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ORIGINAL ARTICLE

Assessing livelihood-ecosystem interdependencies and natural resource governance in Indian villages in the Middle Himalayas

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Abstract

Mountains host high biological and cultural diversity, generating ecosystem services providing benefits over multiple scales but also suffering significant poverty and vulnerabilities. Case studies in two contrasting village communities in the Indian Middle Himalayas explore linkages between people and adjacent forest and river ecosystems. Interviews with local people and direct observations revealed low food availability and decreasing self-sufficiency, under the combined pressures of increasing foraging by wildlife (primarily pigs and monkeys) coupled with seasonal to permanent outmigration by younger men seeking more secure income and alternative livelihoods. Much of the income remitted by migrants to their villages was not retained locally but flowed back out of the Himalayan region through purchases of food produced and marketed in the plains. This threatens the economic viability of villages, also placing asymmetric pressures on resident female, elderly and young people who concentrate labour on local livestock production to the neglect of crop agriculture, further compounding land abandonment and wildlife foraging. Significant traditional knowledge remains, along with utilitarian, cultural and spiritual connections with the landscape. Many beneficiaries of locally produced ecosystem services are remote from village communities (particularly water flows downstream to the plains), but no recompense is paid to stewards of the forested Himalayan landscape. Although local people currently perceive high biodiversity as a constraint to agriculture and other economic activities, the Himalayan landscapes could potentially constitute an asset with appropriate institutional development through promotion of managed bioprospecting, guided ecotourism and payment for ecosystem services (PES) schemes for water supply and under REDD+.

Keywords Middle Himalayas · Community-based management · Livelihoods · PES · Uttarakhand · India

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Introduction

Mountains cover 24% of the global land surface (UNEP-WCMC 2002), providing a variety of critical ecosystem services. They are characterised by high biodiversity, largely due to small-scale habitat diversity across heterogeneous topo-climates, and host approximately one quarter of terrestrial biodiversity, nearly half of the world's 34 biodiversity 'hot spots', and the largest proportion of the world's forests, habitat types and ecological variability (Körner 2009; CBD 2010; 2011; ICIMOD 2010; RSPN 2015). Mountain forests regulate and modify local climatic conditions, contributing to mitigation of global warming as significant carbon sinks (ICIMOD 2010).

Nearly 12% of the global human population lives in mountains (Huddleston et al. 2003) or 20% when those inhabiting mountain edges are considered (Körner et al. 2005). The heterogeneity of natural resources and relative inaccessibility of mountain regions also generates a high degree of cultural diversity, including locally adapted sustainable food systems (crop, livestock, fishing, hunting and forest produce) and utilisation of natural resources for medicinal and diverse other purposes, with consequent high interdependency between local people and the ecosystems they inhabit. However, the often-low productivity and resilience to change of mountain environments means that poverty and human vulnerability are higher in mountains than in other global habitat types (Körner et al. 2005). The socio-economic wellbeing of mountain communities is challenged by their predominantly subsistent economy, fragile environment, physical isolation, inadequate access to markets and inputs, low resource productivity and resultant vulnerability to risks from a variety of natural hazards and disasters (Sharma et al. 2010; RSPN 2015).

In the Middle Himalayas (north-central India and Nepal), forest-based subsistence farming constitutes the main source of food, livelihood and rural economy (Aase et al. 2013; Grover et al. 2015). However, diverse changes have been occurring over recent years in traditional natural resource utilisation patterns in response to population growth, rapid urbanisation, economic globalisation and land use intensification (Sharma et al. 2010; Tiwari and Joshi 2015). These changes have depleted forests and broader biological diversity and disrupted the hydrological regimes of Himalayan watersheds reducing recharge of springs and availability of water for drinking, sanitation and crop production, threatening food and livelihood security (Scott et al. 2018; Tse-ring et al. 2010; Tiwari and Joshi 2014; Chapagain et al. 2016). The interlinkage of forest-based ecosystem services and local livelihood dependence in the Himalayan region has been characterised by Joshi and Negi (2011) and Rasul et al. (2011), among others, with emphasis on valuing ecosystem services. This body of applied research has raised the visibility of ecosystem-livelihood interactions among decision-makers, especially at national and regional levels. Less attention has been placed on ensuing questions of ecosystem governance or institutional assessments that conjointly address ecosystem services and livelihoods (Sandhu and Sandhu 2014).

Governance optimally operates as a multi-stakeholder process involving formal and informal actors and agents in decision-making processes affecting a range of linked individuals and stakeholder groups in society (Funnell 2001). In the Indian Himalayas, forest governance has been constituted as a democratic and responsible intervention process aiming at changes in environment-related incentives, knowledge, institutions, decision-making systems and behaviours with respect to management of forest resources (Leggett and Carter 2012). This is consistent with India's long practice of traditional and decentralised forms of democratic local rural governance, most commonly through *Gram Sabhas* (Village Councils). Operating on a similar delegated and locally accountable basis, *Van Panchayats* (Forest Councils) were established under the Indian Forest Act 1927 as grassroots-level democratic institutions for local-scale participatory management of forests, and particularly Civil Forests. (Civil Forests are forest areas owned by State Government but located within village boundaries, allocated as a resource available for village community use; Civil Forests managed by villages through *Van Panchayats* are known as Panchayat Forests.) The *Van Panchayat* (VaP henceforth) system has a long history in the Indian Himalayas, in particularly in what is now the State of Uttarakhand (Negi et al. 2012) where the first state-approved VaP came into existence in 1931 in the district of Almora. The VaP local governance system emerged out of conflicts and compromises in forest management in the early twentieth century, comprising one of the first global examples of a participatory form of resource management institution officially nested within statutory natural resource governance arrangements (Mukherjee 2003).

This study assesses linkages between rural communities and river and forest ecosystems and agriculture in the densely populated Middle Himalayan State of Uttarakhand, India. It does so using the ecosystem services framework. Our approach analyses specific linkages between, on the one hand, rapidly evolving livelihood strategies and practices and, on the other, institutional mechanisms and innovations for natural resource management. The study considers unique aspects of the lifestyles and livelihoods of the Indian Himalayan rural cultural and ecological system using evidence from two case study villages, considering economic flows and historically grounded decision-making contexts. The first case study examines benefits and gaps in the operation of community governance of forest and linked water resources in Satbaunga village, taking the form of a meeting with representatives of key community-based governance institutions (the VaP and *Gram Sabha*), outlining the complex nested institutions and powers as a context for local decision-making and practical ecosystem and livelihood outcomes. Satbaunga is an ideal case study location to address

community governance of ecosystems as it has a long-established (instituted in 1949) and continuously operating VaP enabling community participation in governance of adjacent forests. The second case study entailed interviews with many residents of Jamira village concerning their livelihood dependencies. Jamira village was selected as it is a regionally typical village size but also is relatively inaccessible, being around 2 km down a rough, meandering track from the nearest motor access and therefore representative of a settlement less directly influenced by urban activities. Whilst a sample of two communities, one addressing governance institutions and the other interviewing residents, cannot represent the full diversity across a heterogeneous State like Uttarakhand, the distinctive differences in accessibility and the formality of devolved governance between the two communities in the Middle Himalayan region provides a contrast from which more general observations can be derived.

Methods

Survey techniques entailed the authors visiting the two localities over a period of 10 days. Some of the authors were familiar with Satbaunga village from previous research (Tiwari and Joshi 2015), though Jamira village was not known to any researcher beforehand.

Surveys in Satbaunga village

Satbaunga village lies in the Ramgarh Development Block of Nainital District, Uttarakhand (29° 24′ to 29° 29′ N, 79° 29′ to 79° 39′ E), encompassing an area of over 75 km^2 between 1025 and 2346 m altitude. The village spans much of the catchment of the Ramgad River, which drains its boundary. The Ramgad River is the principal tributary of the Niglat Gad, which is in turn a significant tributary of the Kosi River. The Kosi River runs down to Ramnagar, where it is impounded and substantially abstracted, leaving only monsoon and residual dry-weather flows running onto the Gangetic Plain (Fig. 1).

Evidence gathering at Satbaunga took the form of a half-day meeting between representatives of the research team ($N = 3$) and members of the Satbaunga VaP ($N = 11$, primarily involved in forest and other natural resource use and management) including representatives from the *Gram Sabha* ($N = 2$, primarily concerned with village welfare and development). All participants, comprising 11 men and 2 women, contributed their views in the meeting in response to research team questioning, discussions taking place in Hindi. Conversation flowed freely with no evidence of it being dominated by the sarpanch (elected head of the Panchayat) or any other individuals. The two Hindi-speaking researchers (PT and BJ) translated for the non-Hindi speaking researcher (ME), all three

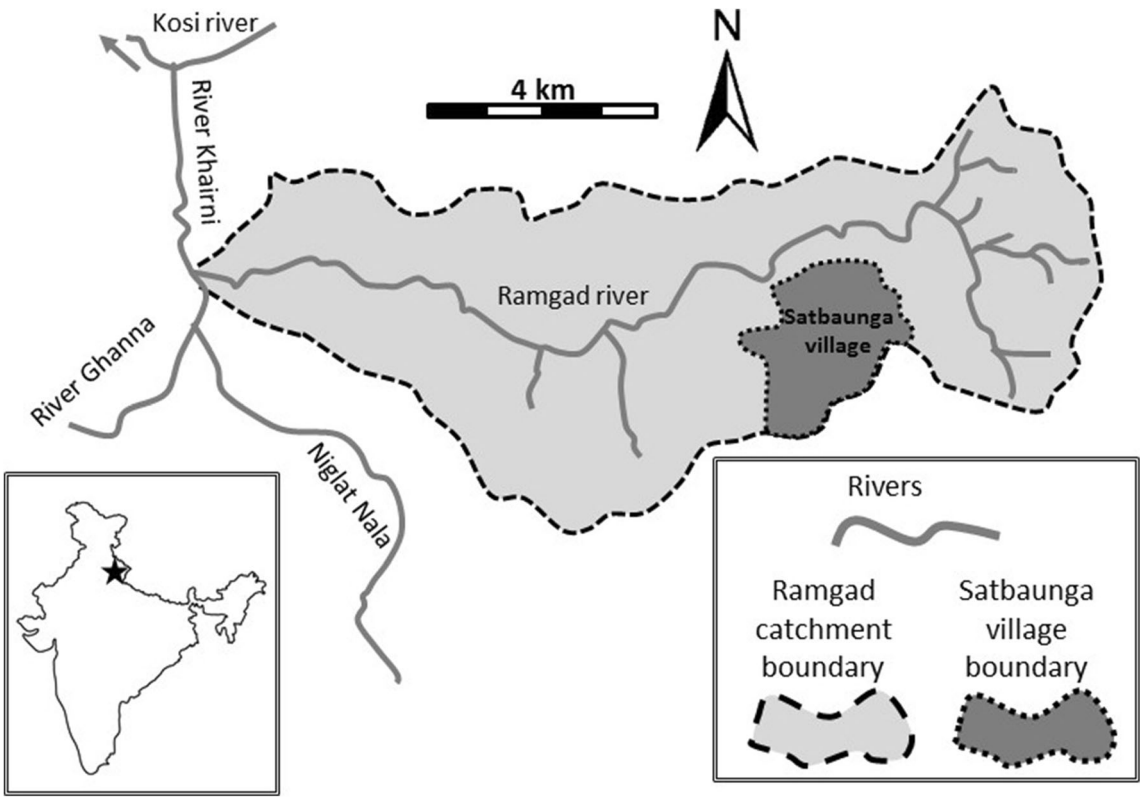

Fig. 1 Location map of Satbaunga village within the Ramgad catchment

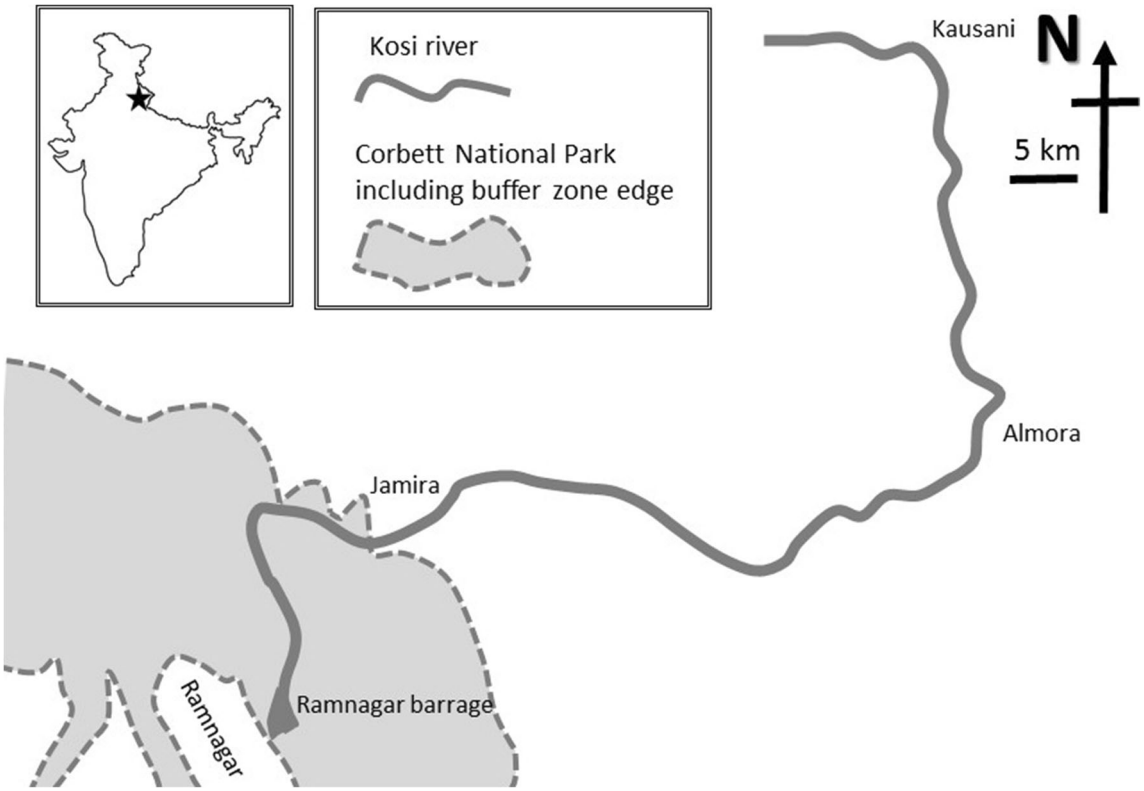

Fig. 2 Location map of Jamira and adjacent towns in the Kosi river catchment

researchers taking written notes in English and collating them following the meeting.

Surveys in Jamira village

The village of Jamira (29° 53′ 26″ N, 79° 23′ 37″ E; 697 m amsl) is also situated in Nainital District, Uttarakhand, located on a steep valley side in the Kosi River catchment (Fig. 2). The terrain is steep, the Kosi River running in a deep gorge (Fig. 3) with the village landscape situated on the steep slopes on the north bank. Forest cover remains extensive, but Jamira enjoys no specific status as a protected site for nature conservation, though more general Government of India (national) forest protection measures limit exploitation of all types of forest at this altitude. There is therefore near-continuous forest between Jamira and, approximately 2 km to the west, the outer extent of the buffer zone surrounding the Corbett Tiger Reserve. The Kosi River is an important natural resource for Jamira and the region. It rises from the rain-fed Lesser Himalayan Ranges at Dharpani Dhar at an altitude of 2500 m to the west of Kausani in Almora district of Uttarakhand, running downstream through Almora then through Betalghat to a barrage at the town of Ramnagar some 168 km from its source. Between its source and the barrage at Ramnagar, the Kosi falls through an average gradient of 12.8 m km^{-1}, the pace and power of the river cutting a deep gorge through the mountain landscape. There is only one impoundment between the source of the Kosi and the barrage at Ramnagar, a small dam at Almora enhancing water availability and constituting the sole water resource for the town.

Interviews were conducted over a period of 5 days by research team representatives ($N = 3$) both by visiting households and by talking with people encountered using the river and surrounding land. The interviewee resource included 7 older men and 14 women of ages from 14 to 70. Though not formally interviewed, the research team

Fig. 3 The Kosi River cuts a deep gorge in the mountain landscape

Table 1 Millennium Ecosystem Assessment (2005) ecosystem service categories

Millennium ecosystem assessment ecosystem service category	Summary description
Provisioning	Physical and other resources extracted from ecosystems to support a diversity of human needs, such as food, fibre and natural medicines.
Regulatory	Regulatory processes within ecosystems maintaining balance, such as pollination, water purification and climate moderation.
Cultural	Aspects of ecosystems providing non-material benefits enriching society, such as those supporting tourism, recreation and spiritual interests.
Supporting	Processes within ecosystems that maintain overall functioning and resilience, such as soil formation, photosynthetic production of oxygen and habitat for wildlife.

Ecosystem services are defined by the Millennium Ecosystem Assessment (2005) as '… the benefits people obtain from ecosystems'

documented points expressed by 34 children visiting the researchers' riverside camp during our visit about their use of the forest and river. Five of the men had gathered to conduct a *Kriya Karam* (a ceremonial cremation ritual) and three were loop (snare) fishing in the river, one man belonging to both groups. In the case of Jamira, gender sensitivity was considered, with the female research member (SK) conducting most interviews in households and with other women encountered using the river and riparian land. As Jamira village comprises only 15 households, interviewees comprised a significant proportion of the population. The two Hindi-speaking researchers (GK and SK) translated for the non-Hindi speaking researcher (ME), who collated written notes in English during or immediately following discussions.

Structure of surveys

At both Satbaunga and Jamira, consent was requested and obtained from all the participants to make notes of the conversations compliant with ethical practice. All responses were anonymised so that respondents felt free to express their views.

The conceptual framework for interviews was the Millennium Ecosystem Assessment (2005) framework of provisioning, regulatory, cultural and supporting ecosystem services (summarised in Table 1). The Millennium Ecosystem Assessment ecosystem services framework was selected as it spans a broad range of benefits and potential disadvantages or losses accruing to a diversity of people from ecosystems and their processes. Although redefined as functions in some reclassifications of ecosystem services (TEEB 2010; Braat and de Groot 2012), supporting services were retained in the analysis as they constitute important considerations in terms of the resilience and capacity of ecosystems to provide wider benefits, and are therefore significant considerations for management decision-making.

A semi-structured approach was taken to information-gathering in interviews. Ecosystem services were introduced into interviews by conversation in locally relevant terms and in a semi-structured way rather than through a rigid questionnaire, reflecting the cultural differences between researchers and local people and the diversity of views and perspectives of interviewee groups. Interviews revolved around people's livelihoods and their relationships with the natural resources. Responses were stratified by the interviewers around different Millennium Ecosystem Assessment ecosystem service categories, enabling interviewees to respond freely and to refer to different values, uses and management approaches to resources, rather than asking them rigorously to stick to a rigid questioning framework. Once all relevant ecosystem service parameters had been introduced and exhausted, interviewees were thanked and their consent to use feedback in an anonymised form was reconfirmed. The research team also made direct observations of land and river use. All feedback, captured as written notes at the time of interview, was later stratified by ecosystem services by the research teams.

We acknowledge that data capture may have inadvertently introduced bias as: (1) differing types of community were interviewed at each site; (2) different researchers conducted interviews at each site including accounting for gender sensitivity; (3) notes were captured in English when the primary interviews were in Hindi; and (4) despite the semi-structured approach, some interviewer bias is inevitable from the steering questions being shaped by the ecosystem services framework. There are no obvious means to quantify these potential sources of bias, so we simply acknowledge the potential for bias. Were repeat surveys to be conducted, methods such as audio recordings could be used, if acceptable to interviewees, for improved retrospective analysis of raw inputs as well as reuse of data by others.

Results

The outcomes of interviews, stratified by the four major Millennium Ecosystem Assessment ecosystem service categories, are addressed below for the Satbaunga and Jamira case study villages.

Findings of the Satbaunga village case study

The Satbaunga village spans 177 households comprising a population of 1441, of which 51% are females. Seventy-nine per cent of the population is literate, with 52% employed (Tiwari and Joshi 2015). The total village common property area spans 237.33 ha, of which 95% is forested, including both Panchayat and Civil Forest (Tiwari and Joshi 2015). Due to the high altitude and cool climate, Almora District is one of the prime horticultural areas of Uttarakhand (Pandey et al. 2017). It nonetheless suffers from a lack of viable domestic economic opportunity, low food self-sufficiency and high male outmigration (Tiwari and Joshi 2015).

Provisioning services at Satbaunga village

The 13 respondents from the VaP and *Gram Sabha* reported that people in Satbaunga access fresh water directly from springs or from small channels for domestic use, and to a limited extent to water crops. ('We have rain-fed agriculture; only 10% is irrigated by hill springs and canals from streams'.) The importance of healthy forests for interception and storage of water was reported to be unanimously understood by the community members: 'Jahan banj wahan pani' ('Wherever there is oak there is water'). Consequently, where banj (Himalayan oak, *Quercus leucotrichophora*) trees occurred, they were taken as an indicator of the presence of shallow groundwater that could be tapped for human uses, and the oak trees themselves were protected (though their leaves and peripheral branches could be cropped for fodder and firewood). Sacred groves of banj protected by local traditional and religious codes were observed around small temples built on springs, historically used as water sources by village people. Many of these groves remain in place and are not exploited for fodder or fuel but, whilst the small temples dedicated to *Vishnu* (God of Water) remained, water is now drawn from piped sources. Traditional knowledge also related to the occurrence of utis (*Alnus nepalensis*), a Himalayan alder tree considered an indicator not merely of soil moisture but of wetlands and springs. Local, consensual bans on the cutting of both banj and utis are founded on traditional knowledge, and the planting of these tree near springs and streams is based on a high degree of awareness among local people about their water-indicating and water-conserving values.

In common with observations elsewhere in the Himalayas (Tiwari and Joshi 2012), the VaP reported that Satbaunga is far from being self-sufficient in food, necessitating economic outmigration of younger men to the cities and the import of staple food from the plains. A further threat to local food sufficiency was reported as arising from the activities of wildlife. Wild pigs (*Sus scrofa cristatus*) and rhesus macaque monkeys (*Macaca mulatta*) were mentioned as problematic for crops, compounded by sambar deer (*Rusa unicolor*) and chital (*Axis axis*, also known as spotted deer). The forests are also host to a strong population of leopard (*Panthera pardus fusca*) and sloth bear (*Melursus ursinus*), with the frequent passage of tigers (*Panthera tigris tigris*). It was also observed that people did not venture outside their houses after dark as a matter of personal safety, leaving their crop pens unattended. The forests therefore represented not only a valued resource but also a reservoir of problematic wildlife species compounding food insecurity. Local people in Satbaunga were permitted to fish the river for subsistence needs without obtaining permission from the Uttarakhand Fisheries Department. However, due to depletion of water resources in the Ramgad catchment compounded by destruction of fish habitats through aggregate mining, fish were no longer an important food resource for the community.

Households in Satbaunga that could afford to do so were reported as using bottled gas for cooking, limiting the use of collected dead wood ('Families can buy dried tree but cannot sell forest products in market') but increasing dependency on commercial fossil fuel resources derived from outside the region. Although utis is commonly used across its primarily Himalayan range for charcoal (National Research Council 1980), it was reported to be protected in Satbaunga owing to its importance as an indicator of the presence of water. VaP and *Gram Sabha* respondents also reported that people in Satbaunga village maintain a high dependence on natural medicine as resources for western medicine were not readily available, and plants were reported as serving a variety of other purposes, such as for washing clothes ('Medicinal plants have higher dependence in rural areas for all diseases, clothes washing, etc.').

A limited quantity of energy is generated from the mouth of the Ramgad River through a pioneering hydropower scheme operated entirely by the community (Taneja 2016). Representatives of families benefitting from this energy in villages along the Ramgad are involved as members of the Ramgad Energy Committee (REC), participating in periodic meetings convened to make decisions about the project. Local, affected people therefore play major roles in the hydropower project and are also involved in related decision-making processes.

Aggregates (sand, gravel and stones) were taken where sorted by water flows in the river valley. This was necessary for local people's construction needs, the only alternative being buying expensive bricks made in, and transported a long distance from, the Gangetic plain.

Regulatory services at Satbaunga village

Inferred from the abundance of insects, plants, trees, birds and other wildlife observed by the researcher team, Satbaunga's forest and farmed ecosystems evidently sequester carbon, store and purify water, contribute to air quality and microclimate amelioration, and provide pollinating, pest and disease control services through their rich biodiversity. The high standing biomass and protection of Civil Forest also clearly makes a substantial contribution to climate regulation. Comments about these regulatory ecosystem services were not, however, offered by village respondents, perhaps as the services appear to be far from limited and were not sought out especially, and are therefore not considered.

Cultural services at Satbaunga village

Whilst the respondents did not agree that they assigned strong spiritual connotations to the forest and its wildlife, they described a deep affinity with their surrounding ecosystems expressed as *Dev Bhoomi* (Home of God). This concept is most strongly associated with the vicinity of Hindu temples where trees, fish and other wildlife are afforded greatest respect and protection (see Gupta et al. 2016). Watercourses in and adjacent to the village were also of religious importance, as for example for conducting *Kriya Karam* (ritual cremation ceremonies at the river's edge).

Community engagement in natural resource protection and sustainable use through VaP and *Gram Sabha* exemplifies commitments to stewardship, equitable allocation and sustainable use shaped by the surrounding forest and water resources. The VaP and Gram Sabha interview group also noted that ecosystem management went beyond controls on exploitation, including proactive measures such as strategic plantation of trees and construction of contour trenches in Civil Forest areas to enhances the ecosystem functions of groundwater and spring recharge for communal benefit ('In catchment areas, we can do some plantation and contour trenches'). Community collaboration in reticulation of water from springs and streams also demonstrates how natural resources form organising principles for community action.

Supporting services at Satbaunga village

Provision of habitat and other linked ecosystem functions (soil formation, photosynthesis, primary production, nutrient and local water recycling) were considered by the research team to be significant. Though welcomed from a cultural perspective, not described in negative terms but instead forming part of the natural infrastructure defining the home landscape of the local population, villages also commented that wildlife created significant impediments to food production ('We see tiger, lots of Panther [leopard], and have problems with wild pigs and monkeys'). Grazing animals were a threat to crops, and predators a deterrent to people's activities (and a risk to lives) particularly by night. From the perspective of the researcher team, habitat provided for wildlife is a significant supporting service generating multiple other services beneficial at scales from the local to the catchment and, in the case of climate regulation, global.

Natural resource governance at Satbaunga village

The VaP and *Gram Sabha* respectively control use and management of Community Forest and water resources and promote village welfare and development including resource enhancement through measures such as contour trenches to improve infiltration and recharge of groundwater ('Collective decisions are made by the Panchayat'). The community at Satbaunga also enjoys limited rights in Reserved Forest mediated by the VaP, offered by State Government in exchange for fire control and other management services best delivered locally. These powers collectively confer a level of sustainability to extraction of forest food, medicines and other useful products.

However, VaP and Gram Sabha representatives expressed frustrations at their incomplete role in, and they believe illegal exclusion from, controlling water rights within the natural catchment landscape. A significant threat was perceived as resulting from the proliferation of second home and resort developments in an upland area of Satbaunga village, and more widely across the district, sanctioned by authorities in higher tiers of government without due recourse to local decision-makers ('Richer people influence politicians'). The Satbaunga VaP felt that this seriously undermined their authority and purpose of protecting the water and other natural resources for the local community, representing a significant gap in powers for the primary decision-making body tasked with sustainable resource management ('*Van Panchayats should have power to decide on drilling* [creating a borehole for water]*, but not at present*'). The lack of a clearly mapped and gazetted village boundary was also seen as an impediment to effective control exerted by the VaP and *Gram Sabha* ('Area of Panchayat is not mapped, which makes tackling encroachment difficult'); a priority to be remedied for more effective and comprehensive community-based management of ecosystem services.

A further gap in effective community management was controls on exploitation of forest resources. Whilst local people have rights to exploit Civil Forest, with some concessions in local Reserved Forest for food, medicines, dead wood and some other goods, villages have no control and receive no benefit from commercial harvesting sanctioned by authority figures in higher tiers of formal government, representing another significant missing power for the VaP to be effective in

resource stewardship for the benefit of the village ('Van Panchayats should be involved and get benefit').

Findings of the Jamira village case study

The village of Jamira comprises 15 households on a steep, forested/mixed gorge-edge landscape descending with sporadic, small flattened areas to the Kosi River. Given the small size of Jamira, the village is part of a cluster of five local villages under a common Gram Sabha and VaP. The land around Jamira had formerly been more extensively farmed, including many small plateaus as well as constructed narrow *nali* (terraces in the hillside), though many of these were observed to have fallen out of use and become invaded by scrub vegetation including substantial areas overtaken by the alien, invasive shrub *Lantana camara*.

Jamira is situated on steep mountainside terrain on the true right bank (viewed downstream) about 48 km river distance upstream from the barrage at Ramnagar. The Kosi is significant to Jamira for several reasons including there being a natural gravel ford across the river, as a spiritual resource and for its fish ecology (particularly populations of the charismatic fish species Golden Mahseer, *Tor putitora*) (Everard and Kataria 2011; Gupta et al. 2014). These fish are actively protected but also sustainably exploited by local people.

Provisioning services at Jamira village

Fresh water was observed to be abundant at Jamira, both in terms of hillside springs and in the clear and fast-flowing Kosi River. Households, livestock and some areas of farmed land were observed and reported by interviewees to be irrigated by tapping into and piping water from the many springs emerging from the hillside. Nonetheless, the village is far from being self-sufficient in food. Farming of trees (papaya, bananas), creepers (pumpkin) and some low-growing crops (arvi, corn) occur in small patches near households (Fig. 4). Some animals are also farmed, including cattle corralled locally to households, and goat-herding exploiting rough grazing. Large tracts of formerly farmed plateau areas (*nali*) now lie fallow, particularly those more remote from the village where deterrence of wild animals proved no longer feasible given wild animal densities, the lower population of young males to police them, and the increasing risk of human-wildlife conflict. Wild Boar (*Sus scrofa*) and Barking Deer (*Muntiacus muntjak*) were identified by local people as particularly problematic for crop destruction, and leopards and tigers were described as 'common' in the area. The community members were quick to point out that, 'We want to do farming, but the wildlife takes too much crop'; 'Only three days back I saw tiger pugmarks right behind my house'; 'Last week our dog was taken by a leopard – he was sleeping under the 'charpai' (a wooden cot) during the night'; and 'There are lesser numbers of villagers to do 24-hour field watch – earlier with more people in village, crops were monitored regularly'.

Fig. 4 Household in the forest of Jamira, with cattle, fruit trees and some crops grown in proximity to the dwelling

Fish represent another food resource available to people in Jamira. However, the fish stock in the Kosi River is protected by the villagers as part of the living landscape that is their heritage (the Hindu concept of *Dev Bhoomi*, or 'Home of God'). Villagers reported that the VaP covering Jamira village '… stopped blasting 9 years ago' ('blasting' is the local term used for dynamite fishing). Villagers also agreed to ban netting on the river, but local, small-scale exploitation of fish is permitted using looping (snare fishing largely for Kalamas: *Bangana dero*) and hand-line bait fishing (largely for Golden Mahseer: *Tor putitora*). Fibre and fuel was reported as is derived mainly from plants, including wood for building and dry wood collected for cooking. It was reported that the VaP '… does not allow tree felling' but that villagers can '… get dead wood with chitty to build' ('chitty' is a term for written authorisation) with fees for this going to a Mangal Dal (a group in the village holding funds for social development). Whilst many households still depend on surrounding wood resources for cooking, those households able to afford it use bottled gas instead. Plants were also reported as still being commonly used for natural medicines ('We use some plants for medicines'), with some also used for adding flavour in cooking. Other low-intensity provisioning use of the river was observed but also reported to include frequent daily collection of aggregates, primarily sand, loaded into paniers on the backs of ponies and transported up the steep slopes for use in construction.

Regulatory services at Jamira village

A wide range of regulatory services were considered by the researcher team to be significant on the basis of the substantially intact and profuse forest and river habitat. Regulatory

services considered significant by the researcher team included: air quality and microclimate regulation (air quality already perceived as high in a locality remote from urbanisation); water regulation (timing/scale of run-off and flooding buffered by natural habitat); natural hazard regulation (particularly dissipation of storm energy); pollination; water purification and waste treatment; and the regulation of pests and diseases through natural predation and breakdown processes. However, feedback from interviewees did not refer to regulatory services (including in locally relevant terms), perhaps as they are not likely to be a locally limiting.

Cultural services at Jamira village

The cultural and aesthetic heritage of the region, and the Kosi River running through Jamira, is highlighted by attitudes of local people to the conservation of Golden Mahseer (*Tor* spp.) not purely for utilitarian reasons, but as charismatic elements (Everard and Kataria 2011; Gupta et al. 2014) of the natural heritage of the village. The children of the village made extensive use of the pools for informal recreation including swimming and playing in the water, play serving an important role in relaxation and development (Frost et al. 2007). The benefit for all of 'cooling off' in clean and safe water, without major aquatic predators and parasite risks in a generally hot climate, adds to the quality of life of all in the village. Significant spiritual and religious value is linked to the river system: during the site visit, the research team observed at close quarters a *Kriya Karam*. Architecture of houses in the village was founded almost entirely on local resources (timber, stones etc.), shaping and emphasising a close connection between ecosystems and local character and lifestyles.

Supporting services at Jamira village

Provision of habitat for wildlife was widely commented upon, many quotes relating to abundant predatory and grazing wildlife of the forest systems impeding food production. Villagers reported that '*There is almost no farming due to Wild Boars and Sambar* [Barking Deer]; *we are not allowed to kill animals*'. Local people did not comment on other aspects of supporting services—soil formation, primary production, nutrient cycling, water recirculation in landscape and photosynthesis (production of atmospheric oxygen)—though these functions were observed by the researcher team as likely to be significant for ecosystem resilience, and the production and supply of all services both locally and more remotely.

Natural resource governance at Jamira village

As noted, Jamira is one of a group of five local villages covered by a common *Gram Sabha* and VaP, responsible respectively for village development and for allocation of rights to villagers to use wood and other forest assets. Stewardship of the forest as *Dev Bhoomi* and use of the watercourse for *Kriya Karam* and other cultural needs highlights strong cultural values as well as uses as a source of livelihood resources. Community collaboration in construction of pipework to reticulate of water from springs is one example of local collaborative action in the village.

Discussion

The Middle Himalayan landscape cannot be dissociated from changing geographical, climatic, biogeographic as well as human pressures. Local people play important roles in management of the ecosystems of which they are dependents and stewards (Folke et al. 2005). Community-based management makes significant contributions to conservation and protection of natural resources and flows of ecosystem services (Tallis et al. 2008), resulting in wide international acceptance of the benefits of community engagement for enduring, effective and equitable nature conservation (Emerton 1999; Larsen and Springer 2008).

Changing land uses and implications for food sufficiency

Subsistence farming and cropping were formerly the dominant and often only available forms of livelihood in the Middle Himalayas, though limited by availability of arable land both due to the steep terrain and increasingly the protected status of forests and their potentially problematic wildlife. Only 15% of land area across Uttarakhand is available for agriculture, upon which more than 70% of people depend for subsistence farming (Tiwari and Joshi 2015). The Hindu Kush Himalayan areas of India, China, Nepal and Pakistan experience the highest degree of food insufficiency globally, persistent undernourishment remaining an urgent challenge (Chappel and Lavalle 2011; Rerkasem et al. 2002). Low food sufficiency is a principal driver of substantial out-migration of younger men from the mid-hills of Uttarakhand, of which 73% do so for long durations and 36% migrating out permanently (Mamgain and Reddy 2017), seeking income to secure remaining food needs though this additional food is mainly sourced from outside the Himalayas. This form of poverty imposes an asymmetrically high pressure on women and the elderly (Mishra et al. 2017), significantly due to the traditional roles of women in resource management (collecting water, medicinal plants, fuelwood and fodder) necessitating walking increasing distances due to environmental stresses and leaving less time to care for themselves and their children and to contribute to productive activities such as participation in education and village governance (Everard 2015).

Responses and observations in this study suggest an accelerating decline in village food self-sufficiency with substantial visible and reported abandonment of the once-extensive farming activities around Satbaunga and Jamira. Respondents in these villages almost exclusively ascribed the cause of this decline as pressure from protected wildlife as, whilst people expressed a significant cultural affinity with wildlife, it undermines the capacity of the village to feed itself. There is for this reason a high dependence on India's urban and intensive farming economies remote from the mountain region where people live. Income remitted from younger males out-migrating to urban economies (mainly in Delhi, Mumbai and other major Indian cities but one young male from Jamira reported as working in America) then exits the village again to purchase food mainly transported in from Gangetic Plain farmland. In effect, much of the economy of the villages is related to urban centres and the Gangetic Plain, with local recycling of money in the community and its surrounding playing a small and declining role undermining long-term rural sustainability.

Successes in community management of resources

Community involvement in forest management through VaPs and *Gram Sabhas* highlights a close connection with forest, spring and watercourse ecosystems, underpinning multiple dimensions of wellbeing among the local communities. People in case study villages access fresh water for domestic and limited irrigation needs from local spring sources fed by surrounding forests and streams. Community stewardship of natural sources by the VaP and *Gram Sabha* plays a significant role in securing these vital resources in Satbaunga, including protecting them from activities potentially compromising their quality and quantity to ensure beneficial outcomes such as food production but also enhancing critical services such as water resource enhancement through measures such as creating contour trenches. Traditional knowledge about the importance of healthy forests for water security is unanimously understood and guides management, including the role of banj and utis as indicators of soil moisture or the proximity of springs. This awareness is encoded in some religious beliefs and structures (small temples). Sustainable management of forest, land and water resources not only maintains the integrity and function of the village ecosystem but may also be significant at catchment scale.

In practice, none of the regulatory and supporting services provided by forest surrounding the two case study villages, considered as significant by researcher teams, were explicitly valued by the local community beyond recognition of their role in maintaining water flows, albeit that they contribute to a range of more directly valued provisioning and cultural services. In fact, the supporting service of 'provision of habitat' was experienced as a disbenefit as grazing and predatory animals limit food production, protection of agricultural lands, and the freedoms of people and security of stock particularly during hours of darkness. However, these regulatory and supporting services provide significant benefits to people at wider geographical scales, ranging from global beneficiaries of climate regulation to catchment-scale beneficiaries of the buffering and purification of water flows, reductions in siltation, and provision of scenic and biodiverse landscapes whether enjoyed directly (e.g. ecotourism) or vicariously.

Assignment of strong spiritual connotations to the forest and its wildlife, description of these ecosystems as *Dev Bhoomi*, the local heritage of small temples, sacred groves close to springs, and the use of watercourses for *Kriya Karam* all highlight strong cultural connections. Community collaboration in reticulation of water from springs and streams also demonstrates how natural resources form organising principles for community action.

Also, despite their evident constraints on food production and personal and stock safety at night, wildlife finding refuges in the forest was not described in negative terms, instead forming part of the natural infrastructure defining the home landscape of the local population. Community engagement in natural resource management through VaP and *Gram Sabha* itself exemplifies commitments to stewardship, equitable allocation and sustainable use.

Gaps in community management of resources

For all the strengths of delegated community governance, major gaps in the execution of responsibilities and power were perceived in Satbaunga in terms of allocation of water rights to resort and second home development, as well as concessions in local Reserved Forest for food, medicines, dead wood and some other goods by authority figures in higher tiers of government. Village representatives felt that they had no control and received no benefit from commercial harvesting, undermining the power of VaPs effectively to steward resources for the benefit of the village communities. Representatives of the Satbaunga VaP felt that this seriously undermined their authority and purpose of protecting the water and other natural resources for the local community. The situation could be improved were village boundaries clearly mapped and gazetted, creating clarity about jurisdictions that, in a less well-defined state, were perceived as exploited by developers and potentially corrupt officials.

Potential economic solutions for more effective governance

Direct marketable opportunities include involving the community in ecotourism (such as guides, caterers, porters and providers of other services) paid for by visitors making use of natural resources protected by the community. Recreational angling (catch-and-release) may be possible on the protected

flows of the Ramgad River and Kosi River, angling having a proven role in river conservation in the nearby Western Ramganga River (Everard and Kataria 2011). Wildlife tourism is potentially economically significant (Kumaon District is already recognised as an attractive location for bird-watching), and cultural tourism may also make a significant contribution (Arunmozhi and Panneerselvam 2013). Such ecosystem-based tourism activities can constitute a positive force for protecting wildlife and ecosystem services supporting local people (Balmford et al. 2002), though this depends on tourism income benefiting local people rather than being asymmetrically apportioned to commercial tourism and hospitality operators (Mladenov et al. 2007). Markets can provide powerful mechanisms for natural resource and ecosystem conservation around the world (TEEB 2010), particularly where direct regulation is ineffective (Mander and Everard 2008).

Payment for ecosystem services (PES) is emerging as a market-based approach to value and assign income to stewards of resources providing benefits to other constituencies. India is exploring introduction of its substantial forest resource into the global Reductions in Emissions from Forest Destruction and Degradation (REDD+) protocols under the Intergovernmental Panel on Climate Change (IPCC). Under REDD+, international payments from major emitters of climate-active gases are recycled to the stewards of designated forests in return for withholding exploitation and undertaking positive management. REDD+ is an unfolding programme in Uttarakhand, India's Ministry of Environment, Forest and Climate Change (MoEF&CC) initiating eight pilot REDD+ projects including one in Uttarakhand (at Mussoorie) (TERI 2015). PES approaches might also usefully be investigated for other services with clearly identifiable remote beneficiaries, such as those benefitting from water resource provision, flood risk attenuation, attractive landscapes, biodiversity, etc. often remote from where services are generated. Further development of PES schemes represents a significant opportunity (Bhatta et al. 2014). However, there are practical problems with quantifying and monitoring ecosystem service production to underpin the development and operation of an effective PES scheme, including appropriate sanctions (Meijerink 2008; Sommerville et al. 2011). Further difficulties are associated with the diversity of communities 'supplying' ecosystem services across a broad landscape and a lack of current awareness of often remote communities benefitting from them. Further difficulties are associated with the diversity of communities 'supplying' these services (Smith et al. 2013). A common solution for this is for the State to act as the primary customer, recirculating tax income on behalf of the different scattered constituencies of both suppliers and beneficiaries (Smith et al. 2013). This type of novel solution departs from a localised governance model and requires more detailed consideration and development that is beyond the scope of this paper.

Returning to the earlier observation about potential introduction of bias, future surveys could be improved by a number of measures including: interviews in a wider spectrum of villages; using the same researcher team for all surveys; and audio recording all responses enabling more detailed scrutiny post-interview as well as providing a raw resource available to future researchers. However, unquantifiable as any introduction of bias may have been, the consistency of observations between case study villages about general issues of declining agriculture and food security, out-migration, lack of local economic recycling, and negligible local appreciation of many supporting and regulatory services of benefit to remote constituencies suggests that key observations were consistent.

Conclusions

India's nested layers of governance, from federal to state to community-scale, is a long-running model for devolved decision-making in a geographically and culturally heterogeneous context. Van Panchayats and *Gram Sabha* represent long-standing devolved governance mechanisms supporting the sustainable use and management of forest and other natural resources supporting the needs of Indian village communities in the Himalayas.

Gaps in the operation and authority of these devolved governance arrangements are evidenced by the water demands of resort and second home developments, and also commercial extraction from Reserved Forests, allocated rights by higher tiers of government without the involvement of village resource stewards.

A clearer demarcation of village boundaries and responsibilities with respect to water, forest and other natural resource management between state and community needs to be drawn in order to involve the community in state-level management decisions affecting the resources supporting their continuing wellbeing.

Mountain ecosystems produce many ecosystems, including those that are consumed and understood by villagers and some that are not limited but that confer benefits to constituencies that may be distant from where the services are produced.

Declining food sufficiency in India's Himalayan villages derives from the activities of protected wildlife, driving out-migration of young males for income, though money remitted to villages is often spent on food also produced outside the mountain region with little local economic recirculation.

India's Himalayan village livelihoods are in effect maintained by income and purchase of goods from outside the region, and particularly urban centres and intensive agriculture in the plains. This represents major challenges if sustainable livelihoods are to be brought into balance with productive ecosystems.

Pressures are likely to intensify due to climate change, human population growth, urbanisation and globalisation trends, to which this system of governance will need to adapt.

Market-based approaches, including direct activities such as recreational angling, ecotourism and cultural tourism as well as indirect markets such as REDD+ and other payment for ecosystem services (PES) transactions, could be developed to enable local people to benefit from the ecosystems of which they are stewards, though this may require state intervention as an intermediary between 'provider' and 'beneficiary' constituencies.

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