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RECEIVED
11 April 2022

REVISED
27 October 2022

ACCEPTED FOR PUBLICATION
22 December 2022

PUBLISHED
11 January 2023

TOPICAL REVIEW

Valuing ecosystem services provided by land commons in India: implications for research and policy

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Keywords: ecosystem services, India, land commons, valuation, value transfer

Supplementary material for this article is available online

Abstract

Commons provide many ecosystem services that support the livelihoods of billions around the world. However, their contribution to people and the economy are rarely estimated in economic terms. Here, we estimate the economic contribution of the land-based commons in India, which cover 66.5 million hectares. We conducted a systematic literature review of publications between 1990 and 2020 and selected 161 peer-reviewed studies to develop an ecosystem services valuation database for India. We identified 34 ecosystem services from this database. We estimate that forest commons provide ecosystem services worth \$2108 ha^{-1} yr^{-1}. Culturable wastelands and permanent pastures, and other grazing lands provide \$861 ha^{-1} yr^{-1} each, and barren and unculturable lands provide \$196 ha^{-1} yr^{-1}. Using the value transfer method, the average value of ecosystem services provided by land commons in India is estimated at \$90.5 billion yr^{-1} (range \$24–192 billion). This broad range reflects the status and condition of those commons. Based on the trends in the decline of land-based commons, we estimate the value of ecosystem services will decline to \$68 billion by 2050: \$750 million worth of ecosystem services can be lost each year over the next 30 years. This will have devastating implications for rural populations that depend on the commons for livelihoods and the delivery of critical ecosystem services. We highlight the need to use ecosystem services valuation in decision-making and policy to protect and sustainably manage commons in India.

1. Introduction

Shared natural resource commons provide many material and non-material benefits that support the livelihoods of around 2.5 billion people (CLEP 2008) globally and perform many crucial ecological functions that underline the well-being of humans and the earth (MEA 2005, TEEB 2010, IPBES 2019). These include the provision of materials such as food, fodder, fuelwood, timber, organic manure, and seeds and non-material benefits such as clean air, water purification, soil retention, carbon sequestration, and flood control. Such ecosystem services make important contributions to achieving many of the sustainable development goals (SDGs; UN 2015). Despite providing numerous ecosystem services, commons are at risk of degradation and decline as a result of human activities, insecure community rights, weak governance, and unfavorable national policies, among other drivers (Dietz *et al* 2003, Stern 2011, Giest and Howlett 2014, Li 2021, Nagendra *et al* 2021). In addition, the contribution of commons to people and the economy are rarely estimated systematically in economic terms, which contributes to underinvestment in these resources by government and private actors (Beck and Ghosh 2000). Understanding the value of

the benefits from these resources will help to inform natural capital accounting, policies, and investment options to better support the sustainable management of commons. As one important contribution to such understanding, this study estimates the economic contribution of the land-based commons in India. The study highlights the importance of commons in India by examining the wide range of ecosystem services provided by them and the economic value of these ecosystem services. It also demonstrates the economic consequence of not managing commons and its impact on the livelihood of millions of people by 2050.

In India, common lands constitute one-fifth of the country's landmass (MOSPI 2011), meet the critical subsistence and livelihood needs of more than 350 million of the rural population, and are of social and cultural significance to rural communities (Gopalakrishnan 2012). Yet many commons are still officially designated as 'wastelands'—a relic of the colonial era, when uncultivated lands were called 'waste' and taken over by the Crown, with a notion that converting those lands to cultivation would generate more land revenue (Baden-Powell 1894). India's commons face widespread degradation (FES 2020), with an estimated reduction in the area of 1%–32% across various districts (NSSO 1999). Expansion of economic activities, human encroachment, and land conversions, along with environmental pollution have contributed to the loss, degradation, and fragmentation of common lands.

There is expansive literature on commons (Ostrom 1990, 2009, Jodha 1997, Jodha 2000, Agrawal 2003, Schlager 2004, Blaikie 2006, Chatre and Agrawal 2008, Chopra *et al* 1989) focused on understanding factors that lead to their overuse and degradation and how best to protect them for long term sustainable development. Despite providing numerous ecosystem services, global commons are at risk of degradation as a result of various human activities and often different policies and programs neglect the commons (Stern 2011). Similarly, the ecosystem services concept has been studied in detail with a focus on their classification, valuation, trade-offs, and integration into policy to protect biodiversity and ecosystem services (Costanza *et al* 1997, Daily 1997). There is a growing literature on the use and effectiveness of ecosystem services valuation, trade-offs and relevance to decision making at the policy level. Some studies (e.g. Chan and Satterfield 2020) argue that there has been an exponential increase in the number of studies on ecosystem services around the world since 2000 but the majority of these studies focus on monetary valuation and there is a need to shift the focus toward more social and policy research about the access and demand of ecosystem services (Wei *et al* 2017, Olander *et al* 2018). Other recent studies argue to focus more on the impacts of specific decisions on the value and distribution of ecosystem services across beneficiary groups (Mandle *et al* 2021). However, several issues remain unresolved such as complex dynamic ecosystem services in space and time, ecosystem services provision to human well-being, and potential for technology to substitute for or enhance ecosystem services (Rieb *et al* 2017).

Therefore, to protect and sustainably manage commons, the economic contribution of commons to society through direct contributions to the livelihoods of commons-dependent households and communities, as well as the flow of ecosystem services needs to be understood by policymakers and the broader public. Here, we develop a conceptual framework linking commons and ecosystem services to study the economic contribution of commons in India. Drawing on the published literature of valuation studies in India, we construct an ecosystem services valuation database and apply the value transfer method, the most common way valuation studies are applied in the policy process (Turner *et al* 2010), to quantify the economic value of ecosystem services associated with land commons in India. Based on the reported trends in the decline of land-based commons, we model the economic value of these commons up to 2050. We then comment on the implications of this work on research and policy to improve the uptake of ecosystem services valuation in decision making for better governance and management of commons in India.

2. Framework to study ecosystem services and commons

In many developing countries, commons play an important role in sustaining livelihood by providing ecosystem goods and services (MEA 2005). This includes the provision of materials such as fodder, fuelwood, timber, organic manure, seed, fruit, etc and non-material benefits such as clean air, carbon sequestration, flood control, etc. The commons are also the source of primary income for many rural dwellers (Jodha, 1986). Despite providing numerous ecosystem goods and services commons are at the risk of degradation as a result of various human activities and often national policies and programs neglect the commons (Stern 2011, Zhang and Meinzen-Dick 2019). A number of negative impacts due to the degradation of commons (for example loss of biodiversity and soil) have been highlighted in many scientific reports such as the Economics of Ecosystems and Biodiversity initiative (TEEB), the Millennium Ecosystem Assessment (MEA), the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (Diaz *et al* 2015, Pascual *et al* 2017). These reports have provided evidence that the loss of biodiversity, soil and other associated ecosystem services have high economic, cultural and

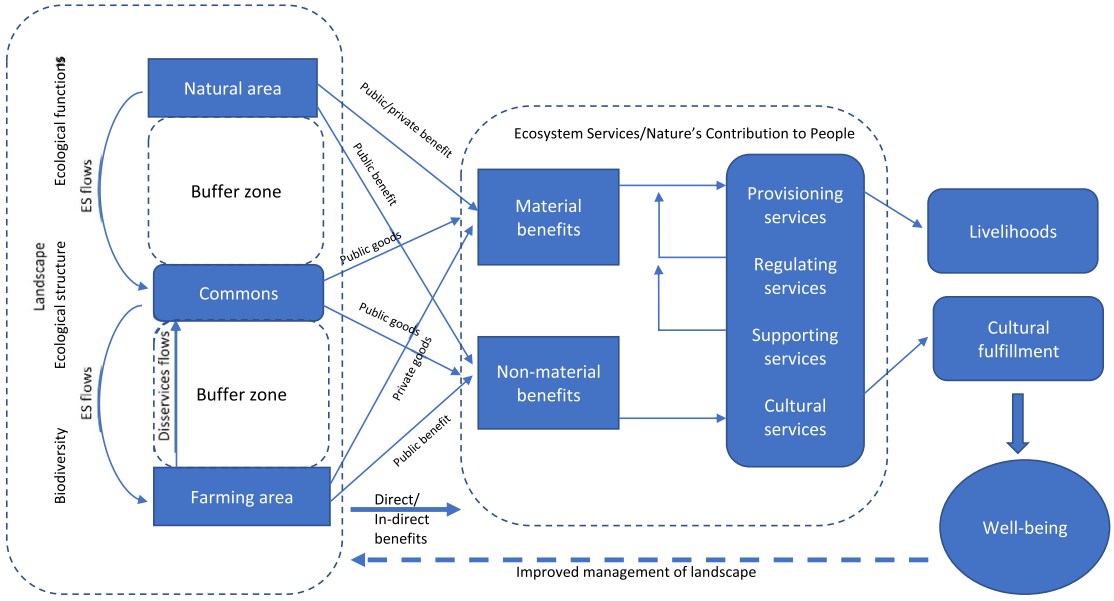

Figure 1. Framework showing the role of commons in the provision of ecosystem services and overall well-being of society and improved management of landscape.

societal costs. Despite this, there is no comprehensive list of ecosystem services from the commons, let alone an estimated total value.

Therefore, it is important to study the role of commons in the provision of ecosystem goods and services and the overall well-being of society. So far 'commons' are not studied in the context of providers of ecosystem services but are studied as a public asset that supports the livelihoods of the rural population around the globe. In terms of the status and functions of ecosystems, the commons often fall between natural (less disturbed) and human-managed (highly disturbed) ecosystems (such as agricultural land and human settlements). While both nature reserves and commons are usually designated as state lands, commons are (in principle) accessible to communities, whereas nature reserve areas tend to have restricted access. As figure 1 illustrates, not only do commons perform vital ecological functions to deliver ecosystem services that benefit local communities and beyond, but they also act as a 'buffer' between the natural and human-managed ecosystems, mitigating human impact on natural areas that are arguably more critical (on a per unit land basis) to biodiversity and the provision of public-good ecosystem services. This is partly achieved through improving the 'connectivity' among ecosystems or land uses. Habitat loss and fragmentation have been recognized as one of the main threats to terrestrial biodiversity (Haddad *et al* 2015). Commons as key components of landscape mosaic help enhance the connectivity among habitats in landscapes.

The benefits of ecosystem services provided by land commons could be both public and private (Sandhu *et al* 2007) (figure 1). Some benefits are private to local communities and farmers, who realize productivity gains due to the flow of ecosystem services from commons such as forests and grazing land. For example, the forest provides habitat and food for pollinators that in turn pollinate agricultural crops and hence lead to private benefits. Around one-third of food production globally (35%) relies on pollinators (Aizen *et al* 2019a) and the world's dependence on pollinators has been increasing (Aizen *et al* 2019b). Similarly, ecosystem services also flow from common areas to the public, for example, carbon sequestration by soil and vegetation, air purification, regulation of regional climate, water supply and filtration, etc. Some of the ecosystem services provided by land commons deliver direct benefits such as fodder, timber, and recreation, while indirect benefits such as air and water purification are realized when 'users' derive health benefits from cleaner air and water (MEA 2005, Sandhu *et al* 2007).

3. Methods

3.1. Systematic literature review

We conducted a systematic literature review of peer-reviewed publications published between 1990 and 2020 to identify and value ecosystem services associated with land commons in India (Jiang *et al* 2021, Chalkiadakis *et al* 2022) using preferred reporting items for systematic reviews and meta-analyses method (Moher *et al* 2009). In order to be comprehensive, we used keywords such as 'commons', 'ecosystem services provided by commons', and 'forest' in India to conduct the search on the Web of Science

database of literature published in English between 1990 and 2020. A total of 273 peer-reviewed articles were found with these keywords. These articles were further screened for (a) at least one clearly defined ecosystem service, (b) quantified ecosystem services, and (c) estimated value of individual ecosystem services using specific economic valuation methods. Such a selection strategy narrowed our selection to 161 articles. These 161 studies provided qualitative and quantitative information about ecosystem services from land use types that have been associated with commons in India, including provisioning, regulating, supporting and cultural ecosystem services (MEA 2005).

These 161 studies were finally selected to form an Excel-based ecosystem services valuation database (supplementary material) to record and organize the extracted information. The structure of the database was adapted from Van der Ploeg *et al* (2010) (see supplementary material for the variables and their descriptions). We used the MEA classification system. Some of the 161 studies included multiple ecosystem services at different sites with multiple values. Each was recorded as a separate data-point for each ecosystem service type, giving a total of 391 data-points in the database. The economic value for each data point was converted to 2020 USD.

3.2. Commons land area

With a population of 1.36 billion people and a land area of 328.7 million hectares, India is the world's second most populous and seventh-largest country (MOSPI 2021b). Around 833.1 million people live in rural areas spread over 255 million hectares of land (MOSPI 2011), representing 69% of the total population and 77% of the total land area.

In India, commons cover 66.5 million hectares of land, based on the areas of four types of land use as reported by revenue villages in the 2011 Census of India; including forests, permanent pastures and other grazing lands (all grazing lands, pastures and meadows), culturable wastelands (land left uncultivated but that has the potential to be productively cultivated) and barren and unculturable lands (deserts, mountains and other lands that cannot be cultivated except at exorbitant costs (MOSPI 2021a). Table S1 (supplementary data) provides commons area under the four types in each of the 28 states and 8 union territories in India.

3.3. Economic valuation

We used the value transfer method to estimate the economic value of ecosystem services associated with commons in India. The value of ecosystem services at one location can be measured using the value of ecosystem services at other sites, allowing values to be transferred from one site to another. This method is known as 'value transfer' or 'benefit transfer' and can be used for both costs and benefits (Koetse *et al* 2015). To calculate the aggregate value, we multiplied a constant unit value per hectare of the ecosystem by the area of a particular ecosystem.

The area where the value of the ecosystem has been determined is called the 'study site' and the area where valuation is required, or unstudied area is called the 'policy site'. The value from the study site to the policy site is transferred using statistical methods (Zhou *et al* 2020). The value of ecosystem services is mostly evaluated for specific ecosystem services at a specific location, whereas the information needed for decision-making often requires aggregate values at larger and spatial scales (Brander 2013, Costanza *et al* 2014). Because the primary valuation studies are usually expensive and time-consuming, value transfer methods have been developed to transfer information (values) from existing studies (Brander 2013, Costanza *et al* 2014).

In our study, we first identified the various ecosystem services associated with the land commons using the MEA classification. We then reviewed the database to identify the values of the various ecosystem services associated with each of the four types of commons, (a) forests, (b) culturable wastelands, (c) permanent pastures and other grazing lands, and (d) barren and unculturable lands. Based on the peer-reviewed journal articles included in the database, the majority of the studies are associated with forest commons. From limited studies associated with agriculture and pasture-based ecosystems, we assume that culturable wastelands and permanent pastures and other grazing lands provide the same provisioning, regulating, supporting, and cultural services. In contrast, barren and unculturable lands do not provide any provisioning services but provide regulating, supporting, and cultural services.

Following the guidance manual on value transfer (Brander 2013), we estimated the aggregate average economic value of ecosystem services of four types of commons—forests, culturable wastelands, permanent pastures and other grazing lands, and barren and unculturable lands.

For each individual study, we extracted the minimum and maximum value estimate for that ecosystem services and the type of common. We then calculated average of these two estimates, producing a single point estimate for that study. For ecosystem services-cover type combinations with multiple studies, we take an average of all these averaged values as the final value for that type of common.

To estimate the aggregate economic value of ecosystem services of four type of commons, we multiplied it by the land area under each type to estimate the total economic value of commons in India for 66.5 million hectares. The economic value is estimated using average unit values and the range of the values following the value transfer method.

Based on this, we estimated the economic value of ecosystem services of four types of commons by the land area in each of the 28 states and 8 union territories in India.

For comparison, we estimated the value of commons in India using an average economic value from global studies, obtained from the TEEB valuation database (Van der Ploeg *et al* 2010). The global average economic value of forests, culturable wastelands, permanent pastures and other grazing lands, and barren and unculturable lands is $4372, $6405, $4793 and $3359, respectively (Costanza *et al* 2014).

Finally, based on the average loss of commons area at 4% every ten years (NSSO 1999), we model the projected value of commons to 2050. We assume that any decrease in area under commons also translates to a loss of ecosystem services value at the same rate. Using linear trends, we calculated the future economic value of commons.

4. Results

4.1. Literature analysis

Various valuation methods have been used in the 161 publications that were included in this analysis to evaluate the economic value of ecosystem services. These include direct market pricing, travel costs, hedonic pricing, replacement cost, mitigation cost, damage cost, opportunity cost, avoided cost, alternate cost, contingent valuation, choice experiments, value transfer, biophysical models, and descriptive/sampling/surveys. Table S2 (supplementary data) shows different valuation methods that were used for different types of ecosystem services in the 161 studies. Table S3 (supplementary data) describes these methods.

4.2. Identification of ecosystem services in commons

Reviewing the 161 articles in our database, we identified 34 ecosystem services associated with land commons in India. Classified according to the MEA classification system (MEA 2005), these ecosystem services include 12 provisioning services; (non-timber forest products (NTFPs), medicines, fuelwood, food, timber, fodder, livelihood, water, raw material, biodiesel, fisheries, honey); 12 regulating services (pollination, soil fertility, climate regulation, soil erosion prevention, air purification, water regulation, watershed, water purification, water conservation, waste treatment, biological control, carbon sequestration); 6 supporting services (soil formation, habitat for species, gene pool, nursery function, nutrient cycling, grazing benefits); and 4 cultural services (recreation and tourism, aesthetic, religious and sacred value, heritage). A description of these identified ecosystem services associated with commons in India is provided in table S4 (supplementary data). The earliest study quantifying ecosystem services associated with commons was found to be in 1991. No study relevant to this research was published in 1992, 1994, 1995, 1998, and 2002 (see figure S1 in supplementary data for a temporal analysis of the 161 studies on ecosystem services associated with land commons in India over a 30 year period). Figure 2 shows the number of studies and value estimates by ecosystem services type identified from the database.

4.3. Valuation of ecosystem services generated by commons

4.3.1. Forests

A total of 26 forest-based ecosystem services are identified and quantified in terms of average economic value in USD (2020) per hectare per year. Aggregated across these ecosystem services, forests commons are estimated to provide an average economic value of $2108.61 ha^{-1} yr^{-1}, with a minimum of $602.89 and maximum of $4612.06 ha^{-1} yr^{-1} (table 1).

Provisioning services generated the highest average economic value of $891.81, followed by regulating services of $827.74, supporting services of $328.27, and cultural services of $60.79 ha^{-1} yr^{-1}. Among forests' provisioning services, food has the highest contribution, averaging at $216.26, followed by livelihood at $162.93, biodiesel at $112, water at $106.01, and fuelwood at $104.42 ha^{-1} yr^{-1}.

Among forests' regulating services, the value of watershed services was estimated at $660.58, carbon sequestration at $79.37, air purification at $32.59, and pollination at $21.96 ha^{-1} yr^{-1}. The value of gene pool as a supporting service was estimated at $180.31, followed by nursery function at $83.49 ha^{-1} yr^{-1}. Among the cultural services, recreation and tourism services from forests are worth around $56.50 ha^{-1} yr^{-1}.

4.3.2. Culturable wastelands and permanent pastures and other grazing lands

The average economic value of the ecosystem services provided by culturable wastelands and permanent pastures and other grazing lands is each calculated as $861.52, with a range of $190.47–1618.15 ha^{-1} yr^{-1} (table 1). The estimated average economic value of provisioning ecosystem services is $664.73, followed by regulating services at $132.84, supporting services at $43.46, and cultural services at $20.49 ha^{-1} yr^{-1}. Among the provisioning services from culturable wasteland and permanent pastures and other grazing lands, the value of food is around $556.94, followed by NTFPs at $73.2, fodder at $11.24, water at $9.99, and fuelwood at $7.69 ha^{-1} yr^{-1} (table 1).

In terms of regulating services, soil fertility contributes a value of $91.09, followed by climate regulation at $22.23, watershed services at $11.18, and waste treatment at $10.71 ha^{-1} yr^{-1}. In addition, the value of nutrient cycling contributed $43.46 ha^{-1} yr^{-1} in

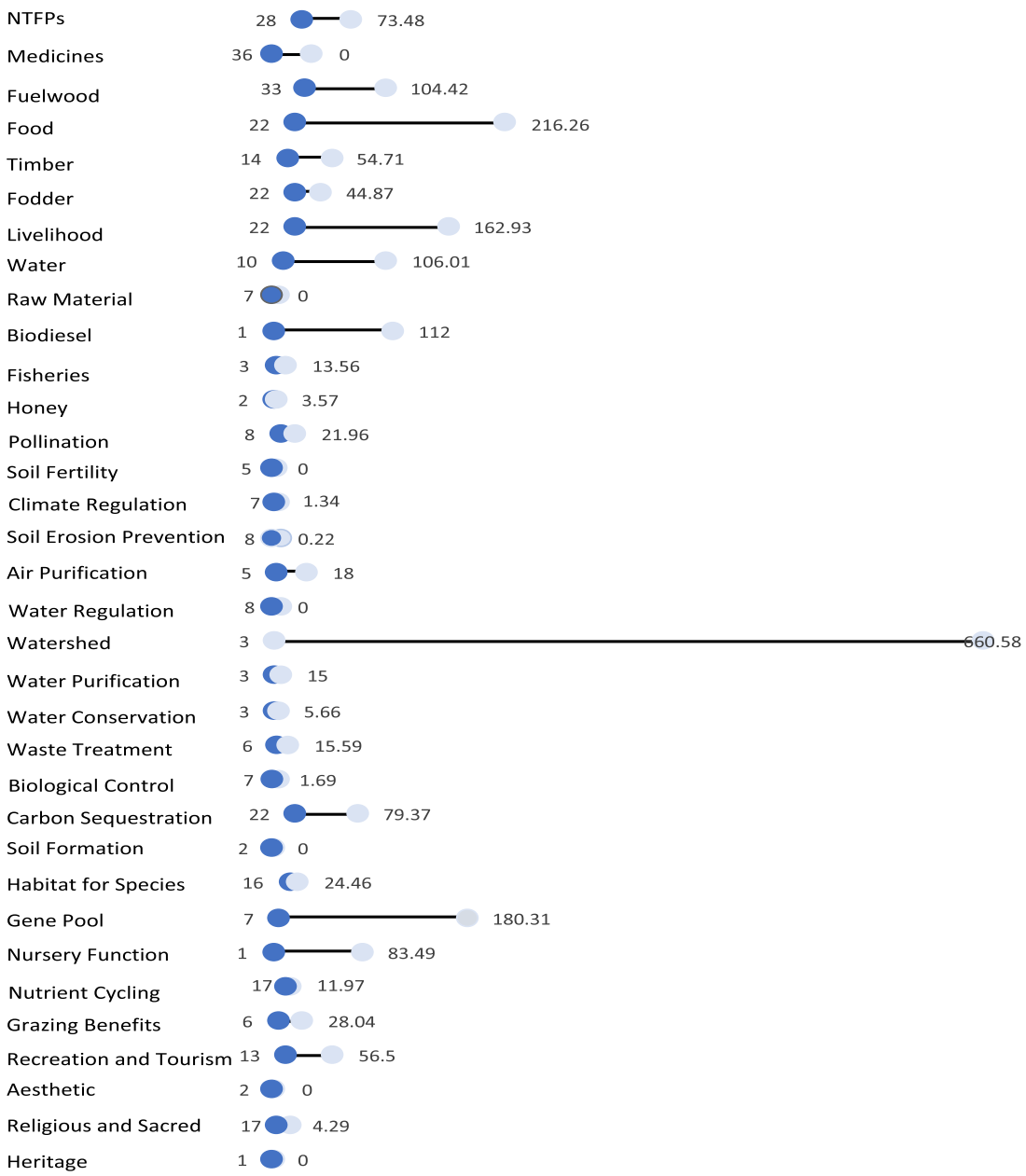

Figure 2. Number of studies (dark) and value estimates (light) by the type of ecosystem services.

supporting services and the recreation and tourism as cultural services contributed around 20.49 ha^{-1} yr^{-1}.

4.3.3. Barren and unculturable lands

Given the name, it is not surprising that 'barren and unculturable lands' have the lowest average economic value of ecosystem services compared to all other types of commons, but even then, the average economic value is estimated to be \$196.79, with a minimum of \$52.69 and maximum of \$429.82 ha^{-1} yr^{-1} (table 1). Among the regulating services, soil fertility has the highest contribution of around \$91.09, followed by climate regulation at \$22.23, watershed services at \$11.18, waste treatment at \$10.71, and biological control at \$1.63 ha^{-1} yr^{-1} (table 1).

4.4. Economic value of land commons in India

Using the value transfer method, we estimate that land commons in India provide ecosystem services worth \$90.5 billion yr^{-1} (range of \$24.6–192 billion yr^{-1}) from a total area of 66.5 million hectares, out of which forests alone contribute \$69.5 billion yr^{-1} (table 2). Culturable wastelands provide ecosystem services worth \$10.7 billion yr^{-1}, permanent pastures and other grazing lands at \$7.8 billion yr^{-1}, and barren and unculturable lands at \$2.3 billion yr^{-1} (table 2). If we apply global average unit values instead of values obtained from studies in India average unit values, ecosystem services provided by land commons in India are worth \$307.9 billion yr^{-1} (table 2).

Table 1. Economic value of identified ecosystem services in different types of land commons in India.

	Ecosystem services	Forests ($ ha^{-1} yr^{-1})			Culturable wasteland/permanent pastures and other grazing lands ($ ha^{-1} yr^{-1})			Barren and unculturable lands ($ ha^{-1} yr^{-1})		
		Average	Min	Max	Average	Min	Max	Average	Min	Max
(I) Provisioning services										
1	NTFPs	73.48	0.45	326.75	73.2	73.20	73.20	0	0	0
2	Medicines	0	0	0	0	0	0	0	0	0
3	Fuelwood	104.42	0.03	658.64	7.69	0.17	15.21	0	0	0
4	Food	216.26	67.46	365.07	556.94	46.37	1067.5	0	0	0
5	Timber	54.71	0.04	217.99	0	0	0	0	0	0
6	Fodder	44.87	0.75	150.9	11.24	6.38	16.76	0	0	0
7	Livelihood	162.93	0.84	452.38	0	0	0	0	0	0
8	Water	106.01	24.48	266.74	9.99	9.99	9.99	0	0	0
9	Raw material	0	0	0	5.67	5.67	5.67	0	0	0
10	Biodiesel	112.00	112.00	112.00	0	0	0	0	0	0
11	Fisheries	13.56	13.56	13.56	0	0	0	0	0	0
12	Honey	3.57	3.57	3.57	0	0	0	0	0	0
	Sub total	891.81	223.18	2567.6	664.73	141.78	1188.33	0	0	0
(II) Regulating services										
1	Pollination	21.96	3.47	40.44	0	0	0	0	0	0
2	Soil fertility	0	0	0	91.09	2.85	260.27	91.09	2.85	260.27
3	Climate regulation	1.34	1.34	1.34	22.23	0.24	44.21	22.23	0.24	44.21
4	Soil erosion prevention	0.22	0.22	0.22	−4.00	−4.00	−4.00	−4.00	−4.00	−4.00
5	Air purification	32.59	32.59	32.59	0	0	0	0	0	0
6	Water regulation	0	0	0	0	0	0	0	0	0
7	Water shed services	660.58	1.53	899.63	11.18	11.18	11.18	11.18	11.18	11.18
8	Water purification and treatment	8.74	8.74	8.74	0	0	0	0	0	0
9	Water conservation	5.66	5.66	5.66	0	0	0	0	0	0
10	Waste treatment	15.59	15.59	15.59	10.71	10.71	10.71	10.71	10.71	10.71
11	Biological control	1.69	1.69	1.69	1.63	1.63	1.63	1.63	1.63	1.63
12	Carbon sequestration	79.37	4.44	415.00	0	0	0	0	0	0
	Sub total	827.74	75.27	1420.9	132.84	22.61	328	132.84	22.61	328

(Continued.)

Table 1. (Continued.)

	Ecosystem services	Forests ($ ha^{-1} yr^{-1})			Culturable wasteland/permanent pastures and other grazing lands ($ ha^{-1} yr^{-1})			Barren and unculturable lands ($ ha^{-1} yr^{-1})		
		Average	Min	Max	Average	Min	Max	Average	Min	Max
(III)	Supporting services									
1	Soil formation	0	0	0	0	0	0	0	0	0
2	Habitat for species	24.46	24.26	24.26	0	0	0	0	0	0
3	Gene pool	180.31	180.31	180.31	0	0	0	0	0	0
4	Nursery function	83.49	83.49	83.49	0	0	0	0	0	0
5	Nutrient cycling	11.97	6.82	17.27	43.46	5.59	81.33	43.46	5.59	81.33
6	Grazing benefits	28.04	1.65	54.55	0	0	0	0	0	0
	Sub total	328.27	296.73	360.08	43.46	5.59	81.33	43.46	5.59	81.33
(IV)	Cultural services									
1	Recreation and tourism	56.5	3.42	259.19	20.49	20.49	20.49	20.49	20.49	20.49
2	Aesthetic	0	0	0	0	0	0	0	0	0
3	Religious and sacred value	4.29	4.29	4.29	0	0	0	0	0	0
4	Heritage	0	0	0	0	0	0	0	0	0
	Sub total	60.79	7.71	263.48	20.49	20.49	20.49	20.49	20.49	20.49
	Grand total	2108.61	602.89	4612.06	861.52	190.47	1618.15	196.79	52.69	429.82

Source: Authors' computations based on 161 studies in the ESV database created by authors. Zero value indicates no study found for the type of ecosystem service that estimated its economic value.

Table 2. Total economic value of commons in India using value transfer method.

Type of commons	Area (hectares)	Average value ($ yr^{-1})	Minimum value ($ yr^{-1})	Maximum value ($ yr^{-1})	Using global average value ($ yr^{-1})
Forests	33 004 442	69 593 644 918	19 898 015 019	152 218 466 667	144 295 420 326
Barren and unculturable lands	11 946 005	2 350 854 314	629 435 000	5 134 631 848	40 126 630 628
Permanent pastures and other grazing lands	9 057 859	7 803 526 767	1 725 250 421	14 656 974 694	43 414 318 641
Culturable wasteland	12 509 034	10 776 783 021	2 382 595 717	20 241 493 460	80 120 363 140
Total	66 517 340	90 524 809 021	24 635 296 159	192 251 566 669	307 956 732 735

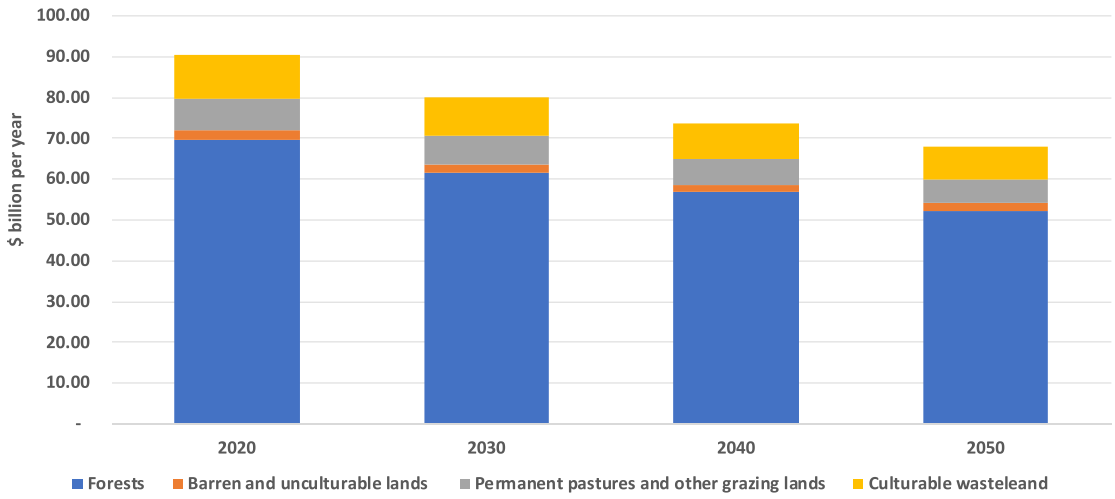

Figure 3. Economic value of ecosystem services associated with land commons in India from 2020 to 2050.

4.5. Economic value of land commons by states

The state-wise valuation of ecosystem services (table S5; supplementary data) shows Rajasthan has both the largest total area of commons (9.8 million hectares) and the highest average value ($10.7 billion yr^{-1}), followed by Madhya Pradesh (at 7.4 million hectares and $10.1 billion yr^{-1}), and Maharashtra (6.7 million hectares, $9.4 billion yr^{-1}). But the spatial area does not always correlate with the economic value: Gujarat has more area under commons, but less economic value than Chhattisgarh, Odisha, Jharkhand, and Tamil Nadu, in large part because of Gujarat's large proportion of barren and unculturable lands, which has a lower value of ecosystem services than forests and permanent pastures and other grazing lands. The results highlight the remarkable spatial variations in the value of ecosystem services across states, driven by both the area and type of land commons in each state.

4.6. Future value of commons to 2050

Based on the average loss of commons area at 4% every ten years (National Sample Survey Organisation 1999), we estimated the economic value of ecosystem services to decline to $80 billion by 2030, $73.8 billion by 2040 and $68 billion by 2050 (figure 3). This amounts to a rapid decline of ecosystem services cumulatively worth $22.5 billion by 2050, which is $750 million each year.

5. Discussion

Both commons and ecosystem services have been mostly studied independently of each other and there is a lack of literature that has explicitly integrated these two. Therefore, in this study, we apply ecosystem services valuation to commons and highlight the economic contribution of commons in India. As a key contribution to the growing literature on ecosystem services and commons, this study advances the field of ecosystem services research by estimating their economic contribution more holistically using the value transfer method. It also demonstrates the loss of economic value when the underlying ecological structure (i.e. commons) supporting the provision of ecosystem services is degraded.

There is a lack of comprehensive policy to protect and manage commons in India due to the lack of the value of benefits that they provide. To address this gap, we use the value transfer method to

estimate a range of ecosystem services value based on a comprehensive review of studies from over two decades, covering different types of commons. The study also advances the use of the value transfer method through its application to influence policy at the country level. By raising the analysis from individual studies to a national scale, it advances the empirical application of value transfer, which was absent in the context of policy making in India. There are four types of commons and individual studies selected for this analysis (161) include ecosystem services in one type of commons (forests, permanent pastures and other grazing lands (all grazing lands, pastures and meadows), culturable wastelands (land left uncultivated but that has the potential to be productively cultivated) and barren and unculturable lands (deserts, mountains and other lands that cannot be cultivated except at exorbitant costs). There is no study at the country scale that captures all ecosystem services in all four types of commons. The best estimate of the total value of ecosystem services associated with land commons is a partial estimate in 2000 (Beck and Ghosh 2000), which estimated the value of commons at $5 billion annually extrapolated from a primary study of seven villages in West Bengal, India.

There is growing literature and interest in the use of the economic value of ecosystem services in understanding trade-offs to better manage natural resources (Brander 2013, Costanza *et al* 2014, Verma *et al* 2017). Our study identifies a total of 34 ecosystem services associated with the commons in India. These ecosystem services not only support the local communities directly but also benefit wider society by regulating climate, sequestering carbon, providing biodiversity etc. Provisioning services such as food, medicines, NTFPs, fuelwood, and fodder account for 42% of the total ecosystem services derived from forest commons, which directly benefit poor and rural communities that are dependent on the commons (table 1).

In economic terms, commons provide material and non-material benefits worth $90.5 billion: $1353 ha^{-1} yr^{-1} from 66.5 million hectares in India (table 2). For comparison, Indian agriculture is estimated to produce a $271 billion gross value added from 159 million hectares, which is $1705 ha^{-1} yr^{-1} (World Bank 2020). However, it is important to note that agriculture is intensively managed to maximize outputs. In comparison, commons are not intensively managed, but provisioning services still account for 42% of the total value of ecosystem services from forest-based commons (table 1).

Continuous reliance on provisioning ecosystem services (mostly material goods) from commons can lead to further degradation of these commons. This will in turn weaken the ecological structure and inhibit the underlying ecosystem function, thereby decreasing the net productivity and ecological function of land-based commons. By contrast, sustainable practices to monitor and manage commons can enhance the provision of ecosystem services and benefits to the local community (provisioning services) and wider society (regulating and cultural services) (figure 1). In addition, any such improvement in the status and condition of commons can facilitate better flow of ecosystem services from forest to agricultural areas thereby improving agricultural productivity.

The economic benefits of land-based commons in India at $90.5 billion yr^{-1} have a broad range of $24.6 to $192 billion yr^{-1}. Such wide variation may be a result of varying status and condition of the commons studied (e.g. degraded common lands provide lower-/fewer ecosystem services), but the 'actual' use and 'realized' benefits of ecosystem services from commons also depend on other factors such as prices, extraction rate, and the number of users. With that caveat, we emphasize that, where community management is effective, there is improved productivity of commons as reflected in their high value (MEA 2005, Sandhu *et al* 2007, TEEB 2010).

Unsustainable management and degradation of commons can result in a rapid decline of the ecological structure that provides this economic value. Our projected value for 2050 (figure 3) shows that $750 million worth of ecosystem services can be lost each year over next the 30 years in India if better policies are not implemented to protect and enhance commons. This will impact the livelihood of millions of rural people in states and union territories in India, where the dependency rate of the rural population on commons is high. To reduce or stop this decline and loss of ecosystem services, there is an urgent need to bring in policy incentives and develop decision making tools to help manage commons more sustainably. Further research is required at a more granular scale to estimate the economic value of commons in partnership with local communities focusing on the village or district level. This will help to better understand trade-offs and any opportunities to finance commons restoration such as entering new and emerging carbon and biodiversity markets.

By estimating the aggregate value of ecosystem services associated with common lands in India, this study can help counter the narratives of commons as 'wastelands,' showing that these resources have a high economic value, not only for the 350 million rural poor who depend on the commons for their livelihoods but also in supporting the agricultural and food system and contributing to the welfare of broader populations. This information can help develop targeted policy responses to protect and enhance the commons. For example, the state-wide breakdown of the value of ecosystem services shows particular states, such as Rajasthan, Madhya Pradesh, and Maharashtra have high areas of commons with

high ecosystem services value. Targeting pockets of high biodiversity may be more effective in increasing the value of ecosystem services than applying blanket policies for conservation. We also acknowledge that there is a need to shift the focus toward more social and policy research about the access and demand for ecosystem services (Wei *et al* 2017, Olander *et al* 2018, Chan *et al* 2020).

The valuation of ecosystem services has been criticized by those who equate putting a monetary value with commodifying ecosystem services—and the commons themselves—in the market (Costanza *et al* 2014). However, most ecosystem services cannot be traded, and the intent of this study is not to suggest that they should be. Instead, valuation helps to make these resources—and their contributions to the economy and to common goals such as the SDGs—visible, highlighting their importance and for the better management of ecosystem services (Costanza *et al* 2014).

The results shown in this study should be considered a conservative estimate. As we included peer-reviewed journal articles for this study, which are focused more on forests than other types of commons and do not include all states. Although the grey literature (e.g. project reports) could expand the geographic coverage and data on different types of commons and ecosystem services, we have relied on the peer-reviewed literature to provide some quality assurance on the methods. For each ecosystem services-common type combination, we use a conservative 'average of averages' approach that produces a more conservative value estimate (Troy and Wilson 2006, Costanza *et al* 2014, Kubiszewski *et al* 2022). Moreover, extrapolating the values of ecosystem services was confined to transferring the values of the services to the area of different common lands as reported by revenue villages in the 2011 Census of India, which does not include data on common lands for certain states. The North-eastern states in particular are known to be rich in forests, making up 50%–80% of their area (FSI, 2019). In addition, we provide a range of value \$24.6 to \$192 billion yr^{-1} that shows variation due to varying conditions of commons in different parts in India. We also estimated that the value of commons using unit value from global ecosystem services is much larger at \$307 billion annually. Thus, our estimate is more conservative but comprehensive estimate.

We emphasize that these results are conservative but must be used in policy response with caution as the value transfer method has several limitations. It can be subject to generalization error in extrapolating values, when the differences between both sites are not fully addressed (Brander 2013, Costanza *et al* 2014, Johnston and Wainger 2015). Several study sites are broad and not location specific (supplementary material). Future research could also include the condition of commons, to estimate the cost of degradation of the commons, or the value of commons restoration.

The framework presented in this study brings together commons and ecosystem services and helps demonstrate the holistic value of ecosystem services associated with commons in India. In absence of these commons, there will be significant impact on the livelihoods of millions who depend on commons, as well as ecosystem services enjoyed by the rest of society, both within India and globally. Economic valuation reported in this study can be used to develop appropriate policy response to support targeted sustainable management of commons for equitable and sustainable development.

Data availability statement

All data that support the findings of this study are included within the article and supplementary files.

Acknowledgments

This work was undertaken as part of, and funded by, the CGIAR Research Program on Policies, Institutions, and Markets (PIM) led by the International Food Policy Research Institute (IFPRI). PIM was in turn supported by the CGIAR Fund Donors. Authors also thank all participants of the workshop on 'Valuation of India's Land Commons: Consultative workshop' held on 14 and 15 July 2021, organized by the Foundation for Ecological Security, India for their feedback, comments and suggestion on the results of the study.

Conflict of interest

The authors declare no competing interest.

Author contributions

H S, W Z, R M conceived the idea and designed research. H S, W Z, R M, H E, S P, J S, J K, P P performed research, analyzed data, and wrote the paper.

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