Change in land use and ecosystem services delivery from community-based forest landscape restoration in the Phewa Lake watershed, Nepal

K. PAUDYAL[a], H. BARAL[a,b], L. PUTZEL[b], S. BHANDARI[c] and R.J. KEENAN[a]

[a]School of Ecosystem and Forest Sciences, Faculty of Science, University of Melbourne, Carlton, Victoria, 3010, Australia
[b]Centre for International Forestry Research, Jalan CIFOR, Situ Gede, Sindang Barang, Bogor (Barat), 16115, Indonesia
[c]Indufor Asia Pacific, 55 Shortland Street, Auckland, New Zealand

Email: kiran.paudyal@gmail.com, h.baral@cgiar.org, louis.putzel@gmail.com, santosh.bhandari@indufor-ap.com, rkeenan@unimelb.edu.au

SUMMARY

Global initiatives to promote large-scale forest landscape restoration (FLR) require adaptive approaches that are consistent with locally relevant models of land use management. Nepal's experience in FLR provides lessons for programme design with potential broader relevance to the Himalayas more generally and to other regions featuring similar upstream–downstream interactions that reflect the requirement of locally appropriate economic incentives for achieving change. The paper analyses land cover change over four decades (1975–2015) from satellite images and evaluate the status of ecosystem services (ES) and benefits delivery from community-based FLR (CBFLR) through community perception and expert's opinion in the Phewa Lake watershed. Results reveal a substantial reversal of land degradation and forest recovery (12.1% of the total watershed area) due to the CBFLR that impact to increased delivery of a range of ES. Notably, while water discharge rates may have decreased following the increase in forest area, siltation has been reduced, protecting water quality in the lake and benefiting local economic development.

Keywords: Nepal, community forestry, ecosystem services, participatory approach, watershed conservation

Changements d'utilisation de la terre et d'utilisation des services d'écosystèmes dans la restoration du paysage forestier dans le bassin versant du lac Phewa au Népal

K. PAUDYAL, H. BARAL, L. PUTZEL, S. BHANDARI et R.J. KEENAN

Les initiatives globales visant à promouvoir la restoration à grande échelle du paysage forestier (FLR) nécessitent des approches adaptables, en harmonie avec les modèles de gestion de l'utilisation des terres localement appropriés. L'expérience du Népal en FLR fournit des leçons pour brosser des programmes potentiellement mieux adaptés à l'Himalaya en général, ainsi qu'à d'autres régions témoins d'interactions tout à la fois dans le courant et contre le courant, reflétant le besoin d'encouragements économiquement appropriés à la localité, pour parvenir à un transformation. Ce papier analyse le changement du couvert forestier durant quatre décennies (1975–2015) avec l'aide d'images satellite, et il évalue le statut des services d'ecosystèmes (ES) et de la production de bénéfices d'une FLR à base communautaire (CBFLR) à travers la perception de la communauté et l'opinion des experts du bassin versant du lac Phewa. Les résultats révèlent un retournement substantiel de la dégradation du sol et du rétablissement de la forêt (12.1% du total de la superficie du bassin versant) dûs à l'impact de la CBFLR sur l'augmentation de la production d'un éventail de ES. En particulier, l'alluvionnement a été réduit, alors que l'écoulement des eaux peut avoir diminué avec la croissance de la superficie forestière, protégeant la qualité de l'eau dans le lac, et étant bénéfique au développement économique local.

Cambio en el uso del suelo y la prestación de servicios de ecosistema procedentes de la restauración comunitaria del paisaje forestal en la cuenca del lago Phewa de Nepal

K. PAUDYAL, H. BARAL, L. PUTZEL, S. BHANDARI y R.J. KEENAN

Las iniciativas mundiales para promover la restauración del paisaje forestal (RPF) a gran escala requieren enfoques adaptativos que estén en consonancia con modelos relevantes a escala local para la gestión del uso de la tierra. La experiencia de Nepal en la RPF proporciona lecciones para el diseño de programas con una mayor relevancia potencial para el Himalaya en general y para otras regiones que presenten interacciones similares entre aguas arriba y aguas abajo, que reflejen la necesidad de incentivos económicos localmente apropiados para lograr el cambio. El artículo analiza el cambio en la cobertura del suelo durante cuatro décadas (1975–2015) a partir de imágenes de satélite y evalúa el estado de los servicios de ecosistema (SE) y los beneficios de la RPF comunitaria (RPFC) a través de la percepción de la comunidad y la opinión de expertos en la cuenca del lago Phewa. Los resultados revelan un cambio sustancial positivo en la degradación de la tierra y la recuperación de los bosques (12,1% de la superficie total de la cuenca) atribuido a la RPFC, que a su vez repercute en un aumento de la provisión de una serie de SE. En particular, si bien las tasas de descarga de agua pueden haber disminuido a raíz del aumento de la superficie forestal, la sedimentación se ha reducido, lo cual protege la calidad del agua en el lago y beneficia el desarrollo económico local.

INTRODUCTION

Growing calls for forest restoration by scientists and international agencies interested in conservation, development and climate change are leading to major new global initiatives targeting land use change and forest restoration (Aronson and Alexander 2013, Haugo *et al*. 2015). For such efforts to succeed and generate expected benefits, approaches relevant to local ecological conditions are needed (Chazdon 2008, Stanturf *et al*. 2014). Where rural people are involved as landowners or managers, targeting state, community and private landholdings is equally crucial in forestry and restoration activities (Barral *et al*. 2015). However, the outcomes of community-based restoration efforts remain poorly studied and there is a risk of repeating past mistakes in attempting to achieve global restoration targets (Haugo *et al*. 2015, Sabogal *et al*. 2015). Socioeconomic and technological contributions from local communities are often ignored in the case of forest landscape restoration (FLR) (Nielsen-Pincus and Moseley 2013) but participatory processes in FLR are likely to be critically important and may result in faster and easier implementation at the landscape scale (Fleming and Fleming 2009, Sayer *et al*. 2013). Examples of community forestry in Nepal have the potential to bring important lessons and insights to the field of FLR and particularly to restoration efforts targeting rural communities in hilly and mountainous landscapes.

The emergence of community forestry in Nepal followed a series of catastrophic policy failures. The 1957 enactment of the Private Forests Nationalisation Act (1957) created controversy and fear regarding ownership of private forests and disrupted traditional forest management systems, resulting in the uncontrolled felling of trees (Gautam *et al*. 2004). By the mid-1970s, vast areas of the mountain landscape appeared devoid of vegetation (Achet and Fleming 2006). Deforestation and forest degradation resulted in an environmental crisis featuring raw material shortages, landslides, upland water scarcity and devastating downstream floods (Eckholm 1975, 1976). In response, a participatory forest management campaign began in the late 1970s. A portion of degraded forest lands was handed to local communities for management, together with certain rights to utilise forest products as community forests. The result was the re-establishment of forest cover on large areas of eroded and degraded agricultural land, grasslands, forests and shrublands (Gautam *et al*. 2004).

A number of studies point to the success of Nepal's community management in restoring landscapes (Gautam *et al*. 2004, Maraseni *et al*. 2005, Niraula *et al*. 2013, Paudyal *et al*. 2017). For example, forest productivity doubled, and production of grass and fodder increased fivefold in the Phewa Lake watershed area (Fleming and Fleming 2009). Consequently, ecosystem goods and services and biodiversity have notably increased (Birch *et al*. 2014, Paudyal *et al*. 2015). Nepal's recent forest resource assessment reveals that the national forest area increased from 39.6% in 1999 to 44% in 2015, a substantial part of which is due to forest restoration in the mountainous regions (DFRS 2015). These outcomes can be clearly linked to community-based forestry (CBF) and watershed conservation campaigns (Niraula *et al*. 2013, Paudyal *et al*. 2017).

Located in western Nepal, the Phewa watershed was a notable example of degradation in the mountainous regions, where forest lands were overgrazed and degraded, stripped of even small trees for fodder and firewood (Fleming and Fleming 2009). In the early 1970s, degradation of farmland, pasture and forests in Phewa watershed caused severe upland erosion and siltation in the lake (Fleming and Fleming 2009). Deforestation and forest degradation on steep slopes with unstable soils and a high intensity of rainfall caused erosion, which at its peak exceeded 30 tonnes per hectare per year (Fleming 1983). The resulting sedimentation of the lake was alarmingly high (Sthapit and Balla 1998), creating the necessary impetus for land conservation (Eckholm 1976). In the late 1980s, the government shifted the focus of conservation programmes from engineering structures to community-based watershed conservation. Almost 50% of the budget for land conservation was allocated to strengthening the capacity of local communities and institutions, with demonstrated outcomes for water quality (Achet and Fleming 2006, Fleming and Fleming 2009, Fleming 1983).

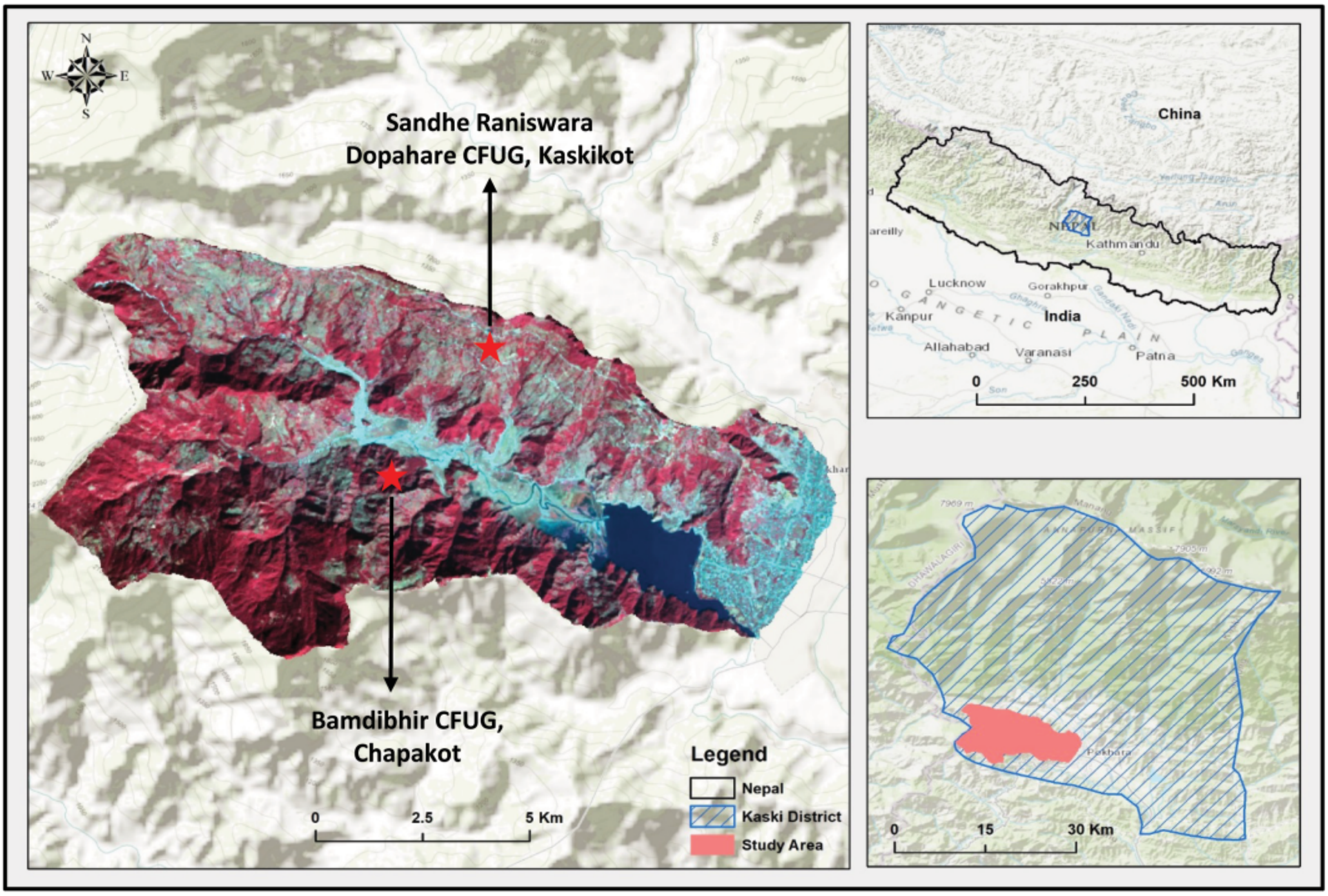
Forest restoration can reinforce links between nature, culture and economy (Brancalion *et al*. 2014) but more studies are needed to substantiate those links and justify increased investment in large-scale FLR. Much remains to be learned about how community engagement and the benefits of participation contribute to restoration outcomes. Improved soil and water quality in the Phewa watershed following restoration have been important for ecotourism and this can be an important economic incentive for forest restoration (Fleming and Fleming 2009). This study aimed to analyse land cover change between 1975 and 2015 and evaluate community perceptions of changes in ecosystem services (ES) and benefits over the same period. This type of multidisciplinary study can provide useful insights regarding the requirements for the success of participatory approaches to FLR implementation.

METHODOLOGY

Study area

The Phewa watershed has a four-decade history of participatory watershed conservation and CBF, and contains a variety

FIGURE 1 *Study area*



CFUG = community forestry user group.

of forest types and restored forest in good condition. It lies between 28°11′39 to 28°17′25 north and 83°47′51 to 83°59′17 east, adjacent to the city of Pokhara. It covers an area of 123 km^2 and extends over the whole or parts of six village development committees (Bhadaure Tamagi, Chapakot, Dhikur Pokhari, Kaskikot, Pumdi Bhumdi and Sarangkot) and the seven wards of the southwestern part of Pokhara (Figure 1). The population of the watershed area is 198 333 (Regmi and Saha 2015) with an average density of 665.51 per km^2. The population is spread across rural areas, with only 27% in the city.

The topography of Phewa watershed is steep (average slope 40%) and ranges in altitude from 850 m at the lake surface to 2 508 m at the peak of Panchase, an important tourist destination. The watershed is oriented from east to west and measures 17 km in length and 7 km in width (Oli 1997). Proximity to Pokhara city and trekking routes to the nearby Annapurna range make the lake and watershed area a popular tourist destination (Fleming and Fleming 2009). In addition to the lake, alluvial plains and fans and moderate to very steep slopes are the dominant landforms of the watershed area (Regmi and Saha 2015).

The watershed comprises 19 streams and small brooks that drain into the lake. The lake surface has been estimated to cover 3.3% of the watershed area (Leibundgut *et al*. 2016), with a water storage capacity of 42.18 million m^3 and an annual average sedimentation rate of 18 000 m^3 (Sthapit and Balla 1998). The annual monsoon regulates the climate in the watershed resulting in a humid subtropical micro climate in the valley compared to the temperate climate of the high mountain region to the north. Heavy monsoon rains (~5 000 mm) trigger landslides and flash floods, contributing to the natural degradation of the steep terrain (Leibundgut *et al*. 2016, Regmi and Saha 2015). Some 40 years ago, siltation was considered a significant threat to the lake ecosystem, but this has been reduced through forest restoration (Regmi and Saha 2015).

Land cover of the watershed comprises forest (49%), agriculture (41%), water bodies and swamp land (5%), built-up areas (3%) and sand (1%) (Sharma *et al*. 2013). Built-up and agricultural lands occupy the majority of the flat and gently sloped area and forests account for all the remaining land (Regmi and Saha 2015). The forests and biodiversity reflect the climatic and altitudinal variation of the catchment area, where subtropical forests are in the lower belt, and temperate forests are in the upper catchment (JICA/SILT 2002).

Watershed conservation efforts started in the late 1970s with technical assistance from the Food and Agriculture Organization of the United Nations (FAO). In the mid-1980s,

TABLE 1 *Summary of methodologies used to analyse land use and land cover change and change in supply of services and benefits from the restored forest landscape in Phewa watershed, Nepal*

Analysis	Data sources/tools used	People involved	Outputs
Land use and land cover (LULC) change	Landsat images ((1975, 1995 and 2015) available from the USGS, Google Earth images and field observation	CFUG members, GIS experts, researchers	LULC maps (1975, 1995 and 2015)
Change in production of benefits and services	FGDs and KISs, repeat photography (1974 and 2014) and field observation	CFUG members, experts, researchers	Radar diagrams that present changes in two periods

'CFUG' - community forestry users' group; 'FGD' - focus group discussion; 'GIS' - geographic information system; 'KIS' - key informant survey; 'USGS' - United States Geological Survey.

participatory watershed protection and forest management initiatives resulted in the devolution of more than 60% of the forested land to communities (DFO 2016, Fleming and Fleming 2009). Seventy-five community forestry user groups (CFUGs), representing 12 739 households, manage a total of 2 739 hectares of forest (DFO 2016).

METHODS

Study design

The study design combined remote sensing techniques with participatory approaches to collect qualitative data on perceived and potential ES benefits of forest restoration (Table 1) (Paudyal *et al*. 2015, Zarandian *et al*. 2016). The study sought community perception (Smith and Sullivan 2014) and expert opinion (Burkhard *et al*. 2012, Palomo *et al*. 2013) through participatory approaches, including focus group discussion (FGD) (Gray 2004), key informant survey (KIS) (Bryman 2001, Patton 2002) and direct field observation. Remote sensing techniques included analysis of land use and land cover (LULC) change from Landsat images captured in three consecutive periods (1975, 1995 and 2015) and integrated into the Geographical Information System (GIS). Local communities,[1] business people,[2] and experts[3] were consulted to investigate the benefits and services that changed as a result of LULC change from landscape restoration.

Sample selection

Although there are no specific rules, qualitative research typically requires a smaller sample size (Creswell 1998, Malterud *et al*. 2016, Morse 1994). The concept of saturation (Glaser and Strauss 1967) and the concept of information power (Malterud *et al*. 2016) were considered for selecting an appropriate sample size for this study. According to these two concepts, a lower number of participants is needed to obtain more information, and adding more participants to the study does not result in additional perspectives or information. Therefore, only two CFUGs (Bamdibhir and Sandhe Raniswara Dopahare) were purposively selected for detailed analysis from the 75 CFUGs in the watershed (Table 2). The selection was carried out in consultation with the District Forest Office (DFO), and the District Soil Conservation Office in Kaski district. The sites were selected according to the criteria that one was highly degraded and one comparatively less degraded at the time when the conservation programme was initiated. Two FGDs were conducted, one for each of the selected CFUGs, where 21 and 24 participants attended respectively. Similarly, 10 respondents were chosen randomly for the KISs from each CFUG during the FGDs. Among 20 KIS respondents, 60% were 50–60 years of age and 40% above 60 years. As far as possible, older people were chosen for an interview to benefit from their direct experience regarding the previous condition of the sites. In addition, one stakeholder workshop was organised in Pokhara, with 36 participants representing CFUG members, business people, government officials and civil society.

Analysis of land use and land cover change

Based on relevant literature (Regmi and Saha 2015, Rimal *et al*. 2015) and consultation with experts, a typology of land use was adopted comprising eight types (Table 3).

LULC classification was carried out using cloud-free Landsat images of the study area from 1975, 1995 and 2015 (Figure 2). The Landsat 2 Multi-Spectral Scanner (MSS) image of February 1975 (Path 153, Row 040), Landsat 5 Thematic Mapper (TM) image of November 1995 (Path 142, Row 040) and Landsat 8 Operational Land Imager (OLI) image of January 2015 (Path 142, Row 040) were downloaded from the United States Geological Survey (USGS). Images were checked for geolocation accuracy using the

[1] Local communities refers to those people from selected CFUGs who have been engaged in watershed conservation and community forest management for a long time.
[2] Business people refers to people from the area surrounding Phewa Lake who own or operate various types of business.
[3] Experts nominated for this study are professionals from government and nongovernmental sectors, having at least an undergraduate degree in forestry, agriculture or environment fields, and are either currently working in, or familiar with, the Phewa watershed.

TABLE 2 *Description of two community forests (CF) selected for community consultation and focus group discussions*

Description	Bamdibhir CFUG	Sandhe Raniswara Dopahare CFUG
Location (address)	Chapakot 3,4,5,6	Kaskikot-6,7, Kaski
Ethnic composition of people	Mixed ethnicity (Bahramin, Chhetri and Dalit).	Mixed ethnicity (Bahramin, Chhetri and Dalit).
Distance from village	Adjoining village	200 m
Distance from motorable road	1 km	500 m
Number of HH in CFUG	134	219
Population within CFUG	712	1 302
Date CF was initiated	22 June 1993	23 June 1993
Date of official registration	16 July 2002	13 March 2007
CFUG Executive committee members	11	9
Forest area (ha)	48.5	22.23
Slope, aspect and exposure	North-east	South
Forest types	Natural forest and plantation (*Alnus* and *Schima* species)	Natural forest and plantation (*Schima* and *Prunus* species)
Condition of forests	Medium	Medium
Primary use of CF	Wood, fuelwood, fodder	Wood, fuelwood, fodder

CFUG = community forestry users' group; HH = households

TABLE 3 *Major land use and land cover (LULC) types in Phewa watershed*

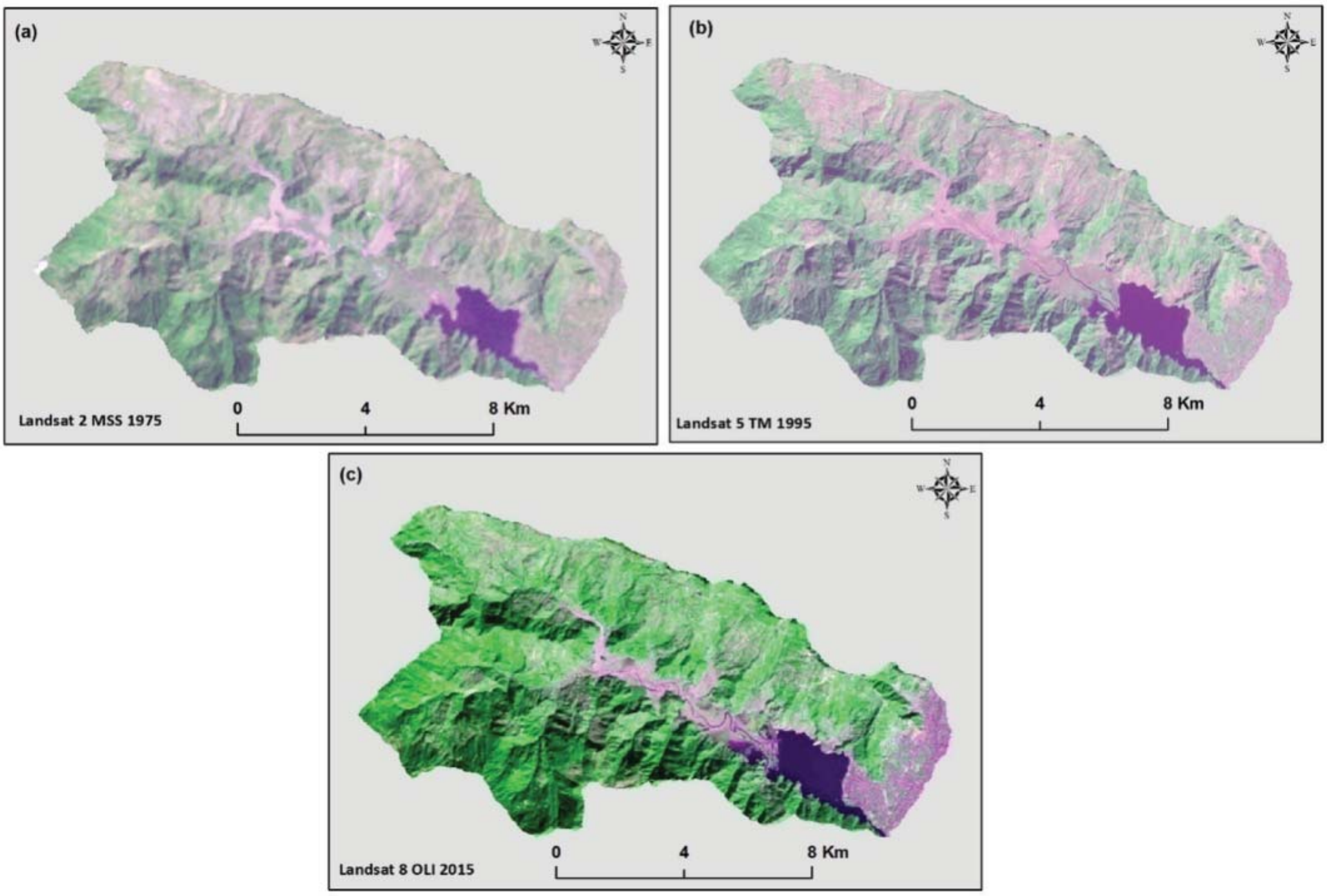
LULC types	Defining land use and land cover types
Dense forest	Trees, shrubs and bushes area with more than 50% crown coverage
Sparse forest	Trees, shrubs and bushes area with 10–50% crown coverage
Grassland	Land mainly covered by grass, having scattered trees, shrubs and bushes and less than 10% crown coverage
Agricultural land	Area with seasonal and perennial agricultural crops including coffee and tea plantations Also includes villages surrounded by farmlands
Degraded land	The area exposed after landslides and flash floods in higher areas, as well as areas covered in sand and debris deposited in lower areas, without any kind of vegetation or crops
Swamp area	Seasonally submerged in water
Water body	Lakes and rivers with clear water
Built-up area	Built infrastructure such as private and public buildings, and roads

Source: Rimal *et al*. 2015; Sharma *et al.* 2013

USGS global 30 m land cover data set. All three images were found correct and aligned with each other at the sub-pixel level. As no geometric correction was required, images were restricted to the study area and used for mapping land use and land cover.

A combination of unsupervised classification and manual interpretation was performed to produce predefined LULC classes. In the beginning, a LULC map for 2015 was created using the Landsat OLI image for 2015. The IsoData classifier ENVI 4.7 was used to generate 10–15 classes from an unsupervised classification of the images. More classes were produced as it is easier to merge them later as required. The classified images were then vectorised and imported into the GIS. The polygons were then manually grouped into predefined classes using expert knowledge and taking Google Earth imagery as a reference. The LULC maps for 1995 and 1975 were produced by working backwards, using the LULC 2015 map as the basis for classification and interpreting satellite imagery manually. Finally, these LULC maps were used to analyse change between three consecutive periods (e.g. 1975–1995, 1995–2015 and 1975–2015) using ArcGIS software. To assess the accuracy of the LULC 2015 map, Google Earth imagery was used as a reference data source following the procedure outlined by Olofsson *et al*. (2013). An overall accuracy of 96% was achieved for the LULC 2015 map, and similar accuracy can be expected for the LULC 1995 and 1975 maps, as they were produced using a similar methodology.

FIGURE 2 *Landsat (MSS, OLI and TM) images of the Phewa watershed that were utilized to prepare land use and land cover maps*



MSS = Multi-Spectral Scanner; OLI = Operational Land Imager (OLI); TM = Thematic Mapper. Notes: (a) image taken in February 1975 (path/row 153/40); (b) image taken in November 1995 (path/row 142/40); (c) image taken in January 2015 (path/row 142/40).
Source: United States Geological Survey web portal: http://earthexplorer.usgs.gov.

Potential and perceived changes in ecosystem services and benefits (1975 and 2015)

A number of ES relevant to the mountainous regions were compiled from recent ES studies undertaken in Nepal (Bhandari *et al*. 2016, Birch *et al*. 2014, Paudyal *et al*. 2015) and were discussed in the FGDs. Using participatory approaches, the participants ranked and selected 10 main ES for detailed study (Table 4). Again, these ES were discussed at the KISs, FGDs and in the workshop, as was the impact of LULC change on the supply of ES in the Phewa watershed area between 1975 and 2015.

In KISs, FGDs and the workshop, the opinions of local people and experts were investigated to characterise perceived[4] and potential[5] changes in ES supply in two periods. For this, participants were asked to gauge and rank their views from 0 to 10, where '0' indicates no benefits and services available and '10' indicates abundant stock and supply. First, research respondents were requested to gauge and assign the value of each ES for 1975 and to repeat the same process to estimate the perceived and potential change for 2015. Information collected from KISs, FGDs and the workshop were tabulated and average values were scaled and analysed. The information generated regarding the biophysical condition of sites was also verified through repeat photography and field observations (Annex 1). The final results were presented in radar diagrams of the relative change in ES after the successful landscape restoration.

[4] Perceived ES refers to stakeholders' perception of the positive contribution of the ecosystem at present, in this case benefits from the restoration efforts in the watershed.

[5] Potential ES indicates the possible additional contribution of the ecosystem, which may not be realised by the stakeholders at the time of assessment but may be realised in the future.

TABLE 4 *Type of ecosystem services used in key informant surveys, focus group discussions and the workshop to investigate the perceived and potential supply of ecosystem services in 1975 and 2015*

Categories	Ecosystem services	Description of ecosystem service
Provisioning services	Wood supply	Services generate timber, food and water; essential to sustaining life and generating income.
	Food production	
	Forage production	
	Fresh water supply	
Regulating services	Sedimentation control	Services reduce degradation of agricultural land and bodies of water, prevent water-related disasters and contribute to global climate change mitigation.
	Carbon sequestration	
	Water regulation	
Support services	Habitat for biodiversity	Increased forest cover and quality offers a conducive environment for a variety of animals and plants.
Cultural services	Recreation and tourism	The economy in Phewa Lakeside depends on recreation and tourism.
	Learning opportunities	The watershed provides an opportunity to learn community-based conservation and landscape restoration models.

RESULTS

Change in land use and land cover

The LULC change map reveals a significant shift in land use in the Phewa watershed over the past four decades (Figure 3, Table 5). In 2015, forests and agriculture comprised the majority of land cover in the watershed, with forest cover more dominant on higher slopes and agriculture prevalent in river valleys and on hill terraces. The built-up area is mostly confined to the river valley and the lower part of the watershed; it is scattered elsewhere.

The analysis confirms that since 1975 dense forests, built-up areas, water bodies and swamp areas have increased in size, whereas the remaining land use types have decreased. Sparse forests, grasslands and degraded lands have declined sharply, while the agricultural area decreased slightly. Dense forests have increased by 1 455 ha (82.3%) from 1 769 ha in 1975 to 3 224 ha in 2015, representing a 12.1% increase in their share of the total watershed. Similarly, swamp areas have increased by 95 ha (157.0%), water bodies by 12 ha (3.0%) and built-up areas by 400 ha (101.8 %) in comparison with the area in 1975. The built-up area has more than doubled, from 3.3% of the watershed in 1975 to 6.6% in 2015. The water body area (i.e. mostly Phewa Lake) increased from 1975 to 1995, but then lost some of its gains in the last two decades. In contrast, the area of sparse forests shrank by 1 040 ha (33.3%), and 209 ha (59.8%) of grasslands disappeared during the study period. It is important to note that degraded lands decreased by a remarkable 261 ha (77.5 %), from 313 ha in 1975 to 52 ha in 2015. Agricultural land decreased slightly from 5 592 ha (46.5%) in 1975 to 5 127 ha (42.5%) in 2015.

Perceived ecosystem services and their change due to community-based forest landscape restoration

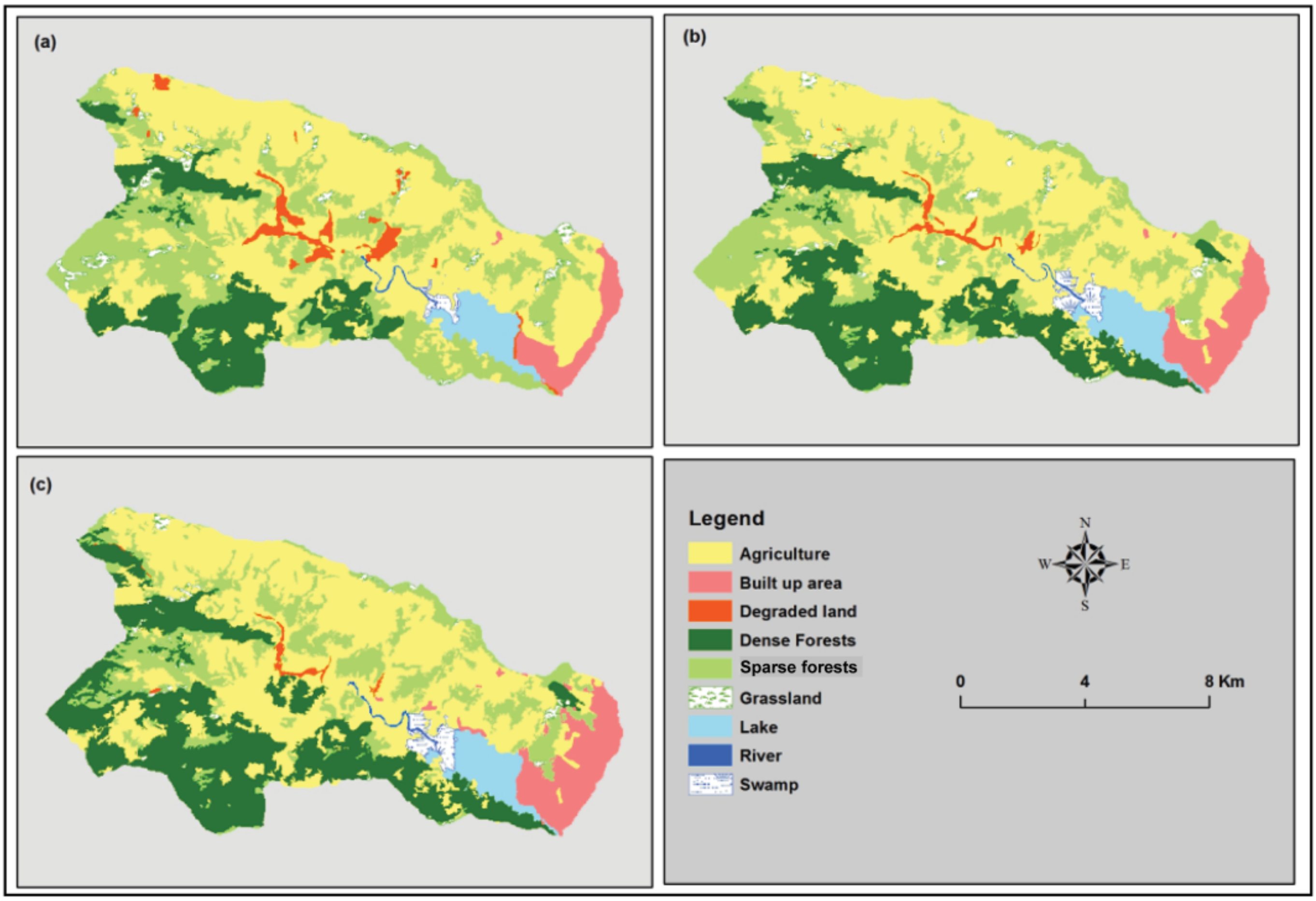
Results indicate that both community and expert study participants perceived that the level of ES delivered in the watershed increased from 1975 to 2015 (except for fresh water yield) as a result of community-based forest landscape restoration (CBFLR) (Figure 4).

Notably, both community and expert participants perceived a major improvement in sedimentation control and water regulation and the potential for further improvement in the former (Figure 4a–f). Both groups agreed that wood production had doubled and that learning opportunities had increased a great deal. Expert perceptions of the increases in carbon sequestration and biodiversity habitat were much higher than community perceptions; conversely, community perceptions of change in food and forage production were higher than those of experts. Both groups agreed that fresh water flow had decreased over the period in which trees and grasslands had been restored. Overall, expert participants saw a greater potential for delivery of a wide range of ES than did community participants, potentially reflecting different priorities or biases.

DISCUSSION

This study presents an overview of LULC change in the Phewa watershed between 1975 and 2015 and the perceptions of local community and expert participants of the provision of a number of ES. Located in a mountainous region, the Phewa watershed was a typical example of a degraded mountain landscape in 1975, with sedimentation posing a serious threat to the lake (Fleming and Fleming 2009, Sthapit and Balla 1998). Changes in forestry legislation and policy in the 1970s that decentralised forest management proved to be an effective tool for community-based forest management and watershed conservation. This resulted in the restoration of ecosystems and habitat for biodiversity, which enhance the supply of ES. This corroborates the findings of earlier studies (DFRS 2015, Gautam *et al*. 2002, 2003, Niraula *et al*. 2013, Regmi and Saha 2015) and has also been observed in other cases from around the world (e.g. Brancalion *et al*. 2014). The

FIGURE 3 *Land use and land cover maps of the Phewa watershed*



Notes: (a) land use and land cover (LULC) map of 1975, (b) LULC map of 1995 and (c) LULC map of 2015.

TABLE 5 *Land use and land cover (LULC) change over a four decade period in the Phewa watershed*

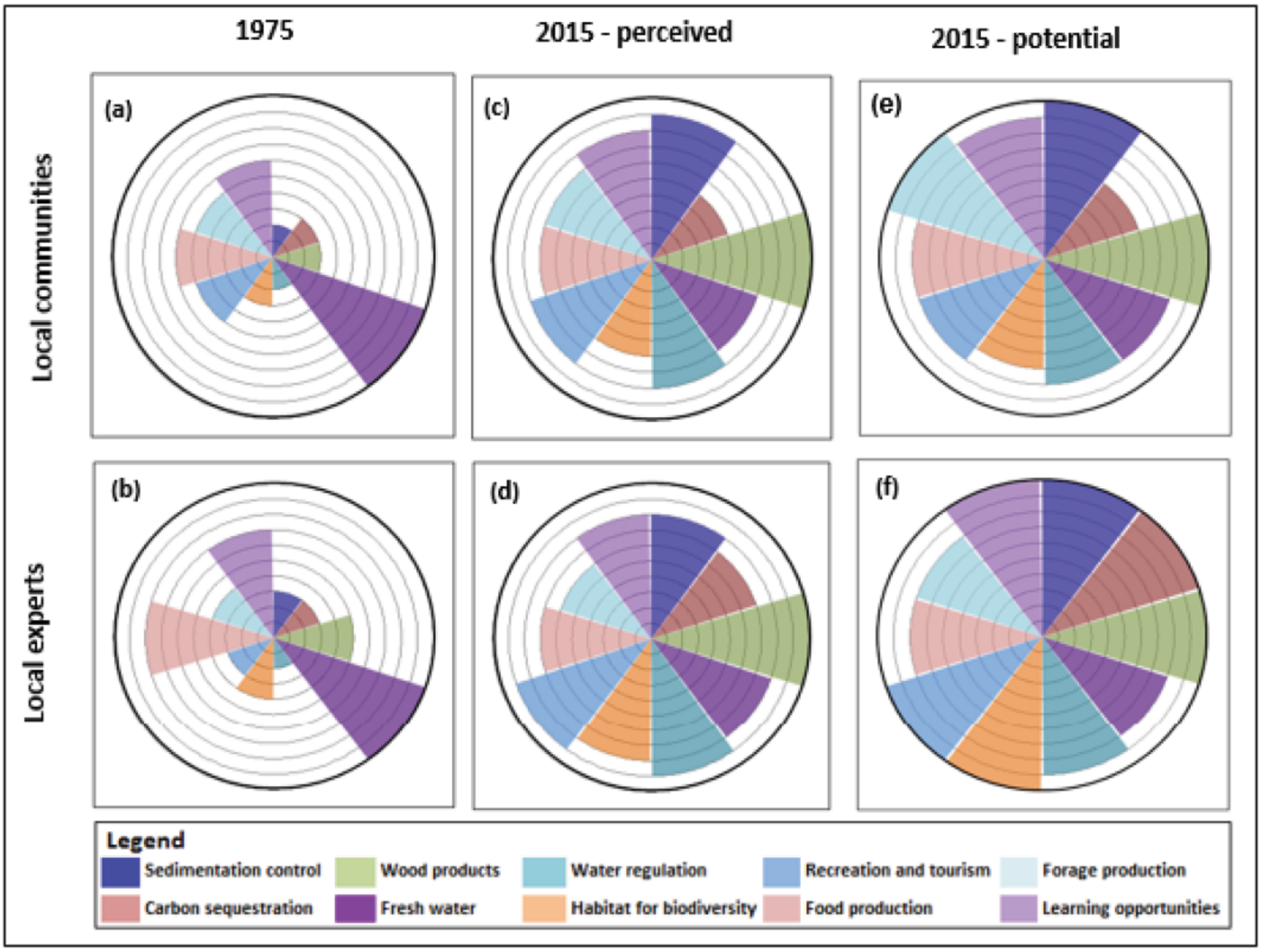
LULC class	LULC maps and area information						Change in area of LULC types						
	1975		1995		2015		1975–1995		1995–2015		1975–2015		
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	% change[a]
Dense forests	1 769	14.7	2 592	21.6	3 224	26.8	+823	+46.6	+632	+24.4	+1 455	+82.3	+12.1
Sparse forests	3 128	26.0	2 552	21.2	2 082	17.3	-573	-18.3	-473	-18.5	-1 046	-33.4	-8.7
Grasslands	352	2.9	223	1.9	143	1.2	-129	-36.6	-80	-36.0	-209	-59.8	-1.7
Agricultural area	5 592	46.5	5 127	42.6	5 127	42.6	-253	-4.5	-212	-4.0	-465	-8.3	-3.9
Swamp area	61	0.5	138	1.1	156	1.3	+77	+127.2	+18	+13.1	+95	+157.0	+0.8
Water body	414	3.4	437	3.6	427	3.5	+23	+5.5	-10	-2.4	+12	+3.0	+0.1
Built-up area	393	3.3	616	5.1	793	6.6	+223	+56.7	+177	28.8	+400	+101.8	+3.3
Degraded lands	313	2.6	122	1.0	70	0.6	-171	-60.9	-52	-42.4	-242	-77.5	-2.0

ha = hectare; LULC = land use and land cover.
[a] Aggregate change in percentage of the total area of the watershed.

results of the assessment contrast with a global trend of declining forest area (Keenan *et al*. 2015), with estimates of increasing forest area over the past four decades comparable to other regions of the middle mountains in Nepal (DFRS 2015, Gautam *et al*. 2003, 2002, Niraula *et al*. 2013).

The success of this community-based restoration approach appears to be attributable to three main factors. First, local communities have significantly contributed to restoration under the participatory watershed conservation and community forestry programmes that have operated since

FIGURE 4 *Illustration of the perceptions of local communities and experts of the changes in ecosystem services in the Phewa watershed between 1975 and 2015 as a result of community-based forest management and watershed conservation*



Notes: (a) status of ecosystem services in 1975 as perceived by local communities; (b) status of ecosystem services in 1975 as perceived by local experts, (c) status of ecosystem services in 2015 as perceived by local communities; (d) status of ecosystem services in 2015 as perceived by local experts; (e) potential of ecosystem services in 2015 in the view of local communities; and (f) potential of ecosystem services in 2015 in the view of local experts. Specific ecosystem services are rated from 0 to 10, where '1' represents no ecosystem services and '10' represents the full potential of ecosystem services.

the late 1970s. Communities in the study sites have benefited from improved access to fuelwood, fodder and non-timber forest products, which are important for subsistence (Table 2). Second, external technical and financial assistance seems to be significant in the success of restoration programmes. During the 1970s and 1980s, the government and local communities replanted a large area of barren land in the watershed with support from bilateral aid projects (DFO 2016). Third, despite cultivation on hill terraces, a substantial proportion of the agricultural lands in the study area were on slopes where crop productivity is of critical concern. Research results provide evidence that more than 8% of agriculture lands were converted to other land uses during the past four decades (Table 5). Many households have abandoned agricultural lands in recent years due to labour shortages and low returns on investments. These shortages are the result of attractive wage labour opportunities for male members of the community in Pokhara city (Fleming and Fleming 2009) and people working abroad.

CBFLR in the Phewa watershed has brought a wide range of economic, ecological and socio-political benefits to local people (Birch *et al*. 2014, Paudyal *et al*. 2015). Some of these benefits are common in nature such as climate regulation, clean air and landscape beauty (Paudyal *et al*. 2016). The restored watershed also supplies a broad range of ES that are of benefit to both local people and globally, corroborating other studies (e.g. Bullock *et al*. 2011, Maraseni *et al.* 2005). For instance, sedimentation retention, wood production, food production, water regulation, natural hazard reduction and habitat for biodiversity have all increased. Phewa Lake and its surroundings are one of the most popular tourist destinations in Nepal and the reforested watershed is providing an excellent tourism opportunity, which is a significant economic asset for the Pokhara Valley (Upreti *et al*. 2013).

In contrast, a few studies have reported a high concentration of pollutants in the water downstream from the business area (Raya *et al*. 2008). However, local communities' perceptions of water quality were related to the upstream area. In addition, recent road construction in the upstream area may lead to an increase in the sedimentation rate, which needs to be addressed by applying minimum soil loss techniques (Leibundgut *et al*. 2016).

Local perceptions of natural resource management have been a popular component of several recent studies, such as landscape change in Mediterranean islands (Aretano *et al*. 2013), land use conflicts in central Sudan (Adam *et al*. 2015), the importance of forests in Borneo (Meijaard *et al*. 2013), land management strategies for payment for ES in the Páramo grasslands (Farley and Bremer 2017), wetland ES in Colombo (McInnes and Everard 2017) and ES within agricultural landscapes in Australia (Smith and Sullivan 2014). Although the use of local perceptions and expert opinions in assessing ES is rather a new concept in Nepal (Paudyal *et al.* 2015), this study shows the apparent relationship between perceptions and the actual use of ES such as the provision of wood, clean water, forage, carbon storage and biodiversity in the study area.

In this study, perceptions of both community members and experts suggested that reforestation had reduced water flow to Phewa Lake and reduced water supply to upland users. This is partly because the improved condition of forests and crops utilised more water in the upper part of the watershed, as several previous studies indicated (Ghimire *et al*. 2013, Gilmour 2014, van Dijk and Keenan 2007). However, surface runoff has decreased, and the infiltration rates have likely been enhanced by the increased forest area, improving overall water regulation in the watershed (Bargues Tobella *et al*. 2014, Ghimire *et al*. 2014, Paudyal *et al*. 2017, van Dijk and Keenan 2007). Local people claim that water scarcity in the upstream area is the result of forest restoration, where a significant amount of water is consumed by increased numbers of trees; however, increased infiltration rates and groundwater recharge may restore flows in the long term.

Improved habitat conditions have provided an opportunity for biodiversity conservation (Pandey *et al*. 2014). The restoration of the ecosystem provides a synergy between carbon sequestration, biodiversity conservation and recreation that further establishes an integrated payment for ES scheme in the Phewa watershed (Maraseni *et al*. 2014). However, there are a number of challenges in this endeavour, such as trade-offs among stakeholders' interests, inappropriate policies, weak political interest in the integration of ES, lack of external funding support and lack of transparent discussion platforms among stakeholders for negotiated management decisions (Carrasco *et al*. 2016, Paudyal *et al*. 2017). Overcoming these challenges requires identifying key areas of agreement and conflict, both within and across stakeholder groups, to be addressed in prioritising ES decisions (Hicks *et al*. 2013).

An interesting fact reflected in this research is that community participants perceived an increase in food production per hectare, while total crop production is relatively lower (see Table 4) because of the land abandoned and conversion of some of the agricultural land into the forest (e.g. Smith and Sullivan 2014). However, the opinions of experts and local communities reflect the fact that food security is relatively higher due to the restoration of landscape productivity in the watershed. Many individuals in local communities have shifted away from agriculture to earn more income from other activities, which has helped improve food security in the study area despite lower crop production.

The results indicate that perceptions regarding the relative supply of ES differ between the local community and experts. Interestingly, experts saw greater increases in globally important ES, such as climate change mitigation and biodiversity conservation, which may be indicative of a certain bias or focus on factors relevant to donors and international audiences. However, experts should have a more balanced view regarding important ES because of their academic knowledge and experience of areas outside the study region (Paudyal *et al*. 2015). Local community members, meanwhile, have a somewhat localised view and are more focused on the immediate. Hence they were more optimistic about the prospects for food production and ecotourism in their area.

CONCLUSIONS

The results of this study reveal a significant increase in forest cover as well as increased density of forests as a result of community-based restoration activities including enrichment plantation, promotion of natural regeneration and improved forest management. The findings corroborate previous studies that the Phewa watershed has been restored through a largely successful CBFLR process. Changes in land cover are accompanied by a perceived increase in the provision and benefits of a wide range of ES, valuable at both local and global scales. Many ES, such as sedimentation control, recreation and tourism, wood supply, water quality, carbon sequestration, water regulation, habitat for biodiversity, landscape beauty and biological diversity were perceived to have increased in the study area. While showing broad agreement in some areas, variances in perceptions between local people and experts in other areas reflect potentially different interests (e.g. in local food production vs. carbon sequestration or biodiversity) or even different realities arising from real experience. However, these differences are not necessarily contradictory regarding the outcome.

The experience of FLR in the Phewa watershed, with positive outcomes in land cover and broadly compatible perspectives of environmental experts and local community members, suggests that the devolution of ownership and management to local people can support the implementation of FLR. Providing a supporting policy framework and strengthening the capacity and resources of CBF organisations should, therefore, be a fundamental aspect of FLR intervention strategies. The livelihood requirements of local people, including opportunities for new enterprises such as tourism, should be central to policy and programme design considerations.

The results of this study depend on the views of two CFUGs that may not represent watershed-wide perspectives regarding significant ES. Hence, this study suggests further research on social values related to ES and benefits, incorporating wider groups of local communities in the watershed and other locations. The impact on the spatial and temporal distribution of important ES by the changes in LULC over four decades would also be an interesting research agenda in the watershed.

ACKNOWLEDGEMENTS

The authors wish to thank members of the two community forestry user groups and experts working in the Phewa watershed, who provided support for the fieldwork. Thanks go to the Center for International Forestry Research (CIFOR) and the UK Department for International Development (DFID)/ the International Forestry Knowledge (KNOWFOR) programme for providing partial funding for the fieldwork and open access fee. We also thank the seven anonymous reviewers for providing valuable comments and feedback.

REFERENCES

ACHET, S.H. and FLEMING, B. 2006. A watershed management framework for mountain areas: Lessons from 25 years of watershed conservation in Nepal. *Journal of Environmental Planning and Management* **49**: 675–694. doi:10.1080/09640560600849962

ADAM, Y.O., PRETZSCH, J. and DARR, D. 2015. Land use conflicts in central Sudan: Perception and local coping mechanisms. *Land Use Policy* **42**: 1–6. doi:10.1016/j.landusepol.2014.06.006

ARETANO, R., PETROSILLO, I., ZACCARELLI, N., SEMERARO, T. and ZURLINI, G. 2013. People perception of landscape change effects on ecosystem services in small Mediterranean islands: A combination of subjective and objective assessments. *Landscape and Urban Planning* **112**: 63–73. doi:10.1016/j.landurbplan.2012.12.010

ARONSON, J. and ALEXANDER, S. 2013. Ecosystem restoration is now a global priority: Time to roll up our sleeves. *Restoration Ecology* **21**: 293–296. doi:10.1111/rec.12011

BARGUES TOBELLA, A., REESE, H., ALMAW, A., BAYALA, J., MALMER, A., LAUDON, H. and ILSTEDT, U. 2014. The effect of trees on preferential flow and soil infiltrability in an agroforestry parkland in semiarid Burkina Faso. *Water Resources Research* **50**: 3342–3354. doi:10.1002/2013WR015197

BARRAL, M.P., REY BENAYAS, J.M., MELI, P. and MACEIRA, N.O. 2015. Quantifying the impacts of ecological restoration on biodiversity and ecosystem services in agroecosystems: A global meta-analysis. *Agriculture, Ecosystems & Environment* **202**: 223–231. doi:10.1016/j.agee.2015.01.009

BHANDARI, P., KC, M., SHRESTHA, S., ARYAL, A., and SHRESTHA, U.B., 2016. Assessments of ecosystem service indicators and stakeholder's willingness to pay for selected ecosystem services in the Chure region of Nepal. *Applied Geography* **69**: 25–34. doi:10.1016/j.apgeog.2016.02.003

BIRCH, J.C., THAPA, I., BALMFORD, A., BRADBURY, R.B., BROWN, C., BUTCHART, S.H.M., GURUNG, H., HUGHES, F.M.R., MULLIGAN, M., PANDEYA, B., PEH, K.S.-H., STATTERSFIELD, A.J., WALPOLE, M. and THOMAS, D.H.L. 2014. What benefits do community forests provide, and to whom? A rapid assessment of ecosystem services from a Himalayan forest, Nepal. *Ecosystem Services* **8**: 118–127. doi:10.1016/j.ecoser.2014.03.005

BRANCALION, P.H.S., CARDOZO, I.V., CAMATTA, A., ARONSON, J. and RODRIGUES, R.R. 2014. Cultural ecosystem services and popular perceptions of the benefits of an ecological restoration project in the Brazilian Atlantic Forest. *Restoration Ecology* **22**: 65–71. doi:10.1111/rec.12025

BRYMAN, A. 2001. *Social Research Methods*. Oxford University Press, Oxford, United Kingdom.

BULLOCK, J.M., ARONSON, J., NEWTON, A.C., PYWELL, R.F. and REY-BENAYAS, J.M. 2011. Restoration of ecosystem services and biodiversity: Conflicts and opportunities. *Trends in Ecology & Evolution* **26**: 541–549. doi:10.1016/j.tree.2011.06.011

BURKHARD, B., KROLL, F., NEDKOV, S. and MÜLLER, F. 2012. Mapping ecosystem service supply, demand and budgets. *Ecological Indicators* **21**: 17–29. doi:10.1016/j.ecolind.2011.06.019

CARRASCO, L.R., PAPWORTH, S.K., REED, J., SYMES, W.S., ICKOWITZ, A., CLEMENTS, T., PEH, K.S. and SUNDERLAND, T., 2016. Five challenges to reconcile agricultural land use and forest ecosystem services in Southeast Asia. *Conservation Biology* **30**: 962–971. doi:10.1111/cobi.12786

CHAZDON, R.L. 2008. Beyond deforestation: Restoring forests and ecosystem services on degraded lands. *Science* **320**: 1458–1460. doi:10.1126/science.1155365

CRESWELL, J.W. 1998. Qualitative inquiry and research design: Choosing among five traditions. Sage Publications, Thousand Oaks, California, United States.

[DFO] DISTRICT FOREST OFFICE. 2016. *Community forestry database*. District Forest Office, Kaski, Pokhara, Nepal.

[DFRS] DEPARTMENT OF FOREST RESEARCH AND SURVEY. 2015. *State of Nepal's forests*. *Forest Resource Assessment (FRA) Nepal*. Department of Forest Research and Survey (DFRS), Kathmandu, Nepal.

ECKHOLM, E.P. 1976. Losing ground: Environmental stress and world food prospects. W.W. Norton & Co Inc., New York, United States.

ECKHOLM, E.P. 1975. The deterioration of mountain environments. *Science* **189**: 764–770.

FARLEY, K.A. and BREMER, L.L. 2017. "Water is life": Local perceptions of Páramo grasslands and land management strategies associated with payment for ecosystem services. *Annals of the American Association of Geographers* **107**: 371–381. doi:10.1080/24694452.2016.1254020

FLEMING, B. and FLEMING, J.P. 2009. A watershed conservation success story in Nepal: Land use changes over 30 years. *Waterlines* **28**: 29–46. doi:10.3362/1756-3488.2009.004

FLEMING, W.M. 1983. Phewa Tal catchment management program: benefits and costs of forestry and soil conservation in Nepal. In: HAMILTON, L.W. (ed.), *Forest and watershed development and conservation in Asia and the Pacific*. Westview Press, Boulder, Colorado, United States, 217–288.

GAUTAM, A.P., SHIVAKOTI, G.P. and WEBB, E.L. 2004. A review of forest policies, institutions, and changes in the resource condition in Nepal. *International Forestry Review* **6**: 136–148. doi:10.1505/ifor.6.2.136.38397

GAUTAM, A.P., WEBB, E.L. and EIUMNOH, A. 2002. GIS assessment of land use/land cover changes associated with community forestry implementation in the middle hills of Nepal. *Mountain Research and Development* **22**: 63–69. doi:10.1659/0276-4741(2002)022[0063:GAOLUL]2.0.CO;2

GAUTAM, A.P., WEBB, E.L., SHIVAKOTI, G.P. and ZOEBISCH, M.A. 2003. Land use dynamics and landscape change pattern in a mountain watershed in Nepal. *Agriculture, Ecosystems & Environment* **99**: 83–96. doi:10.1016/S0167-8809(03)00148-8

GHIMIRE, C.P., BONELL, M., BRUIJNZEEL, L.A., COLES, N.A. and LUBCZYNSKI, M.W. 2013. Reforesting severely degraded grassland in the Lesser Himalaya of Nepal: Effects on soil hydraulic conductivity and overland flow production. *Journal of Geophysical Research: Earth Surface* **118**: 2528–2545. doi:10.1002/2013JF002888

GHIMIRE, C.P., BRUIJNZEEL, L.A., LUBCZYNSKI, M.W. and BONELL, M. 2014. Negative trade-off between changes in vegetation water use and infiltration recovery after reforesting degraded pasture land in the Nepalese Lesser Himalaya. *Hydrology and Earth System Sciences* **18**: 4933–4949. doi:10.5194/hess-18-4933-2014

GILMOUR, D. 2014. *Forests and water: A synthesis of the contemporary science and its relevance for community forestry in the Asia–Pacific region*. RECOFTC Issue Paper No. 3. RECOFTC – The Center for People and Forests, Bangkok, Thailand.

GLASER, B.G. and STRAUSS, A.L. 1967. The discovery of grounded theory: Strategies for qualitative research. Transaction, Piscataway, New Jersey, United States.

GRAY, D.E. 2004. *Doing research in the real world*. Sage Publications, London, United Kingdom.

HAUGO, R., ZANGER, C., DEMEO, T., RINGO, C., SHLISKY, A., BLANKENSHIP, K., SIMPSON, M., MELLEN-MCLEAN, K., KERTIS, J. and STERN, M. 2015. A new approach to evaluate forest structure restoration needs across Oregon and Washington, USA. *Forest Ecology and Management* **335**: 37–50. doi:10.1016/j.foreco.2014.09.014

HICKS, C.C., GRAHAM, N.A.J. and CINNER, J.E. 2013. Synergies and tradeoffs in how managers, scientists, and fishers value coral reef ecosystem services. *Global Environmental Change* **23**: 1444–1453. doi:10.1016/j.gloenvcha.2013.07.028

JICA/SILT. 2002. *Conservation development study on the environmental conservation of Phewa Lake in Pokhara, Nepal*. Final report submitted by SILT Consultants to JICA, Nepal, Kathmandu.

KEENAN, R.J., REAMS, G.A., ACHARD, F., DE FREITAS, J.V., GRAINGER, A. and LINDQUIST, E. 2015. Dynamics of global forest area: Results from the FAO Global Forest Resources Assessment 2015. Forest Ecology and Management **352**: 9–20. doi:10.1016/j.foreco.2015.06.014

LEIBUNDGUT, G., SUDMEIER-RIEUX, K., DEVKOTA, S., JABOYEDOFF, M., DERRON, M.-H., PENNA, I. and NGUYEN, L. 2016. Rural earthen roads impact assessment in Phewa watershed, Western region, Nepal. *Geoenvironmental Disasters* **3**: 13. doi:10.1186/s40677-016-0047-8

MALTERUD, K., SIERSMA, V.D. and GUASSORA, A.D. 2016. Sample size in qualitative interview studies: Guided by information power. *Qualitative Health Research* **26**: 1753–1760. doi:10.1177/1049732315617444

MARASENI, T.N., COCKFIELD, G. and APAN, A. 2005. Community-based forest management systems in developing countries and eligibility for clean development mechanism. *Journal of Forest and Livelihood* **4**: 31–42.

MARASENI, T.N., NEUPANE, P.R., LOPEZ-CASERO, F. and CADMAN, T. 2014. An assessment of the impacts of the REDD+ pilot project on community forests user groups (CFUGs) and their community forests in Nepal. *Journal of Environmental Management* **136**: 37–46. doi:10.1016/j.jenvman.2014.01.011

MCINNES, R.J. and EVERARD, M. 2017. Rapid Assessment of Wetland Ecosystem Services (RAWES): An example from Colombo, Sri Lanka. *Ecosystem Services* **25**: 89–105. doi:10.1016/j.ecoser.2017.03.024

MEIJAARD, E., ABRAM, N.K., WELLS, J.A., PELLIER, A.S., ANCRENAZ, M., GAVEAU, D.L.A., RUNTING, R.K. and MENGERSEN, K. 2013. People's perceptions about the importance of forests on Borneo. *PLoS One* **8**: e73008. doi:10.1371/journal.pone.0073008

MORSE, J.M. 1994. Designing funded qualitative research. *In*: DENIZIN, N.K. and LINCOLN, Y.S. (eds.) *Handbook of qualitative research* (second edition). Sage Publications, Thousand Oaks, California, United States.

NIELSEN-PINCUS, M. and MOSELEY, C. 2013. The economic and employment impacts of forest and watershed restoration. *Restoration Ecology* **21**: 207–214. doi:10.1111/j.1526-100X.2012.00885.x

NIRAULA, R.R., GILANI, H., POKHAREL, B.K. and QAMER, F.M. 2013. Measuring impacts of community forestry program through repeat photography and satellite remote sensing in the Dolakha district of Nepal. *Journal of Environmental Management* **126**: 20–9. doi:10.1016/j.jenvman.2013.04.006

OLI, K.P. 1997. *Phewa lake conservation action plan*. The International Union for Conservation of Nature (IUCN) Nepal and National Conservation Strategy Implementation Programme, National Planning Commission, Kathmandu, Nepal.

OLOFSSON, P., FOODY, G.M., STEHMAN, S.V., and WOODCOCK, C.E., 2013. Making better use of accurate data in land change studies: Estimating accuracy and area and quantifying uncertainty using stratified estimation. *Remote Sensing of Environment* **129**: 122–131. doi:10.1016/j.rse.2012.10.031

PALOMO, I., MARTÍN-LÓPEZ, B., POTSCHIN, M., HAINES-YOUNG, R. and MONTES, C. 2013. National parks, buffer zones and surrounding lands: Mapping ecosystem service flows. *Ecosystem Services* **4**: 104–116. doi:10.1016/j.ecoser.2012.09.001

PANDEY, S.S., MARASENI, T.N., COCKFIELD, G. and GERHARD, K. 2014. Tree species diversity in community managed and national park forests in the mid-hills of central Nepal. *Journal of Sustainable Forestry* **33**: 796–813. doi:10.1080/10549811.2014.925811

PATTON, M.Q. 2002. *Qualitative research and evaluation methods* (Third edition). SAGE Publications, Newbury Park, California, United States.

PAUDYAL, K., BARAL, H., BURKHARD, B., BHANDARI, S.P. and KEENAN, R.J. 2015. Participatory assessment and mapping of ecosystem services in a data-poor region: Case study of community-managed forests in central Nepal. *Ecosystem Services* **13**: 81–92. doi:10.1016/j.ecoser.2015.01.007

PAUDYAL, K., BARAL, H., and KEENAN, R.J. 2016. Local actions for the common good: Can the application of the ecosystem services concept generate improved societal outcomes from natural resource management? *Land Use Policy* **56**: 327–332. doi:10.1016/j.landusepol.2015.11.010

PAUDYAL, K., BARAL, H., LOWELL, K. and KEENAN, R.J. 2017. Ecosystem services from community-based forestry in Nepal: Realising local and global benefits. *Land Use Policy* **63**: 342–355. doi:10.1016/j.landusepol.2017.01.046

RAYA, R.B., SHARMA, S. and GURUNG, G. 2008. Impact of land use on water quality of Phewa Lake Pokhara, Nepal. In: SENGUPTA, M. and DALWANI, R. (eds.) *Proceedings of Taal 2007: The 12th World Lake Conference*, Jaipur, India, 29 October–2 November. 703–716.

REGMI, R.R. and SAHA, S.K. 2015. Impact assessment of land use land cover change on soil erosion status in Phewa Lake watershed of Nepal. *International Journal of Current Engineering and Technology* **5**: 1708–1717.

RIMAL, B., BARAL, H., STORK, N.E., PAUDYAL, K. and RIJAL, S. 2015. Growing city and rapid land use transition: Assessing multiple hazards and risks in the Pokhara valley, Nepal. *Land* **4**: 957–978. doi:10.3390/land4040957

SABOGAL, C., BESACIER, C. and MCGUIRE, D. 2015. Forest and landscape restoration: Concepts, approaches and challenges for implementation. *Unasylva* **245** (66): 3–10.

SAYER, J., SUNDERLAND, T., GHAZOUL, J., PFUND, J.-L., SHEIL, D., MEIJAARD, E., VENTER, M., BOEDHIHARTONO, A.K., DAY, M., GARCIA, C., VAN OOSTEN, C. and BUCK, L.E. 2013. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *Proceedings of the National Academy of Sciences* **110**: 8349–8356. doi:10.1073/pnas.1210595110

SHARMA, B.K., TIMALSINA, K., RAI, R., MAHARJAN, S.K., JOSHI, A. and RAKHAL, B. 2013. *Biodiversity resource inventory, ecosystem assessment of Bhadaure Tamagi VDC, Kaski: An ecosystem-based adaptation in mountain ecosystem in Nepal*. International Union for Conservation of Nature (IUCN), Lalitpur, Nepal.

SMITH, H.F. and SULLIVAN, C.A. 2014. Ecosystem services within agricultural landscapes—Farmers' perceptions. *Ecological Economics* **98**: 72–80. doi:10.1016/j.ecolecon.2013.12.008

STANTURF, J.A., PALIK, B.J. and DUMROESE, R.K. 2014. Contemporary forest restoration: A review emphasizing function. *Forest Ecology and Management* **331**: 292–323. doi:10.1016/j.foreco.2014.07.029

STHAPIT, K.M. and BALLA, M.K. 1998. *Sediment monitoring of Phewa Lake. Watershed management and environmental science*. Institute of Forestry, Kathmandu, Nepal.

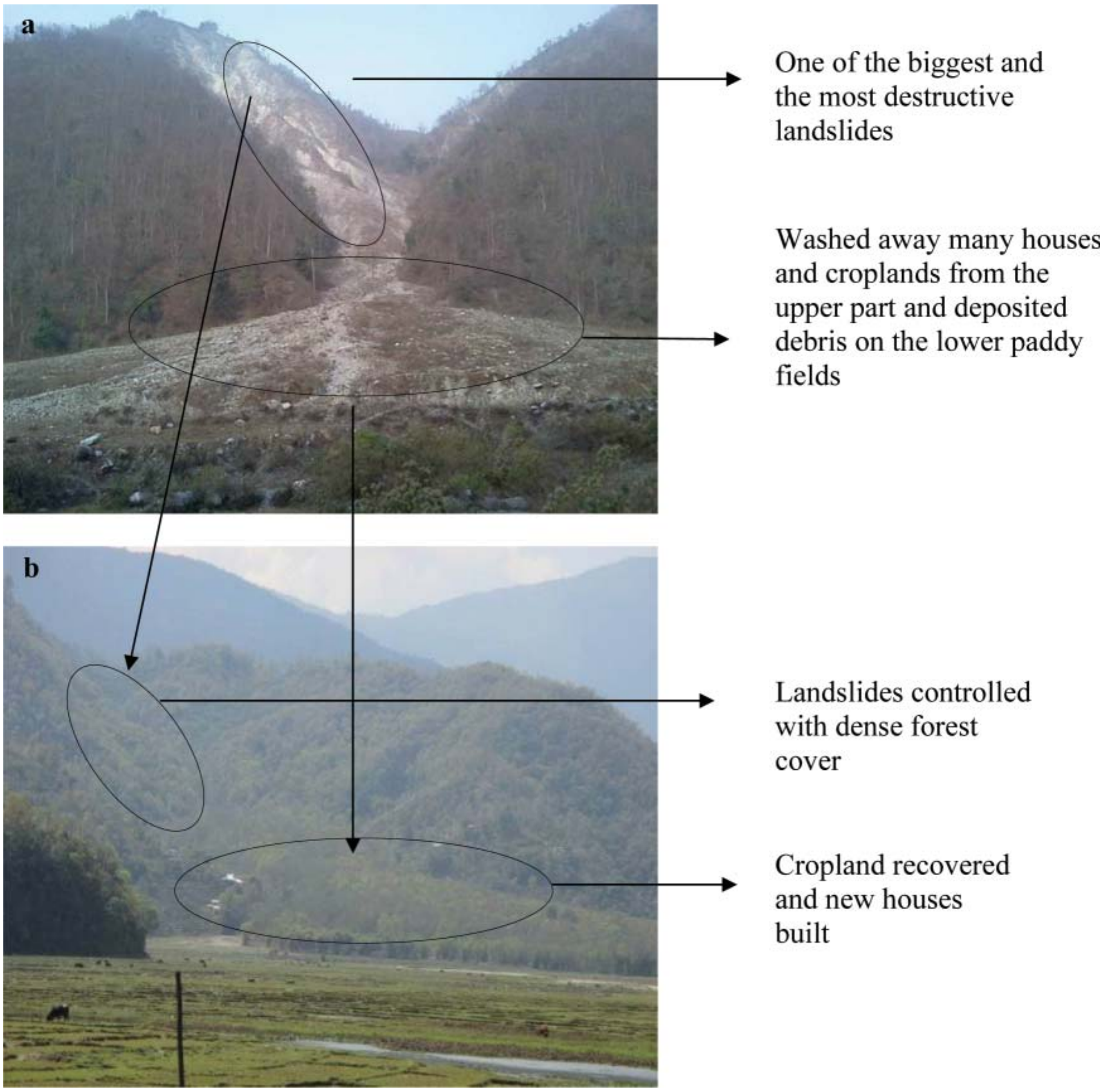
UPRETI, B., UPADHAYAYA, P. and SAPKOTA, T. (eds.). 2013. *Tourism in Pokhara: Issues, trends and future prospects for peace and prosperity*. Pokhara Tourism Council, South Asia Regional Coordination Office of the Swiss National Centre of Competence in Research (NCCR North-South) and Nepal Center for Contemporary Research, Kathmandu, Nepal.

VAN DIJK, A.I.J.M. and KEENAN, R.J. 2007. Planted forests and water in perspective. *Forest Ecology and Management* **251**: 1–9. doi:10.1016/j.foreco.2007.06.010

ZARANDIAN, A., BARAL, H., YAVARI, A.R., JAFARI, H.R., STORK, N.E., LING, M. and AMIRNEJAD, H. 2016. Anthropogenic decline of ecosystem services threatens the integrity of the unique Hyrcanian (Caspian) forests in Northern Iran. *Forests* **7**: 1–27. doi:10.3390/f60x000x

ANNEX 1: REPEAT PHOTOGRAPHY OF THE STUDY AREA

The coverage of the two photographs is different because they were taken from different angles. Circles indicate the tentative location of landslides in two time periods. Photograph A was taken in 1974 at the time of a massive landslide that destroyed more than 200 households and their cropland. Photograph B was taken in 2014 after restoration and shows dense forest in the upper part and restored arable land in the lower belt. The two photographs indicate a significant change in forest cover and restoration of the landscape over the last four decades.



(Photo credit: District Soil Conservation Office, Kaski)