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REPORT

Shifting to settled cultivation: Changing practices among the *Adis* in Central Arunachal Pradesh, north-east India

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Abstract In the hilly tropics, although shifting cultivation is a widespread practice, government policies have attempted to replace it with other land uses. However, several factors determine whether farming communities can make the shift. We tried understanding the factors that facilitate or impede the shift to settled cultivation through interviews with the Adi tribe in north-east India. Although settled cultivation was initiated in the 60s, about 90 % of the families still practise shifting cultivation, observing 13 festivals associated with the annual agricultural calendar. Our results indicate that the economic status of a household determined whether a family undertook settled cultivation, while labour availability was important for shifting cultivation. Often, these nuances are ignored in the Government policies. We conclude that future policies should be mindful of cultural and socio-economic factors that affect the community and of the social-ecological resilience of the landscapes and not use a one-size-fits-all strategy.

Keywords Swidden · Wet rice cultivation · Upper Siang district · Eastern Himalaya

INTRODUCTION

Shifting cultivation or swidden is an agricultural practice as old as the Neolithic, involving long fallow periods that allow soil fertility to recover after 1–2 years of agriculture (Conklin 1961; Spencer 1966). It is characteristic of the nutrient-poor soils of tropical forests, where cultivated lands may require years or decades to become agriculturally productive again (Richards 1952). The practice is labour intensive involving a series of activities from forest clearing to cultivating, harvesting and processing, and dominates the labour calendar of communities that engage in it (Dove 1985). In addition, many tropical forest communities draw strong links between swidden agriculture and their own cultural identity (Ramakrishnan 1992). Several early studies of shifting cultivation as a land use practice concluded that it is highly wasteful, unproductive and required huge swathes of land that could be more effectively used (Borah and Goswami 1973; Bandy et al. 1993; Lianzela 1997; Ranjan and Upadhyay 1999). While, on one hand, its efficacy as a system of production was being questioned, on the other, tropical conservation scientists also saw this as an assault on biological diversity and ecological function (WRI 1985; Bandy et al. 1993; Kotto-Same et al. 1997; Sivakumar and Valentin 1997; Ranjan and Upadhyay 1999). As human populations grew and land became an increasingly scarce resource, fallow periods have also been reducing, potentially reducing the overall productivity of the system, while encouraging previously virgin forests to be converted to agriculture (Ramakrishnan 1992). Other authors take a more nuanced view of this form of agriculture, suggesting that productivity regimes of local crops under swidden may compare well with more market-based monoculture crops (Divakar 1990; Ramakrishnan 1992; Maithani 2005; Nielsen et al. 2006), and that carbon sequestration may be higher in swidden than in monoculture plantations (Fox et al. 2011). In addition, there is an active debate about the relative costs of this form of land use to forests and agro-biodiversity (Watters 1971; Gadgil and Guha 1992; Ramakrishnan 1992; Fox 2000).

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Unmindful of this debate, governments in many parts of the tropics have made active attempts to reduce dependence on this form of land use (O'Brien 2002; Ickowitz 2006; Fox et al. 2009; Rerkasem et al. 2009). Notwithstanding these efforts, swidden is still an integral part of many farming communities' lifestyle and provides resilience during periods of market fluctuation (Cramb et al. 2009). Rather than giving up swidden completely, communities adopt new practices and engage with markets while continuing the practice within a composite farming system, defined by Rambo (1996) in the South-east Asian context as a system in which swidden, settled cultivation, home gardens and tree-based cultivation are undertaken collectively in a landscape (Cairns and Brookfield 2011).

In the Indian north-east, where the practice is locally referred to as *Jhum*, interventions to shift local communities away from the practice towards more intensive settled agriculture have been prevailing for the last six decades (Malik 2003; Maithani 2005). These include irrigation schemes, training programmes, seed and fertilizer subsidies, encouraging mechanization and creating links to agricultural marketplaces (Maithani 2005). As a result of this sustained push, there has been a several-fold increase in the uptake of settled agriculture in many north-east states (Dikshit and Dikshit 2014). However, while the area under settled agriculture has certainly increased, the area under shifting cultivation has not significantly reduced since these programmes began. In the late 2000s, about a tenth of the net sown area in the region was under shifting cultivation, while in the hill states where the practice is more common, a fifth was under shifting cultivation (Wasteland Atlas 2000 2008–2009; Anonymous 2012) This raises the question as to how a system considered economically unprofitable and labour intensive can be resilient to 60 years of systematic efforts to abolish it.

A majority of the 26 tribes inhabiting the state of Arunachal Pradesh in north-east India are dependent on the practice, although most farming communities have more recently taken up settled cultivation as well. A few of the tribes such as the *Apatanis*, the *Singphos* and the *Khamptis* have been practising settled cultivation for longer periods since they settled in river valleys and plateaus with suitable terrain (Das 1997). The estimates of the overall area under shifting cultivation in the State are inconsistent; nevertheless, the evident trend seems to be an increase in area under settled cultivation and a decline in the area under shifting cultivation (Table S1). While area under settled cultivation tripled between the early 1970s to the late 1990s, shifting cultivation is still being undertaken in over 50 % of the net sown area (Anonymous 2012). The increase in area under settled cultivation is due to cultivable lands being opened up as part of developmental policies and interventions, better access due to roads, access to capital (Das 1997) and access to more labour due to recent migration of labourers from other States (Roy 1997).

The factors that determine how communities use their natural resources may derive not merely from economic expediency or technological feasibility. A host of complex socio-cultural factors may work together with these practical considerations in driving resource use patterns (Mertz et al. 2009). Often, these practices are an essential part of a 'way of life', linked to tradition, ritual and cultural identity (Ramakrishnan 1992; Murtem et al. 2008), and communities may be unwilling to shift away from these practices since they are likely to associate this shift with a larger social decay. Understanding how these factors interact can give us insights on how local communities manage their natural assets in the face of external and internal change.

To this end, we studied the socio-economic and cultural factors associated with swidden and settled agriculture in the *Adi* tribe in central Arunachal Pradesh. This is a community that has traditionally practised swidden, although more recently settled agriculture is becoming important in these areas. We used household-based surveys and key-informant interviews in five villages in the Upper Siang district to document the drivers of changes in land use practice in these landscapes.

STUDY AREA AND METHODS

The *Adi* tribe, the second most populous group in Arunachal Pradesh, inhabits East, Upper and West Siang and Dibang valley districts in Arunachal Pradesh. The *Adis* belong to the Tibeto-Mongoloid group of tribes and as among other tribes of north-east India, they exercise customary rights over their natural resources (Borang 1997; Raj 2010). Settled cultivation options have been available to them for relatively long; the British introduced the practice close to the Assam plains in the 1900s, but the practice has been taken up more extensively only recently (Bhattacharya 1965).

Study area

The Upper Siang district (located between 28.13°–29.34°N and 94.17°–95.40°E) was carved out of the larger East Siang district in the year 1994 and adjoins the international boundary with Tibet (Fig. 1). This remote district has a low human population density (5 people per km^2, Census of India 2011) and a relatively high forest cover of about 80 % (FSI 2011). A large part of the Mouling National Park (area: 483 km^2), which is part of the Dihang-Dibang Biosphere Reserve (area: 5112 km^2), lies in Upper Siang. Several subtribes of the *Adi* tribe inhabit the district as well as the

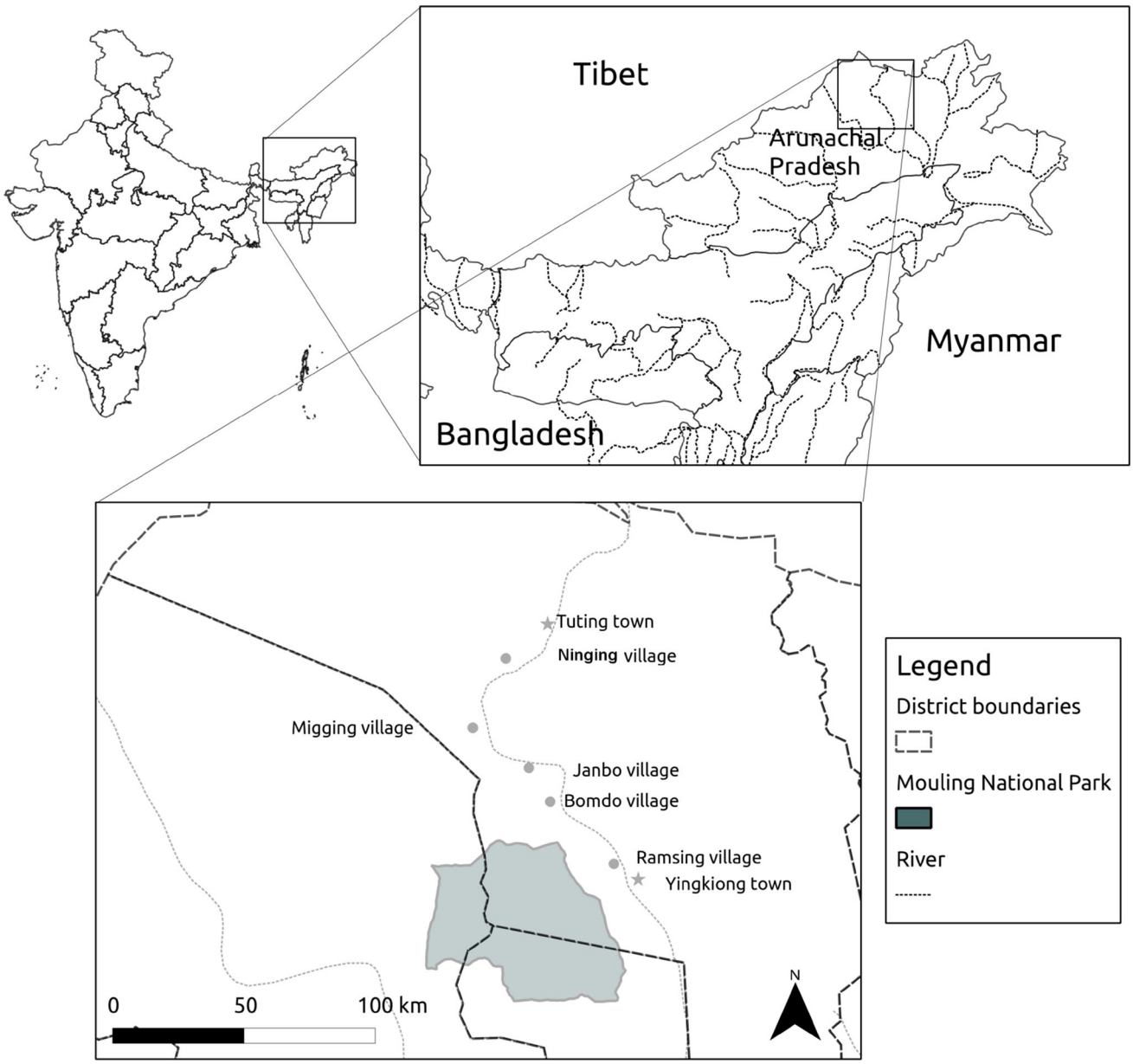

Fig. 1 Study area with locations of the villages where the interviews were conducted, the Mouling National Park and the Siang River in Arunachal Pradesh, North-east India

Memba, *Khamba* and *Idu Mishmi* tribes. Our research was conducted in four villages of the *Ashing* sub-tribe: Ningging, Miging, Janbo and Bomdo and one village of the *Karko* sub-tribe, Ramsing. Bomdo and Janbo are the oldest settlements in the region and the villages found north of these villages up to the international boundary with Tibet are satellite villages of these. These two villages also fall within the important north–south migration route of various sub-tribes of the *Adis* (Bhattacharya 1965; Roy 1966; Nyori 1993). The study villages are located between Yingkiong and Tuting towns, and the communities inhabiting these villages are fairly homogeneous in terms of their agricultural practices.

Shifting cultivation by the *Adis* in the region is undertaken in large blocks surrounding the villages and the fallow period ranges from 10 to 16 years (Borang 1997). Land within the jurisdiction of a village is communally owned with individual plots owned by families and inherited from generation to generation (Teegalapalli and Datta in press). In the study area, settled cultivation was undertaken in the valleys in sites where irrigation by canals was possible, while shifting cultivation was undertaken by clearing the secondary forests in the hillslopes around villages. Primary forest was rarely cleared for cultivation (Teegalapalli and Datta in press). As in other sites in north-east India,

undertaking settled cultivation involved considerable initial investment for building stone walls as well as continuing investments such as purchasing seeds and fertilizers (Rasul and Thapa 2003; Jamir 2015). Villages closer to Yingkiong town had better access to markets than villages further north (Fig. 1).

Data collection

Household surveys and interviews in study villages

In each of the five study villages, approval to conduct interviews was initially taken from the head of the village and the purpose of the research was explained. Broad-level information, covering at least 10 % of the households of each village, regarding their shifting and settled cultivation practice, changes to the practice in the last decade, use of chemicals as fertilizers or weedicides and alternate economic options, was collected from the five villages based on structured interviews (see Table S2 for the questionnaire, Table 1 for village details). We used a snowball sampling method of interviews starting with the village head, who referred us to other households to interview. As far as was logistically feasible, in each village, we interviewed people from different economic strata in the village; individuals with regular Government jobs such as teachers at school, individuals who regularly undertook Government contracts and subsistence farmers, since we expected the economic status to affect the agricultural practice undertaken. In all, 47 interviews were conducted in five villages between January and May 2011.

Key-informant and participant observation surveys in Bomdo village

The first author also obtained general information regarding *Adi* festivals, agricultural calendar, crop diversity and farming practices from Bomdo village during relatively long stays in the village (November–May, every year for 3 years). Information regarding festivals was collected based on open-ended interviews with village headmen/elders and two key informants. A complete agricultural calendar year was covered from field site selection to the harvesting period. Information regarding the crop diversity and farming practices was collected as well as participant observations made during agricultural operations and festivals during the period of residence in the village. Detailed information regarding the number of household members, economic status, overall area under shifting and settled cultivation owned by individual households (74 households) was collected from a key informant (Gram Panchayat Chairman) from Bomdo village and verified from village headmen/elders.

Analytical methods

The number of members in a household partaking in shifting cultivation activities was considered as the labour availability. The economic status of each household was categorized into high, intermediate and low using the following criteria: (1) high—households with one or more members employed in a regular Government job (such as a teacher in the village school); (2) intermediate—households with members undertaking developmental contracts issued by the Government or with a wage labour job (such as road building by the Border Road Organisation); and (3) low—economy based only on agriculture. The two variables, collected from 47 households in five villages, labour availability and economic status were used in a Generalized Linear Model (GLM) with the area of land under settled cultivation and area under shifting cultivation (in the year 2011) as the response variables. Within Bomdo village, with data from all 74 households, a GLM was used with the area under settled cultivation as the response variable and labour availability and economic status as the predictor variables. The data on area of land under shifting cultivation available for each household were over-dispersed, therefore, for the GLM analysis, we used the quasi-Poisson family of distribution for the response variable.

Table 1 Details of the villages where village-level interviews were conducted

Name of village	Number of households	Population	Adi sub-tribe	Number of interviews conducted
Ramsing	67	313	Karko	8
Bomdo[a]	74	394	Ashing	11
Janbo	59	289	Ashing	10
Migging	69	416	Ashing	10
Ninging	58	364	Ashing	8

[a] Questionnaire surveys were conducted in 11 households in Bomdo village. Additional information regarding area under settled cultivation, labour availability and economic status was collected from all 74 households in Bomdo through key-informant surveys

RESULTS

Overall patterns

Shifting as well as settled cultivation was widely practised in the study villages. While settled cultivation was practised by 45 of the 47 households, shifting cultivation was practised by 42 households and about 85 % of the households undertook both. In Bomdo village (the intensively surveyed village), 62 and 69 out of 74 households undertook shifting and settled cultivation, respectively, and 57 households undertook both practices. Each household in the five villages surveyed had, on average, six members with at least two members participating in farming (shifting and/or settled cultivation). Among these households, shifting cultivation was undertaken in groups: about 12 families undertook shifting cultivation together with a fallow period of at least 10 years and the cultivation phase lasted for 2 years. Although our snowball sampling method resulted in a non-representative sample, given that we sampled at least 10 % of the households in each village, we present the average values of some parameters. The average distance of a shifting cultivation field from the households surveyed was 4.6 ± 0.4 km (mean $\pm$ SE). In the year 2011, shifting cultivation was undertaken over an average area of 1.26 ha ($\pm$0.13) by each household, and an area of 1.86 ha ($\pm$0.22) of settled or wet rice cultivation land was owned by each family. The previous years' overall rice production from settled cultivation (705.2 kg ha^{-1} $\pm$ 115.73) was only marginally higher than that from shifting cultivation among the households surveyed (616.6 kg ha^{-1} $\pm$ 94.63, $N = 47$).

Community agricultural practices

Shifting cultivation was largely undertaken by the women of the *Adi* community who regularly visit the fields, undertake weeding 2–3 times during the agricultural cycle and regularly bring back firewood from the fields. The men undertook the tasks of clearing the forest and burning the fields and also often took part in fencing the fields, weeding, sowing, harvesting and carrying back the harvest. The entire village collectively undertook activities such as burning and fencing, and families related by clan worked co-operatively on strenuous activities such as sowing, harvesting and carrying back the harvest. While shifting cultivation was undertaken from March–April to October–November, settled cultivation was undertaken between the months of May–June to October–November.

According to two older respondents, settled cultivation was first undertaken in Ramsing and Janbo villages in the 1960s. Settled cultivation was preferred by the respondents due to relatively less labour involved. Two of the respondents from Bomdo village had purchased land that was relatively far (about 10 km road distance) from the neighbouring Ramsing village, where the land is more suitable for settled cultivation. However, shifting cultivation was considered more important for greater crop diversity—for growing millets and vegetables. Chemicals were more regularly used in settled cultivation fields: 40 of the 47 households used Roundup weedicide during settled cultivation (brand name for the chemical glyphosate *N*-phosphonomethyl glycine), while only 18 of the respondents used the chemical in shifting cultivation fields for weeding.

Economic options

Only four of the 47 respondents mentioned the lack of economic options. Availability of various schemes and contracts brought in by the Government and private companies was the most important economic option for the communities in the Upper Siang district ($N = 29$). Ginger cultivation was the second most availed economic option with 16 respondents marketing locally grown ginger, while livestock such as pigs and mithun (*Bos frontalis*) were also sold in the nearest available markets ($N = 8$). Few households had members with regular income from Government jobs (4) and as teachers at the local school (2). Sale of ginger, fruits, locally grown rice and even handicrafts was an option availed by households in Ramsing, the village closest to Yingkiong town. Contrasting this, the households in more remote northern villages, such as Ningging, were involved in selling woodlots collected from the fallows and secondary forests and stones from the Siang river bank to the more remote town of Tuting, close to the international border with Tibet. Households in one of the villages had additional economic options to undertake wage labour and contracts at a hydro-electric project being planned in the area by a private company.

Recent changes in shifting cultivation practices

The most important change in the agricultural practice was that in the last decade chemical weedicides such as Roundup were being used ($N = 18$). Eleven respondents mentioned that currently sites closer to the village are preferred for shifting cultivation and only two respondents mentioned that fallow periods have declined. Nine respondents mentioned that no changes in the shifting cultivation practice have occurred in the last decade, while four of the respondents mentioned that the practice of shifting cultivation has declined and that of settled cultivation has increased.

Agro-diversity in shifting cultivation fields

From the interviews in Bomdo village, we estimated that sixteen varieties of rice are cultivated in the region: seven

in shifting cultivation and nine in settled cultivation. Some varieties are drought resistant, while others are resistant to high rainfall. These are planted to cover variations in annual rainfall, although the region tends to have relatively high rainfall (approx. 4300 mm annually). Over 30 different varieties of vegetables are grown as well as tubers such as yam and sweet potato, corn, sugarcane and two varieties of millets. Plants such as chillies, brinjals, yam and ginger, among others, are harvested from fallows that are up to 3 years old after cultivation suspension.

Festivals associated with shifting cultivation

Thirteen different festivals related to shifting cultivation are observed by the *Adis* (Table 2). The agricultural cycle begins with the *Aran* festival observed in February followed by the slashing of forests in late February. These festivals correspond with the activities undertaken during shifting cultivation: slashing, burning, fencing, sowing of seeds, weeding and harvesting. These festivals involve warding away evil spirits and appeasing good spirits to strengthen the plants, ensure a good crop and protect their crops from pests.

Quantitative results

Across villages

Across the five villages surveyed, the households with lower economic status had larger areas under shifting cultivation [1.56 ha (mean), $N = 11$] and households with higher economic status had larger areas under settled cultivation [2.12 ha (mean), $N = 9$, Table 3]. In terms of labour availability, households with high labour availability had larger area under shifting cultivation [2.17 ha (mean), $N = 6$]. The GLM results also indicated that the area cultivated was significantly affected by the availability of labour, i.e. larger areas were cultivated by families with more household members participating in shifting cultivation ($p < 0.05$, Table 4a).

Within a village

Settled cultivation has been systematically undertaken in Bomdo village since the year 2000, after two canals were built through a Government scheme to provide irrigation to the fields. Before these canals were built, there were only a few fields where irrigation was possible by diverting natural streams. A majority of the 74 households in Bomdo (77 %) currently practise both shifting and settled cultivation. Relatively few households undertake only one of the practices; 12 households undertake only settled cultivation and 5 households undertake only shifting cultivation. Results of the Generalized Linear Model indicated that households in the lowest economic category had the least area under settled cultivation ($p < 0.05$, Table 4b).

DISCUSSION

Persistence of swidden

Across the Upper Siang district, while settled agriculture has seen an increase, shifting cultivation is still actively

Table 2 Festivals associated with shifting cultivation, their significance and the activities involved

S. no.	Name	Month	Link to agriculture	Description
1	Aran	February (mid)	Marks the beginning of the agricultural cycle	Gifts offered to ancestors and relatives
2	Roje	February (late)	Related to field preparation	Slashing of secondary forests undertaken
3	Ettor	March (early)	Related to crop protection	Fencing of fields undertaken communally
4	Pombui	March	Related to field preparation	–
5	Mopin	March (late)	Related to field preparation	Predicting the fate of the agricultural season using a *shaman*
6	Pyne	May (early)	Related to burning of fields and planting	Festival prior to burning and planting in the case of shifting cultivation and planting in the case of settled cultivation
7	Dinya taku	May	Related to crop germination	Planted fields inspected for new shoots
8	Solung	May (late)	Related to harvest	Prayers offered to spirits for a healthy crop
9	Kabey	June (early)	Related to harvest	Evil spirits are warded away to ensure a healthy crop
10	Aligudung	July	Related to weeding	Weeding of fields undertaken after this festival
11	Takkin	July (late)	Related to pest prevention	Prayers offered to spirits, pest-infected crops removed
12	Leeday	September	Related to harvest	Stoned tied to few crops to symbolize strength and prayers offered to spirits
13	Dokang	October (late)	Related to harvest	Some newly ripe rice is harvested, prepared and eaten

The *shaman* is the medicine-man in a village who is often consulted for foretelling future events

Table 3 Average area under cultivation (in ha) per household in different categories in five villages in the Upper Siang district, Eastern Himalaya, India. Labour availability was categorized as low (1–2 members, $N = 33$), medium (3 members, $N = 8$) and high (4–6 members, $N = 6$), and economic status of households was categorized as low (only agriculture, $N = 9$), medium (with government contracts or wage labour jobs, $N = 29$) and high (employment in permanent government job, $N = 9$)

	Low		Medium		High	
	Shifting cultivation (ha)	Settled cultivation (ha)	Shifting cultivation (ha)	Settled cultivation (ha)	Shifting cultivation (ha)	Settled cultivation (ha)
Labour availability	1.16	1.62	1.19	2.37	2.17	2.4
Economic status	1.44	1.54	1.23	1.86	1.33	2.12

Table 4 Results of the Generalized Linear Model (4a) with annual area under shifting cultivation (2011) as the dependent variable and economic status and labour availability as predictor variables. Data from 47 households in 5 villages. 4b lists the results of the Generalized Linear Model with area under settled cultivation as the dependent variable and economic status and labour availability as the predictor variables. Data from 74 households in Bomdo village (* $p < 0.05$)

	Estimate	SE	*t* value	*p*
(4a) Across five villages				
Intercept	8.93	0.30	29.85	0
Labour availability	0.22	0.08	2.78	0.008*
Low economic status	0.07	0.29	0.25	0.80
Medium economic status	−0.07	0.25	−0.27	0.79
(4b) Within a village				
Intercept	1.87	0.43	4.39	0
Labour availability	0.16	0.14	1.18	0.24
Low economic status	−0.88	0.27	−3.21	0.002*
High economic status	0.2	0.42	0.49	0.63

practised: about a third of the cropped area was under shifting cultivation in the 2000s (Wasteland Atlas 2000 2008–2009; Anonymous 2012). Ninety percent of the households interviewed from the five villages practised shifting cultivation, although settled cultivation was introduced to the landscape in the early 60s. Settled cultivation was also being practised by *Shimongs*, another sub-tribe of the *Adi* community on the opposite bank of the Siang river from the same period (Bhattacharya 1965). Despite the potentially higher yield, lower labour requirements and economic incentives for settled agriculture, swidden is still the mainstay of the region pointing to the resilience of the activity. The practice is intricately linked with the land and the people in a multitude of ways, some of which we discuss here.

Social capital

Shifting cultivation is a collective exercise: while the activity of weeding is undertaken by members of the family, most of the other agricultural operations such as slashing, burning, fencing, sowing, harvesting and carrying back the harvest are all group activities undertaken with the clan members or members from the entire village (Cairns and Brookfield 2011). The swidden fields are also cultivated by the *Adi* collectively, at least 12 households cultivated together. This results in better monitoring of the fields and labour sharing as well as nurtures community bonding. Working collectively has been shown to be an important strength of remote communities that live in mountainous regions and improves the social capital (MacDonald 1998; Swinton 2000). Nyori (1993) described at least three ways in which labour sharing takes place among the *Adi*: close relatives of the family may help each other with the expectation of co-operation if faced with similar requirements, labour that is received conditional on returns in cash, kind or labour and help received based on strictly cash payment. Labour sharing is common among other farming communities as well. Dove (1985) documented similar labour sharing systems in *Dayak* farming communities in West Kalimantan, Indonesia. Further, as shown by several studies as well as ours, tasks undertaken by both sexes contribute significantly to the practice and this aspect of shifting cultivation systems has been appreciated by several researchers (Thrupp et al. 1997; Colfer 2008; Colfer et al. 2015).

Cultural relevance

The *Adi* community still holds deep links of identity with swidden, and their cultural calendar is dominated by festivals and rituals that draw meaning from the practice. Couched within ancestor worship or appeasement rites for weather and fertility gods, the calendar plays an important role in marking critical events associated with the swidden year. On one hand, these rituals may be essential as a community bonding exercise particularly in an enterprise that requires co-operative behaviour, which is the character of shifting cultivation. On the other, these rituals take on a meaning and function of their own, serving as a rich source of self-identity and sense of place. Together with other socio-economic factors, this may be an important driver sustaining swidden in the district.

Environmental suitability

In the hilly tropics, swidden is better suited to the physical environment than settled forms of cultivation owing to the mountainous terrain. Further, a farmer can face significant losses due to the high initial investments if fields are lost to floods and landslides, an instance of which was recorded during this study, while swidden-associated losses to such disasters are temporary. The terrain in the hilly parts of north-east India is one of the reasons several swidden control schemes initiated by the Government have not been completely successful (Rasul and Thapa 2003; Maithani 2005).

Dependence on agro-diversity

The agro-diversity in swidden is another factor that makes the practice attractive to farmers. Besides the 30 varieties of vegetables grown during active cultivation, vegetables are also harvested from fallow swidden fields. The variety of millet (finger millet, *Eleusine coracana*) and the sticky variety of rice (*Oryza sativa var. glutinosa*) used to prepare alcoholic beverages and rice cakes which form an integral part of most festivals are grown only in shifting cultivation fields. This diversity of crops grown in swidden fields also performs the significant function of providing food security to the farmers. Agro-diversity has been suggested to be strongly linked with food security (Thrupp 2000). This benefit of the shifting cultivation system has been documented from several case studies across Asia in a report prepared by the Food and Agriculture Organization (Erni 2015). From the West Siang district, it was documented that 72 crops are cultivated by the *Adis* including cereals, vegetables, pulses, spices and condiments (Yumnam et al. 2011). In the neighbouring state of Nagaland, Nakro (2011) recorded, on average, about 41 crops in shifting cultivation fields, whereas some households cultivated up to 60 crops, which included eight varieties of rice in shifting cultivation and six varieties in terraced cultivation. Agro-diversity facilitates risk minimization and return maximisation as well as promotes diet diversity even with relatively low levels of technology (Harwood 1979; MacDonald 1998).

All these factors suggest that more than merely a form of agricultural production, swidden still continues to be a strongly held cultural construct with the *Adi* communities, associated with a sense of season and place, identity and belonging, and a long historical and cultural connection with the land. In this context, changes in land use practices, with the increasing dominance of settled agriculture, could have unintended consequences of eroding the cultural bonds that potentially confer these social-ecological systems with considerable resilience in the face of multiple forces of change.

Shifting to settled cultivation

The key disincentives to settled agriculture included the lack of economic means for the initial investment and regular purchase of chemical weedicides and dependence of the communities on a diversity of crops customized to grow in shifting cultivation sites. The area owned by a household for settled cultivation was affected by the economic status of the family: households with better economic status had larger areas under settled cultivation. From Bomdo village, the five households that were completely dependent on shifting cultivation were of low economic status. This indicates that the inability to make the initial investment is another limiting factor affecting the shift to settled cultivation. Chemical weedicides, such as Roundup, were also more common in settled cultivation fields, which add to the investment needed in the practice. The terrain could also be an important factor that decides whether a household takes up settled cultivation; two households from the intensively surveyed village reported that they undertook agriculture in the neighbouring village area by purchasing land suitable for settled cultivation.

Settled or terrace cultivation fields are also suitable for only growing rice; for an entire transformation to such a practice, farmers will also need to be trained in maintaining kitchen gardens where other vegetable crops can be grown. An instance of failure of an earlier project in the Siang districts initiated by the Indian Government around four decades ago is provided by Neog (1997). The expensive project ($0.2 million) faced implementation problems such as inadequate irrigation, lack of seed supply and fertilizers and improper selection of sites, but the key reason cited for the failure was that settled cultivation could not provide all the crops that are grown in swidden fields (Neog 1997).

Other nuances, such as shifting cultivation being a communal enterprise whereas settled cultivation being a more individualized form of land use, make a complete shift impractical too. Farmers are also intricately linked to their culture in the form of festivals that are observed throughout the swidden agricultural cycle. In Bomdo village, some adaptations include sowing rice in settled cultivation fields in nursery beds on the day rice is sown in shifting cultivation fields and later transplanting the seedlings into the fields. Some even suggest that farmers can only shift to settled cultivation when the cropping system blends with the traditional festivals (Jha 1997).

Our interviews indicate that the communities in the district increasingly prefer settled cultivation. However, rather than completely giving up shifting cultivation, the *Adi* communities have adopted a 'best-of-both-worlds' strategy; they supplement the production of rice by undertaking settled cultivation and continue traditional farming for other crops and for other benefits. Farming communities across the world have been known to innovate and adapt to changing conditions and to take advantage of available opportunities rather than completely abandon their traditional shifting cultivation practices (Cairns and Garrity 1999; Seidenberg et al. 2003; Padoch et al. 2007).

CONCLUSION

The present day Government schemes are still a legacy of the way shifting cultivation was perceived in the British colonial times which continued during the post-independence period: a need for 'improvement' of land use to 'better' and economically more productive systems was emphasized. In the last decade, schemes such as the Integrated Watershed Management Programme (IWMP) that consider shifting cultivation lands as wastelands have focused on converting these lands into cash crop and horticulture cultivation in Upper, West and East Siang districts. Often schemes, which may not have perceivable local relevance, are welcomed by the States since they result in flow of funds from the Central Government to the State (Maithani 2005). Within our study area in Upper Siang district, an area of 5000 ha was being targeted to provide settled cultivation options to communities in the late 2000s (Anonymous 2004). In the neighbouring East Siang district, the Arunachal Pradesh Government has signed a memorandum of understanding with a private company to grow oil palm (*Elaeis guineensis*) in over 5000 ha in 2014 (Anonymous 2014). These various schemes and projects largely fail to acknowledge the links to the land and with shifting cultivation that people have and there is a need for these schemes to be tailored depending on how integrated the practice is within the communities' economy, culture and lifestyle (Padoch et al. 2007; Teegalapalli and Datta in press).

Given the larger debate over the relative efficacy and biological impact of different forms of agriculture in this region, efforts to push communities towards settled agriculture need to proceed with caution. While communities may already be on this path, driven by changing aspirations and integration with global marketplaces, policy makers must acknowledge that traditional forms of land use may not necessarily be less effective given the natural limitations the geography provides. Shifting away from these land use systems may also inadvertently trigger a more insidious erosion of community identity and social bonds which could have much more significant impacts on the social-ecological resilience of these landscapes, making them much more prone to the vicissitudes of market forces and the inherent uncertainties of monoculture cropping systems (such as disease, pests and reliance on chemicals). Such instances have been well documented from sites in South-east Asia where the ingress of monoculture oil palm plantations has had negative socio-economic impacts on shifting cultivation farmers in the last few decades (Carlson et al. 2012; Obidzinski et al. 2012).

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