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RESEARCH PAPER

Methodological Accounting of the Ecosystem Services Benefits of Community-based Restoration: A Systematic Review

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Abstract: Ecosystem services are important for human well-being; yet, their valuation poses significant challenges, particularly in the context of benefit–cost analyses (BCA) for ecosystem restoration. This is because most ecosystem services are not bought or sold directly on the market. This study systematically reviews the cost and benefit parameters used in BCA and highlights the limitations in accounting for the social benefits of community-based forest restoration programmes. Of a total of 500 research articles, 41 met our inclusion criteria, with only 11 focusing on community-managed projects. The analysis reveals that transaction costs are often underrepresented, while timber resources and carbon sequestration are prioritized. Common valuation methods include the direct market price approach (46%) and benefit transfer (63%). The economic analysis shows a higher median benefit–cost ratio for general forest management projects (2.24) compared to community-managed programmes (1.65). These findings underscore the need to refine BCA variables and enhance economic efficiency in community forest restoration efforts.

Keywords: Benefit Cost Analysis, Restoration, Community Managed Forests, Valuation Techniques

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1. INTRODUCTION

Ecosystems all over the world have undergone substantial changes in recent decades. For example, approximately 24% of the Earth's land is being used for cultivation, causing widespread alterations. The destruction of ecosystems has had profound impacts, with approximately 35% of the world's mangroves and 20% of the world's coral reefs having been lost over the past three decades (Reid *et al.* 2005). These changes have resulted in significant consequences for both human well-being and the environment. To minimize such impacts to the benefit of the environment, much effort has gone into restoring deforested and degraded land worldwide through various restoration projects, such as the Bonn Challenge 2011, a global initiative that aims to restore 350 million ha of degraded and deforested land by 2030, among many others (IUCN n.d.).

Forest ecosystems offer both use and non-use values. Use values encompass direct benefits (DBs) provided by the ecosystem, such as timber, firewood, recreation, fishing, carbon storage capacity, habitats, impressive views, and so on, whereas the non-use values include option, bequest, and existence values (Krieger 2001). Despite its numerous benefits, undertaking an economic evaluation of forest restoration remains a significant challenge because the costs of forest restoration are paid upfront, whereas the benefits accrue over time (Daily 1995). Moreover, many of these values are not traded in the market, and even though they are critical to consider in the trade-off, they are often overlooked in ecosystem restoration projects (Robbins and Daniels 2012). The appropriate valuation of ecosystem restoration projects is crucial because it would help assess the multiple benefits of ecosystem services, thus contributing to effective decision-making, planning, and implementation. It would also improve project transparency by enabling the optimal use of resources (Reid *et al.* 2005; Robbins and Daniels 2012).

Among the various methods of economic valuation, benefit–cost analysis (BCA) is a popular tool used by decision-makers to calculate the cost and possible benefits of a project or a policy. It facilitates decision-making process by incorporating all the costs and benefits of the project for society, including both market and non-market values. In the case of non-market values, a BCA helps provide information to decision-makers on the environmental changes resulting from a policy or project that would benefit society (Atkinson and Mourato 2008), whereas in the case of direct market values, it provides an evaluation of the environmental goods that are directly traded in the market. It is particularly relevant for valuing the provisioning services of the ecosystem, such as timber, firewood, and fodder.

Several approaches have been developed to calculate the non-market value in monetary terms: stated preference, revealed preference, and the value transfer method. Stated preference is captured using survey questions that ask respondents to choose between the scenario or status quo and about their willingness to pay to obtain a specified good (Atkinson and Mourato 2008; Van Zanten *et al.* 2023). Contingent valuation and choice experiments are some of the techniques used in the stated preference method, which uses a hypothetical market scenario to help estimate all the components of a total economic valuation. In contrast, revealed preference is based on the actual preferences of people for environmental goods (Saarikoski *et al.* 2016). It utilizes information from the actual market to determine the value of non-market goods. The hedonic pricing method and the travel cost method are notable examples of the revealed preference method and are used in restoration projects. In the hedonic method, the pricing is based on the attributes of the services (Chee 2004) and is commonly used to evaluate projects in urban areas, whereas the travel cost method is used to evaluate the direct use value of recreational sites (Cheng *et al.* 2019) and the behaviours of recreational users. The value transfer method, another method of calculating ecosystem services, makes inferences regarding the economic value of environmental goods and services at one place based on the existing primary valuation studies in other locations (Hu *et al.* 2020). Finally, the cost of avoided damage is a market-based valuation approach that estimates the benefits of avoiding the damage that would have occurred in the absence of a particular service (Gerner *et al.* 2018).

The BCA also estimates both direct and indirect costs, with the latter subdivided into opportunity costs and other indirect costs. Direct costs in forest restoration projects are mostly the capital expenditures associated with nursery operation, silviculture operation, and protection of the forest, as well as recurrent expenditures, including the costs associated with forest user group (FUG) institution management, such as meetings and travels (Walton *et al.* 2006). Opportunity costs refer to the profits from alternative land uses forgone by maintaining the land under forest cover because keeping land under forest cover excludes the possibility of other land uses. Evaluating the benefits of the next best option to forest cover, or the most likely alternative land use, is a way to assess the opportunity cost. Direct and opportunity costs must be considered to assess the total cost of forest restoration.

Costs are hardly discussed in the restoration literature (Robbins and Daniels 2012). Of the around 2,000 studies conducted on restoration, only 95 provide insightful information on cost data (TEEB 2009). The socio-economic aspects of restoration are often overlooked (Aronson *et al.* 2010;

Wortley, Hero, and Howes 2013). Usually, although communities are reluctant to make monetary contributions, they are willing to play a role in restoration through other means (such as labour contribution) (Rai and Scarborough 2015). Even if direct and indirect costs are taken into account, the opportunity cost forgone may not be included in studies (Rai, Neupane, and Dhakal 2016). To examine the effectiveness of a project, it is imperative to take into account all cost parameters, including the costs associated with monitoring the forest, volunteer time, lost revenue, and other non-monetary benefits. This review provides an overview of the cost and benefit parameters as well as the limitations in accounting for social benefits in the existing literature on restoration projects. Estimating the cost and benefit also helps decision-makers understand the efficiency of the restoration investment.

2. METHODOLOGY

The study systematically assessed the literature using the Google Scholar database, a scientific citation indexing service that offers the ability to search across multiple databases, enabling thorough exploration of the academic and scientific literature.

2.1 Searching for Articles and Language

The search was performed in English using the keywords section of the Publish or Perish 8 software, in a one-time operation, without interrupting the results. The Boolean operator AND was used between the search terms. Only articles published in the English language or translated into English were included as they could be understood by the whole review team.

2.1.1 Search String

We conducted a single search of the literature on 10 May 2023, using the following keyword combination: *cost and benefit AND benefit and cost analysis AND benefit and cost analysis methodological framework AND economic of benefit cost analysis AND economic of forest restoration AND benefit cost analysis forestry programme*

2.1.2 Software and Search Setting

We used the Publish or Perish 8 software to perform a systematic review of studies on BCA of restoration programmes. We set up the environment of the software in such a way that it listed up to 500 articles between 2005 to 2022. For this, we used the Google Scholar search engine due to its comprehensive search capabilities (Gusenbauer 2019).

2.2 Article Screening and Inclusion Criteria

We screened and included articles based on their relevance to the research topic, publication within a specified timeframe, and peer-review status. We only considered studies published in the English language with accessible full texts and clear methodological rigor. Opinion pieces and studies lacking empirical data were excluded, ensuring that our review comprises only high-quality, pertinent research.

2.2.1 Screening Process

Out of 500 research articles, we retrieved 128 articles manually by reading the titles and abstracts. Manual evaluation enabled a contextual understanding of the subject, flexible interpretation, and subjective judgement of the article. We then adopted a hierarchical approach for an in-depth analysis of the 128 articles in the following sequence: title, abstract, methodology, and result. This later helped us develop a review protocol. When we could not individually decide whether to include or exclude an article, we discussed it with the review team to arrive at a decision. We also manually evaluated the 128 articles by inspecting the full text of each article and finally selected 41 research articles (n = 41) for systematic review by removing irrelevant and duplicate articles.

2.2.2 Inclusion Criteria

To ensure quality, articles from inaccessible sources, review articles, books, reports, and working articles were not included in the review (Table 1); we only included articles published in Q1 journals (Table 2).

We further narrowed our selection by considering articles published in English, journals with primary data only, and articles containing the keyword benefit–cost analysis (or cost–benefit analysis) along with any of the other keywords in the title or abstract (Figure 1).

Table 1: Inclusion and Exclusion Criteria for Article Selection

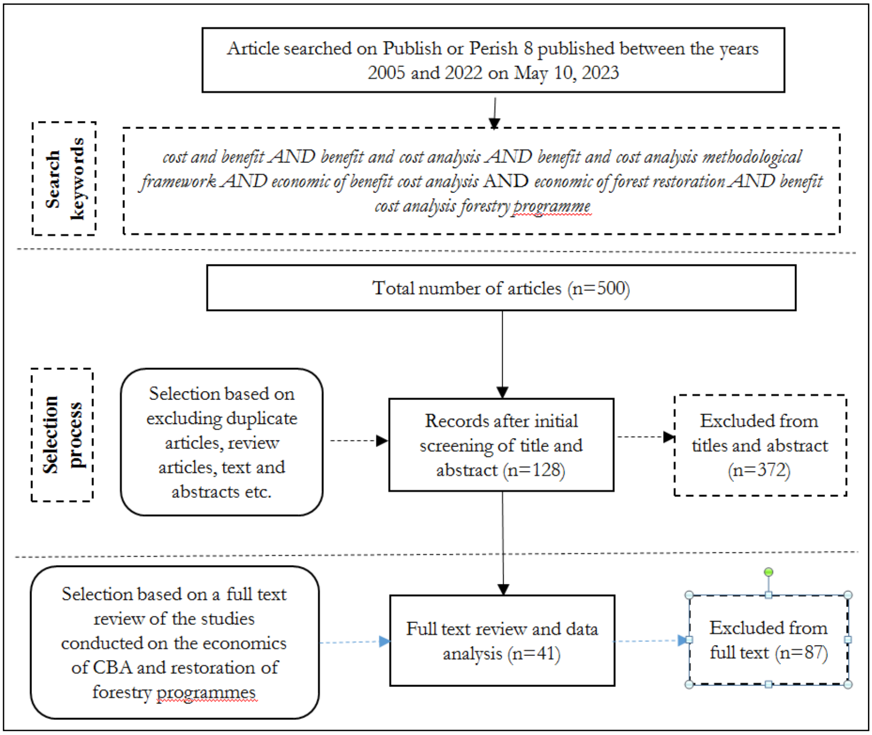
Inclusion criteria	Exclusion criteria
Q1 journal	Other than Q1 journals
Primary research article	Books, reports, and working articles
Article in English	Review article
Keywords included in title and abstract	Inaccessible journal article

Source: Authors' analysis

2.3 Developing a Review Protocol

A review protocol was designed in MS Excel. The protocol was developed based on information obtained from the initial screening of articles. We classified the articles under different headings and subheadings. Articles with similar research themes were included under the same heading. There were five main themes (restoration types, cost parameters, benefits parameters, valuation technique, and economic analysis) and three research designs (qualitative, quantitative, and mixed methods) in the protocol.

Figure 1: Article Selection Stages, Including the Initial Search and Screening Steps to the Final Articles Included in the Review



Source: Authors' framework adopted for review

2.4 Data Coding

The studies selected for the review contained many types of relevant data, including bibliographic information, study characteristics, and other data. Reviewers extracted the data from the articles included and coded them in the worksheet. Furthermore, we held regular discussions on how to refine the protocol and address questionable data that emerged during the coding process.

2.5 Limitations

Although the review process was systematic, there were some limitations. We used only one search engine, Google Scholar, to search for articles.

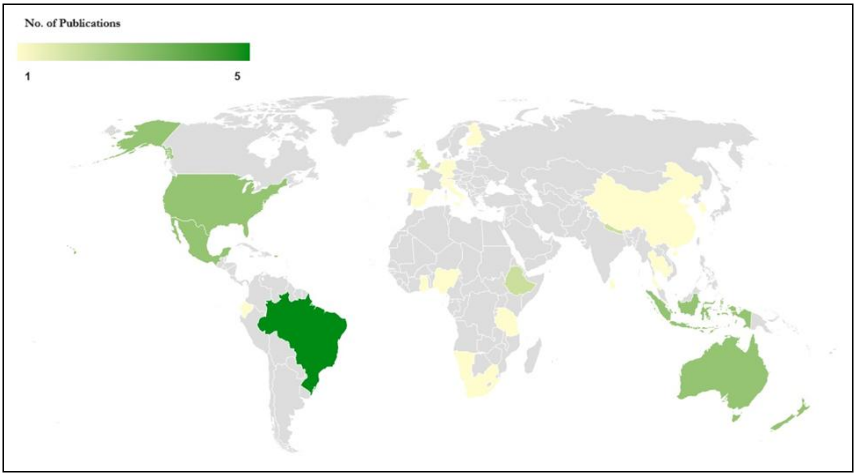
Thus, other relevant articles may have been excluded from the search. Also, even though some local journals and grey literature provided invaluable insights regarding our subject matter, we did not include those articles due to uncertainties regarding the peer review process, which could result in questionable data. The findings of this article are solely based on the search keywords, and the results of this review article align with the findings of the selected articles alone. Data extraction and coding were challenging because of the diverse nature of the methods and indicators in the included studies as well as the different interpretation approaches adopted in each article.

3. RESULTS

3.1 Spatial and Temporal Distribution of the Publications

The articles reviewed were from 24 different countries, spanning six continents (Figure 2), with the highest number of articles from Asia (n = 10, 24.3%), followed by Europe (n = 7, 17%). All other continents (Australia, South America, and North America) had six articles each. Country-wise, the highest number of articles was from Brazil (n = 5, 12.1%), followed by New Zealand, Australia, Indonesia, Mexico, and the USA, with three (7.3%) articles each. Most of the articles only focused on a single country; only two (4.8%) articles (Meyerhoff and Dehnhardt 2007; Stafford *et al.* 2017) covered multiple countries.

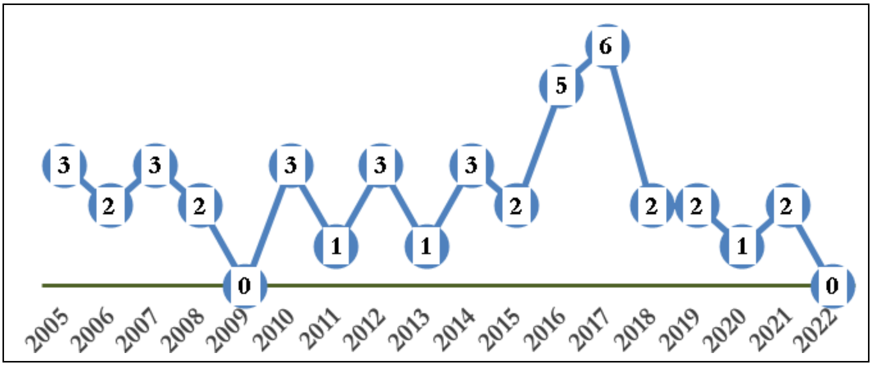
Figure 2: Spatial Distribution of the Selected Studies



Source: Authors' analysis

As stated above, we searched for articles published between 2005 and 2022, but most of the studies were from the last decade of the 2010s (n = 29, 70.7%) (Figure 3). There were no articles published in 2009 and 2022; the latest articles included in our review are from the year 2021, from Nepal (Paudel, Bhusal, and Kimengsi 2021) and Brazil (Bechara *et al.* 2021).

Figure 3: Temporal Distribution of the Selected Studies

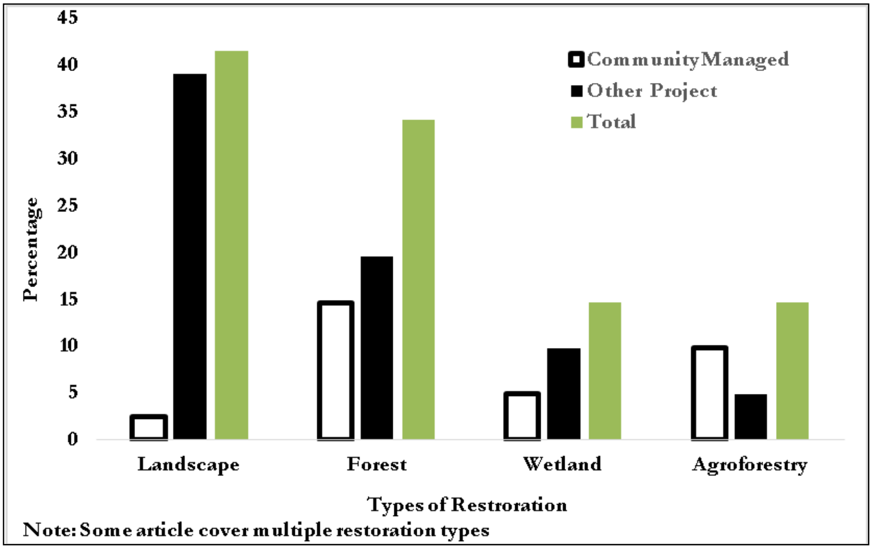


Source: Authors' analysis

3.2 Restoration Types and Data Collection

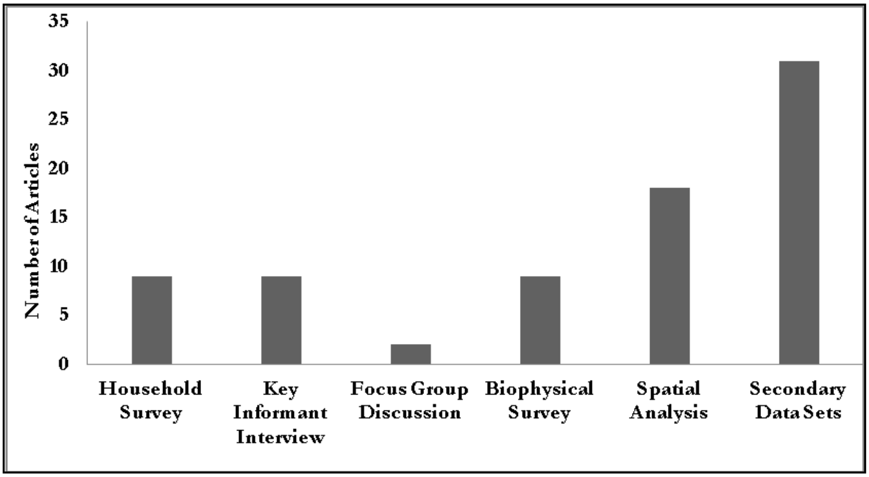
To assess the restoration types, the literature was classified into four main restoration categories (landscape, forest, wetland, and agroforestry), and the management was divided into community management or "others", as shown in Figure 4. The "others" class represents various other management regimes, for instance, managed by non-governmental organizations/ international non-governmental organizations (NGOs/INGOs) or government or private projects. Among them, the majority of articles focused on the landscape category (Almansa, Calatrava, and Martínez-Paz 2012; Balana *et al.* 2012; Crossman *et al.* 2010; Garcia-Quijano *et al.* 2005; Pistorius, Carodenuto, and Wathum 2017) (n = 18, 44%) and on forest ecosystems (Aheto *et al.* 2016; Bechara *et al.* 2021; Keefe, Alavalapati, and Pinheiro 2012; McPherson *et al.* 2017; Moriizumi, Matsui, and Hondo 2010; Paudel, Bhusal, and Kimengsi 2021) (n = 20, 49%). Wetlands were covered by eight articles (Crossman *et al.* 2010; Daigneault, Eppink, and Lee 2017; Jerath *et al.* 2016; Johnson *et al.* 2016; Polizzi *et al.* 2015), whereas agroforestry was covered by ten articles (Djamhuri 2008; Siregar *et al.* 2007; Torres *et al.* 2010; van der Horst 2007). Among the 41 articles reviewed, around 26% (n = 11) covered community-managed restoration projects. However, there was a lack of articles on community-managed landscape restoration projects, with only one publication (Gunawardena and Rowan 2005) being found. In contrast, there were more articles on community-run agroforestry projects (n = 4, 9.75%) than other projects (n = 2, 4.87%).

Figure 4: Coverage of Different Restoration Types in the Articles



Source: Authors' analysis

Figure 5: Data Collection Techniques



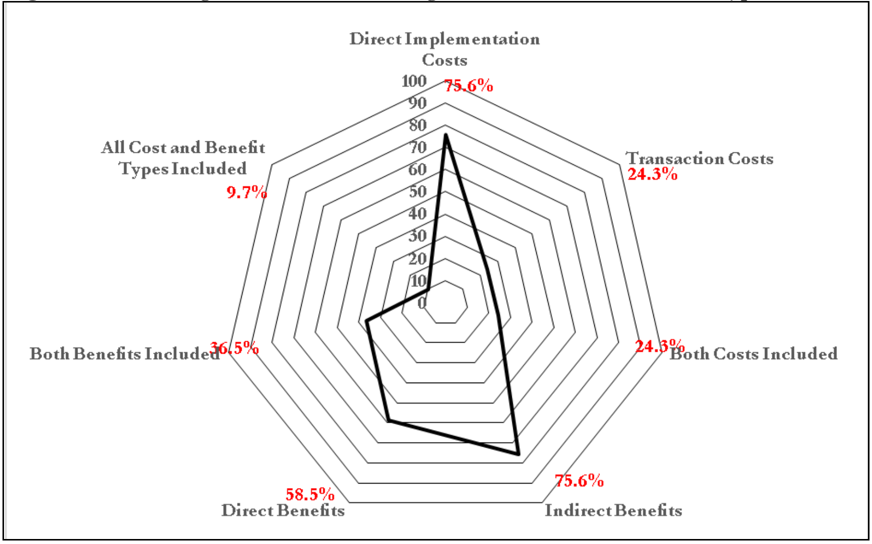
Source: Authors' analysis

For the BCA, various methodologies were used to acquire data sets. The data sources used in the studies were generated mostly through secondary data set sources (n = 31, 75%), and approximately 43% (n = 17) of the articles utilized spatial techniques. Household surveys, key informant interviews (KIIs), and biophysical surveys were each conducted in nine articles, while focus group discussions (FGDs) were conducted in two of the studies (Figure 5). As BCA requires various types of data and parameters, a large number of studies (n = 32, 78%) used more than one data collection technique.

3.3 Cost and Benefit Types

In our analysis, we categorized the studies into two cost types and two benefit types. This resulted in four categorizations: direct implementation cost (DIC), transaction cost (TC), direct benefit (DB), and indirect benefit (IB). DBs are those benefits that are directly enjoyed or utilized by the users or the management. Among the various categories, IB was the one most often used by studies (n = 31, 75%) followed by DIC (n = 30, 73%), whereas TC was the least used (n = 10, 24%). Among the 41 articles studied, only 4 (9.7%) used the four types of costs and benefits. Furthermore, 15 (36.5%) of the articles used both benefit categories, while only 10 (24.3%) included all cost categories (Figure 6).

Figure 6: Percentage of Articles Covering Various Cost and Benefit Types

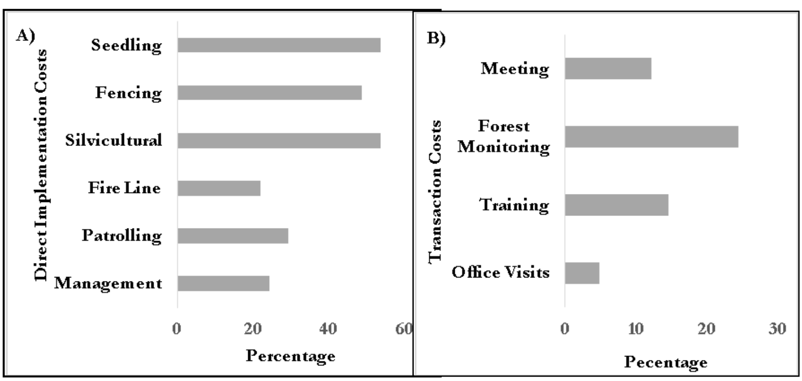


Source: Authors' analysis

3.3.1 Cost Parameters

The two cost types, DIC and TC, were further divided into various cost parameters (Figure 7). The DIC consisted of six parameters: seedling cost incurred during the establishment of forests or plantations, fencing costs, silvicultural operation costs (thinning, pruning, harvesting, etc.) for the management of forests or other vegetation, cost of fire line preparation, costs incurred for patrolling, and the management cost of staff, meetings, and so on. Among these parameters, seedling and silvicultural operation costs were calculated in the highest number of studies: 22 (53.6%) and 21 (51.2%) studies, respectively. The articles incorporating almost all of the cost parameters were the following: Barry *et al.* (2014); Bechara *et al.* (2021); Keefe, Alavalapati, and Pinheiro (2012); Kroeger *et al.* (2019); Paudel, Bhusal, and Kimengsi (2021); Pistorius, Carodenuto, and Wathum (2017); Rai, Neupane, and Dhakal (2016); and Wiskerke *et al.* (2010). The articles calculating fewer cost parameters—one or two only—include Borrego and Skutsch (2014); Daigneault, Eppink, and Lee (2017); Moriizumi, Matsui, and Hondo (2010); Siregar *et al.* (2007); and van der Horst (2007). We found similar trends among these articles, with most of them incorporating seedling costs alone in their study. Fire line construction was the least-utilized parameter in DIC, with nine studies (21.9%) covering it, and its cost was calculated only by those articles that calculated all the other cost parameters in their study (Barry *et al.* 2014; Djamhuri 2008; Verdone and Seidl 2017). Also, 11 articles (26.8%) in the study solely focused on calculating benefits without considering DICs and TCs (Almansa, Calatrava, and Martínez-Paz 2012; Haglund *et al.* 2011; Jerath *et al.* 2016; Jim and Chen 2006; Johnson *et al.* 2016; McPherson *et al.* 2017; Morri *et al.* 2014; Polizzi *et al.* 2015; Strassburg *et al.* 2016).

Figure 7: Number of Reviewed Articles Based on Cost Parameters

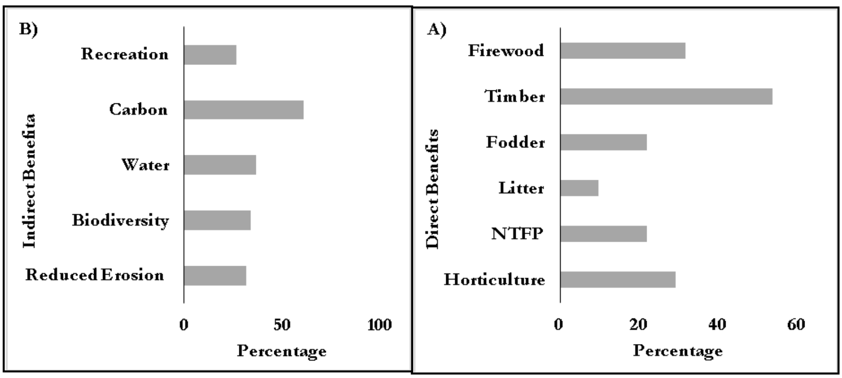


Source: Authors' analysis

3.3.2 Benefit Parameters

For the benefits, various IB and DB parameters were also analysed (Figure 8). Six DB parameters were analysed: firewood, timber, fodder, litter, nontimber forest products (NTFPs), and horticultural benefits. Among these, timber was the most studied DB parameter, by around 53.6% (n = 22) of the studies (Naime *et al.* 2020; Olschewski and Benitez 2005; Warren-Thomas *et al.* 2018), followed by firewood (Morri *et al.* 2014; Stafford *et al.* 2017; Verdone and Seidl 2017) and horticulture (Borrego and Skutsch 2014; Flugge and Abadi 2006; Siregar *et al.* 2007), which were both studied by 31.7% (n = 13) of the articles. The benefit of litter was the least-used DB parameter, with only 9.7% (n = 4) of the studies calculating it (Djamhuri 2008; Flugge and Abadi 2006; Wiskerke *et al.* 2010). Additionally, only eight articles (19.5%) covered the additional DBs offered by NTFPs (Flugge and Abadi 2006; Irawan, Tacconi, and Ring 2013).

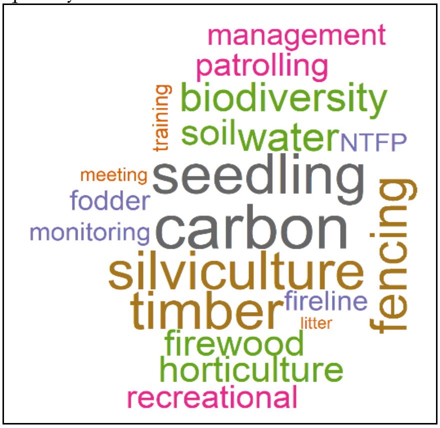
Figure 8: Number of Reviewed Articles Based on Benefit Parameters



Source: Authors' analysis

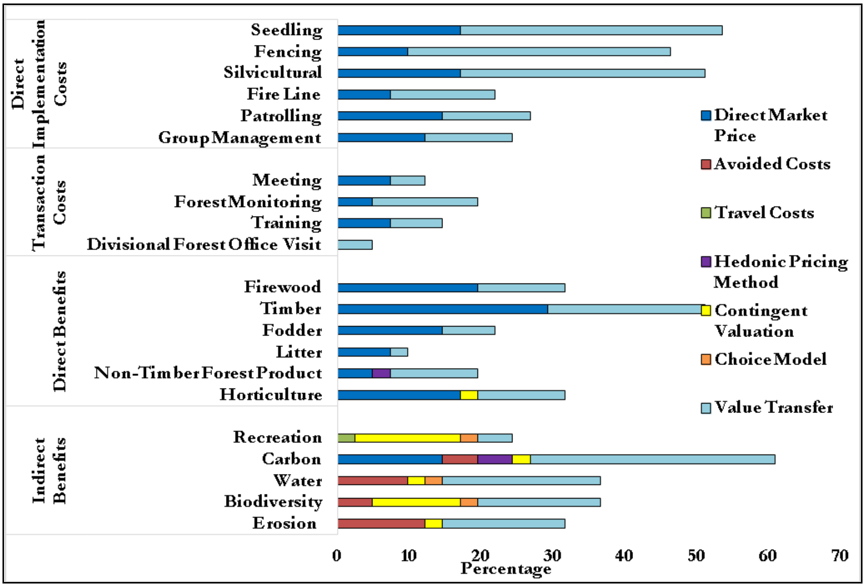
IBs are those benefits that are not directly enjoyed by users. These include recreational activities, carbon sequestration, water purification, increased biodiversity, and reduced soil erosion. Carbon sequestration was the IB most evaluated in the publications we studied, with 25 (60.9%) of the studies calculating it (Jerath *et al.* 2016; Naime *et al.* 2020; Olschewski and Benitez 2005; Verdone and Seidl 2017). The other IBs included water (Kroeger *et al.* 2019; Lee *et al.* 2018), biodiversity (Garcia-Quijano *et al.* 2005; Ndebele and Forgie 2017; Wiskerke *et al.* 2010), erosion reduction (Balana *et al.* 2012; Lee *et al.* 2018; Morri *et al.* 2014), and recreational benefits (Jim and Chen 2006; Logar, Brouwer, and Paillex 2019), which were calculated by 15 (36.5%), 14 (34.15%), 13 (31.7%), and 11 (26.8%) studies, respectively. Finally, there were seven articles (14.6%) that did not include any IB parameters in their study (Aheto et al. 2016; Bechara et al. 2021; Djamhuri, 2008; Haglund et al., 2011; Paudel, Bhusal, and Kimengsi, 2021; Rai, Neupane, and Dhakal 2016; Siregar et al. 2007). The various cost and benefit parameters utilized by the articles are visually represented in Figure 9.

Figure 9: Word Cloud of the Cost and Benefit Parameters Utilized in the Study According to the Frequency of Use



Source: Authors' analysis

Figure 10: Utilization of Different Valuation Techniques for Various Cost–Benefit Parameters



Source: Authors' Analysis

Table 2: Cost and Benefit Parameters and Valuation Techniques in the 41 Articles Selected

Article	Direct Implementation Cost						Transaction Cost				Direct Benefits						Indirect Benefits					Valuation Technique Used
	Seedling	Fencing	Silviculture	Fireline	Patrolling	Management	Meeting	Monitoring	Trainings	Office visit	Firewood	Timber	Fodder	Litter	NTFPs	Horticulture	Recreation	Carbon sequestration	Water	Biodiversity	Erosion	
Balana *et al.* (2012)					✔						✔		✔						✔		✔	Direct market price (DMP), avoided cost (AC), value transfer (VT)
Wiskerke *et al.* (2010)	✔	✔		✔				✔			✔	✔	✔	✔	✔	✔		✔		✔		VT
Pistorius, Carodenuto, and Wathum (2017)	✔	✔	✔	✔	✔	✔	✔	✔	✔			✔						✔	✔	✔	✔	DMP, VT
Siregar *et al.* (2007)	✔		✔									✔				✔						DMP, VT
Irawan, Tacconi, and Ring (2013)		✔										✔			✔			✔				VT
Lee *et al.* (2018)	✔	✔	✔			✔												✔	✔		✔	DMP, VT
Stafford *et al.* (2017)			✔								✔	✔	✔					✔	✔			AC and VT
Djamhuri (2008)	✔		✔	✔	✔			✔			✔	✔	✔	✔		✔						DMP

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Torres *et al.* (2010)	✔	✔		✔			✔	✔	✔									✔				DMP
Ndebele and Forgie (2017)																	✔			✔		Contingent valuation (CV)
Evans *et al.* (2015)	✔	✔	✔		✔													✔				DMP and VT
Kroeger *et al.* (2019)	✔	✔	✔		✔	✔	✔	✔											✔		✔	AC and VT
Verdone and Seidl (2017)	✔	✔	✔	✔	✔						✔	✔			✔	✔	✔	✔		✔		VT
Logar, Brouwer, and Paillex (2019)		✔				✔											✔		✔	✔		Choice model and VT
Gunawardena and Rowan (2005)					✔	✔					✔	✔				✔				✔	✔	DMP
Meyerhoff and Dehnhardt (2007)																	✔		✔	✔	✔	AC and contingent valuation
Daigneault, Eppink, and Lee (2017)	✔	✔																✔	✔	✔	✔	VT
Naime *et al.* (2020)		✔				✔		✔			✔	✔	✔					✔				DMP and CV
Garcia-Quijano *et al.* (2005)	✔	✔	✔									✔					✔	✔	✔	✔	✔	DMP, AC, travel cost, contingent valuation, and VT
Almansa, Calatrava, and Martínez-Paz (2012)											✔	✔				✔	✔	✔		✔	✔	CV
Olschewski and Benitez (2005)	✔	✔	✔									✔				✔		✔				DMP and value transfer
Jim and Chen (2006)																	✔					CV
Polizzi *et al.* (2015)																	✔		✔			CV
Crossman *et al.* (2010)	✔	✔	✔													✔	✔	✔	✔	✔		DMP, CV, and VT
McPherson *et al.* (2017)																	✔	✔				DMP and VT
Warren-Thomas *et al.* (2018)	✔		✔			✔						✔			✔			✔				DMP, hedonic

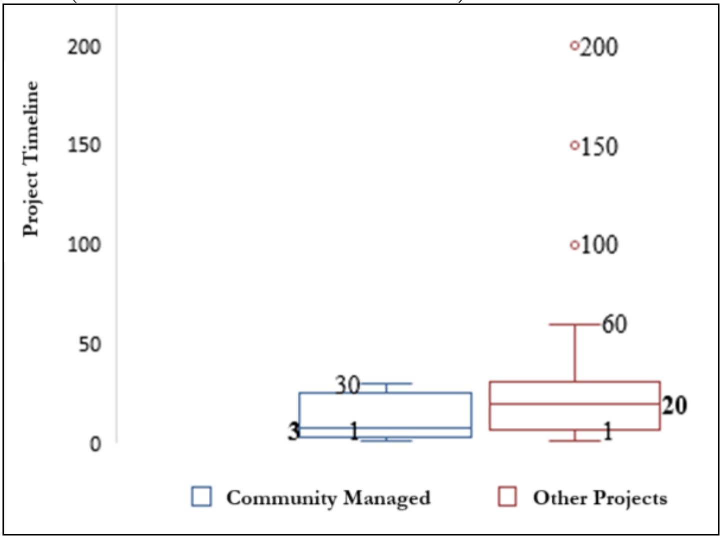
																						pricing, and VT
Aheto *et al*. (2016)	✔		✔			✔						✔										DMP and CV
Jerath *et al*. (2016)																		✔				DMP
Johnson *et al*. (2016)																		✔	✔		✔	AC and VT
Borrego and Skutsch (2014)	✔										✔	✔	✔	✔	✔	✔		✔				DMP and hedonic pricing
Flugge and Abadi (2006)	✔	✔	✔		✔								✔	✔	✔	✔		✔	✔			DMP and VT
Moriizumi, Matsui, and Hondo (2010)	✔		✔								✔	✔			✔			✔				DMP, hedonic pricing, and VT
Haglund *et al*. (2011)		✔	✔		✔			✔				✔			✔	✔						DMP and CV
Barry *et al*. (2014)	✔	✔	✔	✔	✔			✔	✔	✔		✔						✔		✔	✔	CV and VT
van der Horst (2007)	✔		✔														✔			✔		VT
Morri *et al*. (2014)											✔	✔						✔	✔	✔	✔	AC and VT
Strassburg *et al*. (2016)																		✔	✔		✔	AC and VT
Rai, Neupane, and Dhakal (2016)			✔	✔	✔	✔	✔		✔		✔	✔	✔									DMP
Paudel, Bhusal, and Kimengsi (2021)		✔	✔	✔	✔	✔	✔		✔		✔	✔	✔									DMP
Keefe, Alavalapati, and Pinheiro (2012)	✔	✔	✔					✔	✔	✔		✔			✔	✔		✔				VT
Bechara *et al*. (2021)	✔	✔	✔	✔				✔														VT

Source: Authors' analysis

3.4 Valuation Techniques

Economic valuation in the case of forest restoration or natural resources is highly complex due to the presence of both DBs and IBs, which require different methods of valuation. As mentioned earlier, the valuation technique can be market-based, non-market-based, or secondary data valuation. In the literature reviewed, market-based valuations were based on direct market prices, and non-market valuations were based on avoided costs, travel costs, the hedonic pricing method, contingent valuation, choice experiments, and value transfer. Value transfer was used to estimate all cost and benefit parameters. Similarly, direct price was used to estimate all the cost and benefit categories (DIC, TC, DB, and IB) except for some parameters. Refer to Figure 10 for a complete description of the different valuation techniques used in the cost–benefit parameters. Among the studies, 58.5% (n = 24) used more than one valuation method. The most widely used valuation techniques were value transfer (n = 26, 63%), followed by direct market price (n = 22, 53.6%). The contingent valuation method was used by 26.8% (n = 11) of the articles, while the avoided cost method was used by around 19.5% (n = 8), most of which calculated IBs. The most underutilized valuation techniques were travel cost (Garcia-Quijano *et al.* 2005) and choice experiment, used in just one study each (2.43%) (Logar, Brouwer, and Paillex 2019). The use of multiple valuation methods was common in the reviewed articles.

Figure 11: Box Plot Showing the Time Frame Used to Calculate the Net Present Value (Values in Bold Indicates the Medians)



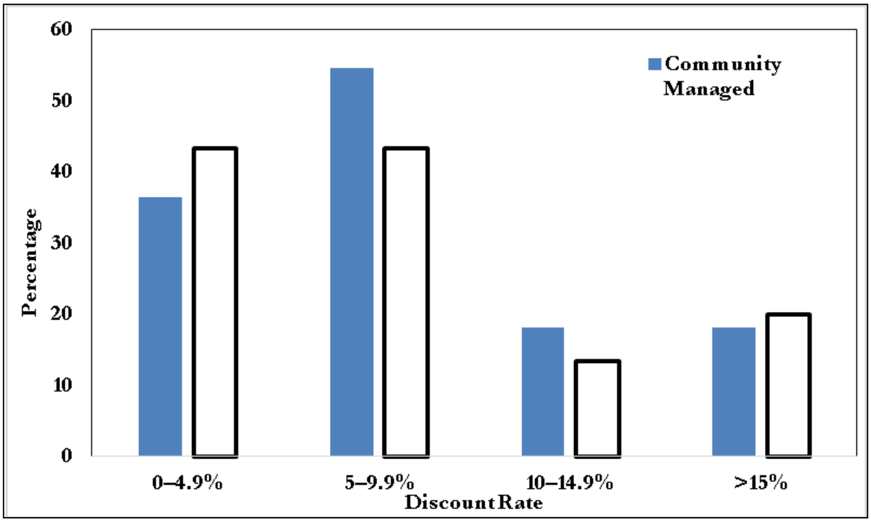
Source: Authors' analysis

3.5. Economic Analysis

3.5.1 Time Period

The calculation of net present value (NPV) was performed in 28 of the 41 studies. The time period used in the study for the calculation of the NPV ranged from 1 to 200 years (Figure 11). The time frames for community-managed projects were comparatively shorter than for those managed through other interventions. The longest period for community-based management was 30 years (Olschewski and Benitez 2005), with a median value of only three years. In contrast, in the case of the "other" projects, the maximum duration calculated was 200 years (Verdone and Seidl 2017), and the median value was also much larger, at 20 years.

Figure 12: Discount Rate Applied by Different Articles



Source: Authors' analysis

3.5.2 Discount Rate

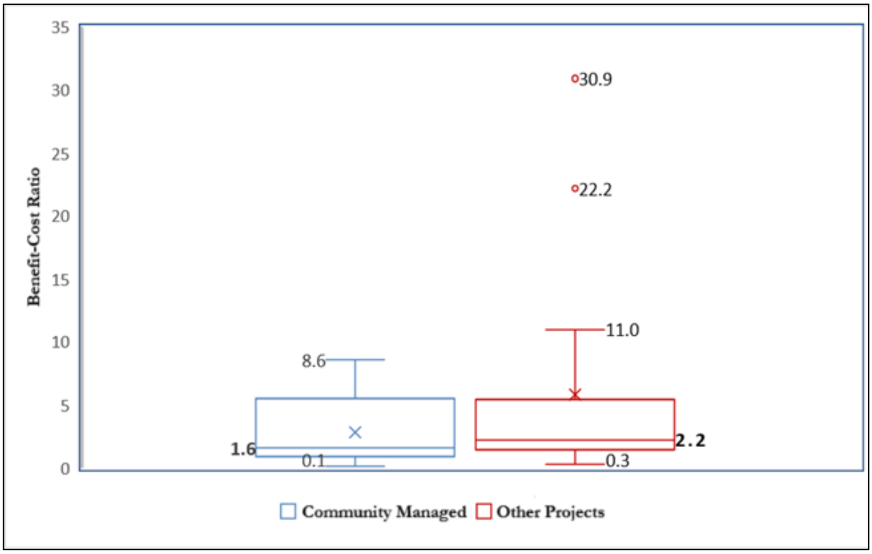
When evaluating the feasibility of an environmental project—that is, the investment interest in the project in comparison to the cash flow it can generate—one of the most essential parameters to be determined is the discount rate (Weitzman 1994). A high discount rate indicates low investment interest in the project, which could result in the failure of the project to be implemented, while a lower discount rate implies lower risk and an increased present value of future cash flows (Pálinkó and Szabó 2012). In the case of community-managed restoration projects, most of the articles (Djamhuri 2008; Moriizumi, Matsui, and Hondo 2010; Ndebele and

Forgie 2017; Torres *et al.* 2010) used a discount rate between 5% and 9.9% (Figure 12). For restoration projects other than those managed by the community, a similar number of articles (n = 13, 43.7%) used discount rates between 0% and 5% (Evans *et al.* 2015; Kroeger *et al.* 2019) as well as 5% to 9.9% (Balana *et al.* 2012; Pistorius, Carodenuto, and Wathum 2017).

3.5.3 Benefit–Cost Ratio (BCR)

Among the reviewed articles, 31.7% (n = 13) calculated the benefit–cost ratio (BCR), and in 29.26% (n = 12), the BCR was calculated for different scenarios. For calculating the BCR, we used only the maximum and minimum BCR values that were reported in the studies. The BCR values ranged from 0.09 to 30.92 (Figure 13). The median values of the BCR reported in the "other" projects were slightly higher as compared to those in the community-managed projects (2.24 vs 1.6) (Figure 13). The highest and lowest values reported in the community-managed projects were 8.57 and 0.09, respectively, whereas in the case of the "other" projects, it ranged from 0.3 to 30.92. Overall, the BCR reported in the "other" projects was slightly higher than that in the community-managed projects.

Figure 13: Boxplot of BCRs Reported in the Community-Managed and Other Projects (the Marker Indicates Mean Values, while the Values in Bold Are the Medians)

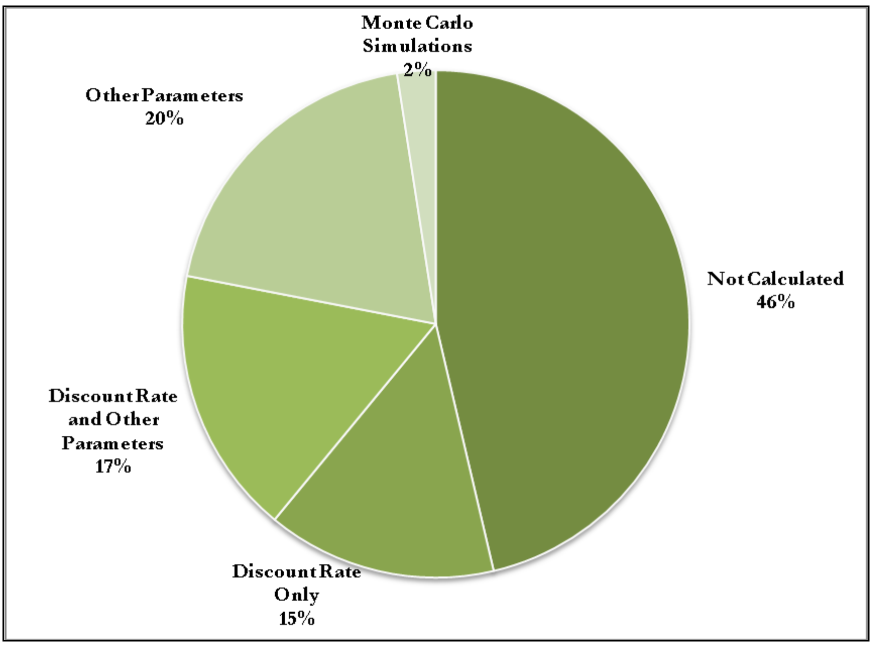


Source: Authors' analysis

3.5.4 Sensitivity Analysis

For any project evaluation, there are various externalities that can change the outcome of the BCA analysis. For instance, using lower discount rates can yield a higher NPV than higher discount rates. Hence, it is vital to perform a sensitivity analysis by changing various parameters. Similar to the sensitivity analysis, the Monte Carlo simulation also evaluates changes in the economic valuation of a project as a function of changes in various inputs (Mooney 1997). Only 54% (n = 22) of the articles we reviewed had conducted sensitivity analyses (Johnson *et al.* 2016; Warren-Thomas *et al.* 2018; Wiskerke *et al.* 2010), and the techniques used were different. In 14.6% (n = 6) of the articles, the sensitivity analysis was performed by varying different types of discount rates, while in 17% (n = 7), different discount rates, along with other variables such as land use changes, were used. In 20% (n = 8) of the studies, various other parameters were used to perform the sensitivity analyses. For example, in Daigneault, Eppink, and Lee (2017), 72 different modelled scenarios were tested to evaluate the economic feasibility of the national riparian restoration programme in New Zealand. Furthermore, the Monte Carlo simulation was utilized in just one of the studies (Meyerhoff and Dehnhardt 2007).

Figure 14: Various Methods Were Used for Sensitivity Analyses in the Articles Reviewed



Source: Authors' analysis

4. DISCUSSION

Among the articles included in the review, there is a slight predominance of articles from Asia, whereas other continents have an almost equal share in the rest. This may be due to the fact that many countries from Asia have made official commitments to support the Bonn Challenge through restoration projects; for example, Bangladesh, India, Mongolia, Pakistan, and Sri Lanka have made formal agreements to restore an almost 22.65 million ha in total to support the initiative. Likewise, other land restoration projects have also been implemented in the Middle East and the East and South Asian regions (Stanturf and Mansourian 2020). The pledges made to restore degraded land in the Bonn Challenge also emanate from countries in Latin America, Asia, and Africa, which could account for the representation from these continents. Regarding the methods used, many studies used spatial techniques and secondary data sets rather than primary methods such as biophysical surveys, KIIs, and FGDs. This can be attributed to the popularity of value transfer methods because they are time-efficient and cost-effective and can be applied easily when primary valuation studies are not viable (Van Zanten *et al.* 2023).

4.1 Parameters Used in the Benefit–Cost Analysis

Various methods have been used for the valuation of ecosystem services: monetary, non-monetary, and mixed methods (Farber, Costanza, and Wilson 2002; Turner *et al.* 2016). DBs such as timber, firewood, fodder, and the other regulating services offered by the ecosystem have metrics for assessment (Mandle *et al.* 2021) and are often traded in the market at a certain price, which is also in line with the results of our study.

In contrast, the IBs offered by the ecosystem generally include services such as fresh air, habitats for wild animals, scenic views, and many others, which are difficult to assess monetarily. These types of value are of great importance, even more so if the forests are managed by locals, because their traditional knowledge is put to use, their cultural identity is preserved, and the general well-being of the communities involved in managing the forest is improved (Chan *et al.* 2016; MA 2005). Although these kinds of value are significant, unlike in the case of DBs, assessing them is difficult because they are not bought or sold directly in the market and are difficult to trade. They are also based on the preferences of people, whose choices and perceptions play an important role in evaluating such ecosystem services (Milcu *et al.* 2013). Therefore, economists have developed techniques such as benefits transfer, contingent valuation, and willingness to pay to measure such benefits (Brander 2013). Most of the articles in our study used such techniques to estimate IBs. For example, in a study conducted in two districts in Uganda, 90% of the population ascribed value to the existence of the forest and gave high priority to other non-use values of the ecosystem (Bamwesigye *et al.* 2020). Such results indicate the importance of the forest for the locals, and these techniques play an important role in capturing all the social benefits and value associated with non-market services.

The other cost parameters, such as the TCs associated with the social BCA, are also important. In the articles we reviewed, the direct cost of seedlings, fencing, and silvicultural management was accounted for by most of the studies, but the TC was not well documented. It is necessary to determine the cost of managing forest resources (TC) in order to prevent conflicts in management (Adhikari and Lovett 2006). The time and money spent on meetings, monitoring the forest, and training are of great significance but are not well represented in the articles we reviewed. Excluding these cost parameters may put the feasibility of the project in question (Phan *et al.* 2017). Therefore, all such costs should be considered while conducting the social BCA to support effective decision-making.

Timber, firewood, and fodder are some of the DBs offered by the ecosystem. Most studies (Anup, Koirala, and Adhikari 2015; Parajuli, Lamichhane, and Joshi 2015) have given a lot of importance to such benefits while estimating the cost–benefit relationship, as evident in the results of our study, because people value this benefit as a direct source of income from the forest. For example, in a study conducted in the Ayeyarwaddy region of Myanmar, it was found that 43% of household incomes come from selling timber and firewood (Aye *et al.* 2019). Similarly, another study conducted in Bangladesh showed that such forest products have been supporting the livelihoods of forest-based communities and are a major source of income for local communities (Miah *et al.* 2012). This may be the reason for including such benefits in most studies. However, other benefits offered by the forest have been overlooked, such as NTFPs, litter, and other agricultural products. These values are not considered when calculating the BCA of the forest programme. NTFPs are a source of income and also an important source of food for forest-dependent communities when no other source is available (Sunderlin *et al.* 2005). Therefore, these should be well incorporated in studies. A similar situation is seen when calculating IBs. Most articles prioritized carbon sequestration while measuring IBs. However, the other benefits offered by the ecosystem, such as the preservation of biodiversity and the watershed, are also of high value and should be included when measuring the social benefits of the project.

4.2 Economic Analysis of Ecosystem Restoration Projects

Economic valuations help decision-makers justify the implementation of projects. In our study, we reviewed articles to obtain data on the calculation time period, discount rate used, reported BCRs, and sensitivity analysis. We found that the BCA of community-managed forests is often for a shorter period as compared to other management programmes. This may be due to the fact that the costs and benefits of community-managed forests are usually calculated within the operational plan time frame; for example, in Nepal's community forest management practice, the costs and benefits are usually calculated for five years, which aligns with the duration of the operational plan (Rai, Neupane, and Dhakal 2016). This may also be the case for other participatory forest management programmes. Community-based restoration helps to rehabilitate deforested and degraded land, as reported by Gautam, Shivakoti, and Webb (2004). However, because a short period of time is used to calculate the NPV of community-managed forests, there are fewer studies that have evaluated the costs and benefits of the project after its inception, making it more difficult to assess the efficiency of these management practices (Wortley, Hero, and Howes 2013). Assessment is essential as, otherwise, it may seem that the government is shifting the burden of conservation to the community, as such management practices are facilitated by the government, and almost 67% of the total forest land in Asia is owned by the state. Although the policy arrangements of the participatory forest management programme are intended to empower locals and ensure equal sharing of benefits, the implementation of these policies in developing countries leaves much to be desired (De Royer, Van Noordwijk, and Roshetko 2018; Pathak, Yi, and Bohara 2017). Therefore, it is imperative to calculate the costs and benefits of such management projects regularly to ensure equal benefit-sharing among the FUGs.

The BCRs in our reviewed articles ranged from 0.09 to a maximum of 30.92. The BCR is an indicator of whether the project will be profitable or not. A value of 1 or above represents a positive NPV, whereas a value below 1 indicates a negative NPV. The results of our study show a lower BCR for community-managed projects. However, due to the small sample size of our study, the findings are not conclusive. Furthermore, in the case of government-managed projects, various national-level (Daigneault, Eppink, and Lee 2017) and global-level projects (Verdone and Seidl 2017) were analysed, and they had much higher BCRs (22.2 and 30.92, respectively) than small projects. The results are in line with those of Lovelock, Barbier, and Duarte (2022), who reported that the benefits from small restoration projects are lesser as there are limited biodiversity benefits and a higher implementation cost per ha.

In the case of discount rates, we found that most articles used discount rates of <10%. In contrast, Browne, Fraser, and Snowball (2018) reported in their review article on wetland restoration that most of the articles used a <5% discount rate. This is a consequence of there being no guidelines for the choice of discount rates. Rather, the choice is subjective and ethical. Fundamentally, applying a higher discount rate in certain cases can result in long-term damage to biodiversity and ecosystems. Conversely, a lower discount rate for the broader economy might boost investment and growth, which could, in turn, cause more environmental degradation (Gowdy *et al.* 2012). Furthermore, the selection of discount rates is a topic of debate among environmental economists (Browne, Fraser, and Snowball 2018). To overcome this issue, the best way is to combine various discount rates through sensitivity analysis (Georgiou and Turner 2012). We also found that most of the sensitivity analyses were performed by combining different discount rates or by combining various other parameters with discount rates. Sensitivity analysis is a necessity for BCA, as the various assumptions made for the BCA may not be true. Among the articles we reviewed, only 54% had performed a sensitivity analysis. Furthermore, only one article had conducted the more robust Monte Carlo simulation (Meyerhoff and Dehnhardt 2007). Our results are in line with the remarks of Wainaina *et al.* (2020), who were critical of the sensitivity analyses done in landscape restoration BCA studies and recommended a more thorough methodology, such as the Monte Carlo simulation, to be implemented in future studies.

5. CONCLUSION

This article provides a systematic review of the methodologies used in the literature for the economic evaluation of community-based ecosystem restoration projects. The review clearly demonstrates that, worldwide, considerable effort has gone into assessing ecosystem restoration at the landscape level through cost and benefit analyses, with minimal focus on the assessment of community-managed restoration projects, in general. For economic evaluation, the DIC has been used much more than the TC. In contrast, many of the studies calculated IBs rather than DBs. There is a definite bias towards the calculation of certain cost–benefit parameters. For example, the TC was calculated in only 10 of the studies. Similarly, there is a lot of focus on certain benefit parameters, such as timber and carbon sequestration. While these are definitely the major benefits worldwide, in the case of community-managed restoration projects, other benefits, such as NTFPs and horticultural and leaf litter for manure production, are equally valuable and should not be ignored.

Economic analyses of community-managed restoration programmes were carried out for a shorter time frame and generated comparatively fewer BCRs than government-managed projects. However, it's important to note that these two kinds of projects cannot really be compared due to various reasons like the scale of projects, the different discount rates utilized, and differences in the cost–benefit parameters used. Our results imply that there is room for improvement in the calculation of the economic efficiency of community-based restoration programmes. Furthermore, sensitivity analyses were not performed in 46% of the articles, which is another area that needs to be improved while carrying out BCA analyses on restoration types in the future.

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Data Availability statement: This paper is based on a systematic review of literature, so no primary data is collected.

Conflict of Interest Statement: No potential conflict of interest was reported by the author.

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