From the ecosystem to the organization: Theoretical reflections on the articulation between Accounting for the Management of Ecosystems (AfME) and Comprehensive Accounting in Respect of Ecology – Triple Depreciation Line (CARE-TDL) models

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Abstract

The growing concerns over ecosystem degradation and its unsustainable use increased over time, which eventually led to the prioritization of ecosystem management in international agreements and the recognition of the need for socio-environmental accounting and ecosystem accounting innovations. But the ecological issues remain, not due to technical limitations, but rather, because the articulation between these accounting systems, or typology of ecosystem accounts, is not cohesive enough to motivate and guide ecosystem management. This research study aims to advance the interdependencies and necessary flows among accounting for biodiversity and ecosystems innovations by contributing to a cohesive articulation between two models, established respectively at the corporate/organizational perimeter and on perimeters relevant for collective ecosystem management: respectively, CARE-TDL (for business accounting) and AfME (for ecosystem-centric management accounting). Using qualitative research methods for data collection and analysis (document analysis, workshop, and case study), we were able to elaborate on a theoretical case study and articulate their CARE-TDL and AfME accounts. We concluded that the application of CARE-TDL and AfME models could be synthesized into four steps (in any order) with corresponding general questions in navigating their way to ecosystem management and its accounting. Each general question opens the issue towards several articulation points. The articulation points, in turn, raise questions for future ecological accounting and conservation science research. By determining and addressing one articulation point at a time, we are a step closer to better equipping, structuring, and operationalizing the assumption of public and private responsibility for biodiversity and ecosystems.

Keywords: ecological accounting, biodiversity and ecosystems accounting, typology of ecosystem accounts, Accounting for the Management of Ecosystems (AfME), Comprehensive Accounting in Respect of Ecology – Triple Depreciation Line (CARE-TDL)

Introduction

In meeting the growing demands for basic services and social and economic development, the human population has rapidly altered the ecosystems and subjected the global biodiversity to negative change (UNEP, 2005 ; Steffen *et al.*, 2015). The concerns over ecosystem degradation and its unsustainable use increased over time, which eventually led to the prioritization of ecosystem management in international agreements (UN, 1972 ; Brundtland, 1987 ; UN, 2000 ; CBD, 2010 ; UN, 2015). The implementation of agreements led to the recognition of socio-environmental accounting and ecosystem accounting innovations. But the challenges concerning degradation and unsustainability remain, not due to technical limitations, but rather, the articulation between these accounting systems is not cohesive enough to motivate and guide ecosystem management (Rambaud & Feger, 2019).

The current business and national accounting systems limit the integration of biodiversity and ecosystem services into their design (Feger & Mermet, 2017). Innovations are proposed at these two levels, but their ability to generate the expected changes is bound to disappoint since the initial purpose at these two levels is not for ecosystem management at the very beginning. They thus cannot address the need to focus on the inter-organizational management of specific ecological entities or issues and collective action of related multiple organizations (Feger & Mermet, 2018 ; Feger & Mermet, 2021 ; Feger *et al.*, 2019). The national accounting innovations (or government accounting for natural capital) operates at a macro level and considers ecosystem management as extending the state's conventional national accounting systems for public action and policy making. On the other hand, business accounting innovations (which is divided into two parts – ecological management accounting for the company and corporate environmental balance sheet accounting) are designed for the use of one organization. These treats ecosystem management as an issue to be solved by extending the business' conventional accounting perimeters.

The ecosystem-centric management accounting is the most recent innovation domain among the typology of ecosystem accounts. It addresses the lack of collective perimeters in business accounting innovations and introduces management accounting to specific ecological entities or issues (Feger & Mermet, 2017 ; Feger & Mermet, 2018 ; Feger & Mermet, 2021 ; Feger *et al.*, 2019). Such "Accounting for ecosystem management" entails focusing on specific ecological entities or issues and collective action of multiple organizations related to it, in which the ecosystem-centric management accounting is founded on.

While accounting for biodiversity and ecosystems innovations at the business, national and ecosystem levels have social and environmental transformative aims, none of them can ultimately and solely achieve this

goal (Feger & Mermet, 2021). The development of the ecosystem-centric management accounting innovations highlights the interdependencies and necessary flows among them in their application for better ecosystem management.

In this research study, we focused on the interdependencies and necessary flows among two accounting perimeters: business accounting and ecosystem-centric management accounting innovations. We articulated two respective accounting models, namely, Comprehensive Accounting in Respect of Ecology – Triple Depreciation Line or CARE-TDL (for business accounting) and Accounting for Management of Ecosystems or AfME (for ecosystem-centric management accounting). In doing so, we developed a theoretical case study and its set of CARE-TDL and AfME accounts that are consistent and complementary between these models, which we referred to as the articulation process.

Accounting for the Management of Ecosystems (AfME) and Comprehensive Accounting in Respect of Ecology – Triple Depreciation Line (CARE-TDL) models

AfME is the sole accounting model under the ecosystem-centric management accounting innovations within the collective perimeters. As it is within the collective perimeters, its primary goal is to assist interacting organizations or "actors" with their collective action in managing an ecological entity or issue of their concern (Feger, 2016 ; Feger & Mermet, 2018). Moreover, by applying the principles and rationale of management accounting, AfME's design targets to implement sound governance systems for ecosystem management and to quantify and evaluate the relevant biodiversity and natural capital (ecosystem services and ecological entities such as soil, water, etc.) relevant for action and decision-making (Feger & Mermet, 2018). Since there are variations according to the natural capital in focus and the management structure of each interacting organization, the articulation of AfME's accounts should be adaptable enough to accommodate this range of situations.

For the monitoring and evaluation of collective and individual accomplishments of the actors, may it be biophysical, administrative, or financial, the AfME model revolves around the creation of three levels of accounts (Feger, 2016 ; Feger & Mermet, 2018).

The first level of accounts includes the ecological issues monitoring and pressures accounts, which actors in the collective system share publicly and among themselves and serve as their standard reference. The second level of accounts refers to the accounting for actors' contributions to ecological restoration. These accounts monitor the actors' commitments as well as their direct and indirect contributions to the achievement and creation of their ecological goals and values at an inter-organizational level (Feger & Mermet, 2018). The third level of accounts is the actors' accounts, which entail the balancing of their efforts and obtainments (ibid., p. 16). Obtainments refer to the internal evaluation of actors' participation in collective management of the ecosystem, including their gains or losses (if any).

The next accounting model of our focus is the CARE-TDL, which is among the corporate environmental balance-sheet accounting and within the corporate perimeters. CARE-TDL falls under the integrated accounting model type, which puts social and environmental aspects on an equal footing with financial aspects in the accounting documents (Richard *et al.*, 2018) of a single organization. This inclusion in the organization's central accounting documents (balance sheet and income statement) results in a more reliable representation of the organization's financial solvency compared to the extra-financial accounting model type.

To further understand the CARE-TDL model, it is vital to discuss the conceptual underpinnings behind its inception. First, CARE-TDL addresses the issue of current business accounting innovations regarding the central accounting entity by applying both formal and conceptual perspectives of integration (ibid., p. 3). Second, CARE-TDL's conceptual basis is the notion of strong sustainability, as opposed to weak sustainability (Richard *et al.*, 2018 ; Rambaud & Feger, 2019). Sustainable development for strong sustainability is only possible if an organization separates financial and natural capitals, instead of allowing substitutions between each other and only considering their total sum (Richard *et al.*, 2018). However, an organization is still allowed to do internal substitutions among natural capitals as long as these are non-renewable (and replaceable by other natural resources) and must not reach critical status (e.g., extinction) (ibid., p. 300).

The third one is about CARE-TDL's analysis of the notion of capital (financial capital) and its implications in the non-financial (natural capital) context. CARE-TDL's definition of capital applies the historical cost accounting theory, which is consistent with the strong sustainability perspective of sustainable development (Rambaud & Feger, 2019). In this model, the organization follows the principle of repayment/ payment of money brought to the company over time and the monitoring of its use and consumption in the organization (Richard *et al.*, 2018). If we extend this principle to natural capital, in addition to financial capital, then this would also require the organization to refund or preserve the natural capital they utilize over time (Rambaud & Feger, 2019).

The articulation process

The theoretical case study (Feger, 2020) is fictional and inspired by the actions of *Centre d'etudes et de*

sauvegarde des tortues Marines de Méditerranée (CESTMed),[1] a non-profit association established in 2003 and has been officially recognized as the only sea turtle rescue center in the French Mediterranean coast since 2007. Without claiming to be faithful to CESTMed's case, the purpose of the theoretical case study is to illustrate the possible functioning of AfME on a stylized and simplified case of safeguarding a subpopulation of Mediterranean Sea turtles. These fictitious marine turtles, estimated at around 2,000 individuals, transit annually off the Camargue coast in France, where they also lay eggs occasionally.

We simplified the problems of the collective action model, strategies, and negotiations between actors to bring out more clearly the different accounts, their design and structure, and the circulation of accounting information among these accounts. We considered the theoretical case study as a working document wherein we recall its key features and further discuss its ecological accounts.

Moreover, the theoretical case study is initially narrated from the viewpoint of an actor, an organization who manages a specific ecological entity or concern and seeks the facilitation of a collective action with other concerned actors. As such, it starts from the viewpoint of the ecosystem-centric model, and then its linkage to CARE-TDL comes afterward (Figure 1).

Synthesis of the articulation of AfME and CARE-TDL models

During the articulation process, we followed the guidelines in creating the two sets of ecological accounts, determined their differences and discrepancies, and tried to improve the consistency and complementarity. There were challenges along the way and it is important to highlight all of them and how we were able (or not able) to address them. While noting the articulation points, we have also determined the four steps in applying AfME and CARE-TDL models and their corresponding general questions in doing the task at hand (Figure 2).

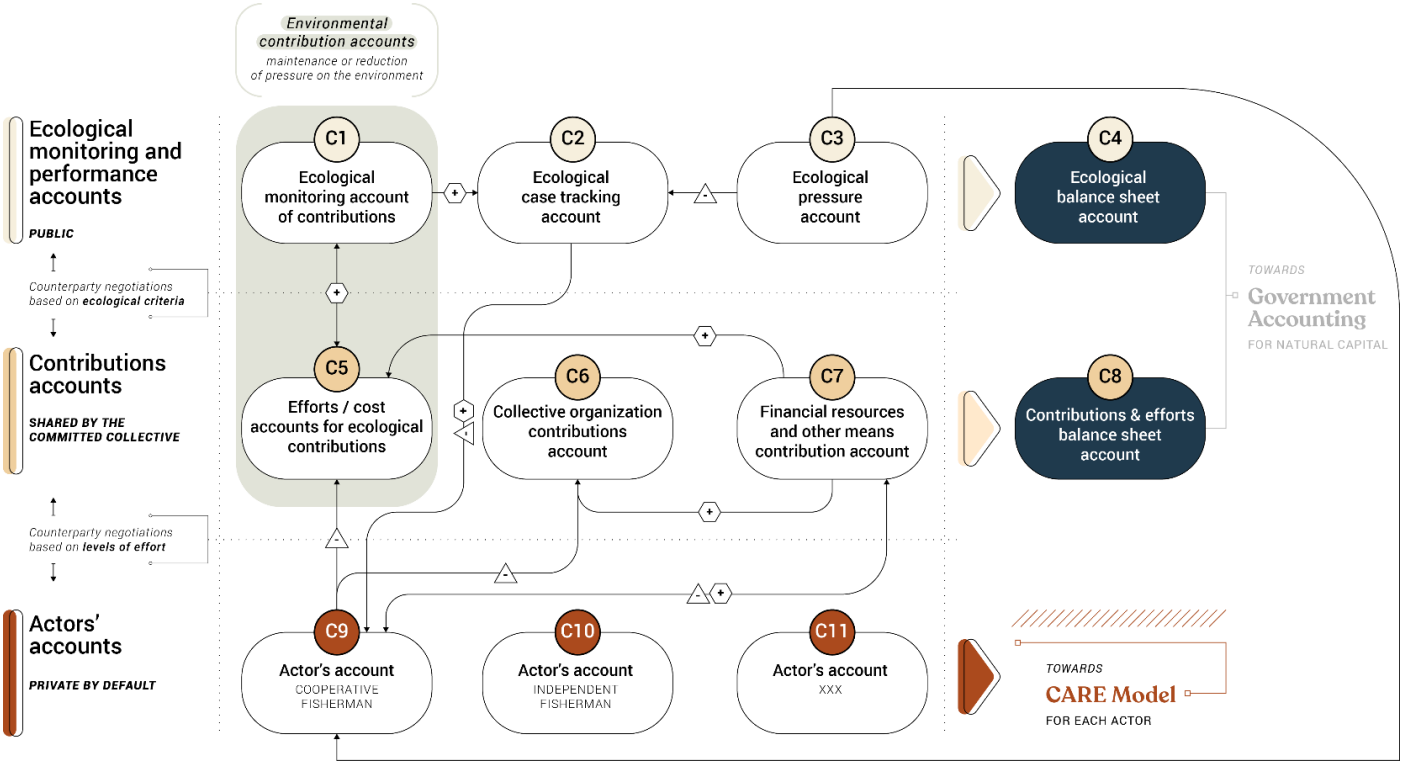

Figure 1. Revised design of the ecosystem-centric management accounting model framework (Feger, 2016 ; Feger & Mermet, 2018 ; Feger, 2020)

The first step is to understand the collective's structure of uses, impacts, and pressures towards the ecological entity of focus, in terms of biophysical indicators and data. It can be illustrated by mapping the ecological pressure account (C3) and putting responsible actors for each pressure and the quantity of impact of each pressure in ecological terms. The second step is to use the map to determine the contribution or preservation activities in achieving specific ecological results. We can assess the actions and its repetitions and the various actors conducting them. Next, the third step is to assess the costs at the level of ecosystem-centric accounts. Lastly, the fourth step is to allocate the collective costs to

[1] Center for research and conservation of Mediterranean Sea turtles

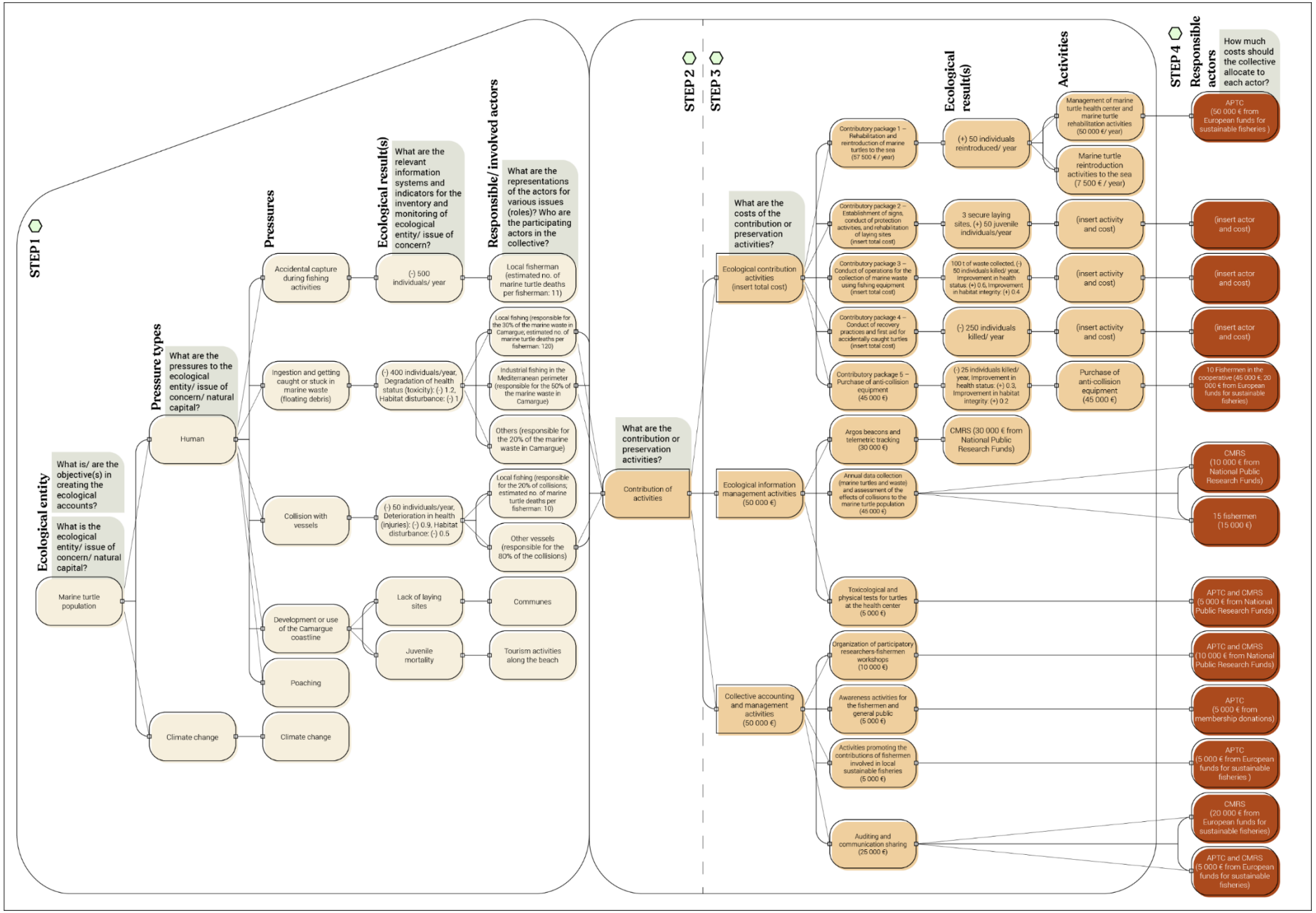

Figure 2. Synthesis of the articulation process using the theoretical case study

individual costs using the concept of *work unit*. The allocation is always a topic of negotiation within the collective. In the absence of work unit, the collective may base their decisions on several topics – which contribution activities need prioritization, who are the actors that need these resources the most (e.g., in terms of their financial capability, level of costs and efforts they bore and responsibilities in the pressures), among others.

In the end, we can articulate among biophysical data, financial data, at the collective and individual business levels. However, still, these four major steps have their own specific issues and questioning.

Tables 1-4 synthesize the general question in navigating these steps and the significant articulation points in creating ecological accounts.

Table 1. Articulation points for step one

General question(s)	Question(s) for articulation	Articulation points
1. What is/ are the objective(s) in creating the ecological accounts?	1.1. How do the two accounting models differ in focus?	The ecosystem-centric model focuses on the collective management of the said ecological entity or issue, while CARE-TDL focuses on the internal governance of the actors' corporations and integrated their debts toward the ecological entity.
2. What is the ecological entity/ issue of concern/ natural capital?	2.1. Is ecological entity the same as natural capital?	The ecosystem-centric model uses the term ecological entity. On the other hand, CARE-TDL conceives ecological entity as the natural capital and its use as a loan or ecological debt that an organization should pay, which can be referred to as liabilities. To consider an ecological entity as a natural capital, we need to fulfill all the following conditions – a clear matter of concern and description, determined level of preservation, and effective and concrete preservation activities.
	2.2. What is the level of preservation of the natural capital?	We usually consider a population of species as one ecological entity since the object of concern is not each individual species but its whole group. The inclusion of other species, which is always subject to negotiation, entails an addition to the ecological entity that would require another set of accounts. Theoretically, an actor would have different accounts for various species affected by their activities, and these accounts would correspond to each other. Moreover, the answer to this question depends on which viewpoint we are looking into. Is it from the viewpoint of an organization that accepts its ecological debt (CARE-TDL) or from the collective (ecosystem-centric), which is usually led by a motivated actor or organization?
3. What are the pressures to the ecological entity/ issue of concern/ natural capital?	3.1. How to properly determine the pressures?	The challenge of identifying the extent of pressure to be accounted for mostly concerns the ecosystem-centric model due to its moving perimeter. The collective can either extend the perimeter to an environmental issue with broader scope or they can just focus it on various specific pressures. However, in the absence of national and regional targets and recognized ecological thresholds, who gets to decide what pressures do the collective record in their account? Would it be possible to negotiate this issue among themselves? Determining pressures in ecosystem-centric model is more often like that of *de facto* management in strategic management analysis. The analyst (or accountant, in our case) tries to objectively identify all the pressures responsible for a specific environmental concern and finds ways to measure these pressures. However, in answering how to determine pressures from CARE-TDL viewpoint properly, the articulation question would be slightly different. The viewpoint would be from a single organization asking how to properly determine *their* (and not the collective's) pressure on natural capital. Like the articulation points in question 2.2, answering this question depends on which perspective we are looking at, making both of these topics subjective as much as being an objective one.
4. What are the relevant information systems and indicators for the inventory and monitoring of ecological entity/ issue of concern?	4.1. How do we evaluate and monitor the impact of each pressure to the ecological indicators?	Although this is not the focus of our study, this issue raises many questions about conservation science. Unlike in monetary terms, the collective can only put estimates in the recording for each indicator, such as the increase or decrease of the population count for every attributed pressure. Therefore, for each ecological entity or issue, there needs to be a specialist for each domain. As a consolation, having estimations provide us a framework of what needs to be measured ideally.
5. What are the representations of the actors for various issues (roles)? Who are the participating actors in the collective?	5.1. How do we objectively allocate each pressure to the responsible actors within and outside the collective?	In the absence of references from conservation science, how can the collective decide on the allocation as objective as possible? The decision of actors for this negotiation topic is crucial in determining their individual ratios of pressures (which is a part of a broader pressure this group belongs to) or ecological debt. From the viewpoint of management accounting, the use of the work unit concept can be a way of addressing this challenge. The discussion of this concept in detail is included in the results section under the C3 account. We will also reencounter this in step four.
	5.2. Why is there a need to include actors outside the collective during this step?	Following the de facto ecosystem management concept from strategic environmental management analysis (Mermet, 2011), all the responsible organizations, within or outside the collective, who are objectively determined as responsible ones, should be present in C3 account. The collective includes other organizations who are not motivated to participate or do not know about their environmental impact. Although it raises questions about who is legitimate to establish this account for others, this is also important since

		these organizations can potentially enroll in the collective.
	5.3. How does the characterization of pressures relate to the CARE-TDL accounts?	The C3 account of ecosystem-centric model affects the structuring of CARE-TDL accounts because actors record pressures as assets, which are important to create value. One narrative of the CARE-TDL model is that we cannot separate value creation and damages. It is a way to make the business actors realize that their business model can create value because it has is a negative impact on environment. To reimburse what they impacted, they would also recognize the need for a collective reflection. Other actors can impose or encourage other actors to accept their responsibilities and act on it. This action is again showing the advantage of double-entry principle. We cannot separate assets and liabilities. An actor cannot separate the fact that they have collective accountability about preservation because they (1) damage a specific ecological entity (or entities), and (2) have assets, so they create something valuable out of it.

Table 2. Articulation points for step two

General question(s)	Question(s) for articulation	Articulation points
6. What are the contribution or preservation activities?	6.1. Why is there a need for distinction among these activities?	The ecosystem-centric model identifies the different contribution activities as activities that have positive (1) direct and (2) indirect effects on the improvement of the ecological entity. The latter is further divided into three different sub-activities concerning (1) the information systems for the evaluation and monitoring of the ecological entity, (2) the organization and use of ecological accounting to ensure the collective's management and coordination, and (3) the allocation of collective financial resources. The CARE-TDL model, on the other hand, uses the term preservation activities. This model identifies these activities according to types of ecological (and social) investment of the organization. An investment is under financial issues if it relates to the organization's core activities using financial capital (e.g., avoidance cost, cost for access to natural capital), subject to certain societal and ecological performances of the business, such as the social and ecological solvency. Next, an investment is under natural issues if it relates to the organization's activities related to the use of extra-financial capital or natural capital. Lastly, an investment is under the preservation of capitals if it refers to the provision of earmarked financing to help the business maintain the natural capital. The third step further discusses the relation of the activities in these two models.

Table 3. Articulation points for step three

General question(s)	Question(s) for articulation	Articulation points
7. What are the costs of the contribution or preservation activities?	7.1. How do we relate the costs of activities in the ecosystem-centric and CARE-TDL accounts?	In our theoretical case study, the collective (ecosystem-centric model) accounted for five major activities have direct effects on the improvement of the ecological entity, and two major indirect activities pertaining to (1) the information systems for the evaluation and monitoring of the ecological entity and (2) the organization and use of ecological accounting to ensure the collective's management and coordination. The collective allocates the common resources to these activities, in addition to the individual resources provided by the actors. Assuming that the collective already allocated the costs and resources (see fourth step for discussion about allocation), these are carried over to the actors' individual accounts. When the fishermen accounted these activities using the CARE-TDL model, the accounts introduced us to the different types of costs (or investment) that each activity entails. Under the financial issues, we have the avoidance cost and cost for access to the natural capital. One of the direct activities in the ecosystem model corresponds to avoidance cost since the fisherman accepted to pay this cost, which changes their business model, hence its inclusion under the financial issue. Moreover, the asset obtained from this cost is recorded as equipment for decreasing ecological debt because it aims to lessen their pressure on the ecological entity. Next, the indirect activities relating to the prevention of the degradation of the natural capital correspond to the cost for access to the natural capital. This is a necessary cost that is shared by the actors to guarantee their correct use of the natural capital. It also serves as the operating cost to administer the ecosystem-centric accounting but is totally separated from the operating cost per se of the actor's organization. The CARE-TDL model's main aspect is the use of the ecosystem (natural capital), which causes its degradation, and the conduct of activities that directly restore the ecosystem. However, the costs for access to natural capital are challenging to evaluate relative to the ratio of degradation. These costs are indirect contributions, which question their identification as liabilities because they are not causally related to a use (asset) of the natural capital and the relative restoration for implementation according to its use. Costs for access to the natural capital exist as debts because of a trigger, a precise justification to record an item in the accounts. The trigger being the willingness of the fisherman to account for their ecological debt (liabilities) either as debt (if they cannot pay at the present) or as an expense (if they pay at the present). In the case study, since the fisherman can have access to the collective ecological information and they do not have to pay for its management and access, then they have a social debt towards the scientists (APTC and CMRS) who conduct the scientific work. The recording of this social debt is not about the transformation of the fishermen's business model, but the acknowledgment of the impact of their

		business model on the marine turtle population. If the fishermen want to preserve the natural capital, they must have this debt in their accounts and their willingness to preserve the natural capital serves as a trigger in its recording in the balance sheet. Under the natural issues, the fisherman records the preservation or maintenance cost for the natural capital, which can either be ex-ante (prevention) or ex-post (restoration) cost or both. The remaining direct activities in the ecosystem model corresponds to this cost. Lastly, the remaining indirect activities relating to the restoration of the degradation of the natural capital correspond to the cost for preservation of capitals. The same with the cost for access to the natural capital, this fisherman considers this liability as a social debt towards the scientists who conduct the scientific work.
	7.2. How do we account for incurred costs?	The accounts of the ecosystem-centric model recognize the incurred costs by the fishermen. This cost is related to their purchase of anti-collision equipment. However, this equipment may have helped them not hurt the marine turtles, it still lessens the number of their fish catch. The incurred costs do not account for in the CARE-TDL model, technically. Yet, its reflection in the ecosystem-centric model is important during negotiations among actors. Accounting only shows the realities of activities; hence incurred cost is avoided in the accounts. However, there are ways to make it visible from an economic viewpoint – one way of reflecting incurred cost is through budgeting and creating cases of scenarios. We can implicitly generate different scenarios, assess them, identify the costs, and conduct a cost-benefit analysis. There are gains and losses in each scenario, and thus, we are not comparing numbers but scenarios. The recognition and visibility of these scenarios should be settled in the ecosystem-centric accounting model for negotiations. At the same time, the actors can also assess the scenarios at the business level (but not through CARE-TDL model) to strategically analyze their options in the future, as each scenario would affect their access to the natural capital. We can consider the ecosystem-centric model as the extension of natural issues of the business plan. Typically, in the realm of business, business plans provide the owner's plan to finance its business and are used for negotiations with capital providers (investors, banks, suppliers, etc.) to access a specific financial capital. For example, we need to borrow a capital worth 2 000 000 € for our startup business. 1 000 000 € can come from the investors (without dividends for ten years) and another 1M from a bank. However, the bank would only agree if the investors are willing to pay a bank interest. The interest rate is sometimes high, and so the investors may disagree. If this does not work out, we can always go back to our business plan and look into the evaluation of other different scenarios regarding the structure of financial capital. It may be a business plan, but it can also be accounting in some ways because it must be consulted permanently as the group grows, as the resources and evaluation
		changes, etc. After determining sources of capital, the next discussion should be about sources of revenues (extensions, etc.). Every business is based on scenarios, not opportunity cost, and thus the latter is different from incurred cost. It is because we need a connection between costs and revenues and specific business activities.

Table 4. Articulation points for step four

General question(s)	Question(s) for articulation	Articulation points
8. How much costs should the collective allocate to each actor?	8.1. How can the collective objectively allocate the costs?	From the CARE-TDL viewpoint, the actor (e.g., fisherman) needs to record the measurements of their pressures and connect them with the different costs for preservation. While there are some pressures that we can directly assess from a simple individual viewpoint, most of the issues are at the collective level. To understand one business's viewpoint, we need to know the assessment at the collective level, such as total costs and its allocation to individual actors. Measuring an issue can be either from a collective or an individual business viewpoint, but more importantly, the results should always be consistent with each other. What we can have as an answer for this articulation issue is the accounting concept called work unit. Businesses typically use this concept for their indirect cost. Indirect cost is not directly traceable to any activity which makes it hard for the business to allocate. Work unit is a specific quantity that is linearly correlated to indirect cost and is easily associated with each activity. For example, in the case, let us assume that the collective can measure the collective cost and has the data for accidental capture under pressure 1. This provides us the monthly collective cost associated with accidental capture. The problem now is how to allocate this problem to each business. Since we have the monthly data, we can choose the work unit or quantity that is linearly correlated to the monthly collective cost (indirect cost) and can also be associated with each business easily. We can test several quantities, and although it is a mere convention, businesses accept this practice. Work unit is included in an accounting epistemology, wherein we conceptualize or interpret reality from a classical accounting viewpoint and conventions. We apply the concept of work unit because it is impossible to allocate things objectively in our case study, basing the allocation on a mere accounting convention. While following an accounting convention is an objective way of answering our articulation question, it can also be subjective since the collective is not limited to only applying this concept during allocation. One term we can associate to using work unit is pragmatism; since pragmatism is typically what is both subjective and objective and can also be neither be both.

Conclusion

Doing the articulation process was quite forward. However, what we have synthesized is far from being linear. We have determined the four steps in applying AfME and CARE-TDL models and their corresponding general questions in doing the task at hand. Since there are different starting points, either from the collective or individual actor's viewpoint, and varying situations and levels of management, it is highly probable that the four steps are not to be pursued in the same order. We draw the general questions with the inspiration of helping a collective or an individual actor to reflect on their ecosystem management and to navigate their way in its accounting. However, as we found out during the articulation process, each general question opens issues towards several articulation points. The articulation points, in turn, raise questions for future ecological accounting and conservation science research.

Since what we have discussed so far are purely theoretical, applying AfME and CARE-TDL into practice is another story. We have only explored minimally the different management issues or variables that could affect the creation (design and structure), articulation, and success of ecological accounts. However, what is clear and constant is the specificity of the management of each ecological issue that would surely lead to more detailed articulation question and points. With the numerous ecological issues in the world, providing each of them specific management and accounting may seem a daunting task. Nevertheless, determining and addressing one articulation question or point for the improvement of ecological accounts for a specific ecological issue is enough to bring us a step closer to better equipping, structuring, and operationalizing the assumption of public and private responsibility for biodiversity and ecosystems.

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