Traditional knowledge and biocultural diversity: learning from tribal communities for sustainable development in northeast India

Ranjay K. Singh [a] , Jules Pretty [b] & Sarah Pilgrim [b]

[a] Department of Extension Education & Rural Sociology, College of Horticulture & Forestry, Central Agricultural University, Pasighat, 791102, Arunachal Pradesh, India

[b] Department of Biological Sciences, University of Essex, Wivenhoe Park, Colchester, Essex, CO4 3SQ, UK

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Ranjay K. Singh[a]*, Jules Pretty[b] and Sarah Pilgrim[b]

[a]*Department of Extension Education & Rural Sociology, College of Horticulture & Forestry, Central Agricultural University, Pasighat 791102, Arunachal Pradesh, India;* [b]*Department of Biological Sciences, University of Essex, Wivenhoe Park, Colchester, Essex CO4 3SQ, UK*

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This paper presents a synthesis of grassroots activities designed to promote the learning and conservation of traditional knowledge and related biocultural resources among *Adi, Monpa* and *Khasi* tribes of northeast India. The results indicate that the participation of knowledge holders in various village level activities can enhance the promotion of traditional practices, learning of knowledge and conservation of related resources. Knowledge holders of varying age groups and social systems have many notable traditional practices that provide promising solutions to current challenges. The promotion of traditional knowledge-based products can also facilitate the conservation of resources and the subsistence survival of people. Strong multi-level networks between all stakeholders are needed to ensure the sustainability of traditional knowledge and conservation of biocultural resources of communities of northeast India.

Keywords: traditional knowledge; biocultural diversity; conservation; livelihoods; sustainable development; northeast India

1. Introduction

Traditional knowledge (TK) is a body of knowledge accrued within a group of people across generations of close contact with nature. It is a local and cumulative body of knowledge, practices and beliefs held by local people (Turner and Berkes 2006). It evolves through adaptation to local environmental circumstances, and is handed down through generations by different forms of cultural transmission (Berkes 2009, Berkes and Berkes 2009). It may contain knowledge and practices concerning food, medicines, hunting, fishing, agriculture, home gardening, handicrafts and other skills developed to sustain the local population (Turner 2005, Mishra *et al*. 2009, Singh *et al*. 2009a). TK and biocultural diversity are interwoven with each other and can be essential components to ensure the sustainable development of communities living in mountain ecosystems (Braton 1989, Agrawal and Gibson 1999). Biocultural diversity comprises the variability of biological species and ecosystems, and the distinctiveness of cultural groups who interact with these resources (Posey 1999, Cocks 2006, Berkes 2009, Berkes and Berkes 2009, Singh and Srivastava 2009).

Despite the importance of TK however, the erosion of this knowledge base has been observed in many communities across different countries due to socio-political

changes and development pressures, marketisation and commodification (Swiderska 2006, Pilgrim *et al*. 2007, Turner and Turner 2007, Singh *et al*. 2009a). It is important to assess the value of biocultural diversity and associated TK in relation to learning and conservation (Berkes 2009, Berkes and Berkes 2009) whilst protecting the intellectual property rights (IPR) of communities (Singh *et al*. 2009a, Singh and Srivastava 2009). The growing need to conserve TK and biocultural diversity is now widely recognised and of growing concern (Pretty 2003, 2007, Pilgrim *et al*. 2007).

The northeastern (NE) region of India is considered one of the most bioculturally diverse regions of India (Yumnam 2008, Singh and Srivastava 2009). Diverse communities, traditional agriculture, governance of resources through indigenous institutions, a high degree of forest dependency, and the use of ethnic foods and medicines have resulted in a rich heritage of culturally-embedded TK (Singh and Sureja 2006). This has the potential not only to protect biodiversity and ecological functioning (Ramakrishnan *et al*. 1996, 2002, Singh and Sureja 2006), but also to sustain the cultural diversity of NE India (Singh 2004, Singh and Srivastava 2009).

The women in this region are major stakeholders and custodians of knowledge, conserving food and medicinal plants in both *jhum* land and home gardens (Singh 2004, Mishra *et al*. 2009). Working with and studying tribal women can advance our understanding of community TK, including its typology and status among different age and social groups (Turner and Turner 2007, Mishra *et al*. 2009). It can also facilitate the development of sustainable technologies and products and could contribute to sustaining the biocultural resources and livelihood systems that persist (Ramakrishnan *et al*. 1996, 2002, Singh *et al*. 2009a).

Despite the rich knowledge of women, and their role in conserving biocultural diversity as experimenters, conservators and stabilisers of foods, medicines and other indigenous resources, their contribution is rarely recognised at policy level (Swaminathan 1998, Singh, A. 2007, Singh, R.K. 2007). Moreover, centrally formulated policies and technologies on resource conservation have tended to be implemented without due recognition and participation of local people and their indigenous institutions (Agrawal and Gibson 1999, Ramakrishnan, 2005, 2007). Governments have rarely played a significant role in assessing the erosion of TK, including implications for the conservation of biodiversity (particularly among younger generations) and the livelihoods of tribal people (Singh and Srivastava 2009).

2. Objectives

The objectives of this study were to (1) identify community knowledge holders and document their TK; (2) promote conservation of TK related biocultural resources through educational activities (recipe[1] and biodiversity contests[2]); (3) establish village traditional knowledge banks (VTKB[3]) and community knowledge gardens (CKG[4]) in a participatory manner to enhance biodiversity conservation and promote TK based micro-enterprise; and (4) organise workshops in order to facilitate knowledge holders and discuss various issues relating to TK.

3. Ethnography of projects areas

The NE of India, the seven sisters state, consists of Assam, Arunachal Pradesh, Nagaland, Tripura, Mizoram, Meghalaya and Manipur. Its 2000 km perimeter borders with Bhutan, China, Myanmar and Bangladesh. It is connected to the rest of

India by a narrow 20 km wide corridor of land. The NE region is one of the most bioculturally diverse parts of India, with each state having distinct cultures and traditions. This region is the home to more than 166 distinct tribes speaking a wide range of languages (APHDR, 2005), as well as a diverse range of habitats for thousands of species of flora and fauna (Yumnam 2008).

Meghalaya state is bounded on the north by Assam state and on the south by Bangladesh. The state has three major tribes, namely *Garo, Khasi* and *Jaintia* living on the western, central and eastern hills of Meghalaya. The *Khasi* tribe depends primarily on agriculture and forest resources for their survival. This community raise pigs, cattle, sheep, goats, poultry, ducks and undertakes fish farming, practises *jhum* agriculture (slash and burn agriculture) for the cultivation of local crops, while settled cultivation is performed for the horticulture crops (pineapple, banana, citrus, etc.) and long-duration paddy.

Arunachal Pradesh is a forbidding and formidable state of NE India. It covers 83,743 sq. km with Bhutan to the west, Tibet and China to the north, Myanmar to the east and the Indian states of Nagaland and Assam to the southeast and south. The state is considered one of the richest and most biodiverse regions in the country, bestowed with a wide range of virgin forests full of diverse plant resources (Mahanta and Tiwari 2005) and indigenous crop species cultivated under *jhum* and in home gardens (Singh, A. 2007, Singh, R.K. 2007). The state is home to 26 tribes and 110 ethnic groups. Among them, the main tribal communities are *Adi, Nyshi, Monpa, Tagin, Idu, Khampti, Tangsa, Nocte, Singpho, Mishmi, Miji, Wancho, Apatani, Aka, Sherdukpen, Khawa*, and *Hill Miri* (Mahanta and Tiwari 2005). These tribes reside in the forest and depend heavily on it for their socio-cultural, food and livelihood requirements (Singh and Srivastava 2009). *Jhum* cultivation is a widely practised farming system among most of the tribes of Arunachal Pradesh.

This project focused on *Adi* and *Monpa* tribes in Arunachal Pradesh. The *Adi* tribe practice *jhum* cultivation and depend heavily on forest resources using subsistence-based practices, including trapping and hunting (Singh, R.K. 2007). Rice, the meat of wild animals and a large number of wild plant species collected from the forest and *jhum*-land serve as their staple foods (Singh, A. 2007, Singh, R.K. 2007). The *Monpa* tribes are mostly found in the West Kameng and Tawang districts of Arunachal Pradesh. *Monpas* are Buddhists with close cultural and religious affinities with Bhutanese and Tibetans. *Monpas* depend on traditional agriculture with subsistence horticulture farming and conserve more than 32 indigenous land races for their subsistence (Singh 2004, Singh *et al*. 2007). The economy of *Monpas* is agrarian-based, and indigenous institutions play a pivotal role in the governance and management of natural resources (Singh and Sureja 2006).

4. Approach and methods of projects implementation

This research was carried out in East Siang, West Kameng and Tawang districts of Arunachal Pradesh, and Ribhoi districts of Meghalaya states (Figure 1) between 2003 and 2008. Four projects were implemented on the documentation of TK, grassroots activities and conservation of biocultural diversity. The major activities reported here were conducted in Arunachal Pradesh. From Meghalaya the *Khasi* tribe was selected, while in Arunachal Pradesh activities were carried out among *Adi* and *Monpa* tribes. The range of activities initiated is shown in Table 1, although only the major achievements are synthesised and presented in this paper.

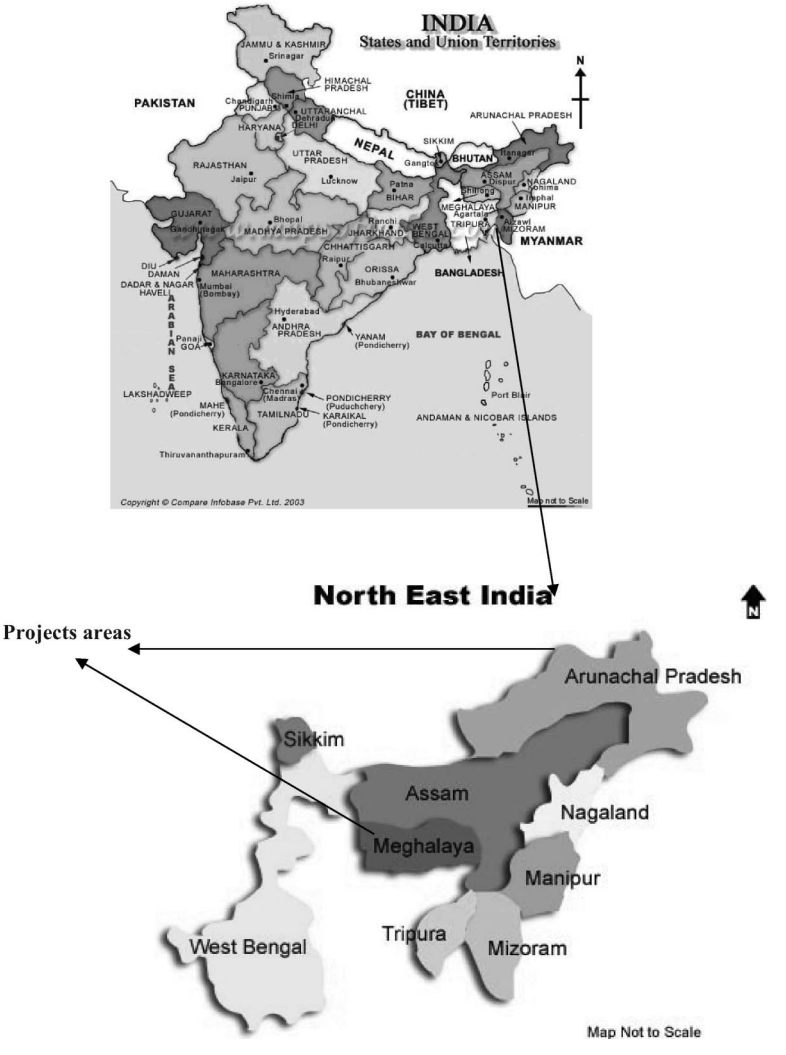

Figure 1. Map of study areas.
Source: www.northeastindiadiary.com/maps.html [Accessed 6 August 2009].

The reported activities and respective results vary according to community. A series of village workshops were organised among *Adi* communities, during which 800 members of *Adi* (500 women and 300 men) participated. On the basis of these, a state-level workshop was organised on TK, which included developing a community consultation protocol (CCP), prior informed consent (PIC) and looked at the protection of IPR of knowledge holders. All activities at village level were implemented using participatory techniques with the help of customary institutions (*Kebang* of *Adi, Chhopa* of *Monpa* and *Darbar* of *Khasi* tribes), *Gaon Burha* (head of village customary institutions) and the village Panchayat (village level unit of democratic institution). The list of knowledge holders and elders were obtained from *Gaon Burha* and the secretary of the village Panchayat. The wisdom of knowledge holders was confirmed through interview and then later studied in detail.

Table 1. Initiatives and different activities carried out on the promotion of TK and conservation of biocultural resources of northeast India.

Initiatives	Objectives	Location	Outcomes
Exploration of traditional knowledge experts	Exploration of best indigenous practices on agriculture, foods, animals health, human health and overall biodiversity conservation	Arunachal Pradesh and Megahalya	Total of 966 indigenous practices have been explored from 180 knowledge holders and were included in national green knowledge register
Exploration of elder knowledge holders (> 60)	Identifying the long and time-tested TK which are used in solving problems of health, food & nutrition and biodiversity conservation	Different districts of Arunachal Pradesh	Total of 724 practices were explored from 50 elder tribal women
Traditional food competition and recipe contests	To explore gender specific TK on foods and their potential for marketing and micro-enterprise development	East Siang district of Arunachal Pradesh	45 women were rewarded in 15 contests with prizes for their creative use of biodiversity in foods. 150 local plants are explored that are used in food and medicines
Biodiversity contests among rural people and school children	To develop the knowledge and attitudes among younger participants towards indigenous plants, biocultural resources and their use	Villages of East Siang district, Aruanchal Pradesh	35 knowledge holders of villages were rewarded in 10 biodiversity contests, and 30 school children were rewarded in 10 biodiversity contests organised in schools
Participatory reciprocal learning and group competitions among college students towards biocultural diversity	Promoting participatory learning towards biocultural diversity with villagers	College of East Siang district, Aruanchal Pradesh	Seven group competitions were organised and students learned a number of practices in a reciprocal manner from their counterpart

(*continued*)

Table 1. (*Continued*).

Initiatives	Objectives	Location	Outcomes
Establishing village traditional knowledge Bank (VTKB) and community knowledge garden (CKG)	Construct and maintain a database on TK at village level to promote conservation of knowledge, plants and micro-enterprises. Domestication of plants species	East Siang and West Kameng districts of Arunachal Pradesh	More than 200 traditional practices are documented and shared through the village-level committee. Three CKGs were established
Plants sample collection used in traditional practices	Preparation of herbarium based on traditional knowledge for preparation of a community knowledge register	At institute and village level	More than 1000 plant samples collected and are currently being taxonomically classified
Promotion of biodiversity conservation champions and indigenous institutions involved in conservation	Mobilising grassroots people for community-led biodiversity conservation and rewarding them at regional and national level	East Siang and West Kameng districts of Arunachal Pradesh	More than 20 grassroots biodiversity conservators were rewarded and promoted. Six indigenous institutions were integrated with the conservation initiatives. Three national seminars were organised in Arunachal Pradesh on the same themes
Participatory village workshops	To learn with knowledge holders on various issues of use and conservation of bioresources	Villages of East Siang district, Aruanchal Pradesh	10 workshops were organised and results were published in a reputable journal
Village and state level workshops and national seminars on the issues of TK, PIC and IPR	Identifying and examining the findings explored through different activities. Developing CCP and implementing PIC at community level to ensure equitable benefit shares of knowledge holders	Dirang (West Kameng district), Tawang (Tawang district), Pasighat (East Siang district) and Ribhoi district (Meghalaya)	10 village, 1 state level workshop and 2 national seminars were held on the issues of TK, biocultural resources and PIC. Total of 1000 PIC have been signed by traditional knowledge holders

The plant-related contests and competitions were organised in a participatory manner with the help of the customary chief, village elders and knowledge holders, as well as a team of formal scientists (Davis and Wagner 2003, Gupta 2005, Singh 2009). The winners of each event were interviewed individually to record their knowledge and quantify the information.

During interaction and interviews with knowledge holders, semi-structured interview schedules with open-ended questions were used to generate quantitative data. The information collected during the projects was both qualitative and quantitative. The knowledge holders and participants of projects consented to share their TK through signing of a PIC form.

5. Results

5.1. Establishment of traditional village knowledge bank (VTKB)

The first systematic VTKB of India was established in Sibut village of East Siang district, Arunachal Pradesh. This comprised a village level committee including *Gaon Burha*, male and female members of the village Panchayat and village elders. More than 200 traditional practices[5] were explored relating to foods, medicines, agriculture, animal husbandry, handicrafts, cosmetics and the overall biodiversity conservation approach of the community. Traditional practices were documented in both hard copy and digital form and handed back to the VTKB committee after a village workshop. Scientists trained knowledge holders on how to manage the database, add new information, screen outstanding practices for value addition, and refine TK-based micro-enterprises. Community members were trained in the use of PIC before passing on TK and biocultural resources to second parties, and the importance of ownership of traditional practices. A group of women from Sibut village have now formed a self-help group (SHG) and they are processing outstanding traditional food practices that add value in the local market. Thus, they are providing an empirical model of promoting TK and conservation of biocultural resources combined with income earning.

5.2. Establishment of community knowledge garden (CKG)

Three CKGs (two *Adi* and one *Monpa*) were established on private lands voluntarily donated by the tribes. A total of 16 medicinally and culturally important plant species[6] have been domesticated in the CKG of Dirang village (West Kameng district), set-up by a well-recognised knowledge holder named Mr Lobsang. A total of 26 indigenous plant species[7] of food, medicinal and cultural importance have been domesticated from the community forest and *jhum* lands in each of the two CKGs among *Adi* tribes of Sibut and Yagrung villages (East Siang district). These CKGs are now being further used to domesticate RET (rare, endangered and threatened) species of the region. For example, Mr Lobsang of Dirang village (West Kameng district) has started a plantation of critically endangered tree species called *mirangmose* (*Gymnocladus assamicus* ex. P.C. Kanj). Similarly, among the *Adi* tribe 12 knowledge holders have started a plantation of culturally and medicinally important[8] vulnerable tree species called *Dekang* (*Gymnocladus burmanicus* C.E. Parkinson)[9] (CHM-Thai 2009) in their respective CKG. These CKGs are thus becoming more important in local

communities where transition is fast and elders of respective societies wish to sustain their tradition of local foods and medicines.

5.3. Traditional practices and tribal women of NE India

Table 2 shows that a total of 724 traditional practices were identified by elder women of the *Adi, Monpa* and *Khasi* tribes. This was despite the fact that the project ran for only two years with a total of 50 elder women. Comparing the explored practices of elder women (totalling 724) with the young to middle-aged women's practices (totalling 966), it is important to note that the latter was obtained from a total sample of 180 young to middle-aged women, suggesting that each elder woman knew significantly more ($Z = 6.4$, $p < 0.01$) traditional practices overall.

5.4. The recipe and biodiversity contests

Of the *Adi* women who participated in the recipe contests, middle to old aged *Adi* women (>35 to 72 years) knew of more traditional practices relating to foods than young women of the same community (Table 3). There was a highly significant difference between these age groups with regard to use and practice of traditional foods ($Z = 9.8$, $p < 0.01$). Middle to old aged women were experienced in making traditional foods using terrestrial and aquatic resources as well as the culturally important fermented foods and traditional drinks. The results of 10 biodiversity contests organised among *Adi* men and women further revealed that women knew significantly more than men ($Z = 13.7$, $p < 0.01$) in terms of knowledge and uses (Table 4). The only exception was observed in the case of plants species used in hunting, constructing houses (*Chang ghar*) and making handicrafts, which are male dominated activities in *Adi* communities.

The group contest among *Adi* college students revealed that young people of rural backgrounds had significantly more knowledge about indigenous plants and wild animals resources used in foods ($Z = 7.5$ and 12.8, $p < 0.01$) than the students of semi-rural and urban areas (Figure 2). Further, a significant difference in the knowledge level between the students of semi-rural and urban areas ($Z = 5.9$, $p < 0.01$) was noted. A similar pattern of knowledge was recorded among the school children who participated in the plant biodiversity contests (Figure 3). The group of college students also participated in the later village workshops. When their knowledge was compared with the knowledge scores of elder *Adi* member of villages, a significant difference ($Z = 18.9$, $p < 0.01$) was found, with elder villagers holding higher levels of knowledge than young people (Figure 4).

5.5. Biocultural resources in Adi communities: current losses and future use

The workshops indicated that loss of biocultural diversity and related TK are caused by a number of factors (Table 5). Observant of the pace of the shrinking forest and degradation of related resources, one-third of women mentioned that they have started domesticating food plants such as *onger* (*Xanthoxylum rhetsa* D C.), *ogen* (*Solanum nigrum* Linn.) *ongin* (*Clerodendrum colebrookianum* Linn.), *paput*

Table 2. Summary of different number of traditional practices explored from elder women of northeast India.

Traditional practices*	*Adi* (n1 = 160)		*Monpa* (n2 = 47)		*Khasi* (n3 = 23)		Total	
	Young to middle aged n1 = 120	Elder n2 = 40	Young to middle aged n1 = 40	Elder n2 = 7	Young to middle aged n1 = 20	Elder n2 = 3	Young to middle aged women (180)	Elder women (50)
Ethnomedicines								
(i) Used in humans	112	82	52	45	22	18	186	145
(ii) Used in animals	25	14	32	18	07	05	64	37
Plant-based foods	150	150	80	54	38	26	268	230
Aquatic resources based foods	25	25	17	12	18	10	60	47
Wild animals (mammals, reptiles and insects) based foods	30	12	24	04	11	06	65	22
Fermented foods	13	18	14	11	12	09	39	38
Traditional alcoholic beverages	06	8	05	06	07	05	18	19
Plants and animals based foods used in medicines	16	20	21	15	14	08	51	43
Local techniques relating to sustainable access and harvesting of forest resources	08	03	14	05	03	01	25	09
Techniques in agriculture for conserving local crops varieties	14	08	09	10	07	03	30	21
Biopesticides	03	04	14	03	03	01	20	08
Items of domestic importance	14	10	19	20	10	08	43	38
Handicrafts	26	17	32	25	19	12	77	54
Cosmetics	09	06	07	05	04	02	20	13
Total	451	377	340	233	175	114	966	724

Notes: *The name of particular bioresource cannot be disclosed here, because of the agreement with knowledge holders signed through PIC for protecting their IPR on traditional practices.

The mean age of 180 *Adi, Monpa* and *Khasi* women who were in range of young (>27 years) to middle aged (<56) was 47.8.

The mean age of young to middle-aged women according to tribes: *Adi* women = 43.7, *Monpa* women = 45.5, *Khasi* women = 41.3.

The mean age of 50 elder women (*Adi, Monpa* and *Khasi*) was 67.9

The mean age of elder women according to tribes: *Adi* women = 65.7, *Monpa* women = 67.7, *Khasi* women = 64.9.

Table 3. Summary of results on recipe contests obtained from the participants of *Adi* women.

Categories of foods demonstrated during contests	Calculated mean score values per person of each foods items		'Z' value
	Young (n1 = 15)	Middle to old age (n2 = 30)	
Foods prepared from local crops species	6.9	11.74	5.6**
Foods prepared from ethnobotanicals accessed from community forest, *jhum* land and home garden	13.7	28.6	12.9**
Foods prepared from indigenous fishes	3.5	9.4	7.8**
Foods prepared from wild animals and insects	4.6	12.8	6.3**
Plants based fermented foods	2.7	4.9	5.9**
Fish based fermented foods	2.6	7.8	8.3**
Traditional alcoholic beverages	2.1	5.6	4.8**
Medicinally important traditional foods	3.5	7.2	5.7**
Traditional foods important for festivals and other cultural occasions	3.5	10.7	7.4**
Overall 'Z' value	9.8**		

Notes: Young age participants (>16 years < 35 years) with mean age 28 years; middle to old-aged women (>35 to 72 years).

Total number of recipe contests/food competitions was 15.

A score 1 was assigned to each item of food demonstrated during the contest to quantify the practices and to test the level of significance through applying 'Z' test.

**Significant ($p < 0.01$) at 'Z' test.

(*Gnaphalium affine* D. Don.), *gobar oying Amaranthus spinosus* Linn.), *gende* (*Gynura crepidioides* Benth.), *koppi* (*Solanum indicum* Linn.) and *koppir* (*Solanum torvum* Swartz.) in their home gardens. Apart from food value, these species are medicinally important for curing various human ailments and diseases[10]. Their objective in conserving these plants was to avoid travelling to the forest edges daily for gathering these resources and reducing expenditure on allopathic drugs.

The reduction in plant populations is believed to be caused by commercial agriculture (47.4%), degradation of natural habitats (31.7%) and lack of care for plant species by young generations (22.3%). By contrast, the reduction in animal populations was perceived to be due to the fall in traditional hunting (using *Aconite ferox* as poison) and the increased trend of commercial hunting using airguns and pistols (Figure 5). The problem has been aggravated with improved communication and transportation to anterior forest locations. This has caused a change in food and nutritional security of the *Adi* community. Increasing modernisation and sedentary life have further reduced the physical activity levels of local people as stated by workshop participants. In earlier times, hunters walked 30–40 km over 7–8 hours of hunting, and in some cases stayed in the forest for 15 days. Women used to walk 4–5 km daily in search of ethnobotanicals used in their foods.

Originally, the *Adi* community was non-vegetarian, preferring to combine local cereals, millets and pulses along with ethnobotanicals, the meat of wild game and aquatic resources. In recent times, changes have occurred in their food habits, particularly near towns (e.g. Mirbuk, Mirsam, Napit and Poglek villages), with

Table 4. Summary of plants biodiversity contests result obtained from the participants of the *Adi* community.

Categories of plants demonstrated during the contests	Calculated mean score values per person of each species group		'Z' value
	Men (n1 = 15)	Women (n2 = 20)	
Local crop species used for local food	8.6	17.9	15.6**
Ethnobotanicals used in traditional foods	17.3	32.7	11.8**
Plants species used in making fermented foods	4.3	10.7	9.7**
Plants species used in preparing traditional alcoholic beverages	3.8	7.6	7.4**
Ethnomedicinal plants used for human health	17.6	32.9	8.6**
Ethnomedicinal plants used for curing ailments and diseases in animals	6.4	11.8	9.8**
Plants used for animals feed	8.7	18.5	7.5**
Plants used for hunting	3.5	0.5	8.8**
Plants used for fishing	4.7	12.4	7.9**
Plants used for house construction	14.3	6.7	11.2**
Plants used for making handicrafts	9.5	4.7	9.3**
Plants used in religious, cultural and spiritual occasions	13.4	6.8	8.6**
Overall 'Z' value	13.8**		

Notes: The mean age of *Adi* men was 37.6 and women 45.3.
Total number of biodiversity contests was 10.
**Significant ($p < 0.01$) at 'Z' test.
A score 1 was assigned to each item of food demonstrated during the contest to quantify the practices and to test the level of significance through applying 'Z' test.

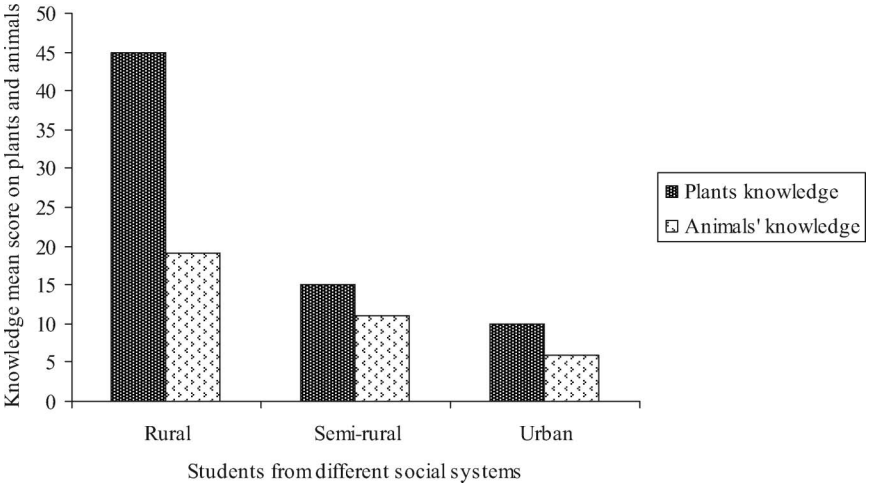

Figure 2. The knowledge difference about biocultural resources (plants and animals) among the students belonging to various social systems.

people increasingly consuming cereals, pulses, commercial vegetables, exotic fish, eggs and the meat of goat, buffalo, beef and chicken imported from plains of north and central India. The ratio for use of these foods with traditional foods is 70:30 in

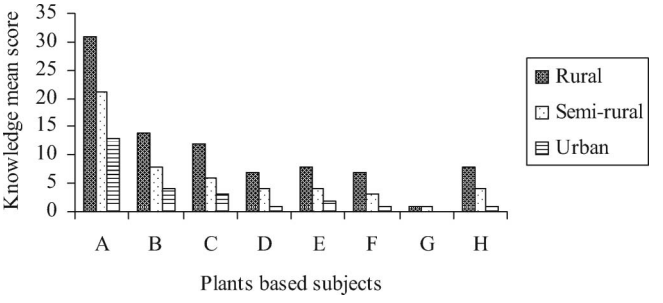

Figure 3. Knowledge status of school children about indigenous plants biodiversity.
Notes: A = Plants used in food; B = Plants used as medicine; C = Plants used as animal feeds; D = Plants used for religious occasions; E = Plants used in making handicrafts; F = Plants used in fishing; G = Plants used in hunting; H = Plants used to make various items for households use.

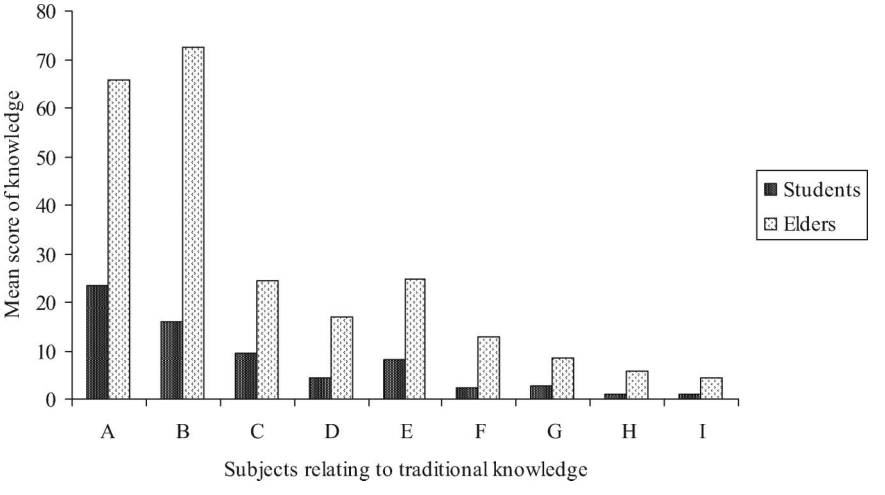

Figure 4. The knowledge difference about biocultural resources (plants and animals) between the younger generation (mean age 17 years) and elders (mean age 62 years).
Notes: 'Z' value 18.9; $p < 0.01$. A = Plants used in food; B = Plants used in medicines; C = Wild animals used in food; D = Wild animals used in medicines; E = Aquatic biodiversity used in food; F = Aquatic biodiversity used in ethomedicines; G = Festivals and cultural occasions on plants and animals; H = Spiritual ceremonies relating to biodiversity; I = Rural social institutions that nurture knowledge and learning.

sub-urban areas. This change in food habit has also affected the use of plants conserved in home gardens, on the *jhum* land and in community forests.

The opinion of village workshop participants showed that the majority of women (68.9%) and men (57.8%) believed that use of local biodiversity in ethnomedicines and foods is still important for their survival. The use of indigenous plants and wild animals continues to contribute (89.5%) to festivals, marriage ceremonies, religious events and other spiritual needs. It was also believed that if existing TK and practices are refined, it might improve the livelihoods of women working as part of the subsistence economy (according to 46.8% of women).

Table 5. Factors contributing loss of biocultural diversity as perceived by *Adi* knowledge holders.

Factors	Response (%)*
Deforestation caused by increasing population	52.5
Commercial agriculture	45.25
Overexploitation of bioresources (plants and animals)	57.8
Privatisation of community resources	48.3
Migration of young people in search of employment	32.5
Attraction of young generation towards materialistic culture	68.9
Pace of commercial market	40.3
Globalisation	32.3
Disintegration of joint family into nuclear one	45.5
Mono-centric developmental approach	52.4
Lack of coordination between conservation and developmental agencies	57.9
Top-to-bottom led approach of government for development	38.6

Notes: *Multiple response.

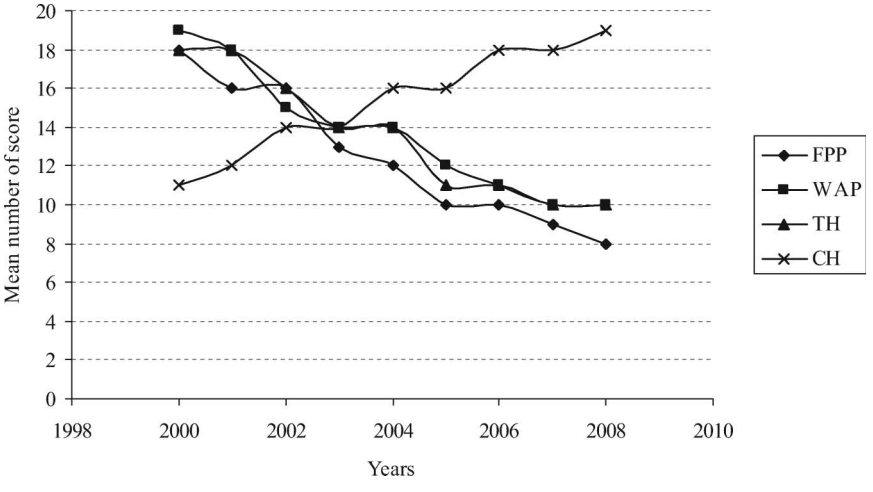

Figure 5. Trends of changes in food plants, animal population and the hunting system among the *Adi* tribe.
Notes: FPP = Food plants population; WAP = Wild animal population; TH = Tradition of traditional hunting using the *Aconite ferox* plant; CH = Commercial hunting using an airgun and pistol.
The scores for populations of plants and animals were generated following the participatory rural appraisal (PRA) procedure, i.e. historical matrix (IIED and HNWCP 1997). In this exercise, 25 members participated. Out of a score of 20 assigned to each item, the individual value has been generated in the focus group discussion (FGD).

5.6. Types of community knowledge and benefit sharing mechanisms

The synthesis of activities carried out in the projects indicates that there are four types of knowledge systems among the knowledge holders (Table 6). These vary according to attributes, types of problem-solving approaches and degree of transmission from one person to another. The benefits derived from these knowledge systems also vary (Table 7). Whether refinement and validation of the respective TK

Table 6. Types of community knowledge observed in the study areas.

Knowledge typology	Attributes	Extent of outcomes network with members of society
Individual knowledge	A creativity of one's mind that may be traditional or modern in nature, gender specific and developed over the period of time	Self-centred and unicellular network mostly with family members. Benefit small number of people but may have potential to benefit large population. Transmission is very difficult
Group knowledge	The creativity of group of members who develop a particular knowledge collectively to solve a particular problem. Depends on group dynamics	Group centred, networked with homogenous members, depends on the credibility and trustworthiness of each member who generates this knowledge to solve a particular problem. Transmission of this knowledge is moderately possible
Modified/refined knowledge	Informal experiences and refinement made in existing traditional practices (individual and or community both) to rectify inadequacy and improve the efficacy in solving a particular problem	Group and/or mass scale, may be networked with group or small number of people. Benefits to the moderate level and have the potential to benefit large population. Transmission is moderately possible
Community traditional knowledge	Known and/or practised by the maximum number of community members, collective generation by the members living on a certain geographical area	Mass scale, networked with majority members of a community. Benefits to a high level with more objectivity. Transmission is common and easy

are required to make them more widely known among other non-user groups or not, the majority (69.7%) of participants indicate that they can be transferred to similar situations with little refinement and validation, since in most of the cases the practices are used and appreciated by the whole community and are found in the public domain. Most knowledge holders (68.8%) from the more isolated villages (Maryang, Kebang, Damro, Thembang and Namsu) want the maximum portion of benefits to be allocated to them through their customary institutions (*Kebang* and *Chhopa*). In contrast, the knowledge holders from transitional villages (Mirbuk,

Table 7. Response percentage of knowledge holders (*Adi, Monpa* and *Khasi*) regarding benefit shares distributions to various heads arising from different types of traditional knowledge.

	Kinds of traditional knowledge							
	Community TK		Individual TK		Refined TK		Group TK	
Heads of benefit shares	MRKH (%)	PBS (in 100)	MRKH (%)	PBS (in 100)	MRKH (%)	PBS (in 100)	MRKH (%)	PBS (in 100)
Knowledge holders/group/ village community	95.5	40.0	80.0	70.0	75.4	65.0	68.9	54.0
Innovation promotion fund	85.0	20.0	70.0	10.0	63.9	5.0	47.6	5.0
Researchers who add value	75.4	5.0	95.0	5.0	51.2	5.0	52.8	3.0
Institutional overheads	89.0	10.0	81.0	5.0	43.7	5.0	48.4	3.0
Conservation of respective habitat and plants species	92.5	25.0	87.0	10.0	79.0	20.0	73.3	35.0

Notes: MRKH = Mean response of knowledge holders in percentage; PBS = Proportion of benefit shares out of 100; Total number of knowledge holders from three communities were 230.

Mebo, Mirsam, Yabgo, Sibut, Miram, Yagrung, Balek and Gune) suggested a different approach. They wanted the benefits of TK to be directed through the village Panchayat. The reason for this was that the benefits directly enrich the social system and ensure equal resource rights among community members. They believed it would also promote a sense of co-operation among community members.

6. Discussion

Elder women have higher TK than younger women, and could therefore be a source of inspiration for learning about TK and biocultural resources (Swaminathan 1998, Singh R.K. 2007). This might be because of the high level of cultural ethics, attachment and positive attitudes towards TK among elder women (Turner 2005, Honey Bee 2009). Some differences found between men and women's TK are most probably attributable to gender specific roles and responsibilities within communities (Mishra *et al*. 2009). Socio-cultural background, age and interaction of local communities with their surrounding natural resources affect the learning of TK, and *Adi* society elders hold more TK than the younger generation (Agrawal and Gibson 1999, Singh A. 2007, Singh R.K. 2007, Mishra *et al*. 2009).

In the face of rapid urbanisation and economic development, indigenous biodiversity and related TK systems are being eroded at an alarming rate among the ethnic populations of NE regions of India (Singh *et al*. 2009a). This in turn has weakened communal bonds which support the nurturing of TK and related resources (Agrawal and Gibson 1999). As demonstrated here, locals perceive that there are several ways to promote TK and thus revive related biocultural resources (Table 8). Some NGOs and institutions are working with local communities to help

Table 8. The proportion of women with knowledge on conservation and revival of TK and biocultural resources.

Suggested ways for conservation of biocultural resources	*Adi** (%)	*Monpa** (%)	*Khasi** (%)
Culturally responsive education and inclusion of TK into local course curriculum	40.4	46.9	49.6
Developing community specific database of knowledge holders	74.5	69.5	52.6
Creation and promotion of inter and intra knowledge networks between knowledge holders	61.7	64.8	51.4
Promoting participation of knowledge holders in the related projects	54.9	59.6	39.7
Promotion of knowledge holders in the decision-making process	78.3	66.2	75.6
Publication of common TK in local languages	84.4	71.9	80.7
Incentives to knowledge holders from government side	88.9	67.5	58.9
Supporting and developing TK based enterprises	79.6	45.8	59.8
Bottom to top level of conservation initiatives	43.47	34.4	48.2
Appropriate government policies on conservation of biocultural resources at grassroots level	39.6	28.6	35.1
Equitable benefit share to knowledge holders	59.7	50.7	41.4
Protection of IPR relating to TK and biocultural resources	63.6	42.9	62.8

Notes: *Multiple response.

domesticate, conserve and increase local biodiversity for use in traditional medicines, foods and for other purposes (Braton 1989, Agrawal and Gibson 1999, Posey 1999, King 2003, Cocks 2006).

The concept of CKG is new, but with the help of traditional healers, local villagers, school teachers and children, rural institutions are mobilising populations (SRISTI 2002). Another objective of such effort is to create a knowledge network to sustain TK and promote learning between TK stakeholders. The CKG have the scope to increase the abundance of wild plants that are uncommon, rare or endangered (Singh and Srivastava 2009). These can be conserved at both the community and individual levels, thus allowing the villagers to develop their knowledge networks and promoting TK based micro-enterprise (Gupta *et al*. 2003).

A considerable degree of gender difference was observed in biodiversity contests among school children and village people. The participation of girls was higher

(62%) than boys (38%), and they had more knowledge. A similar trend was noted in biodiversity contests among rural adults. This confirmed the findings of others (Singh, 2004, Singh, A. 2007, Singh 2009a) that women possess more knowledge and interest in plant biodiversity, and thus are described by some as custodians of conservation (Mishra *et al*. 2009, Gupta 2009). The recipe and biodiversity contests have the potential to increase awareness among local community members about the importance of TK and mobilise them to think about conservation of plant species (thus, biocultural resources) (Maikhuri *et al*. 2005, Singh and Mukherejee 2008, Singh 2009). As reported elsewhere, such approaches could activate learning institutions and stimulate grassroots action towards the promotion of TK and conservation of related plant species (Singh and Sureja 2005, Singh 2009).

The VTKB approach facilitates the recording of TK in written and digital forms at the village level (Singh *et al*. 2009a). The VTKB has become the model for people themselves to collect and pool information for the villager register (kept in VTKB library). Community members screen best TK based practices and, with the help of scientific organisations, add value to the plant-based products in order to strengthen the local market, improve income levels and sustain livelihoods. Other studies also suggest that different forms of the VTKB such as a village knowledge register (VKR) can contribute greatly to the field of conservation of TK and related biocultural resources (Gadgil *et al*. 1993, 2000).

In the move towards sustainable development and the conservation of TK, efforts are also being made elsewhere in India to capture, document and convert TK into micro-enterprise opportunities. The primary results of such initiatives in India have revealed important findings. Four products, including a nutrient supplement, baby massage oil, a skin cream and an incense stick, have been chosen from village knowledge registers to be converted into micro-enterprise opportunities. All the knowledge holders of these products formed a SHG named *Amala*. The products were tested and standardised and will now be available in the market under the brand name SAHYA. This demonstrates a success story from TK documentation to the promotion of related market products while improving economic income of knowledge holders (NIF 2007 personal communication).

The village workshop was useful for exploring and promoting TK based practices where a community faces changes in local food consumption, medicines and livelihoods. The issue of conserving biocultural resources and promoting TK was a concern and matter for debate among the participants of a state-level workshop held in November 2006 at Pasighat, Arunachal Pradesh. This workshop was based on the results of a series of village workshops and comprised different cultural groups of Arunachal State. Being a chief guest of event, Shri Tako Dabi, Hon. Minister for Water Supply and Assembly Affair, described his concern about the rapid erosion of culturally-rich TK among younger generations of *Adi* and other communities. He emphasised that TK and related biocultural resources are important sources of natural and social capital for various tribes and provide the basis for the sustainable development of Arunachal Pradesh state (Singh and Srivastava 2009). Despite this, the state government did not develop any specific policy or strategy for promoting TK and conserving related biocultural resources until 2003. In 2003, the Arunachal Government reviewed its developmental policies and formulated state policies that showed interest in promoting TK, related biodiversity and protecting IPR of knowledge holders (APHDR 2005). However, much more still needs to be done to protect the biocultural diversity of Arunachal Pradesh (Singh, R.K. 2007), including

prioritising TK promotion and conservation of bio-resources for community knowledge-led development (Agrawal and Gibson 1999, Singh R.K. 2007, Singh 2008a, 2008b).

The village workshops made local people aware of some of their valuable plant resources such as the critically endangered tree *Gymnocladus assamicus* (among *Monpa* tribe) and culturally and the medicinally important tree *Dikang* (among *Adi* tribe). Communities have now started conservation of these trees in CKGs (Singh 2008a). Plants, animals and related cultural practices are now recognised as 'collective heritage' as opposed to individual 'property'. This supports the results reported by Te Pareake Mead (2005) and Swiderska (2006). Having emerged from a community context, the concept biocultural diversity reflects the holistic worldviews of tribal people (Swiderska 2006, 2009, Singh 2008a).

Ethically speaking, little work has focused on PIC of TK in India at the grassroots level (Singh 2008b). It was observed that TK holders know nothing of PIC or its implications in the case of TK. The Convention on Biological Diversity (CBD), India's Biodiversity Act, 2002 and other policies emphasise that second parties must access and use TK only after acquiring PIC (Zedan 2005, Swiderska 2009). However, knowledge holders reported that most often they share their TK with a second party (except in this study) without the use of PIC. Interviews with TK holders demonstrated that PIC can be used as one of the defence mechanisms to protect IPR of knowledge holders while sharing their TK with a second party. Numerous academics, NGOs and governments have considered the need to provide some form of recognition and protection for TK through implementing and signing PIC (Gupta *et al.* 2003, Zedan 2005, Singh 2008a). However, there is a lack of agreement as to whether IPRs should be applied and, if so, what would be the format for protection and provision of benefits (Gupta *et al.* 2003). In order to do this, it is necessary to understand the typology of TK, its importance and scope, including its widespread use in ethno-medicines, ethnic foods, agriculture, and ethno-veterinary practices, together with the question of its definition (Singh 2008b). The starting point for any discussion about TK protection should clearly address why there is a need to protect this knowledge, and what ways and means are required to achieve its protection (Gupta *et al.* 2003, Jishnu 2009). To realise this goal, and before addressing the issues of IPR, attention will need to focus on the effective implementation of PIC as a pre-requisite to carrying out research with TK holders (Singh 2008b).

7. Conclusions

TK systems, far from being archaic and irrelevant to policy makers, offer solutions to the challenges of food, nutrition, medicines and livelihoods of local communities. They also act as novel tools for evolving and nurturing local practices that can sustain the health of local ecosystems. In the case of biocultural diversity, TK is contained within the local language and culture. Resource dependent communities frequently have an intimate knowledge of their local biodiversity, but this varies according to gender and age. Some traditional knowledge/practices offer opportunities for developing contemporary food and medicinal products, including weaning foods, food preservatives and functional foods, as well as primary healthcare treatments. Similar health and nutritional practices from different villages can be pooled and new products developed, packaged and branded to generate income and employment for local communities.

In the light of globalisation and modernisation, TK systems and related biocultural resources are eroding among the younger generations, and there needs to be rapid intervention to prevent further loss and thus ensure the continuity of both the subsistence economy and resource base. Organising grassroots activities and contests enhances the promotion of TK and conservation of biocultural resources. These raise the interests of local people about foods, ethno-medicines and other practices. Such approaches may be helpful to prevent knowledge erosion and revitalise TK. The benefits obtained depend largely on the typology of TK, and distribution patterns are influenced by the variability in indigenous institutions where TK is found. Recognition of customary laws and institutions may form the basis of *sui generis* systems at all levels. It can determine the access to rights over community traditional knowledge and bio-resources, procedures for PIC implementation and equitable benefit sharing between knowledge holders.

8. Recommendations

It is suggested that the following should be key priorities for the promotion of TK and conservation of biocultural resources:

(1) identification of local knowledge experts with all types of TK should be prioritised;
(2) considering the strength and role of women as TK holders, they must be taken into account in the promotion of TK and conservation of biocultural resources;
(3) the TK of elder women must be recorded, digitalised and utilised;
(4) understanding the existence of informal institutions and their role in biodiversity conservation, governance of resources and sustainable livelihoods is vital for participatory development;
(5) while establishing VTKB, each component of TK (e.g. physical, biological, cultural, social, institutional, political and spiritual) should be taken into account to learn about the genesis of knowledge and its science;
(6) the presence of CKG for the domestication of rare, endangered and threatened (RET) species and their sustainable use may be enhanced through government support;
(7) organising recipe and biodiversity contests must be made mandatory by environmental agencies to facilitate learning and transfer of TK and slow down its erosion;
(8) the National Rural Employment Programme (NREP) implemented by the Government of India (where minimum income and food security are guaranteed to poor people) can contribute a great deal by creating a traditional food and medicines page for village websites throughout the country. This will not only promote grassroots-based learning, but will also support and encourage more knowledge retention at the village level;
(9) the village websites created through NREP could also be linked with a village traditional knowledge bank and community knowledge garden;
(10) the active participation of formal research and developmental institutions may prioritise the strategic issues of TK promotion and integrate scientific knowledge with TK to facilitate the refinement and value addition of products for the development of TK based micro-enterprise;

(11) adopting community consultation protocol (CCP) and using prior informed consent (PIC) must be formalised with customary and democratic institutions at the village level for mainstreaming the ethics of research on TK, IPR protection and ensuring equitable benefit sharing between knowledge holders.

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Notes

1. A recipe contest is a grassroots ecoliterary tool in which rural women are mobilised in a participatory manner to demonstrate their culinary creativities in making traditional foods using the best possible options from indigenous biodiversity. In the last, the best three contestants are rewarded in each village in a well-organised formal meeting. The winners are further taken into account for the promotion of TK and their involvement in village level planning on biodiversity conservation (Singh and Mukherjee 2008).
2. A biodiversity contest is a grassroots ecoliterary tool in which participants (village people, school children and college students) are mobilised in participatory manner. The participants are given sufficient duration to contact sources of learning (traditional knowledge holders and also other published sources), collect samples of plants and information on their use and plants' habitat. The best contestants are rewarded in a formal gathering. These winners are then encouraged to promote TK-based learning and education, and assess knowledge erosion on biodiversity in their respective villages (Singh and Mukherjee 2008).
3. Village traditional knowledge bank (VTKB) is a participatory 'bottom-to-top approach' of conserving, promoting and protecting the traditional knowledge and related biocultural resources of a community. A village level committee consisting of the customary chief, democratic village institutions, healers, elders of village, school teachers and formal scientists is formed. This committee takes the lead in organising meetings, pursuing villagers and setting protocols for recording, documenting (both hard copy and digital) and screening the best practices for their promotion under micro-enterprises. The knowledge holders and villagers are trained about use of PIC (prior informed consent), its terms and conditions and the precautions while sharing the TK with second party in order to protect IPR (intellectual property rights). The ultimate object of VTKB is to conserve TK, related biodiversity and culture, protect IPR and promote economic activities at the village level (Singh and Mukherjee 2008).
4. A community knowledge garden (CKG) is an approach which establishes a garden of biodiverse indigenous plants that are of medicinal, foods, religious and other importance on either private or clan's land. While establishing the CKG, the plant species that are facing threats and becoming extinct are given first priority. The knowledge holders of a village decide on the list of plants and the site for plantations is chosen with the help of ecologists. On a certain fixed day, the customary chief of the community, Village Panchayat and knowledge holders call upon villagers to walk to the community forest and *jhum* lands from where plants are collected (through sustainable methods of harvesting and uprooting) with the help of an ecologist, botanists and an anthropologist to transfer them to a particular selected site. After planting, a register is made in which the name of knowledge holders of concerned plants species, date and year are registered to make the planted species legal and historical in the presence of a customary chief and Village Panchayat. Ultimately, after forming a village-level committee, the maintenance and rational harvesting protocol of the plant species planted are set-up to sustain the CKG (Singh and Mukherjee 2008).

5. The concerned knowledge holder did not consent to the disclosure of the names of plant species.
6. As note 5.
7. As note 5.
8. The *Adi* community did not consent to the disclosure of the medicinal usage of this species
9. A tree species found at 150–200 m MSL (mean sea level) in a subtropical climate under the community conserved forest of the *Adi* tribe. The first author discovered it first as a new species in India. This species has been in the cultural usage of *Adi* tribe (Singh *et al.* 2009b).
10. Detailed descriptions of the medicinal usage of plants species cannot be disclosed because of the agreement made with knowledge holders through PIC and to ensure their IPR.

References

Agrawal, A. and Gibson, C.C., 1999. Enchantment and disenchantment: the role of community in natural resource conservation. *World development*, 27 (4), 629–649.

APHDR, 2005. *Arunachal Pradesh human development report 2005*. Itnagar, India: Department of Planning, Government of Arunachal Pradesh, 25–205.

Berkes, F., 2009. Evolution of co-management: role of knowledge generation, bridging organizations and social learning. *Journal of environmental management*, 90, 1692–1702.

Berkes, F. and Berkes, M.K., 2009. Ecological complexity, fuzzy logic, and holism in indigenous knowledge. *Futures*, 41, 6–12.

Braton, M., 1989. The politics of government-NGO relation in Africa. *World development*, 17 (4), 569–587.

CHM-Thai, 2009. Thailand Environmental Agency, the list of endemic, rare and endangered plants in Thailand. [online] Available from: html:chm-thai.onep.go.th/Publication/Doc/ONEP17/02-PicturePage.pd [Accessed 22 August 2009].

Cocks, M., 2006. Biocultural diversity: moving beyond the realm of 'indigenous' and 'local' people. *Human ecology*, 34 (2), 185–200.

Davis, A. and Wagner, J.R., 2003. Who knows? On the importance of identifying 'experts' when researching local ecological knowledge. *Human ecology*, 31, 463–489.

Gadgil, M., Berkes, F., and Folke, C., 1993. Indigenous knowledge for biodiversity conservation. *Ambio*, 22, 151–156.

Gadgil, M., *et al.*, Members of the People's Biodiversity Initiative, 2000. New meanings for old knowledge: the people's biodiversity registers program. *Ecological applications*, 10, 1307–1317.

Gupta, A.K., *et al.*, 2003. Mobilising grassroots technological innovations and traditional knowledge, values and institutions: articulating social and ethical capital. *Futures*, 35, 975–987.

Gupta, A.K., 2005. Recipe contests: rewarding culinary creativity. *Honey Bee*, 16 (4), 8–11.

Gupta, A.K., 2009. Laying the foundation: sowing the seeds of future. *Honey Bee*, 20 (1), 3.

Honey Bee, 2009. A century of wisdom: Puriben. *Honey Bee*, 20 (1), 9.

IIED and HNWCP, 1997. The hidden harvest: the role of wild foods in agricultural systems, local-level assessment of the economic importance of wild resources in the Hadejia-Nguru wetlands, Nigeria. *IIED research series*, 3 (3), 27–31.

Jishnu, L., 2009. Dilemma on traditional knowledge. *Business Standard*, 10 August [online]. Available from: http://www.business-standard.com/india/news/latha-jishnu-dilemmatraditional-knowledge/363227/ [Accessed 10 August 2009].

King, L., 2003. *Sharing a world of difference: the earth's linguistic, cultural, and biological diversity*. Paris: UNESCO-Terralingua-World Wide Fund for Nature.

Mahanta, D. and Tiwari, S.C., 2005. Natural dye-yielding plants and indigenous knowledge on dye preparation in Arunachal Pradesh, Northeast India. *Current science*, 88 (9), 1474–1480.

Maikhuri, R.K., *et al.*, 2005. Does the outreach programme make an impact? A case study of medicinal and aromatic plant cultivation in Uttranchal. *Current science*, 88 (9), 1480–1486.

Mishra, S., Singh, R.K., and Singh, A., 2009. Dynamics of *Adi* women's traditional foods in varying socio-ecological systems of Arunachal Pradesh: a source of learning and inspiration. *In*: A. Lindgreen and M.K. Hingley, eds. *The new cultures of food: marketing opportunities from ethnic, religious and cultural diversity*. Farnham: Gower, 203–222.

Pareake, Mead, A., Te, 2005. *Emerging issues in Maori traditional knowledge: can these be addressed by United Nations Agencies? [online]*. Panama: Division of Social Policy and Development, Secretariat of Parliament Forum on Indigenous Issues, United Nations. Available from: www.un.org/esa/socdev/unpfii/documents/workshop_TK_mead, p 3–20. [Accessed 11 August 2009].

Pilgrim, S.E., Smith, D., and Pretty, J., 2007. A cross-regional quantitative assessment of the factors affecting ecoliteracy: policy and practice implications. *Ecological applications*, 17 (6), 1742–1751.

Posey, D.A., 1999. *Cultural and spiritual values of biodiversity*. London: UNEP/ Intermediate Technology Publications.

Pretty, J., 2003. *Agri-culture: reconnecting people, land and nature*. London: Earthscan.

Pretty, J., 2007. *The earth only endures: on reconnecting with nature and our place in it*. London: Earthscan.

Ramakrishnan, P.S., 2005. Mountain biodiversity, land use dynamics and traditional ecological knowledge. *In*: U.M. Huber, H.K.M. Bugmann, and M.A. Resoner, eds. *Global change and mountain regions: an overview of current knowledge*. The Netherlands: Springer, 551–561.

Ramakrishnan, P.S., 2007. Sustainable mountain development: the Himalayan tragedy. *Current science*, 92 (3), 308–316.

Ramakrishnan, P.S., Das, A.K., and Saxena, K.G., 1996. *Conserving biodiversity for sustainable development*. New Delhi, Indian: National Science Academy, 246.

Ramakrishnan, P.S., *et al*., 2002. *Traditional ecological knowledge and managing biosphere reserves in South and Central Asia*. New Delhi, India: UNESCO and Oxford IBH.

Singh, A., 2007. *Traditional foods and associated knowledge systems relating to health and nutrition among Adi women of East Siang district, Arunachal Pradesh*. Thesis (MSc). Banaras Hindi University, Varanasi, UP, India.

Singh, A., Singh, R.K., and Sureja, A.K., 2007. Cultural significance and diversities of ethnic foods of Northeast India. *Indian journal of traditional knowledge*, 6 (1), 79–94.

Singh, R.K., 2004. Conserving diversity and culture: Pem Dolma. *Honey Bee*, 15 (3), 12–13.

Singh, R.K., 2007. Community based forest resources management through socio-cultural institutions: dynamics of biodiversity conservation and subsistence living of *Adi* tribe under subtropical ecosystem in eastern Himalayas. *In*: Paper presented at the international conference on *Sustaining communities and development in the face of environmental challenges*, 26–28 July, Halifax, Canada, Canadian Society of Ecological Economics.

Singh, R.K., 2008a. Traditional ecological knowledge and institutions in conservation of critically endangered biodiversity: learning from the *Monpa* community in Eastern Himalaya, Arunachal Pradesh. *In*: Paper presented at the 12th biennial conference on *Governing shared resources: connecting local experience to global challenges*, 14–18 July, Cheltenham, International Association for the Study of Commons.

Singh, R.K., 2008b. Implications of prior informed consent for the conservators of indigenous biological diversity of Northeast India. *Indian journal of traditional knowledge*, 7 (4), 655–665.

Singh, R.K., 2009. Recipe contests among *Adi* rural women: method to enhance conservation of biocultural diversity. *In*: Paper presented at the *32nd Annual Conference of the Society of Ethnobiology, Food: Crops and Non-crops*, 1–4 April, 3, Tulane University, New Orleans, Louisiana.

Singh, R.K. and Mukherjee, T.K., 2008. *Ecoliterary tools: methodology and approaches on biocultural knowledge learning and conservation*. New Delhi: NISCAIR.

Singh, R.K. and Srivastava, R.C., 2009. Biocultural knowledge and *Adi* community: conservation and sustainability in the biodiversity hotspot of Arunachal Pradesh. *Current science*, 96 (7), 883–884.

Singh, R.K., Srivastava, R.C., and Mukherjee, T.K., 2009a. Community based sustainable natural resources management and development in Northeast India. *Current science*, 96 (1), 19–21.

Singh, R.K., Srivastava, R.C., Adi Community, and Mukherjee, T.K., 2009b. Culturally important Dekang *(Gymnocladus burmanicus* C. E. Parkinson): an addition to the flora of India from Arunachal Pradesh. *Indian journal of traditional knowledge*, 8 (4), 482–484.

Singh, R.K. and Sureja, A.K., 2005. Biodiversity contests: an innovative method to make knowledge dam and conserve biodiversity. *In*: Paper presented at the national symposium on *Changing concepts of forestry in 21st century*, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, 21–22 October, Himanchal Pradesh, India.

Singh, R.K. and Sureja, A.K., 2006. Community knowledge and sustainable natural resources management: learning from the *Monpa* tribe of Arunachal Pradesh. *T.D: The journal for transdisciplinary research in Southern Africa*, 2 (1), 73–102.

SRISTI, 2002. *Gyan van: A report of the ninth* Shodh Yatra *held from Samadra to Bhadarva villages of Kheda district, Gujarat, India [online]*. Society for Research and Initiatives for Sustainable Technologies and Institutions (SRIST). [online] Available from: http://www.sristi.org/cms/?q=en/9th_shodh [Accessed 1 August 2009].

Swaminathan, M.S., 1998. *Gender dimensions in biodiversity management*. New Delhi: Konark Publishers.

Swiderska, K., 2006. Banishing the biopirates: a new approach to protecting traditional knowledge. *Gatekeeper series IIED*, 129, 1–18.

Swiderska, K., 2009. Information and views for the CBD Expert Group on traditional knowledge associated with genetic resources. Hyderabad, 16–19 June 2–6, [online]. Available from: http://www.cbd.int/abs/submissions/absgtle-03-iied-en.pdf [Accessed 5 August 2009].

Turner, N.J., 2005. *Earth's blanket: traditional teaching for sustainable living*. Quebec Street Suite, Vancouver, BC: Douglas & McIntyre.

Turner, N.J. and Berkes, F., 2006. Coming to understanding: developing conservation through incremental learning in the Pacific Northwest. *Human ecology*, 34, 495–513.

Turner, N.J. and Turner, K.L., 2007. Traditional food systems, erosion and renewal in Northwestern North America. *Indian journal of traditional knowledge*, 6 (1), 57–68.

Yumnam, Y.J., 2008. Rich biodiversity of northeast India needs conservation. *Current science*, 95 (3), 297.

Zedan, H., 2005. Intellectual property and development – biodiversity and traditional: biodiversity and access to genetic resources [online]. *In*: Paper presented at the convention on biological diversity, in the seminar on *Intellectual property and development*, 2–3 May, Geneva, Switzerland, WIPO, p. 24. [online] Available from: http://www.wipo.int/edocs/mdocs/mdocs/en/isipd_05/isipd_05_www_103974.pdf [Accessed 3 August 2009].