP.

We found that in participatory processes for environmental assessment and planning, the challenges to overcome knowledge dichotomies between knowledge systems and disciplines and to include diverse and relational knowledge are mostly related to sharing of power. The way in which soil science planners

justified the exclusion of Kaxinawás and of social science planners from part of the process by claiming that this did not concern or was not relevant to them, indicates that existing power inequalities and perceptions of differences between knowledge systems remained present. This resulted in a reduction of the diversity of knowledges and worldviews in the outcomes which could have been prevented if power had been shared more equally along the process among planners and with Kaxinawás (cf. Agrawal 1995; Nadasdy 2003). We also saw that power was imposed by planners when they did not consult locals about their interest in using the SISA 'graphical' outcomes. Finally, we observe that while SISA outcomes were overall considered legitimate by Kaxinawás, because they reflected discussions on local priorities and needs, a stronger voice of locals to shape processes could have resulted in a more comprehensive representation of diverse knowledges and worldviews, as well as in an enhanced legitimacy, validity, and relevance of policy outcomes.

6. Conclusion

This paper has shown that incongruences and resonances between global to local discourses related to different knowledge systems, disciplines, and worldviews affect how diverse and relational knowledge and worldviews are included in policy processes and outcomes of environmental assessment and planning. We also showed that despite differences between discourses, their encounter during participatory processes can enable inclusive and legitimate outcomes. Each discourse contributed to these outcomes in different ways. While the ES discourse contributed to the inclusion of ecological processes in the planning of resource management, the NCP discourse stressed the role of both culture, ILK, and of different values on ecosystems and biodiversity. Accordingly, a cross-fertilization between the ES and NCP discourses facilitated the inclusion of ILK and cosmovisions in their diversity and holism. On the other hand, both NCP and ES assessment frameworks still insufficiently account for PCN. To include PCN during the assessment was however crucial to include the interplays between people and nature while adapting resource management practices towards biodiversity and human well-being.

The first lesson we draw from our analysis is that science-policy interface processes taking place at different levels and scales, including ES and IPBES scholarship and practices, can advance the legitimacy of environmental assessments, and the effectiveness of policy and planning that is informed by these assessments. They can do so by recognizing the interrelations between nature and people and by assessing how material NCP are entwined with PCN via both the non-material (knowledge and values) and material

(practices) dimensions of people's culture. The second lesson we draw is that the effectiveness of assessments can be enhanced if they are more directly connected with planning and management practices and if they connect classification categories and values associated with ES and NCP frameworks to concrete local (and extra-local) needs, priorities, aspirations, and existing practices. Both these lessons can be supported by science-policy interfaces explicitly accounting for and incorporating diverse knowledge systems, disciplines, worldviews, and practices comprised in environmental assessment and planning contexts.

Our final conclusion concerns participatory processes. We have seen in our case that the intercultural approach employed provided the openness, engagement, and trust that are necessary for a reciprocal, interdisciplinary, and participatory collaboration, and for the co-production of legitimate policy outcomes. Assessment processes can benefit from investing into participatory processes to enhance the appropriate inclusion of ILK in ways that respect its holistic as well as contextual character. Flexibility is an important attribute of these processes. This flexibility depends on the degree to which planners with different disciplinary backgrounds are able to share power among themselves and with IPLC. Our study suggests thus that the legitimacy and effectiveness of environmental assessment and planning can be improved when actors on the science-policy interface facilitate participation and engagement that gives voice to participants who hold different knowledge systems and disciplines, that focuses on common objectives, aspirations, and priorities which account for both people and ecosystems' roles, and that connects assessment to planning and practice.

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ORCID

Fernanda Ayaviri Matuk  <http://orcid.org/0000-0002-5152-5566>

Jelle Hendrik Behagel  <http://orcid.org/0000-0002-3997-3446>

Esther Turnhout  <http://orcid.org/0000-0002-2190-2076>

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