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Assessing social values of ecosystem services in the Phewa Lake Watershed, Nepal[1]

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Abstract

Community-based forestry (CBF) has developed through co-evolution of human societies, social values and biophysical systems shaped by long-term community activities. CBF has been practised for nearly 40 years in Nepal and has resulted in the restoration of forest cover to a considerable proportion of the mountain regions. In the Phewa watershed, restored forests are important for the subsistence of local communities and the provision of economically valuable recreation, aesthetic and cultural services for a wider group of stakeholders. In that context, this study aims to assess the social values of ecosystem services (ES) and their relative importance to different stakeholders. Community perceptions and expert opinions to assess and prioritise ES in the watershed were sought through focus group discussions and key informant surveys. There were 23 ecosystem services relevant to the local communities and other stakeholders in the watershed. Sediment retention, recreation and ecotourism, freshwater, firewood and timber were priority ES for local benefits, while recreation and ecotourism, biodiversity maintenance, sediment retention and carbon stock were priority ES for wider (regional – global) benefits. Priority ES revealed key areas of correlation and conflict between different services and between stakeholder groups. For local benefits, trade-offs were identified between provisioning services and regulating, habitat and cultural services. Synergies were predominant between regulating, cultural and habitat

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services. The study indicated that the social values concept is a promising tool for eliciting people's preferences in the ES assessment and analysis of trade-offs and synergies in developing countries where community involvement is the dominant approach of forest management.

Keywords: Nepal, community forestry, watershed conservation, participatory approach, social-cultural values, ecotourism, sedimentation

1 Introduction

The ecosystem services framework is increasingly being used as a tool for natural resource management (Chan et al., 2011; Fisher et al., 2009; Lamarque et al., 2011; Lele et al., 2013; Oteros-Rozas et al., 2014). Ecosystem services assessment has been given importance in international initiatives such as the Millennium Ecosystem Assessment (MEA), the Economics of Ecosystem and Biodiversity (TEEB) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (Oteros-Rozas et al., 2014). However, most of these studies have focused on biophysical assessments and economic valuation (Garcia-Llorente et al., 2011; Nieto-Romero et al., 2014; Plieninger et al., 2013; Schroter et al., 2014; Seppelt et al., 2012) while social values have received less attention (Chan et al., 2012; Cole et al., 2015; Martin-Lopez et al., 2012; van Riper et al., 2017). More broadly, community values and, local knowledge have been essential components of natural resource management for several decades (Sherren et al., 2010), although social value has been given a lower priority (Smith and Sullivan, 2014). Recently, the importance of integrating social perspectives of ecosystem services (ES) has been promoted as a strategy for sustainable development (Caceres et al., 2015; Chan et al., 2012; Martin-Lopez et al., 2012; Nagendra et al., 2013; Reyers et al., 2013).

Social values for ecosystem services represent benefits that ecosystems provide to society (Kendal et al., 2015; Kenter et al., 2015) and the perceived quality of natural ecosystems for human well-being (MEA, 2005; van Riper et al., 2017). They indicate which services are directly experienced by individuals and are tied to intrinsic motivations to own, manage, and protect natural resources (Brown and Fagerholm, 2015). Some recent studies have been focused on social values approach in woodlands and forests (Sherrouse et al., 2014), grasslands (Lamarque et al., 2011), coastal zones and mangroves (Cole et al., 2015), watersheds services (Zagarola et al., 2014) and on a regional scale (Bryan et al., 2010; Raymond et al., 2009). However, their focus has been on cultural services; the social values ascribed to provisioning, regulating and supporting services have largely been disregarded (Plieninger et al., 2013). This oversight may be due to a lack of expertise, confusion over defining social values (Felipe-lucia et al., 2015) or methodological difficulties (Bagstad et al., 2016). A growing interest in the use of 'social value of ecosystem services' is not yet methodologically aligned with what is actually being assessed and valued in ecosystem services (Nahuelhual et al., 2016).

Table 1: Importance of social values for ecosystem services (ES) in planning and management of resources

Statements	References
It values attributes of the society to the place people live in and to ES as individuals or as a group in a landscape	Scholte et al., 2015, Zoderer et al., 2016
Many ES are co-produced through the integration of ecosystem processes and social actions and ES assessment cannot be separated from the social values.	Lakerveld et al., 2015
Over-emphasizing instrumental values in ES research poses a risk of limiting the voices of people who are most affected by environmental management decisions	Zagarola et al., 2014
It offers a means of quantifying cultural and other services to inform environmental planning and management decisions and elaborates more socially feasible solutions for all ecosystems.	Bagstad et al., 2016; Brown 2013
It is a useful tool to prioritise ES and trade-offs that link to the stakeholder perceptions.	Iniesta-Arandia et al., 2014

Application of social values in landscape management and planning are manifold (Table 1). A few studies have used social values and local preferences (Scholte et al., 2015) and they highlight the relevance of social values in ES assessment and valuation in landscapes that have been shaped by long-term community activities (Iniesta-arandia et al., 2014; Lakerveld et al., 2015; Martin-Lopez et al., 2012; Oteros-Rozas et al., 2014), such as community-based forestry. In fact, community-based forestry (CBF) has developed through co-evolution of human societies, social values and biophysical systems (Zoderer et al., 2016) and is driven by societal priorities, considering what society wants from their forests. This, in turn, is governed by both traditional practices and locally developed rules and regulations. CBF often implicitly incorporates different ES values, but these are often not transparent to local communities or wider users and decision makers. Linking the social values concept to CBF is, therefore, a potentially innovative tool for stimulating thinking regarding the importance of ecosystem services from community forests (Pandey et al., 2016, 2014).

In Nepal, community-based forestry emerged following a series of catastrophic policy failures prior to 1970. These resulted in an environmental crisis due to massive deforestation that triggered widespread landslides, raw materials shortage and water scarcity in the mountain regions and flooding in the plains (Gautam et al., 2004). The success of CBF in the restoration of Nepalese mountain landscapes has been widely recognised (Maraseni et al., 2014, 2005; Maraseni and Pandey, 2014; Paudyal et al., 2017c). However, local people have not fully realised the benefits of this restoration resulting from their activities. Local people can realise greater benefits if an ES approach is mainstreamed into community-based forest management (Paudyal et al., 2017a, 2016), with a focus on meeting the needs of local communities and providing rights, justice and equity in the distribution of benefits accruing from efforts to restore degraded watersheds (Cronkleton et al., 2017; Paudyal et al., 2017b).

Recent research has explored the relationship between ecosystem services and community-based forest management (Birch et al., 2014; Paudyal et al., 2017a). Appropriate method to assess the social values would contribute to a broader understanding of this relationship (Pan et al., 2016). Priorities are determined by socially and individually-held values (Al-assaf et al., 2014) however, these values and attitudes regarding natural resource management vary between rural and urban populations (Hicks et al., 2013; Williams et al., 2017). In the case of CBF, a significant variation in the selection of priority ecosystem services has been observed between rural and urban people. Rural people are more emotionally attached to forests and surrounding landscapes compared to urban people, as a result of regular interactions with landscapes in various facets of life (Pan et al., 2016; Williams et al., 2017) and it is necessary to identify these differences for effective management decisions (Bryan et al., 2010; Kumar and Kumar, 2008).

Multiple interactions occur between ecosystem services in community-managed forests because they provide numerous benefits to several users (Briner et al., 2013). Understanding such interactions and associations (positive and negative) is required for managing multiple ES (Bennett et al., 2009). Trade-offs occur when an improvement in one ES results in a decline in another (Howe et al., 2014) or among stakeholders when a particular ES is prioritised by one stakeholder at the expense of the preference of others (McShane et al., 2011). Conversely, when stakeholders assign similar priorities to multiple ES, synergies can emerge (Hicks et al., 2013). Synergies and trade-offs create opportunities and conflicts, and their study can provide decision-makers with information to maximise benefits and transparently address conflicts (Bennett et al., 2009; Crouzat et al., 2016; Hicks et al., 2013).

This study aims to assess perceptions of the social values of ecosystem services resulting from community-based forestry and to assess and prioritise ecosystem services for different stakeholders based on these perceptions. An additional aim was to identify areas of agreement (synergies) and conflict (potential trade-offs) among priority ES. The study was undertaken in the watershed of Lake Phewa (hereafter Phewa watershed in western Nepal where six upstream community forest user groups (CFUGs), downstream business people and experts were consulted using mixed methods research to record their perceptions and opinions.

2 Social valuation framework

Many frameworks have been used for ES assessment and prioritisation (Boyd and Banzhaf, 2007; Costanza et al., 1997; de Groot et al., 2002; MEA, 2005; TEEB, 2010). It has been suggested that monetary valuation frameworks are incapable of accommodating public values and preferences (de Oliveira and Berkes, 2014; Kumar and Kumar, 2008; Ulgiati et al., 2011) and that economic models and valuation methods are limited to represent the entire social values, instead of signaling that economic values exclude social values. These approaches are also not appropriate in developing countries, because of a lack of expertise, data and time (Paudyal et al., 2015) and a lack of well-established ES markets (Caceres et al., 2015). Instead, non-economic evaluation and assessment offer ways of understanding underlying social preferences that may be hidden by monetary language (Chan et al., 2012; Martin-Lopez et al., 2012). Researchers have therefore called for a new approach which integrates economic, ecological and social values (Felipe-lucia et al., 2015; Lopes and Videira, 2013) and that can bridge the gap between research and policy decisions and promote people's participation in the decision-making process for ES management (Lopes and Videira, 2013).

The conceptual framework developed in this study is comprised of three major components: context, method and value articulation, which provides a coherent base for the assessment of ES (Fig. 1). Each component contributes to social valuation decisions and promotes social learning, starting with context and society and then focusing on evaluation methods that elicit social preferences and articulation of values for policy decisions. Under the framework, three different issues were recognised and examined in the watershed: (i) social values, i.e., traditional knowledge, practices, and resource use patterns; (ii) spatial and temporal contexts of ES distribution; and (iii) stakeholders and local institutions and their evolving interactions. The diversity in CBF harbours many different social values, forms of traditional knowledge and different ES that change across spatial and temporal scales (Lamarque et al., 2011). Hence a multi-scale assessment is necessary (Trabucchi et al., 2013) to capture a diversity of opinions and stakeholder interactions. As the framework is intended to guide decision-making, it is important that values are representative of the targeted area and incorporates input from a broad representation of stakeholders (Castillo et al., 2005; Moreno et al., 2014).

The framework involves participatory methods and a high level of stakeholder participation. Many studies use participatory methods to elicit social values of ES (Maass et al., 2005), and to rank them based on local preferences (Garcia-Llorente et al., 2012). However, the choice of methods rests on stakeholder type, quality of results and the scope of the study (Felipe-lucia et al., 2015). Qualitative methods are more useful than quantitative in studies like this because they provide a comprehensive understanding of the interactions between people and the landscapes (Chan et al., 2012). Assessments based on a variety of opinions and interactions among stakeholders through participatory tools can provide a rich picture of social values (Paudyal et al., 2015). The last part of the framework discusses the aggregation and articulation of ES values in alternative scenarios for decisions.

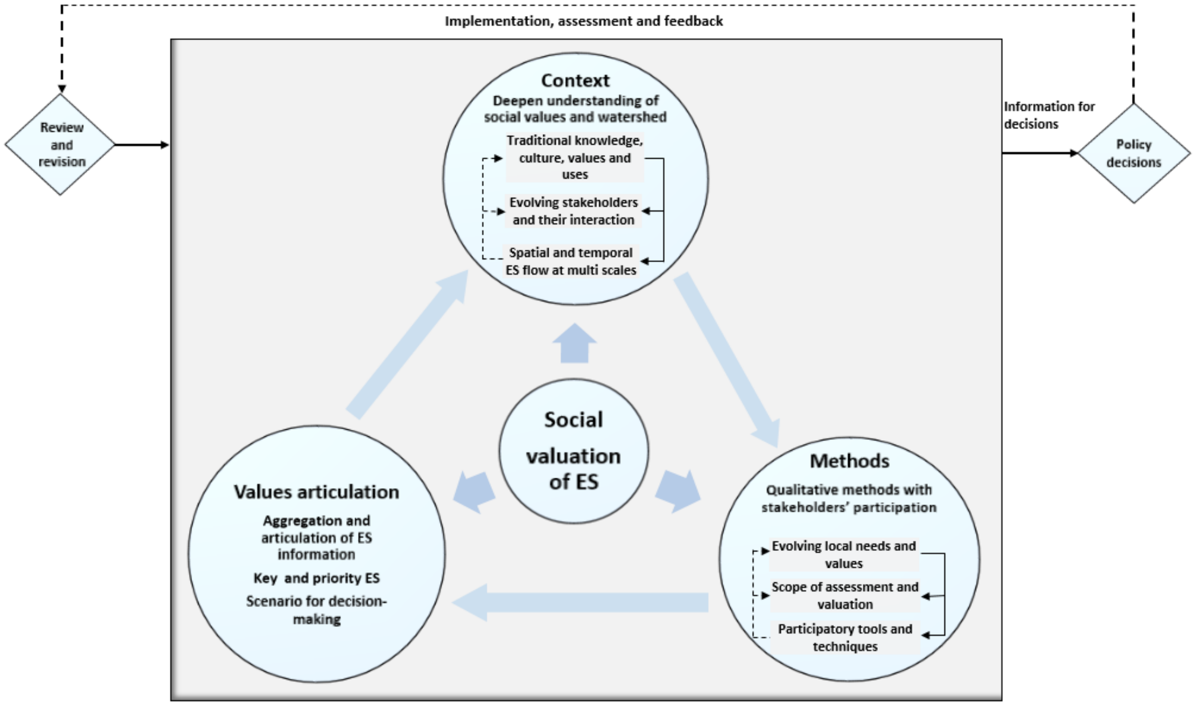


Fig. 1: Social valuation of ecosystem services framework for assessing and valuing ecosystem services in a data-poor region. All stages of the framework require an iterative process that ensures maximum stakeholder interaction for appropriate information to support decision making.

3 Methods and materials

3.1 Study area

We selected the watershed area of Lake Phewa as the research area because it is accessible, is a successful case of participatory watershed conservation, has a long history of CBF and a variety of forest types and restored forests in good condition. The watershed provides water for drinking, hydropower and irrigation. It feeds the beautiful Lake Phewa that is the backbone of Pokhara's tourism and economy (Regmi and Saha, 2015). The watershed lies between 28°11'39 and 28°17'25 north latitudes and 83°47'51 to 83 ° 59'17 east longitudes and is adjacent to the Pokhara Metropolitan City. It covers an area of 123 km^2 and extends over the Pokhara Metropolitan City and a small portion of the upstream is in the Annapurna Village Council (Fig. 2). According to census 2011, the population of the watershed is 198,333, with an average density of 665 persons per km^2; the population is unevenly distributed between village and city (Regmi and Saha, 2015).

The watershed represents a micro-region of the mountain environment with vast topographical disparities from mountain valley to steep slopes, and an elevation range from 850 masl at the lake to 2,508 meters above sea level (masl) at Panchase Peak (Regmi and Saha, 2015). The lake, the town, and treks into the nearby Annapurna range make the watershed a popular tourist destination (Fleming and Fleming, 2009). The climate in the watershed is characterised by the humidity of the subtropical monsoon, moderate temperatures, heavy monsoon rainfall (~5000 mm), and distinct seasonal variation (Regmi and Saha, 2015). Landslides or flash flooding are triggered by the seasonal rainfall that contributes to the natural degradation of the steep terrain (Leibundgut et al., 2016).

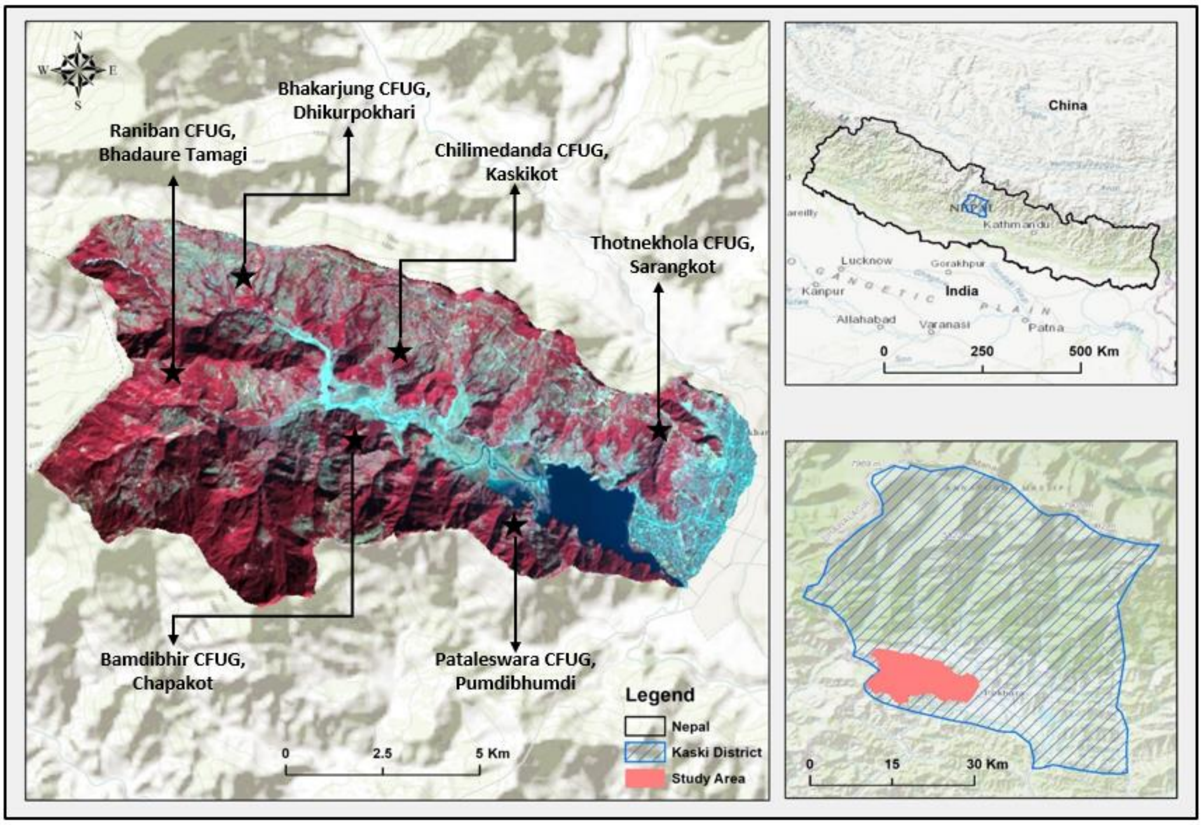


Fig. 2: Phewa watershed and location of the six case study sites in the upstream areas

Forests occupy 44% the watershed, followed by cropland (~43%), water bodies and swamp areas (~5%), built-up areas (~5%) and degraded land (~1%) (Paudyal et al., 2017b). Built-up areas and agriculture occupy the flatlands and less steep areas, while forests dominate the mountain slopes (Rimal et al., 2015). A total of 2,739 ha of forests is being managed under CBF by 75 CFUGs which comprise 12,739 households in the watershed (DFO, 2016), that is, more than 60% of the forested area. Phewa Lake covers about 3.3% of the area and stores 42.18 million m^3 water (Leibundgut et al., 2016). Siltation has been perceived as a significant threat to the Lake with annual sedimentation loads of 18,000 m^3 in the late 1990s (Sthapit and Balla, 1998).

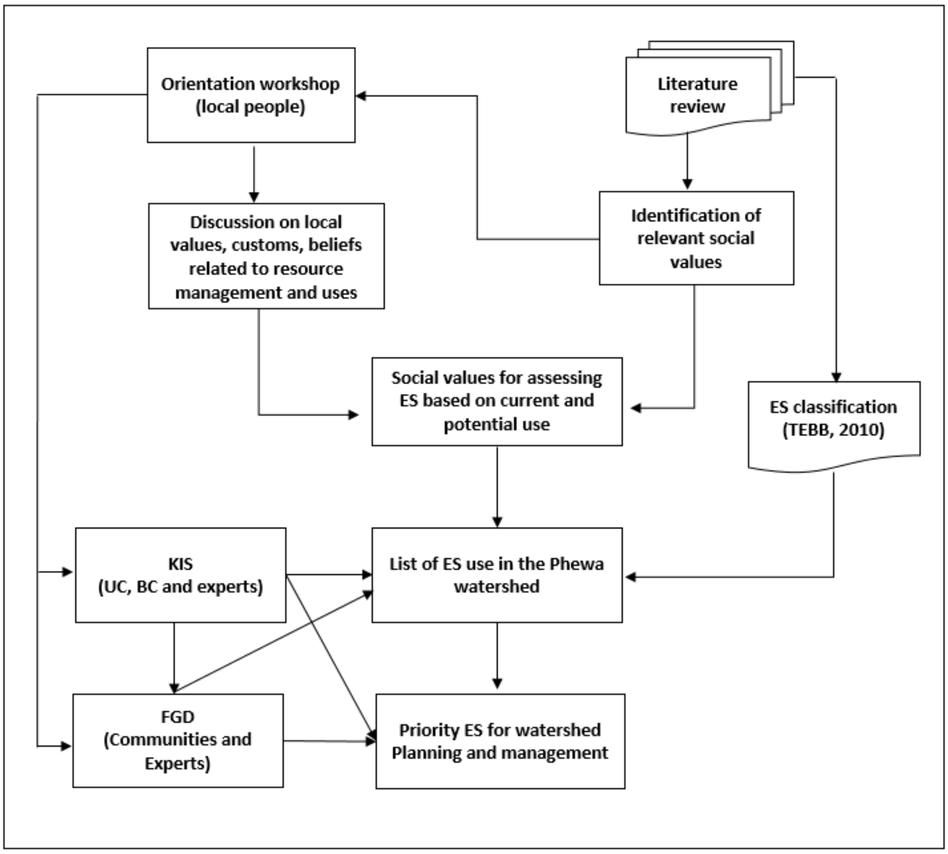


Fig. 3: The methodological framework for the study. Acronyms: 'BC' –business communities, 'ES' – ecosystem services, 'FGD' – focus group discussion, 'KIS' – key informant survey, 'TEEB' – The Economics of Ecosystems and Biodiversity, 'UC' – upstream communities

3.2 Study design

This study used a social research approach to carry out a qualitative assessment of ES. Participatory tools such as focus group discussions (Gray, 2004) and key informant surveys (Bryman, 2001; Patton, 2002) were utilised to explore community perceptions (Smith and Sullivan, 2014) and elicit expert opinions (Burkhard et al., 2012). Stakeholder workshops were conducted to identify public use and social values. The literature on social values was reviewed with a particular focus on history and resource use patterns from similar areas that might be applicable in the Phewa watershed. Orientation workshops were conducted to inform local people and experts to ensure conceptual clarity and define data requirements for the research. Local values, beliefs, cultures and current resource use in the watershed were also discussed during these workshops. The workshops ensured support from stakeholders for this research, enhanced common understandings among participants, and helped with design questions for the key informant survey and focus group discussions.

3.3 Sample selection

Relevant stakeholder groups were initially selected to explore a participatory approach for ES assessment following the orientation workshop. Although there were many stakeholder groups with their specific stakes in the Phewa watershed, we selected only three important stakeholder groups for further consultation during the research. They were: (i) upstream local communities (hereafter upstream communities – 'UC'), who have been engaging in watershed conservation and CBF for a long time and are considered key suppliers of ES in the watershed, (ii) downstream business communities (hereafter business communities – 'BC'), who are involved in business at the Lakeside in Pokhara and are potential buyers of the ecosystem services that supply by the UC, and (iii) experts either currently working in, or familiar with, the Phewa watershed. The experts were selected because they can play facilitating roles in the research process, expedite the potential payment mechanisms and offer their expertise. At the first workshop in Pokhara participants recommended selecting one CFUG from each former Village Development Committee. Hence, we randomly selected six CFUGs: *Totnekhola, Chilimedanda, Bhakarjung, Raniban, Bamdibhir*, and *Pataleswora* from the 77 CFUGs (Table 2). These groups were representative of the whole watershed, from the lower elevation zone near the lake to the higher mountains near Panchase peak, where most of the sites have natural forests in good condition. We conducted further orientation workshops at each selected site from July to August in 2015. Sixty respondents for the key informant survey were identified in these workshops, ten from each CFUG, including members of disadvantaged groups such as women, indigenous minorities and marginalised people. A workshop with the business communities was used to identify ten people for the one-to-one survey, one from each organisation working in surrounding the Lake. Ten experts were also identified at the workshops for detailed interviews.

Table 2: Community forestry user groups (CFUG) and their community forests (CF) in the Phewa Watershed

Description	**Thotnekhola CFUG**	**Chilimedanda CFUG**	**Bhakarjung CFUG**	**Raniban CFUG**	**Bamdibhir CFUG**	**Pataleshwara CFUG**
Location (address)	Pokhara-26, Kaski	Kaskikot-4, Kaski	Dhikurpokhari-4, Kaski	Bhadauretamagi-1, Kaski	Chapakot 3,4,5,6	Phumdibhumdi -5, Kaski
Distance from Village	Adjoining village	Adjoining village	Adjoining village	300 m	Adjoining village	500m
Distance from road	500 m	200 m	Contiguous	Contiguous	1 km	2 km
No. of households	152	179	189	241	134	80
Total Population	811	598	736	1216	712	355
CF initiated	13 April 1993	12 July 1996	05 Sep. 1993	12 June 1995	22 June 1993	22 June 1993
Official registration	28 June 2004	15 July 2001	19 Dec. 1999	06 May 1999	16 July 2002	13 March 1999
Exe. Committee (No.)	14	9	11	11	11	9
Total forest area (ha)	88.3	104.1	107.8	14.2	48.5	51.4
Slope and, aspect	North-east	West	East	North-east	North-east	North

The 60-people interviewed from mountain communities comprised 72% farmers, 10% local business owners, 8% job holders and 7% social workers. Of these, 65% were men and 35% were women. Most of them (48%) were 45-60 years old, 27% were 30-45 years, and 22% were over 60 years old (Table 3). Most (93%) are literate, but 60% did not complete high school. The economic status ranged in size according to the landholding, jobs, and small enterprises, in which 35% of respondents earned less than US$ 1,000 per year. Participants from upland communities had been engaged in CBF for 5-25 years. More than 50% of participants had never heard of the term 'ecosystem services', but they understood the meaning and value of each service. Similarly, respondents from business communities were drawn from various businesses and trade associations including hoteliers, tourist booksellers, restaurant owners, boat operators and tour guides. Most of them were between 30 and 45 years of age, had completed higher secondary level and earned an annual income of more than the 10,000 US dollar. All the experts had postgraduate qualifications and were over 30 years of age.

Table 3: Demographic characteristics of participants selected for key informant survey in the Phewa watershed

Categories		Upstream local community		Downstream business community		Experts	
		n=60	%	n=10	%	(n=10)	%
Sex	Men	39	65	8	80	9	90
	Women	21	35	2	20	1	2
Age (year)	<30	3	5				
	30-45	16	27	4	40	5	50
	45-60	28	48	4	40	4	40
	>60	13	22	2	20	1	10
Education	Illiterate	4	6.7	1	10		
	Literate < secondary	54	90	3	30		
	Undergraduate	1	1.7	5	50		
	Postgraduate	1	1.7	1	10	10	100
Occupation	Farmer	43	72				
	Labourer	2	3				
	Business	6	10	10	100		
	Employee	5	8			8	**80**
	Social worker	4	7			2	20
Ethnicity	Brahmin-Chhetri*	28	47	6	60	8	80
	Indigenous minority+	20	3	3	30	2	20
	Dalit@	12	20		10		
Annual income (US$)	<1000	21	35				
	1,000 - 5,000	14	23	**1**	10	3	30
	5,000- 10,000	19	32			7	70
	>10,000	6	10	9	90		

Note: One US$ equals approximately 100 Nepalese rupees. **Brahmin-Chhetri* refers to a higher cast and level of education. +*Indigenous minorities* have been living for a long time in close association with the natural resources. @*Dalit* refers to the marginalised group in specific occupations.

3.4 Assessment of ecosystem services

Social values and public uses of the landscape are closely interconnected. Beginning with the work of Rolston and Coufal (1991), social value typologies (Brown, 2013) have been developed and used in forest management (Brown and Reed, 2000; Rolston and Coufal, 1991) , studies of protected areas (Brown and Weber, 2011; Zhu et al., 2010) and ES mapping (Cole et al., 2015; Sherrouse et al., 2014; van Riper et al., 2017). The TEEB (2010) typology was used to categorise ecosystem services such as provisioning, regulating, cultural and support services. We began by investigating social values in the research literature and derived themes to be discussed with local communities in focus group discussions (Table 4) to ascertain the variety of current and potential uses of watershed resources

(Annex 1) and to link those to social values.

Table 4: Social values of ecosystems related to the Phewa watershed in western Nepal

Social values	**Importance in Phewa watershed**
Economic	The watershed is economically important because it provides timber, firewood, grass, food, minerals, fresh water for drinking and irrigation that supports subsistence livelihoods. Local people use these raw materials for small businesses.
Life-sustaining	The watershed produces, preserves, cleans, and renews air, soil, and water and regulates local to global climate.
Biodiversity	Forests and other types of lands provide habitat for a variety of wild animals and plants.
Aesthetic	People enjoy the scenery, sights, sound, and smell that give us pleasure and happiness.
Recreation	Forested landscapes provide a place for favourite outdoor recreation activities such as a picnic, hiking, walking, boating, and paragliding and much more.
Spiritual	Forested landscape possesses many sacred, religious, or spiritually special places to people, where they worship and show respect for culture and nature.
Learning	People can learn about the historical, socioeconomic and biophysical conditions of the watershed through scientific observation or experimentation.
Therapeutic	Forests/landscapes make people feel better, physically and mentally.
Historic	The watershed including Phewa Lake has a natural and historical significance that matters to the people living in the watershed and beyond.
Cultural	These places allow people to continue and pass down the wisdom and knowledge, traditions, and way of life of our ancestors.
Future	These places allow future generations to know and experience the watershed and the Phewa Lake as it is now.
Intrinsic value	We value watersheds in and of themselves, whether people are present or not.

The assessment among the stakeholders involved analysing the responses in the key informant survey and linking current and potential uses. First, we oriented each participant regarding various ecosystem services, and current and prospective public uses. We obtained opinions regarding ‘current uses’ by asking the question: ‘in your opinion, what is the level of use of this community forest resource?’ Responses were on a four-point scale, where ‘1’ indicates no use and ‘4’ indicates high use (1 = no use, 2 = little use; 3 = moderate use, 4 = high use). Similarly, we asked each participant to rank ‘potential uses’ using a similar scale (1 = strongly oppose, 2 = oppose, 3= favour, 4 = strongly favour). The interview then proceeded based on questions and possible options within each issue, such as type and scale of benefits (or type of users) of the ecosystem services. This process was repeated for each of the 60 respondents across the six CFUGs, ten business people and ten experts. Responses were coded and tabulated. Simple statistics (e.g., mean and standard deviation) were used to analyse data and the results were presented as bar charts. If more than 50% of participants had a combined positive response of ‘high use’ and ‘moderate use’, that particular use of watershed resources was classed as a ‘current use’. Uses that were ranked as ‘strongly favoured’ or ‘favoured’ by more than 50% of participants were classed as ‘potential uses’. In the next step, if more than 50% of participants had an aggregated positive response of ‘current and potential use’, that particular use of watershed resources was considered as an ‘ecosystem service’. Additionally, participants were also engaged in a discussion regarding the relevance of ecosystem services in the context of the watershed, and results were summarised in the tabular format.

3.5 Prioritisation of ecosystem services

The Social Values for Ecosystem Services tool has been widely used from local to regional levels (Bagstad et al., 2016; Sherrouse et al., 2017, 2014; van Riper et al., 2017). In this study, we asked each key informant to distribute 100 preference points across 23 ES (Table 5) in a way that reflected the importance they ascribed to each ES. Each respondent did this twice, firstly from the view of local benefits, then from the view of wider benefits. Point values for each ES were entered into an Excel sheet for the three groups. A ‘priority value index’ was calculated for each ES based on the total points from all respondents assigned to that ES. An average priority value was calculated between respondent groups for comparison. Based on the workshop discussion, it was decided that different weights would be assigned to different communities (50% to UC, 20% to BC and 30% to experts) to calculate an aggregated index for priority ecosystem services.

3.6 Interaction among priority ecosystem services

Trade-offs occur when the production of one commodity or services impacts on the capacity to supply another commodity or service (Hicks et al., 2013). Once priorities had been assessed, ecosystem services were compared to find relationships between the pairs. Although there are many quantitative methods available to identify trade-offs and synergies of single to multiple ES (Deng et al., 2016; Garcia-Nieto et al., 2013; Hauck et al., 2013; Mouchet et al., 2014; Raudsepp-Hearne et al., 2010), we chose the pair-wise comparison method because it is practical and easy to operate and ensures the involvement of local people and experts efficiently and reliably (Turkelboom et al., 2016). A literature review (Baral et al., 2014; Bullock et al., 2011; Garcia-Nieto et al., 2013; Rana et al., 2017; Yang et al., 2015) and expert opinions provided the basis for the scaling of the outcomes of these associations into four categories: 'strong synergies (++)', 'weak synergies (+)', 'strong trade-offs (- -)', and 'weak trade-offs (-)'. The outcome of synergies provides an opportunity to bundle the ecosystem services for possible payments for ecosystem services and outcome of trade-off analysis offers options to select ecosystem services with minimum trade-offs in landscape management. A stakeholder workshop involving local people, business communities and experts was conducted for this comparison. Stakeholder responses were systematically documented and analysed using a pairwise correlation matrix based on positive and negative associations for local benefits and then for ES with wider benefits. Finally, stakeholders produced two correlation matrices.

5.1 Results

5.1.1 Important ecosystem services and their connection to social values

Drawn from the knowledge and perceptions of upstream residents, 81.5% of the sampled respondents recognised that ecosystems from Phewa watershed delivered 23 ES to society (Fig. 4). Members of the business communities and experts were in full agreement with this list. Responses received varied from 35 (58%) to 60 (100%) regarding the identification of ecosystem services (Table A1). Ecosystem services that were well-known and easily understood by local communities were provisioning and cultural services, because of their historical and cultural associations with the watershed and daily consumptive uses of resources for subsistence livelihoods. Local people were also familiar with many regulating services (e.g. sediment retention, flood and landslide control, carbon stock and water regulation) and habitat services (e.g. habitat protection and biodiversity maintenance), although they had limited direct experience with these services. Local people were less aware of some ES, such as crop pollination and air quality regulation, perhaps because of their indirect benefits to the society or weak linkage to the local economies. This study further identified that many ES benefits from the watershed are widely distributed from on-site to the global scale (Table 5). For example, timber, firewood, forage, wild foods, and other non-timber forest products (NTFPs) are available to the local people and those in adjoining areas, whereas most of the regulating and specific cultural services are accessible to a wide range of individuals within the watershed and beyond. Some ES such as carbon stock increases, habitat for biodiversity and recreational benefits supplied by the watershed are globally important.

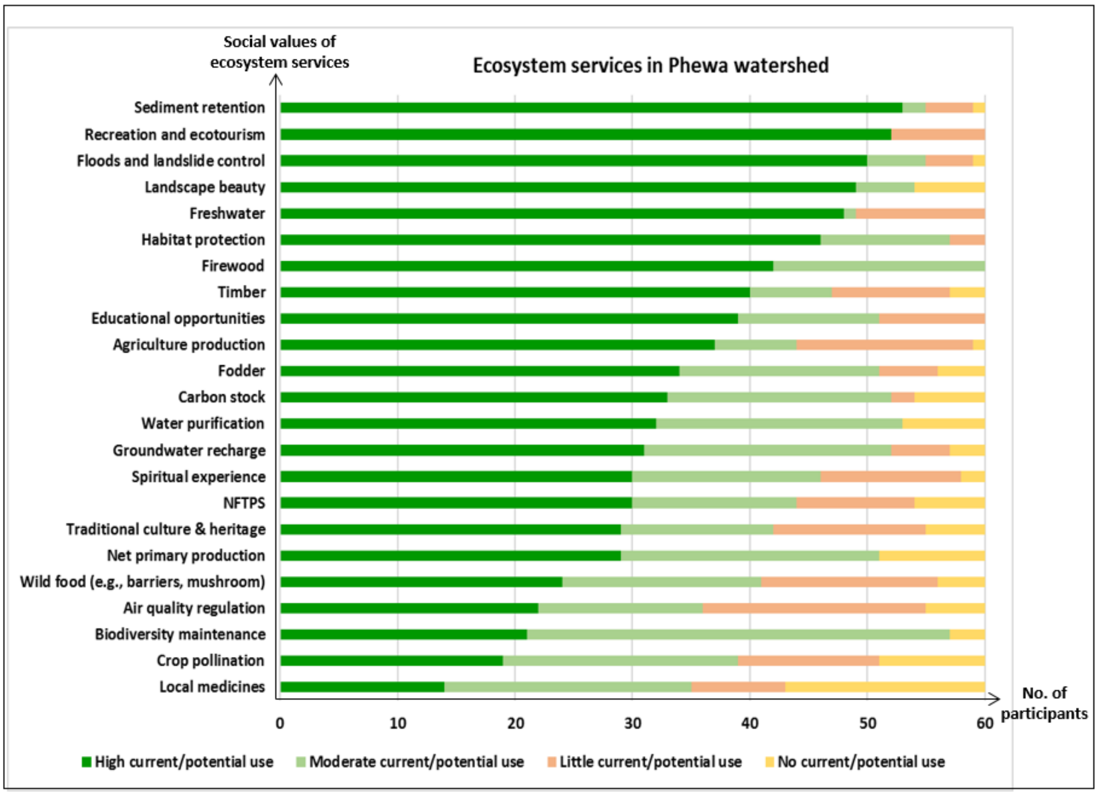


Fig. 4: Upstream communities' perceptions regarding watershed capacity to supply various ecosystem services (ES) that were defined by existing and potential uses of Phewa watershed's resources. The Y-axis presents the ES, and the X-axis denotes the number of participants indicating their perception regarding each ES.

Table 5: Key ecosystem services and their benefits for local and global beneficiaries as perceived by upstream communities in the Phewa watershed

Social value types	ES type and category	Underlying motivation of local people to indicate the presence of particular ES	Indicator	Scale of benefits	User types
Economic	Timber (P)	Timber is traditionally used as local construction material and seldom sold to a nearby city for money.	No. of large and mature trees per ha	O-R	Private
	Firewood (P)	Abundant preferred firewood species which is the primary source of rural energy.	Woody biomass / No. of firewood species per ha	O-L	Private
	Fodder (P)	Forests supply forage to livestock that is an integral part of local economies although decreasing in recent years.	No. of fodder trees in forests and cultivated lands	O-L	Private
	NFTPs (P)	Forests supply NTFPs which are a source of raw materials for small enterprises and basis of rural economies.	No. of trees, shrub and herb species	O-L	Private
	Wild foods (P)	Wild foods and vegetable items, including berries, mushrooms, bamboo shoots and yams from forests contribute to the livelihoods of poor people.	No. of food producing species (e.g., berries, mushrooms, yams) per ha	O-L	Private
	Crop production (P)	Most households possess at least a small parcel of crop land for food production as a primary source of livelihoods.	Total cultivable lands (ha)	O-R	Private
	Local medicines (P)	Forests supply raw materials for traditional *Ayurvedic** medicines and thousands of people work collecting and processing these medicines.	No. of species of medical value per ha; harvestable amount (tons) per ha	O-R	Private
	Freshwater (P)	Water for drinking, irrigation and hydropower generation is available from the watershed. It also supplies water to Phewa Lake, supporting recreation activities and eco-tourism.	No. of springs, ponds, and streams; no. of projects using water (drinking, irrigation, hydropower.)	L-N	Private/ public
Life-sustaining	Carbon stock (R)	Increased forests sequester carbon from the atmosphere at a higher rate, and increased biomass indicates a higher amount of carbon storage. Numbers of trees have increased in cultivated lands and home gardens.	Increasing area of forest cover / No. of trees per ha; % of large trees per ha	O-G	Public
	Air quality regulation (R)	Forests filter the air and remove odours, pollutant gases (nitrogen oxides, ammonia, sulphur dioxide and ozone) and dust particles out of the air by the action of leaves and bark.	Total leaf area; amount of pollutants in air	O-G	Public
	Groundwater recharge (R)	The increased forests reduce the runoff rate and assist water percolation.	Water volume availability downstream in a year	O-N	Private/ public
	Water purification (R)	The landscape filters out and decomposes organic waste introduced into land and water and can assimilate and detoxify compounds through soil and subsoil processes.	Amount of quality/pure water throughout the year	O-N	Private/ public
	Sediment retention (R)	Improved condition of land and control of flood and landslides reduce the deposition load to the lake in recent years. Improved forest health protects the watershed from soil loss.	Rate of siltation per year	O-G	Private/ public
	Floods and landslide control (R)	Replenished mountain forests have reduced landslides, erosion and soil loss and improved terrace and bio-engineering works, reducing the number of floods and landslide incidents upstream.	Amount of soil loss per ha per year	O-N	Private/ public
	Crop pollination (R)	Forests provide habitat for many insects such as bees which help in pollination of forest and agriculture crops.	No. of pollinators; quantity of food production per year	O-R	Private/ public
Biodiversity	Habitat protection (H)	Increased area and quality of forests show well-protected habitat that provides refugia to many flora and fauna.	No. of plants and wild animals	O-G	Public
	Biodiversity maintenance (H)	Improved habitat supports conservation of many flora and fauna species from terrestrial and aquatic ecosystems.	No. of new plants and wild animals		Public
Biodiversity and economic	Net primary production (H)	Retaining topsoil and nutrients supports fast biomass increment and indicates higher total production.	Gross production per ha per year	O-N	Private/ public
Recreation and economic	Recreation and ecotourism (C)	Watershed provides opportunities for recreation activities such as boating, swimming, walking, hiking, climbing, paragliding that support tourism.	No of recreation sites/visitors	O-G	Private/ public
Learning	Educational opportunities (C)	Several studies (short and long) have been conducted by national and international researchers in every year.	No. of researchers/visitors	O-G	Private/ public
Aesthetic	Landscape beauty (C)	Visitors express visual appreciation of the natural scenery of the Lake and Himalayas from every part of the watershed.	No. of visitors appreciating the views of the watershed	O-R	Public
Spiritual	Spiritual experience (C)	Many stupas, temples and other traditional worship sites; present and forests have been conserved for religious purposes.	No. of stupas, temples and other traditional worship sites	O-R	Public

Social value types	ES type and category	Underlying motivation of local people to indicate the presence of particular ES	Indicator	Scale of benefits	User types
Cultural	Traditional culture and heritage (C)	The watershed maintains landscapes and culturally significant species for heritage values and a sense of cultural identity.	No. of historical sites	O-R	Public

Note: Capital letter in bracket represents the Economics of Ecosystem and Biodiversity (2010) categories of ecosystem services: 'P' – provisioning services, 'R' – regulating services, 'C' – cultural services, 'H' – habitat services, 'CBF' – community-based forestry, 'ES' – ecosystem services, 'NTFPs' – non-timber forest products, 'No.' – number, 'ha' – hectare; Key to scale of users (adapted from Paudyal et al., 2015): 'O' - onsite users, 'L' - local users; 'R' - regional users; 'N' - national users; 'G' - global users.

**Ayurvedic* medicine: A system of medical practice that originated in the ancient Indian subcontinent. In Sanskrit, *Ayur* means life or living, and *Veda* means knowledge, together indicating the "knowledge of living" or the "science of longevity."

Economic, life-sustaining and biodiversity values were found to be very significant to users in the watershed (Fig 5). Economic values were associated with ten different services. Similarly, biodiversity and life-sustaining values were ascribed to seven services. Recreation, learning, spiritual, cultural and aesthetic values supported at least one ES. However, four social values (e.g., future, intrinsic, historical and therapeutic) did not directly accompany any ES. Discussions revealed that people only realised the economic value to a limited extent because of the extractive nature of associated ES such as food, timber, fodder and water. Many ES are yet to be realised by the local people because of their non-consumptive uses and the difficulty in perceiving them at local scales, for instance, air regulation, climate regulation, and habitat protection.

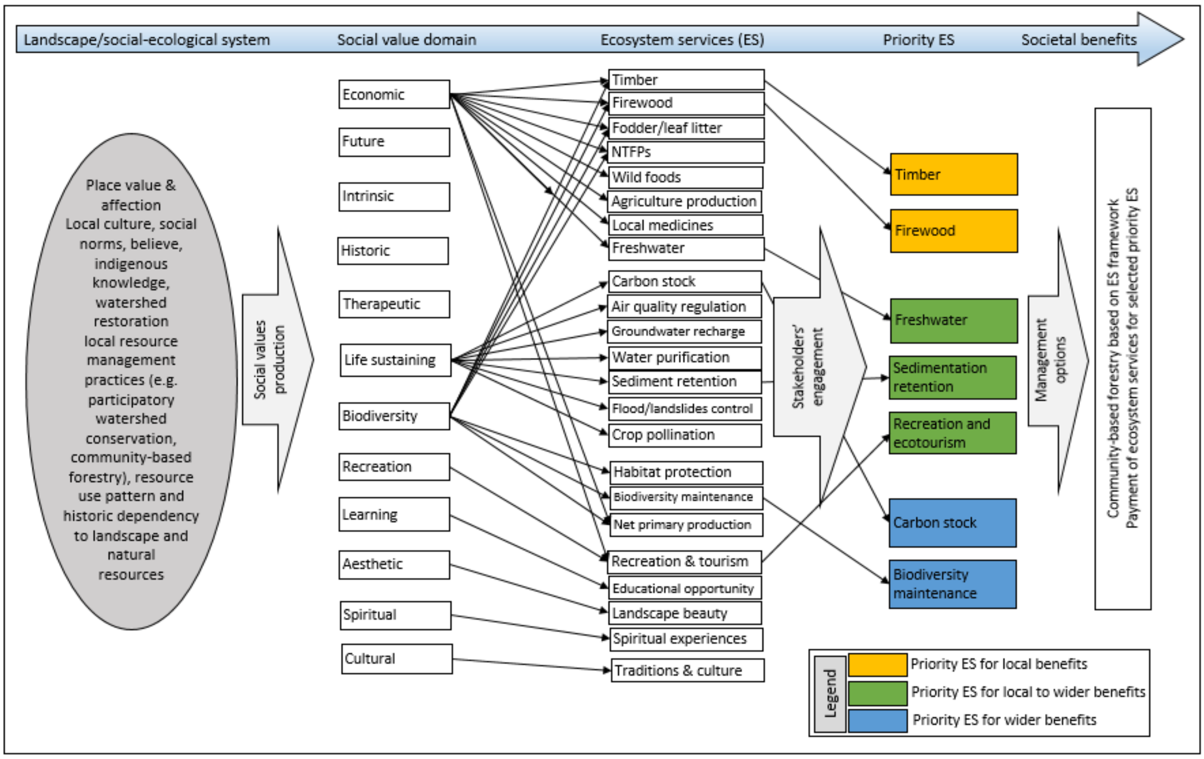


Fig 5: Linkages between landscape attributes and social values in assessment and priority ecosystem services in Phewa watershed

5.1.2 Priority ecosystem services

There were significant differences among the priorities assigned to the 23 ES, with a distinct variation between local and wider users and beneficiaries (Fig. 6). For local recipients, sediment retention was the highest priority, followed by recreation and ecotourism, fresh water, firewood, and timber (Fig. 6a). Recreation and ecotourism was seen as the highest priority ES for their wider scale benefits, followed by biodiversity maintenance, carbon stock, sediment retention and fresh water (Fig. 6b). Sediment retention, recreation, and ecotourism and fresh water were the highest priority for both categories (Table A2). Provisioning services were given the highest priority for local benefits, whereas regulating services were accorded top priority for wider benefits.

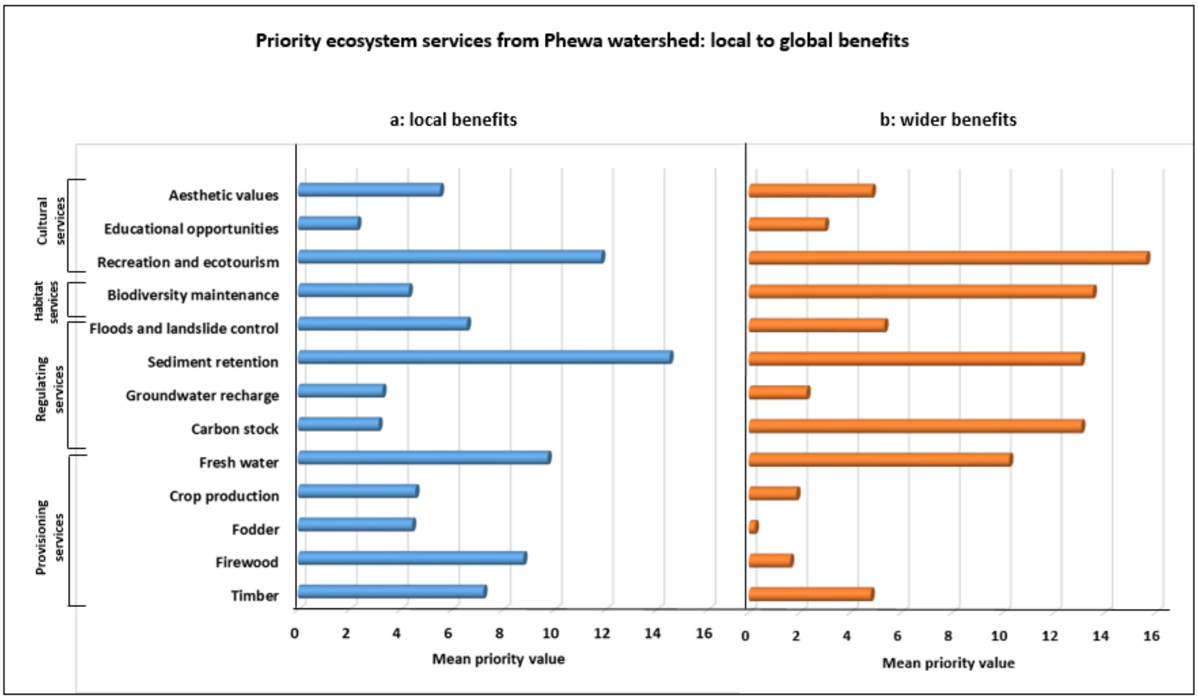
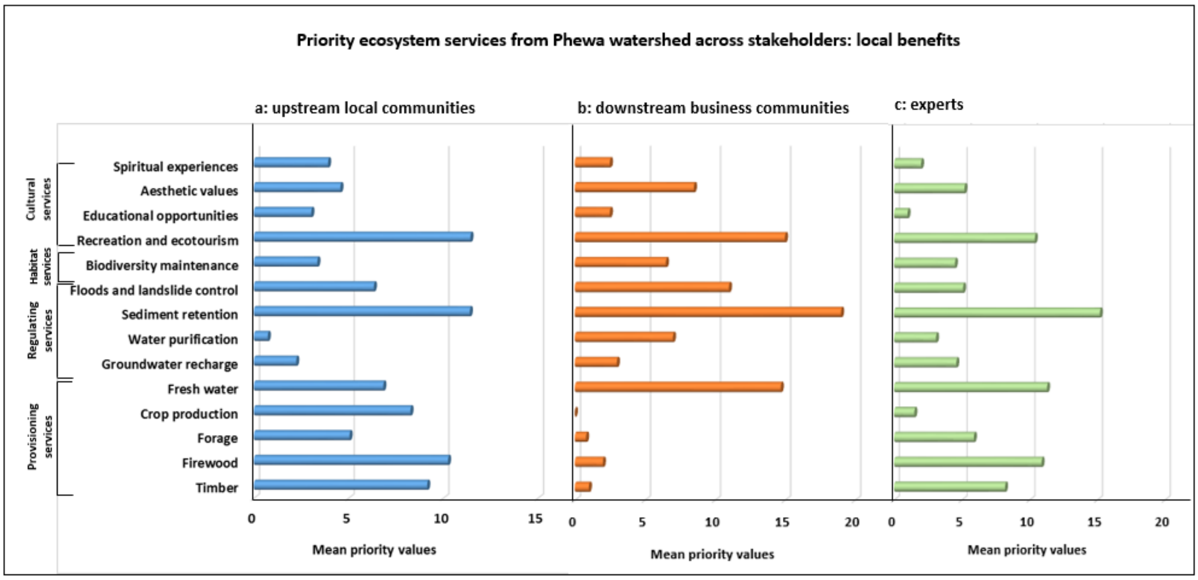


Fig. 6: Distribution of perceived priority rating of ecosystem services provided by the Phewa watershed and comparing their importance in the context of (a) local benefits and (b) wider benefits. The X-axis shows mean priority values corresponding to ES at Y-axis.

Priorities of upstream communities were different from those of business communities and experts, due to group dynamics, background, interests and experience. Varied views were observed among stakeholders as to whether community-based forestry provided more local or wider benefits (Fig. 7).

For instance, upstream communities and experts accorded similar priorities to local benefits, such as recreation, ecotourism, sediment retention, firewood, timber, crop production and fresh water (7a and c), whereas the business communities focused more on regulating and cultural services that were related to their businesses, such as sediment retention, recreation, ecotourism, fresh water, landslide control and landscape beauty (Fig. 7b). However, the three groups expressed similar views on the priority ES for wider benefits: sediment retention, recreation and ecotourism, biodiversity maintenance, carbon stock and fresh water were given the highest priority ES, but in different orders of priority (Fig. 7d-f). Moreover, a variety of different views were recorded among respondents from the upstream communities. For example, women assigned priority to firewood, fodder and drinking water for domestic consumption, whereas men assigned a higher priority to timber production for household construction or income and water for irrigation. Dalit, poor and occupational groups prioritised wild foods, NTFPs and raw materials for their small enterprises. Retailers and teachers ranked sediment control and ecotourism higher.



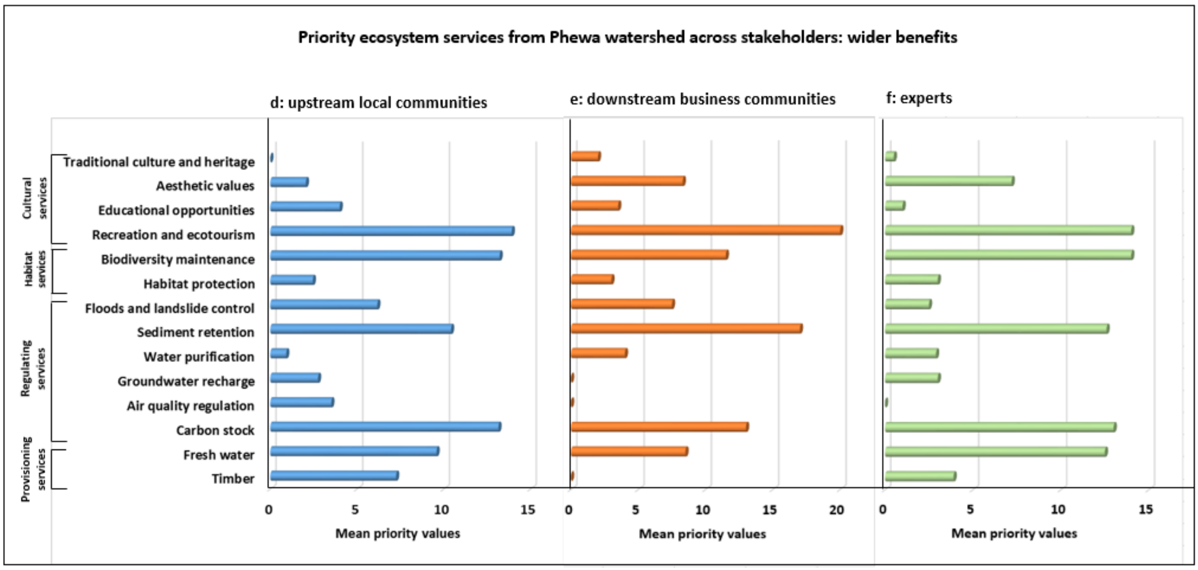


Fig. 7: Comparison of priority ecosystem services from local to wider benefits across stakeholders. The X-axis shows mean priority values corresponding to ES of Y-axis. 'a' indicates priority ES for local benefits from the upstream communities (UC), 'b' indicates ES for local benefits from the business communities (BC), 'c' shows ES for local benefits from experts, 'd' demonstrates ES for wider benefits from the UC, 'e' displays ES for wider benefits from the BC, 'f' shows ES for wider benefits from experts.

5.1.3 Interaction between priority ecosystem services

Participants identified the substantial interaction between different ES. There were 45 interactive pairs among the ten priority ES, where synergies and trade-offs were obvious (Fig. 8). Provisioning ES generally had negative inverse relationships with regulating, habitat and cultural services and there were negative relationships between different provisioning services. On the other hand, regulating ES were highly correlated with one another. Upstream communities ranked provisioning services higher, while the business communities prioritised regulating services. This shows obvious trade-offs among priority ES for local benefits. Out of 45 pairs of associations between ES, 28 pairs indicated potential trade-offs (17 strong and 11 weak) and 17 pairs showed synergies (eight strong and nine weak, Fig. 8a). While crops, firewood and timber were high priority ES for local livelihoods, they involved the highest potential level of trade-off with other ecosystem services. In contrast, sediment retention, recreation and ecotourism and biodiversity maintenance showed strong synergies. Freshwater showed synergies with firewood and timber and trade-offs with agriculture crops.

Synergies were predominant among priority ES for wider benefits. Out of 45 combinations of ES, 33 indicated synergies (16 strong and 17 weak), while only 12 pairs showed potential trade-offs (eight strong and four weak, Fig. 8b). In contrast with local benefits, priority ES for wider benefits such as recreation and ecotourism, sediment retention, carbon stock, landslides and flood control and aesthetic values exhibited synergies between them (seven to eight pairs of each service out of possible nine correlations), but they conflicted with the production of timber and fresh water. Freshwater input to the Phewa Lake had synergies with aesthetic values and recreation and ecotourism.

ES (rank) \ ES (rank)	Recreation and ecotourism (2)	Fresh water (3)	Firewood (4)	Timber (5)	Flood & landslides control (6)	Aesthetic values (7)	Crop production (8)	Fodder (9)	Biodiversity maintenance (10)
Sediment retention (1)	++	- -	- -	- -	++	++	- -	- -	+
Recreation and ecotourism (2)		+	-	- -	++	++	+	-	++
Freshwater (3)			+	+	- -	+	- -	+	-
Firewood (4)				-	- -	- -	- -	-	-
Timber (5)					- -	- -	- -	-	-
Flood and landslides control (6)						++	- -	-	+
Aesthetic values (7)							+	-	++
Crop production (8)								-	- -
Fodder (9)									- -

a

ES (rank) \ ES (rank)	Biodiversity maintenance (2)	Carbon stock (3)	Sediment retention (4)	Fresh water (5)	Floods and landslide control (6)	Aesthetic values (7)	Timber (8)	Educational opportunities (9)	Groundwater recharge (10)
Recreation and ecotourism (1)	++	+	++	+	++	++	- -	+	+
Biodiversity maintenance (2)		++	++	-	++	++	-	+	++
Carbon stock (3)			++	- -	+	+	- -	+	+
Sediment retention (4)				- -	++	++	- -	+	++
Freshwater (5)					- -	+	++	+	-
Floods and landslide control (6)						++	- -	+	++
Aesthetic values (7)							- -	+	+
Timber (8)								+	-
Educational opportunities (9)									+

b

Fig. 8: Interactive correlations among priority ecosystem services from the Phewa watershed which created either synergies or trade-offs. ‘a’ indicates synergies and trade-offs among priority ES for local benefits and ‘b’ shows synergies and trade-offs among priority ES for wider benefits.

5.2 Discussion

This study confirmed that there are spatial associations between social values, local practices and resource use in ES assessment that are consistent with previous studies (Martin-Lopez et al., 2012; Oteros-Rozas et al., 2014; Zoderer et al., 2016). A framework was designed and implemented to evaluate ES assessment in CBF regimes that depend on participatory tools to bring together inputs from communities and experts (Felipe-lucia et al., 2015). The use of this framework demonstrates how stakeholder knowledge, experiences and perceptions can potentially be used to represent ES information spatially. The novelty of the framework lies in the continuous deliberations among the stakeholders from the beginning of the study and ensures co-production and communication of knowledge about different management options (Lopes and Videira, 2013) that leads to more sustainable CBF management.

In line with previous studies, our results revealed that social values were heavily influenced by place and demographic characteristics (Zoderer et al., 2016). For example, members from Raniban CFUG were more interested in conservation of historical and cultural sites and services to promote opportunities to develop ecotourism by linking with the Lakeside tourist hub. In contrast, participants from Bamdibhir CFUG prioritised regulating services for the protection of villages from landslides. They had reclaimed a significant portion of the village from old landslides (Paudyal et al., 2017b).

Local perceptions of the ES value depend on the individuals, where they live or work and their interactive relationship with the location (Oteros-Rozas et al., 2014; Scholte et al., 2015; Zoderer et al., 2016). In this study, women's views were based on reflections of their experience in landscape conservation and resource use. They are strongly connected to the environment and dedicated to landscape conservation, thus reinforcing the concept of women's 'ethic of care' towards the environment (Dietz et al., 2002). Consistent with the results of Martin-Lopez et al. (2012), women were more likely to prioritise and value provisioning services such as firewood, forage and NTFPs and other natural materials. In the study area, women are mostly involved in the collection and processing of materials to support local livelihoods. On the other hand, professional people such as school teachers and small traders prioritised regulating and habitat services because of their interest in the maintenance and expansion of their businesses.

One ES could be associated with multiple social values, while one value might be linked to multiple ES (Table 5). Indigenous knowledge was linked to watershed management and subsistence livelihoods that are shaped by local problems such as landslides, floods, water scarcity, the collection of forest products, siltation in the Lake, threats to business and the economy and their efforts to resolve them. For instance, firewood, timber, NTFPs and water are important for local livelihoods and require the active use and management of the forest, while sediment retention, flood and landslide control are both local and wider benefits of forest restoration. While recreation and ecotourism are important to the local economy, habitat protection, biodiversity and carbon stock are considered potential sources of income for local communities that might be linked to increased tourism in future.

Priorities assigned to ES depend on perceived benefits, supply capacity and market demand (de Juan et al., 2017; Hicks et al., 2013). The supply capacity of many ES, such as sediment retention, recreation and ecotourism, fresh water, firewood and timber meant they were ranked higher for local benefits. Sediment retention, biodiversity maintenance, carbon stock and fresh water were more important wider benefits. This result indicated that regulating services had high priority, followed by cultural and provisioning services at local level, a similar result to some other studies (Castro et al., 2011; Martin-Lopez et al., 2012) but contrasting with others (Hartter, 2010; Iftekhar and Takama, 2007).

Priorities of ES varied across respondents due to a complex set of factors, including community needs, traditions and perceived social values of ES (Paudyal et al., 2015). In fact, these factors are likely to explain to a large extent the differences in priorities given to ES between rural and urban respondents. For example, upland communities prioritised provisional ES such as firewood, timber, forage, water and agriculture crops essential for local benefits, because their subsistence livelihoods are based on these services (Martin-Lopez et al., 2012). However, upland communities assigned high priority to biodiversity maintenance and carbon stock for wider benefits with the aim of connecting them with additional benefits that could accrue through various market/non-market instruments such as payment for ecosystem services (Paudyal et al., 2018).

Synergies and trade-offs associated with ES are the result of different priorities across stakeholders and identify potential conflicts or opportunities that may arise in decision-making processes (Hicks et al., 2013). The restoration of the forests changed the ES supply situation in Phewa watershed and produced multiple trade-offs and synergies to be considered in management decisions. The empirical evidence showed trade-offs between provisioning and regulating services, in line with many other studies (Hicks et al., 2015; Kragt and Robertson, 2014; Raudsepp-Hearne et al., 2010), while synergies emerged between regulating and cultural services (Fig. 8).

Trade-offs were prevalent among ES for local benefits. Firewood, timber, agriculture crops and forage are a part of local livelihoods and their heavy consumptions was traded off strongly to sediment retention by causing floods, soil erosion and landslides upstream. Unlike Rana et al. (2017), our results revealed that harvesting of forest products had adverse impacts on biodiversity and carbon stocks (Peh et al., 2016). Freshwater also had a significant trade-off with agriculture production because crops consumed a high quantity of water (Baral et al., 2013), but showed synergies with timber, firewood, and forage harvesting activities that reduce evapotranspiration (Ghimire et al., 2014; van Dijk and Keenan, 2007). However, synergies outweighed the trade-offs among priority ES for wider benefits. For instance, carbon stocks and biodiversity maintenance were highly positively correlated, corroborating the findings of Peh et al. (2016) but contrasting with other recent studies (Mandal et al., 2013; Rana et al., 2017). This synergetic association was due to the dominance of natural mixed forests, where higher biodiversity is likely to support a large amount of carbon stocks (Day et al., 2013). Likewise, sediment retention, flood and landslide control and aesthetic values were directly correlated with one another because these can be grouped into a bundle of ES (Raudsepp-Hearne et al., 2010).

5.3 Conclusion

This study aimed to quantify the social values ascribed to ecosystem services in the forests of the Phewa watershed in western Nepal, where there has been considerable landscape change over the last 30 years associated with community-based forestry. The results indicated that the watershed provides 23 ecosystem services to local communities and a wider set of users across Nepal and beyond. This study demonstrated the spatial associations between public uses, social values and ES supply. However, these values and ES benefits were perceived differently across different communities, genders and occupations. Timber, firewood, forage, wild foods, non-timber forest products are services provided to the local people of the watershed and those in the adjoining areas, whereas most of the regulating and some cultural services benefit a wider range of people within the watershed and beyond. While carbon stock, biodiversity maintenance and recreation and ecotourism were globally important, local people did not ascribe high value to these services.

Different communities and community members assign different priorities depending on the perceived benefits accruing from the landscapes, the level of supply and market demand. Provisioning services were highly prioritised for local benefits, whereas regulating services were a high priority for wider benefits. Sediment retention and recreation and ecotourism were assigned high priority by all stakeholders, delivering local to global benefits. These differences in priority among ecosystem services created trade-offs and synergies that varied across stakeholders and scale of use. Trade-offs were particularly prevalent between provisioning and regulating services, and a greater diversity of ecosystem services was positively correlated with the provision of regulating, support and culture services. While livelihoods of upstream communities depend on provisioning services, they also prioritised regulating services. These synergetic relationships provide an opportunity for integrated investment that can generate multiple benefits for local and wider communities.

Although social values are being widely used for assessment of cultural services, this study shows that this approach can be used to assess any ecosystem services. Further, the process of the evaluation and prioritisation of ecosystem services through the social valuation approach used for this study is also relevant to other parts of Nepal and to other developing countries seeking to support the integrated approach natural resource management to livelihood enhancement, poverty reduction and environmental conservation.

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