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A standard framework for assessing the costs and benefits of restoration: introducing The Economics of Ecosystem Restoration (TEER)

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Abstract: *While the policy momentum behind ecosystem restoration has never been stronger, restoration finance remains insufficient. A crucial information gap to unlock finance is the lack of robust and consistent data on the costs and benefits of restoration. This is due in part to the wide variety of contexts, interventions and objectives of restoration projects, and to the absence of well-defined standards and protocols for cost and benefit data collection. To fill* *this gap, we developed a standard framework to assess the costs and benefits of restoration projects and specific restoration interventions. The associated template for data collection, which was tested for usability during a piloting phase, is the first output of The Economics of Ecosystem Restoration (TEER), a multi-partner initiative under the aegis of the UN Decade on Ecosystem Restoration. It is the first attempt ever to improve the robustness and comparability of data on the economics of ecosystem restoration collected from the field at a global scale. Widespread adoption of this framework and associated template by a wide range of organizations implementing or financing restoration would allow for standardised data to be fed into a jointly owned database of restoration costs and benefits and serve as a basis for the further investigation of the economics of ecosystem restoration, including cost-benefits analysis. Better information on costs and benefits will help to inform acurate budgeting access to finance for restoration projects, and make them more likely to achieve their set goals and desired quantitative outcomes (e.g. area restored).*

Key words: Cost-benefit analysis; Data collection; Environmental economics; Standard methodology; Database; Restoration project; Restoration finance; Private sector investment

Implications for practice:

- *Ex-post evaluations of ecosystem restoration initiatives have shown their limitations at providing cost-effective, comparable and consistent data on their costs and benefits.*
- *A standard framework is needed to ensure that costs and benefits data is collected throughout all stages of implementation, with sufficient information on the baseline, context and specific interventions.*

- *A dynamic, global database on the costs and benefits of ecosystem restoration would be a precious resource to a variety of restoration actors, for planning purposes, and as a basis for further analysis of the economics of restoration.*
- *Better information on the costs and benefits of restoration is a key contribution to the socio-economic pillar of the monitoring framework under the United Nations Decade on Ecosystem Restoration.*

Main text:

The case for standardized costs and benefits data collection on restoration

<u>Restoration is needed but costly, thus costs and benefits data are crucial to scale funding needs and to inform resource allocation decisions</u>

Land degradation costs countries more than $6 trillion per year in lost ecosystem services value, including agricultural products, clean air, fresh water, disturbance regulation, climate regulation, recreational opportunities, and fertile soils (Sutton et al. 2016). Yet, restoration remains markedly under-funded: the annual funding gap for restoration is estimated at US$ 300 billion (Credit Suisse et al. 2014; Ding et al. 2017). Providing more reliable and granular data to estimate clearly up-front and running costs, as well as the short- and long-term benefits of restoration projects in a particular context is essential to better inform public and private investors and project stakeholders (such as governments/public agencies, communities, NGO-supported practitioners) about the potential investment returns, help develop Public–Private Partnerships to co-finance restoration projects, and better assess economic and financial risks/rewards ratio.

Restoration practitioners and researchers, as well as communities involved in restoration, also lack reliable information that brings together insights from ecology and economics (Holl & Howarth 2000) and that can help evaluate cost-effectiveness of restoration in different contexts (Kimball et al. 2015). More context-specific data is needed to help identify how various elements of context affect the cost of interventions, and how economies of scale play out. Given the long time-scales required for restoration, projects need to be developed and financed based on accurate estimates of the actual costs of reaching their stated objectives and outcomes. Data beyond the lifespan of the project is also needed to assess the benefits obtained from restoration and implications for opportunity costs. Under-budgeted projects are problematic: they are likely to fail and they could lead to an overestimate of actual land restoration efforts. Projects that are over-budgeted could lead to the inefficient allocation of scarce resources for restoration, within or across projects. Better data on costs and benefits could also help prioritize interventions and projects. Finally, restoration implementation costs may be used as entry data for decision-support tools on the prioritization and optimization of restoration such as the one developed by Strassburg et al. (2020).

Cost and benefit data is seldom and inconsistently collected

Costs are rarely discussed or analyzed in the restoration literature (Robbins & Daniels 2012). In certain contexts, restoration work may be conducted by practitioners that are not used to publishing and quantifying the price of ecosystem destruction (Holl & Howarth 2000). Existing databases of restoration projects are generally specific to restoring a particular ecosystem or geography (like water streams, e.g. Jenkinson et al. 2006). Also, they do not consistently account for costs (Society for Ecological Restoration, 2021). In 2009, a TEEB (The Economics of Ecosystems and Biodiversity) study reported that in a review of 2 000 restoration studies, only 95 of them (less than 5%) provided meaningful cost data (TEEB 2009). Another review found that only 2.5% of publications on the outcomes of restoration had recorded information on the cost of restoration, and that research heavily skewed towards the United States and Australia (Wortley et al. 2013).

To further understand the availability of data, we also conducted a review of the literature on forest restoration costs in tropical and subtropical countries across a range of restoration interventions (see Supplement S1 for details of the methodology). Our search retrieved 61 relevant studies from both academic and grey literature that provided restoration cost estimates from specific countries. Of these, 23 had adequate and robust cost data that broke down restoration costs by 1) technique, 2) stage of project (implementation vs. maintenance) and 3) provided data that allowed costs to be calculated per unit area per year.

Results clearly show a wide range in costs for each intervention type (Table 1), which persists even when these data are broken down by continent. The width of the range often reflects a poor documentation of the underlying specific drivers and of the different components of cost for a given restoration context. This makes existing data and their wide ranges quite unhelpful for planning and costing future restoration work. Such variation could be explained by a number of factors: (i) the cost of doing restoration is intrinsically variable depending on many factors related to the local biophysical and socioeconomic context; (ii) planning, implementation and monitoring activities vary considerably within each restoration intervention category; and iii) differences in the categories of costs recorded (for example the cost of compensating or purchasing land - potentially one of the largest costs - was rarely recorded). Our proposed standard framework guides the user through pre-defined expenditure categories, which should limit the variability in iii) and ensure that the scope of costs recorded is the same across data points. It also requires the user to provide elements of the biophysical and social context and to select a specific intervention or set of interventions from a closed list.

Such information could help explain the remaining variability observed across contexts and across restoration interventions.

Our literature review concurs with previous efforts (TEEB 2009; De Groot et al. 2012) that also demonstrate a lack of systematic reporting, a lack of comparability across contexts and categories of restoration interventions and a lack of data generally, especially in tropical contexts. This is mainly due to the lack of a common standard for reporting (Blignaut et al. 2014). To tackle the issue of data discrepancy, researchers (Robbins & Daniels 2012; Ding et al. 2017; Iacona et al. 2018) have begun to advocate for standardization of the costs of conservation and restoration projects. This need motivated the initiation of T.E.E.R. (The Economics of Ecosystem Restoration), as a multi-partner umbrella initiative, that seeks to develop the knowledge base on the economics of ecosystem restoration (see Supplement S2 for the list of contributing partners).

A proposed standard for the recording of restoration costs and benefits – the TEER framework

Objectives and principles

The TEER initiative aims to generate policy-relevant data and analyses on all economic aspects of restoration. The template for data collection (see Supplement S3) is the first output produced by the TEER initiative, together with guidance appendices on some of the concepts it relies on (see Supplement S4). The framework of operational concepts for recording the costs and benefits of restoration presented in this paper, along with the Excel-based template, will guide future data collection efforts with a systematic tool to collect and assemble data. The resulting database can be used as a resource to benchmark costs and benefits for specific restoration intervention or mix of interventions over a given area and within a given context, based on comparable data points. Additionally, and analysis of correlation between cost and context variables could be used to develop statistical models that predict costs based for a specific intervention in a given context, even those where data does not exist. This information may be useful ex-ante to implementing organizations seeking to budget accurately for a restoration project, for funding bodies to evaluate the respective cost-effectiveness of a project and for governments wishing to evaluate more realistically the financial implications of policy pledges and commitments expressed in area terms. Granular restoration costs and benefits data could also be useful for financial analysis and guiding private investment in restoration projects.

Methodology

The framework and template's inception is the result of online and in-person consultations conducted with a wide range of partner organizations convened by the Forest Landscape Restoration Mechanism of the Food and Agriculture Organization of the United Nations (for the full list of contributing organizations see Supplement S2). Through these consultations, partners agreed on a set of variables for data collection on restoration costs and benefits (given a specific context and intervention). The template includes for each such variable, a question, a closed-list or open answer and an additional field for comments. The template was pilot-tested in seven restoration projects over six different countries (Brazil, Lebanon, Mozambique, Niger, Peru and Zambia) to gather feedback on its usability, and revised accordingly.

Scope

The coverage of the template is currently limited to the restoration of terrestrial ecosystems. The template was developed primarily to collect cost data on restoration projects, which we define as a time-bound intervention or series of interventions aimed at improving the ecological integrity and/or rehabilitating one or several ecosystem functions of a given site or ensemble of sites. Restoration is here seen as a continuum of improvement over a degraded baseline state, which encompasses a wide range of interventions, from improvements of a specific ecosystem function (e.g., water quality) to the full recovery of native ecosystems (Gann et al. 2019).

Ecosystem restoration projects vary hugely in their temporal and spatial scale, goals and interventions (Romijn et al. 2019). The template aims to be flexible enough to encompass that diversity, however the experience of the pilot phase indicates that it may be better-suited to projects of a certain financial scale and complexity than to more direct forms of restoration where the land owner is also the funder and implementer of restoration interventions. Cost data collection in such contexts could be done through simpler questionnaires that have been developed, for example in the context of legally-mandated restoration in Brazil (Brancalion et al. 2019).

Principles

Ex-post collection or expert reconstruction of detailed information on past restoration projects on the ground can be in practice very difficult and very costly (as it requires more specialized skills to investigate ex-post, compared to the skills needed to fill-in/report relevant data ex-ante or on course of a project). To facilitate broad data collection, the template will mainly be used during the life of the project, through local project managers. We sought the engagement of a wide base of partner organizations early on in the design of the framework, to promote future uptake of the template (see Supplement S2 for more details of the partners). The template seeks to balance the exhaustivity needed to ensure consistency in the provision of information on costs, interventions and context with simplicity for respondents. In that perspective, guided questions, with a closed list of possible answers, built from agreed or widely used categories, were privileged in the template to: (i) reduce the time needed to fill in information, even for non-specialists; (ii) avoid any ambiguity in the answers; and (iii) facilitate comparisons across projects.

Operational concepts of the TEER framework for restoration cost data

To ensure consistency of the reporting on costs and eventual comparability of entries in the database, the framework relies on a number of operational concepts, which guided the development of the template:

Intervention unit

Cost information at the project level usually lacks specificity due to the fact that one project often combines a range of different interventions at a variety of spatial and temporal scales, contexts and sometimes with different, placed-based objectives. This limits the possibility to use project-level data as a basis of the database and for comparison purposes. In the TEER framework, restoration projects are broken down in “intervention units”, defined as a relatively homogeneous area of land (in terms of land cover, land use and degradation level), over which the same restoration intervention or combination of restoration interventions is applied. Intervention units within the boundary of the same project do not need to be spatially continuous. The costs and benefits information is collected and entered in the database at that level, together with additional information about the overarching project. A restoration project can be implemented in one or several intervention units, as long as it is planned and implemented within a common framework (objectives, budget, timeframe, partners), under the responsibility of the same entity.

Restoration interventions

For each intervention unit, the respondent must inform the whole portfolio of interventions conducted or planned, with their start and (planned) end dates. Interventions must be chosen from a closed list that distinguishes between “enabling and instrumental responses” (e.g., community consultations, clarification of natural resources-use rights, land degradation assessment and mapping) and “direct biophysical responses” (e.g., enrichment planting, grazing pressure management, rainwater and runoff harvesting, fencing or other activities that foster natural regeneration,). This list of interventions was developed based on the assessment on land degradation from the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES 2018) and refined through the piloting phase of the template. These categories of interventions are more detailed than broad typologies of restoration interventions (e.g., IUCN 2014 , van Noordwijk et al 2020) that may cover vastly different realities in terms of the actions actually implemented – and costs incurred. Additional information can also be entered to provide more details on the intervention, such as the composition of planted species and seed type and source.

Baseline and context-related variables

In order to be compared, restoration costs need to be provided together with relevant information on the baseline of degradation and on the wider context in which the project operates, including environmental and social dimensions (Kimball et al. 2015). The template includes a comprehensive list of data to be collected in order to describe key environmental (e.g., land cover, level of degradation), socio-economic (e.g., local income, food security, gender equality) and legal dimensions (e.g., land tenure type, protected area status) that: (i) characterize the project's context and baseline; and (ii) might impact significantly its costs and potential benefits. We compiled a list of 108 variables and corresponding questions characterizing a context and baseline, out of which 50 were eventually retained, 20 at the project level and 30 at the intervention unit level (see Supplement S2 for full details). Information of relevance but that can be obtained directly from existing international or national data, such as national economic or social indicators, were removed from the template to alleviate the task of the respondent. Some biophysical variables may also be informed directly or verified through the geographical coordinates of the intervention units.

Expenditure categories

In a similar effort to propose a standard framework for recording the costs of conservation interventions Cook et al. (2017) and Iacona et al. (2018) draw on the experience from other fields such as healthcare to argue that standardized accounting is facilitated by listing the categories of costs to be included and the use of guidelines. The commonly used budget categories of implementation and maintenance costs fail to capture some of the costs of restoration such as opportunity costs and a variety of additional costs such as planning, facilities or volunteer time (Robbins & Daniels 2012). Cost data on unpaid labor is not included, but an assessment of this input is requested in number of person/days, to help future assessments of the opportunity costs that the restoration may represent for local communities. The template breakdown of expenditure categories aims to be detailed enough to encourage consistency in the reporting while also applicable to a wide range of interventions (Table 2). Feedback from the piloting phase was used to refine these categories and their descriptions, ensuring that costs can be allocated appropriately. The format of the template encourages cost reporting by intervention unit where possible, whereas costs that are not specific to a given intervention unit can be recorded at the project level and apportioned later in ex-post treatment of the data. Opportunity costs are recorded indirectly through the assessement of benefits prior and after the restoration intervention.

Benefits

Access to standardized data on costs may be useful in its own right, for policy and programming purposes, and for the very design of ecosystem restoration projects. Yet, assessing costs without benefits provides only a partial view of the financial attractiveness of the restoration projects. Investors also need to understand the short, medium- and long-term economic, environmental and social profitability of restoration projects, including but not restricted to those benefits that can be marketed or financially realized (Gitz et al. 2020). The relationship restoration interventions and environmental and social benefits is not always straightforward and context-specific modelling may be needed to better understand this causal relationship in a given study area over a period of time. Modelled benefits of ecosystem could be used as a proxy, yet often lack in specificity and accuracy (Daily et al. 2009). To improve this, the TEER benefit module has been designed to collect empirical data on the full range of benefits of restoration interventions, consistently and continuously, over long periods of time.

The proposed standardized benefit module of the template collects, for each intervention unit, information on two categories of benefits: (i) benefits with a market value and (ii) other environmental and social benefits. The first category refers to the net increase in benefits resulting from land restoration efforts that can be sold on the market. The second refers to improvement of ecosystem functionality through land restoration as well as the associated safety net, health benefit, and job opportunities that are important to the livelihoods of local communities, even if they are not directly exchangeable in the market place.

To estimate the marketable benefits, quantitative information for ecosystem goods generated on the intervention units such as the number of units produced on land and market price of each unit is collected at “Year 0”, prior to the restoration interventions. The expected increase or decrease in these benefits after completion of the restoration interventions is then informed in percentage of change from Year 0. Environmental and social benefits are only assessed quantitatively, with the user providing indications on the direction of change in their provision, the rate of such change, and whether quantitative assessments are planned as part of the project.

Establishment/monitoring phase

The cost section of the data collection template offers two possible tiers for cost data entry. Tier 1, where costs are entered annually, and Tier 2, where costs are broken down between two main phases: establishment phase and monitoring phase. The establishment period (equivalent to the project implementation period) is defined as the window of time in which restoration interventions take place in the area under consideration. These include both categories of enabling (preparation) and biophysical interventions described above. The monitoring (or maintenance) period covers the timeframe after the end of the interventions to monitor their outcomes or to conduct small maintenance interventions. Either tier of data entry ensures that an average annual expenditure can be calculated across categories.

Breakdown of expenditure by intervention

A limit of the above-presented typology of expenditures is that it does not break down the expenditure per specific restoration intervention. Therefore, in cases where more than one intervention are implemented in a given unit, an additional module of the template requests that an estimated breakdown be provided of the proportion of the overall expenditure that was allocated to each intervention.

'Dashboard' module

After having filled out the template, the user can access a summary of the economic information submitted. This "dashboard" provides a number of graphs (breakdown of expenditure by category and by intervention unit, costs vs. financial benefits for each intervention unit, yearly net present cash flow, investment profile in future and present value, as well as a visual summary of the various interventions and their respective expenditure over time). By selecting an appropriate discount rate, the user can also consult the Net Present Value and Internal Rate of Return of the project, automatically calculated from the data entered. These outputs from the use of the template provide the building blocks of a cost-benefit analysis and could be used for financial planning or to assess the economic soundness of a project, thereby representing an incentive for potential respondents to fill out the template.

Next steps

Data collection

The exact timeline for data collection throughout the lifetime of a project remains to be decided among partners and will depend on the overall duration of a given project but will likely include a number of recommended set points such as: (i) project inception year (to ensure accurate capture of baseline state); (ii) year 2-3, or mid-project, to collect data on the first years of expenditure; (iii) year 5-10 or end of the funding period, with projection of the monitoring costs and expected benefits. This timeline highlights the long-term dimension of the effort required to gather economic data on restoration.

Based on the experience of the piloting phase the time required to fill out the template is estimated at one day of work for a project manager, although this could vary substantially depending on the complexity of the project and prior availability of financial expenditure information. As an incentive, the TEER framework offers to project managers a standardized and ready-to-use protocol to integrate cost data collection in project design and implementation, right from project inception. Analysis drawn from the database will be openly published by the usual rules of scientific communications (e.g. peer-reviewed papers), but in a first stage the raw content of the database will not be open to the public, but only to the TEER members, to address concerns of data privacy and ownership and provide further incentive for data contribution. This may evolve if the TEER partnership decides so.

Towards a database on the costs of restoration

Gathering enough data will require a wide range of partners to use the TEER framework to collect information on a diversity of restoration projects and interventions across all major biomes and under diverse socio-economic contexts. Eventually, any organization that contributes data will be able to use this database as a reference point for ex-ante estimation of costs and benefits of future restoration projects, based on information on comparable projects already available in the database. It may also be used to explore restoration options and better understand their costs and expected benefits in different contexts.

To accelerate the constitution of a database, alongside data collected from projects as they are being implemented, data could also be gathered from projects at the initial stage by entering planned costs and benefits or from projects ending or already closed as long as enough information can be retrieved from project documents to meet the essential varaibles of the TEER framework. Data from these different types (see Figure 1) would be appropriately labelled in order to allow filtering in the database between these categories of data quality.

The database, of which a proof-of-concept version was developed based on data collected from the piloting phase, would offer three main levels of data: (i) project; (ii) intervention unit; (iii) interventions. Access to project-level information would show, for each project, their overall cost, the number of intervention units covered, the overall area of intervention, as well as the portfolio of interventions. Due to confidentiality concerns, access to information at that level may be restricted. Conversely, confidentiality concerns might be easier to overcome where data from a project is disaggregated by intervention units, which can be filtered by their context, baseline state or geographies. Information on individual interventions within a unit or group of units may also be useful to explore not only the average cost of restoration but also the type of interventions that are most applied within a certain restoration context.

The value of a global database on the costs and benefits of restoration is directly linked to the number and the diversity of restoration projects it will eventually include. Data collection using the template will be the main focus of the TEER in the coming years. The framework of underlying concepts can also be used for any publication presenting information on the costs and benefits of restoration, in order to facilitate aggregation to the TEER database.

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Table 1. Cost data retrieved through a search of the literature on forest restoration in the tropics and subtropics (23 studies).

Intervention	**Cost category (per ha)**	**Costs ($US/ha)**
Assisted natural regeneration	*Establishment* *Annual maintenance (yr 1-5)*	Range = $12-3,880 Range = $2-213
Agroforestry	*Establishment (y1)* *Annual maintenance (yr 1-5)*	Range = $125-1,240 Range = $5-720
Planted forests (for restoration)	*Establishment (y1)* *Annual maintenance (yr 1-5)*	Range = $105-25,830 Range = $167-2,421
Planted forests (commercial/monoculture plantations)	*Establishment (y1)* *Annual maintenance (yr 1-5)*	Range = $34-6,888 Range = $43-150

Table 2. List of expenditure categories

	Intervention Unit level **Where the breakdown of this expenditure across intervention units is not known, it can be entered at the project level instead.*
Paid Labour*	Any paid labour executed related to the actual implementation of any of the interventions within the intervention unit, regardless of the contractual relationship. For this category, the value is captured by standardized units (e.g., person/days) alongside the financial value.
Consumables*	Cost of any supplies used on a specific intervention unit. This includes seeds and seedlings, fertilizers and herbicides, food for workers. This may also include the cost of material used for the construction of temporary structures directly linked to the intervention (e.g., tree nursery, fences), where these structures are used exclusively for the intervention unit.
Meeting costs*	Meetings costs include all expenditures related to the organization of meetings related to the intervention unit such as venue, per diems, food, travel costs.
Compensation for land not used or income foregone	Any compensation in kind or in cash that is given to farmers and/or land users to compensate the loss of income for loss of land use or modified practices

Unpaid labour	Restoration projects are likely to demand time from local populations, either directly in the implementation of the activities or through their presence at information meetings, consultations etc. This time needs to be accounted for as an economic investment from the community in the restoration project and is recorded in standardized units (person/day) that can be monetized ex-post through value transfer methods.

	Project level
Project assets	Includes all the investment and operating costs linked with the infrastructures and equipment acquired by the project for its implementation. Examples include costs of first acquisition, depreciation, maintenance costs for things like vehicles, machinery, buildings and land.
Services, taxes and other financial costs	Includes taxes, bank fees, overheads of the organization and the cost of legal and accountant services.
Third party contracts	The implementation of restoration interventions may require sub-contracting a variety of third parties to provide specific services. Where the breakdown of the value of these contracts alongside the expense categories listed above is known, these costs should be ventilated accordingly, and any overheads included in other financial costs. Where this breakdown is not known, the cost can be included in this category.

Figure 1 – Different data types in the TEER database