Community knowledge and sustainable natural resources management: learning from the *Monpa* of Arunachal Pradesh

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Abstract: Community knowledge and local institutions play a significant role in sustainable comanagement, use and conservation of natural resources. Looking to the importance of these resources, a project, funded by the National Innovation Foundation (NIF), Ahmedabad, India was implemented to document the community knowledge associated with agriculture and natural resources in few selected *Monpa* tribe dominating villages of West Kameng and Tawang Districts of Arunachal Pradesh, India. Dynamics of various indigenous practices, gender role, culture and informal rural social institutions, cultural edges significantly contribute in managing and using the natural resources sustainably. Experiential learning and location specific knowledge play a pivotal role in ecosystem sustainability. Study also indicates the synergistic relation existing between local knowledge and ecological edges, thereby helping in sustaining livelihood in high altitude. Indigenous resource management systems are not mere traditions but adaptive responses that have evolved over time.

Key words: *Monpa* tribe, natural resources management, pastoralist, biodiversity, local institutions, community knowledge, sustainability.

1. Introduction

The indigenous knowledge systems (IKS) to manage and enhance biodiversity and natural resources are generated through learning (Pretty, 1998), saturated with spirit and culture (Posey, 1999), became tuned to local needs over centuries and detailed knowledge

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allowed people to adapt to social and ecological change (Warren, 1992). Human communities worldwide have played a central role in shaping nature's diversity and its associated functions. Both natural processes and human management have generated and sustained a vast array of genetic, species and ecological diversity. Within agricultural systems the agricultural biodiversity fulfils a number of important roles, including food and livelihood security. Dynamic and complex rural livelihoods usually rely on plant, animal and ecosystems' diversity (Thresher, 1992), both wild and in different stages of domestication. Different types of biodiversity and natural resources conserved and used by different people at different times and in different places, contribute to the sustainable livelihood strategies in a complex fashion. In addition to contributing to environmental sustainability, agricultural biodiversity saved by local people helps to sustain many production functions both in low external input and high input-output agriculture (Pimbert, 1999 and UNEP-CBD, 1999). However, many modernizing interventions and colonial administrations have ignored the importance of local knowledge and skills, resulting in erosion of knowledge and undermining of formal and informal institutions that were central for the sustainable management of biodiversity and natural resources (Wilken, 1987 and Pretty and Chambers, 1993). These institutions include rules about the use of biological resources and distribution of benefits, tenure, conflict resolution mechanisms and methods of enforcing rules, cultural sanctions and beliefs (Pimbert and Pretty, 1995 and Pimbert, 1997). While most communities want to preserve and develop their indigenous knowledge (IK) and continue to share it among community members, many have seen their knowledge begin to disappear (Warren, 1990 and Warren *et al.*, 1993). Lifestyle changes, in particular, have hampered the transmission of knowledge from elders to the younger generation (Singh, 2004). Communities may want to preserve their knowledge for a number of reasons. Some communities have identified a range of economic benefits to be gained from sharing their IK with others.

The local community does not want to have these economic benefits stripped from them (Wavey, 1993). For example, some aspects of IK can contribute to industries such as eco-tourism (Balaba, 1995), culture (Posey, 1999), clothing, art, cosmetics, agriculture, etc. Specific products and services, which have existing or potential markets outside the community, may be related to a community's knowledge. The identification, preservation and use of a community's IK can, therefore, help the community achieve its own economic development goals (Balaba, 1995 and Emerton, 1997a). Preserving IK will also contribute to the cultural (Posey, 1999) and political goals of self-identity, self-reliance and self-governance by creating a strong, ongoing appreciation within the community of its history and its roots (Scott, 1994 and Turiho-Habwe, 1995). For many communities, these reasons will be the most important

ones for preserving and protecting their knowledge (Emerton, 1997b). By preserving and protecting their IK and ensuring their ownership of it, local people can better enjoy and share the potentially wide range of benefits that stem from their knowledge (Richards, 1993). In recent years, interest in this knowledge has greatly increased, often stimulated by the search for tribal peoples' knowledge of medicines, sustainable use of the environment and their cultural practices and arts.

Looking to the importance of such treasure of community knowledge and sustainable natural resource management system, an effort has been made to learn with *Monpa* tribe and explore their knowledge systems of natural resources use and conservation dynamics. The basic objective of this study was to examine and learn the facts that local people perceive, conserve and use towards managing natural resources for sustaining their livelihoods and ecosystem.

2. Research Methodology

Looking to the nature of study, a number of anthropological and ethnographical tools such as interviews, life histories and direct observations have been adopted to explore the data. These tools help to shape a consistent story about connections between culture in an ethnic group and its dynamics with natural resource use (Jacobs-Huey, 2002). Consistency with collateral support and physical evidence help in controlling bias while maintaining the high quality and integrity of information gathered through ethnographical work. A survey questionnaire was applied to a conventional mixed sample and open ended questions were asked. This survey was the main source of quantitative information about the features and components of indigenous agro-biodiversity, natural resources and women's role in its management.

Although the survey is an effective research tool, it only provides a static depiction of processes and for that reason we choose to back up survey results with data collected using other tools such as life histories, participant observations and field transects. For the sampling, 5 villages each from Dirang and Tawang were selected randomly based on the ethnicity, types of agriculture, remoteness, forest cover and dependency of *Monpa* tribe on the use of natural resources. From each village, 12 farmers (thus total 120) having the age of more than 50 years and diverse knowledge of farming systems along with overall natural resources were selected randomly from the list provided by the Village Extension Worker. Focus group discussions were organized separately with men and women to learn about the dynamics of natural resources like use of *Paisang* (oak tree, *Quercus griffithi* L.) leaves, management of agricultural crops, use of aquatic and non-aquatic biodiversity and use of local animals' products.

To have the comprehensive knowledge of natural resources and agricultural practices, the resource flow maps were developed in each village with the old age and knowledgeable farmers to know the resource use pattern at village level. To measure the cultural value of indigenous crops, the use of crop product on certain occasions like festivals, marriage and meeting the needs of ethnicity were used as the criteria and has been scored on three point continuum i.e. high (3), medium (2) and low cultural values (1).

Food value of local crops was also measured using the same scale adopting the nutritive value, extent of use, frequency of use and compatibility of foods with socio-cultural values as the criterions. Similarly, the economic value of local crops was ascertained by using three point continuums as high, medium and low with the score of 3, 2 and 1, respectively, based on the local market, income efficiency, local availability, scope of using local crops byproducts and the extent of cost involved in the inputs used for cultivation. The inference has been drawn by calculating the mean score of each crop.

These activities yielded in-depth information about issues, trends and concerns of biodiversity and natural resources. Informants were chosen to include three different generations from the community (Maundu, 1995). The purpose here was to build qualitative approximations to explain social and individual processes, phenomena and changes over the generation. This was done by focusing on the internal experience of those individuals who are active participants in the local scenario. The fieldwork was carried out with a multidisciplinary team consisting of experts from crop science, as well as the State Department of Agriculture, Horticulture and Forests.

Prior to leaving for the study area, the researchers have discussed about methodology and tools of study with village chief and few selected knowledgeable persons of local resources (wisemen) and modifications have been made accordingly. The field process involved daily rebriefing and crosschecking to identify gaps in data collection and to recognize emerging issues for further probing. Informed consent has been obtained from the community for sharing and publishing their knowledge system. While seeking informed consent, the researchers explained the purpose of the research, sponsors of research, potential benefits and possible problems associated with the research for people and the environment. During ongoing communication of research, the objectives, methods, findings and interpretations from inception to the completion of the project was discussed with community members to validate the facts. At each stage, researchers have respected the privacy, dignity, cultures, traditions and rights of *Monpa* community. They were given opportunity to read the summarized facts of research through their *Gaon Burha*. A *Gaon Burha* is the chief of a village. He is usually selected by the villagers,

as a result of his higher age and experience. An explanatory research design was adopted to draw inference from the study (Singh, 2004).

3. Results and Discussion

3.1 Sustainable natural resource management by Brokpa *(pastoralists)*

Natural resources have for centuries been an integral part of peoples' diet, economy and culture. For people living in or near forests, plants and animals provided foods, medicines, hides, building materials, income and were the source of inspiration. River provided fish, water and other food and construction materials and soil provide a source of sustenance (Steiner, 2004). Appreciation of participatory approaches and sociological aspects in these natural resource management, agricultural research, and extension science promote local knowledge as a key to sustainable development (Brokensha *et al*., 1980; Richards, 1985; Chambers *et al*., 1989; Warren *et al*.; 1989 and Homann, 2004). Many facets of local people's knowledge are elaborated here. It is all based on empirical research. Aspects of natural resources, soil and vegetation taxonomy, indigenous agrobiodiversity, water and forestry resources and tenure arrangement concepts are described to see the dynamics and rationale behind community based natural resource management (Tamale, 1994 and Homann, 2004).

For a long time, local people and *Brokpa* (pastoralists) have developed location specific holistic strategies of sustainable management of natural resources and improved livelihoods at the high altitudes of Dirang and Tawang. *Brokpa* are semi-nomadic pastoralist people of the *Monpa* tribe who live mostly in forest regions. They are experts in making yak *ghee*, milk cheese (*Cchurpi*) and products from their animals' skins. These are supplied to trading markets.

Pastoral communities have always played an important role in sustaining the rangeland ecosystem by means of traditional norms and access strategies. Periodic migration by *Brokpa* from one place to other ensures that natural resources are not used to the point of exhaustion and ultimate extinction. In addition, their herds browse the vegetation, stomp the soil, transport seeds of wild species and fertilize the land, all of which benefit the rangeland and the maintenance of its biological diversity. Rangeland is conserved through sophisticated techniques embedded in complex social and cultural institutions. More than 80 percent of the surface area is situated in a rainfed ecosystem and a great extent of this consists of rangelands, largely inhabited, cared for and used by the *Brokpa* pastoralists until recent government and other external influences began to upset their equilibrium with the traditional natural resources on which they depend and its management pattern. Other studies also indicate

that this kind of rangeland ecosystems can effectively be managed and used in a sustainable manner by local pastoralists (Finkel and Darkoh, 1991 and Kisamba-Mugerwa, 1995).

For three decades, there has been no policy aimed at the upliftment of pastoralist community. It left them in a state of despair. During the field trip, local communities overwhelmingly admitted that under present conditions they would eventually be forced to give up their traditions and livelihoods, much to their regret. It implied that they would be incurring enormous cultural and material loss to the State. The pastoral communities comprise 40-50 per cent of the total village population of the study area. Over the years their number has been declining due to modernisation and cultural erosion. Notwithstanding existing economic difficulties, pastoral communities produce about 8-10 livestock products and 25-30 per cent ethnic foods. Modernity has not affected the life style of *Brokpa* living in far-flung areas. However, some *Brokpa* near to town of Tawang have resorted to joining the army and starting their own enterprises. These activities have affected their traditional way of life. The *Brokpa,* who have a nuclear family system, live in separate family units after getting married and have the social norm to divide their property equally among the children.

The land selected for community grazing should be of slight slope to avoid soil erosion and sustain natural vegetation. Dung and urine of sheep are utilized by local farmers to fertilise and enrich the soil. Fertility of the land thus depends partially on the number of sheeps available. As a rule for resource management the *Brokpa* uses some part of his earnings on making the soil fertile. For a desired piece of area, a temporary bamboo or wooden fencing is erected and during night, sheep herding (*Terske*) is arranged. A hut called *Brokbrang,* locally constructed of stones and wood, is used as the residence during grazing. For this practice, they get their remuneration in terms of local grains and indigenous fermented alcoholic beverage (*Lohpani* and *Rakshi*) made from local varieties of rice, barley, finger millet, maize and wheat. Land where sheep herding has been arranged is utilized in different manners, depending on the types of soil and the nature of crops. The local agricultural land is categorized in three broad categories i.e. top hill agriculture, middle hill agriculture and foothill agriculture. Accordingly, indigenous maize and paddy crops are grown in foothills, while finger millet is planted in the middle hills and wheat and barley are grown in top portions of the hill. Preference is given for sheep herding in the top parts of the hills, because here barley, wheat and some temperate vegetables like *Mann* (*Allium* sp.), *Laipatta* (*Brassica* spp.), local potato, onion, etc. are grown, where carrying and transportation of organic manure is difficult.

3.2 Rangeland utilization strategy: dynamics of livestock rearing and natural resource management

The pastoralists move their herds throughout the year to optimise utilisation of rangeland resources for maximum meat and milk production. As a result of movement and grazing, the herds stay healthy and produce a reliable supply of milk and meat that meet the demands of *Brokpa* households. The elder pastoralist sees and conducts ecological skirting, which includes identifying and classifying plants and precisely assessing the water-holding capacity of distant pastures. They then draw up plans for the movement of herds on the basis of this report. They conduct trans-human intra-annual and inter-annual livestock movements, not only in search of forage and water, but also to carry out the organized skirting of ecology of the area. For grazing of yak, *Dzomo* (a female crossbred of Yak), cows and sheep, there is a private and common system. Every hamlet has its own communal grazing land. Along with this, many clusters of hamlets also select one common grazing land, which is managed by community initiatives. The grazing lands are selected near the available local water resources (*Nala*, small and large rivers, as well as ponds and fountains) where the soil is light black in color with high percentages of clay, full of vegetation for the grazing of sheep, goats, cows, horses and yak. Every grazing land is named in local parlance based on the name of hills, rivers, lakes and forest.

Different rules and norms, formulated by elder community members and headed by *Gaon Burha*, are strictly followed in managing the common grazing lands. These arrangements have a bearing on issues, such as group grazing and avoiding over-grazing or non-seasonal access. If the animal of a particular person has grazed or entered into the grazing lands of a neighbouring hamlet, then there would be a conflict which is resolved by an indigenous institution called *Chhopa* (governed by the elder members of community and headed by *Gaon Burha*). To settle the conflict, the suffering person consults elderly people and the *Gaon Burha* of the hamlet. The matter is placed before this indigenous institution with the required proof of evidence. After looking to the gravity of conflict, the *Goan Burha* passes a consensus judgement, taking into consideration the jury's confidential opinion. The fine is then imposed on the person who is guilty. This fine may vary from Rs 1000-5000 and sometimes even Rs 10 000. Earlier in the 1940s and 1950s, fines were determined in terms of the local grain crops (maize, barley, wheat and finger millet) and the local breed of sheep and yak.

3.3 Grazing system, use of animal products and the management of natural resources

For the grazing of yak, sheep, goats and other animals, a particular date is decided by the people of a hamlet to avoid conflict and instead try to sustain the available forage and grass. All pastoralists take part in moving their animals away for grazing. The total number of grazing days are decided in advance, beyond which if someone is accessing the grazing land more, then he is fined by the *Goan Burha.* This mechanism helps to sustain the rationale and equitable benefit share arising from grazing land throughout the year. At the onset of summer, the pastoralist climbs with the animals towards the up-hills for grazing, thus maintaining the whole year cycle.

The local religion plays a spiritual role in the process of accepting the conservation and preservation of natural resources. The Buddhist religion restricts the member of *Monpa* tribe not to plug the bamboo shoot at an early stage for consumption. It is considered to be as bad as killing a baby. The dynamics of the ecosystem and food security has forced them to use bamboo leaves as the fodder for their yak and *Dzomo*. Therefore, the cutting of grass is restricted from yak grazing lands. However, under scarcity, bamboo leaves are cut and fed to the *Dzomo*. When ice-freezes cover the grasses during winter season, local yaks are allowed to scratch the ice and graze.

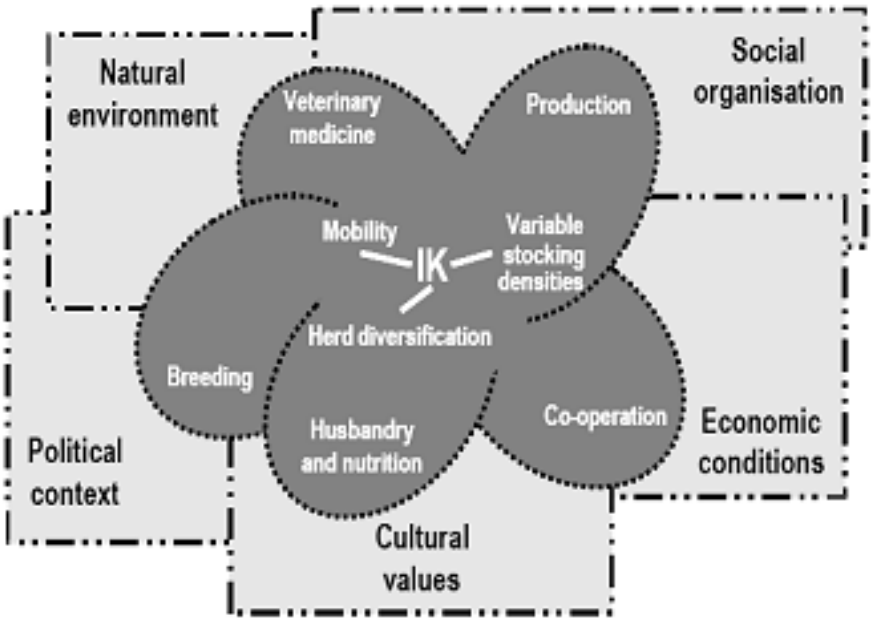

Figure 1. Model of pastoralists' knowledge in opportunistic range management (Adapted from Sandford, 1983).

According to the customary law, the sheep and goats are moved towards lower area of hills (free from ice-cover) where grasses are easily available. Up to that point in time, the local pastoralist could move up to the *Khalaktang* hills (highest accessible point of local hill near Tawang) to search for grasses during the summer season. In the winter, they will return to their original place in search of grazing for the sheep. The application of most aspects of pastoralists' knowledge depends on the ability to pursue what is called the 'opportunistic approach' [(Sandford, 1983 (Figure 1)] in which the number of livestock grazing is continuously adjusted according to the available forage. An important issue is to determine to what extent the creation of such dynamic natural resource management areas at high altitude is possible. Judgements of this nature are usually taken, based on prevailing social and cultural perspectives. Research findings point to the fact that natural resources at high altitudes are owned by individuals and groups in terms of customary and legal rules (Elmqvist *et al.,* 2004).

In tradition of the *Brokpa,* only the male folk play a major role in moving the herds for the purposes of grazing. The females are responsible for the domestic work and making ethnic foods for the males. *Brokpa*s are responsible for supplying milk products and meat of yak to different villages after the months of summer grazing. Yielding potentials of calf is given due recognition for their proper rearing. If the yak calf is not of a good breed and healthy, it is likely to be killed by *Brokpa* and meat is kept inside the skin of the same calf which is later supplied to the livestock owner. The skin of calf and other adult animals are also used as container for preserving the *Cchurpi* (milk based indigenous cheese) and ghee.

Dum (wool) is only made from local breed of sheep around Tawang and Dirang. Ghee, wool and *Chhurpi* are made around the borders of Arunachal Pradesh and Tibet. *Dum,* harvested from local sheep are not used for weaving sweaters, but instead for other cloths like trousers, shirts and caps. It is also the best source of income for empowering the *Monpa* women. The *Dum* is sold in a unit of *Hrang* (7 *Hrang* = 1 kg). Now government has taken initiative and the Department of Veterinary Services is making an effort to introduce improved breeds of sheep and yak in order to improve the milk yield and the accompanying income. However, local *Brokpas* do not respond positively to these initiatives. They claim that these breeds do not match to their culture and ethnic identity.

To cure diarrhoea, influenza and dysentery in sheep and yak, the tuber of a famous local plant called "*Tshando"* [a small shrub found between cracks in the rocks, producing blue coloured flowers and germinate naturally in temperate zones] is used as an ethno-veterinary medicine. The tender shoots of this plant is given in a mild and moist form. Very small quantity (sometimes measured in mg) is given to animals with local beer made from indigenous barley or maize.

Yak live and grow well in the temperate climate at the elevation of more than 3000m above sea level where snowfall occurs and temperatures vary between 8-15°C. In such climates, yak produces good quality wool and meat. The wool harvested from the local yak is used for making various types of cloth and other items. For example, the *Monpa* tribe residing around the areas of Tawang bordering China, make bags from yak wool and use them for carrying food materials to agricultural fields. For rearing yak, grazing lands are kept separate, because these animals need more grazing on a single site. This is in stark contrast with sheep grazing. The sheeps need more frequent trampling and can be taken along roadsides for grazing. The yak and *Dzomo* breeds are reared during the calving period under the prevailing local grazing and forest conditions. After calving, the yak is fed with a mixture of common salt and flour of finger millet, barley and maize. It helps in recovering the pain after calf delivery and increases the milk yield.

In the 1950s, feeding common salt from Tibet was a fixed custom and was very popular among the farmers with yak and *Dzomo.* They obtained the product by means of the barter systems prevalent between the *Monpa* tribes of Tawang and Tibet. The exchange was not only in salt, but also many types of crop seeds, such as local beans, pea, carrot, onion, garlic, ginger, milk products [*Cchurpi* (cheese), ghee etc], wheat, barely, etc. After independence, local people increasingly resorted to feeding common salt to their yak. In beginning it was difficult to make the yak adapt to the Indian salt.

At a specified barter point in the hills, *Brokpa* would exchange the yak and sheep milk products for grains such as maize, barley and wheat in dealings with local villagers. But now this system of barter has changed with the passage of time. One farmer, Mr. T. Dondup, explained:

> Previously the *Brokpa* were accustomed only to get the grains of indigenous crops during the exchange of milk products, but now they are taking cash and thereby the milk products which were our cultural identity are going to be eroded. At present, if anyone needs these products to eat, he/she will find it in a nearby market. This changed system has affected the food habit of *Brokpa* and instead of eating maize, barley, wheat and fingermillet they are eating fine rice. The government policy of supplying rice from cooperatives has affected our cropping system and thus weakened the dynamics of exchange of grain and milk products and also led to the cultural erosion.

3.4 Dynamics of indigenous agro-biodiversity, community knowledge and natural resource management

Observations revealed that local farmers are quite aware of the importance of indigenous agro-biodiversity and natural resource management. Over the years they have learned from nature to determine locations specifically suited for cultivating the indigenous crops and forestry. Maize is a staple food crop, managed, produced and conserved with the pine trees (*Pinus*

roxburghi) and *Paisang* tree (Oak). Dirang is situated at an altitude of about 6000 ft amsl and falls under a rainfed agro-ecosystem of the Eastern Himalayan region. Accordingly, farmers grow and manage indigenous maize along with other local food crops giving more emphasis to pulses and millets. Local maize is more preferred and can be used in a variety of ethnic foods, more compatible to the food habits and religious as well as the ethnicity of the *Monpa* tribe (Singh, 2003a). For instance, these foods are offered during the Buddhist festival of *Lohsar.* Local varieties of maize are sown in the last week of April, to first week of May each year. The sowing of maize is subjected to observations on the biometeorology of the new leaves of two major indicator plants – *Solubalu* (a small tree producing white flowers which indicates the onset of rain) and *Panchangmeto* (a shrub with deep green and brown spot leaves, indicating increasing temperature). The priest (*Lama*) of *Gompa* (a Buddhist temple) decides the time of agricultural practices based on *Moh* (an ancient scripture, the interpretation of which is done only by selected *Lama's*). Most of the agro-ecosystem is situated in undulating land with blackish to reddish brown soil of medium texture with attributes of moisture stress.

To improve the productivity of maize and save energy, time, labour, money and ultimately conserve natural resources, farmers have developed location specific practices. The dry leaves of pine and *Paisang* tree are collected, either from community forests or private lands, by women. They are kept, either in shade or behind foothills in the direction of winds to avoid direct sunlight and wind on the leaves. In the sloppy maize field, pine leaves are preferred while in plain field dry leaves of *Paisang* are more preferred. It provides nutrients to soil and the oil content of leaves help to bind the soil particles. This is particularly the case in light textured soil and undulating land. Interestingly, following these practices facilitates in weed suppression (due to *allelopathic* effect), leads to the improvement of soil fertility and total biomass in local varieties of maize, *rajma* bean (Frenchbean/Common bean), soybean and cucumber.

The seeds of the local varieties of maize are spread in the fallow land and ploughed using a local plough drawn by a bull. Then dry leaves of *Paisang* and pine are spread uniformly over the soil, primarily by the women. There are three indigenous varieties of maize namely *Fenthina* (dwarf variety, duration 3 months), *Thinasheru* (tall variety, duration 5 months) and *Baklangboo* [medium tall variety, sown for the festival of *Lohsar* [*January to February*], duration 4 months]. These indigenous varieties are location specific and grown under varying micro-farming situations (Singh, 2003b, Singh, 2003c and Singh, 2003d). *Fenthina* is grown in the most fertile soil near kitchen gardens. *Thinasheru* is grown in main agricultural land where the soil is black to brown and land is undulating, while *Baklangboo* is cultivated in gentle slopes and shifting lands. On an average plant to plant spacing is 0.6m in tall varieties and 0.3-0.5m in dwarf varieties. With the exception of the *Fenthina* maize,

the local leaves of *Paisang* and pine tree are also equally popular in other crops.

The most popular use for maize is in the preparation of local beer (*Cchang*), which is used to cure many human and animal diseases. It is an integral ingredient in the feed for milking cows, pigs and poultry. The selection of crop species and types of cropping (mostly mixed) is decided by a whole community or village. The objective is to avoid crop loss from wild animals and insect pests and spread the risk among community members. If maize is grown after using the pine tree and *Paisang* trees leaves as natural mulch, there is a better opportunity to diversify the cropping systems by incorporating indigenous varieties of *rajma* bean (*Phaseolus vulgaris* L.), *lab lab* bean (*Lab lab purpureus)*, black gram (*Vigna mungo* L.) and soybean (*Glycine max*) as mixed crops. Besides, it also minimises the inputs needed for sole cropping. To conserve these indigenous crops along with *Paisang* and pine trees, a festival *Chheskaran* is celebrated during March through which spirit is induced to protect crops from insect pests and evil spirits.

For the outstanding efforts in *in-situ* and *ex-situ* indigenous agro-biodiversity conservation, the *Monpa* women deserve praise. They resort to a variety of strategies that are primarily compatible with their customs, culture, socio-economic conditions, and biophysical parameters of locality, exchange systems of biodiversity, spirit, food habits and ethnic values (Singh, 2003a). The women folk select the seeds from healthy plants. They then grade and store it with the seeds of *timbur* (*Xanthoxylum* spp, a spice) to avoid insect pests during the time of storage. They decide in what kind of bin these crop seeds would be stored. They even know from experience the proper storage temperature. The women have a range of diversified gene banks of indigenous varieties of wheat, barley (*Bong*, with or without awns), *Phaphda teeta* (buckwheat), *Phaphda meetha* (buckwheat), paddy (*Sungsungbara*), finger millet (*mandua*), Indian bean (*Lab-lab purpureus*), rajmabean (*Phaseolus vulgaris*), millet (*Bundagmo, Panicum psilopodium var. psilopodium),* coriander (*Ush*), bottle gourd (*Lau*), cucumber (*Manthong),* soybean (*Lee*), pumpkin (*Broomsa peela*, *Broomsa saphed, Cucurbita moschata*), bitter gourd (*Kaibandu*), spinach (*Taktak*), field pea, mustard species (*Lai Saag*, varieties *Leme* and *Penche*, *Brassica* spp), garlic (*Lamm*), *Mann bada* (*Allium* spp.), *Mann Chhota* (*Allium* spp.), onion (*Chong*), millet (*Moo*, *Panicum psilopodium* var. *coloradum*) and chilli (*Solu*) and varieties of maize (*Fenthina*, *Thinasheru* and *Baklangboo*). Many spices, like star anise (small and big varieties), *timbur* (prickly ash, *Zanthoxylum armatum*) and corn pepper are commercially available from local markets and are sold by women. These are a rich source of income. Two very famous local beers called *Rakshi* and *Lohpani* are beverages from indigenous varieties of maize, barley, finger millet and fox-tail millet which are culturally important for them. *Brokpas* act as a bridge in the indigenous seed exchange chain in times of barter. They often touch the

boundary of Tibet and Bhutan and through this process their ancestors brought more popular local varieties of Indian bean, millets, soybean and cucurbits. Looking to the importance of these genetic materials for sustainable agriculture, these have already been pursued for its conservation at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi in the name of *Monpas* as conservator.

The farmers of Tawang select most of their agricultural land at the foothill where the soil is black and permanent cultivation is possible (70-80 per cent, *Kshumleng*), while *Jhum* cultivation is done in about 10 per cent of the agricultural land in the studied areas. *Jhum* cultivation takes place on the basis of forest cover density and is done for growing a number of local crops. But the same tribe around Dirang does *Jhum* cultivation popularly for raising finger millet nurseries, which later on will be transplanted in gently sloping land; and to grow some vegetables and plantation of fruit crops.

The cultivation of indigenous crops like garlic, amaranths, mustard, barley, pea, wheat, fox-tail millet, pearl millet, finger millet, barnyard millet, beans, soybean, carrot, maize, *jowar* (*Sorghum bicolour*), *bajra* (*Pennisetum glaucum*) and sugarbeet are common in the ecology of Tawang. It signifies the adaptive management of agrobiodiversity and ecosystem. Horticultural crops like plum, peach, pear, and walnut, some of the exotic varieties, have been introduced in Dirang valley. Since the 1990s, a few improved varieties of tomato, chilli, cauliflower and cabbage have also been introduced and adopted by some rich farmers, who cultivate their crops for commercial purposes at varying elevations around Tawang and Dirang valley.

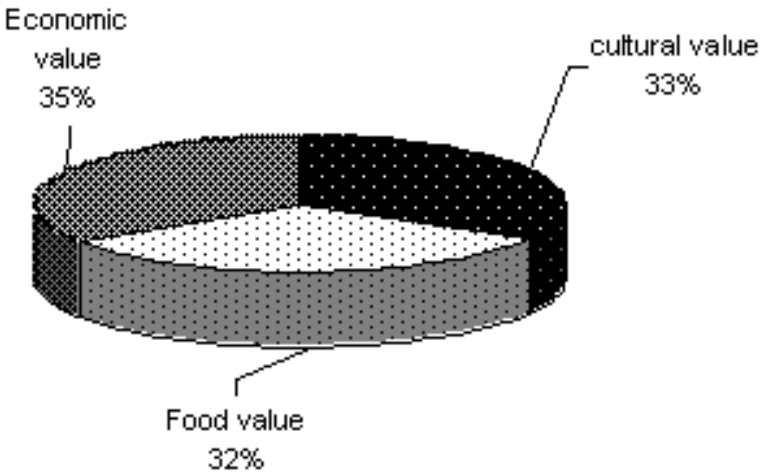

Fig 2 Contribution of indigenous agrobiodiversity in socio-cultural and economic life of the Monpa tribe

The contribution analysis of the documented indigenous agro-biodiversity of Tawang and Dirang valley indicates that the *Monpa* tribe plays an important role. Culturally they contribute 32 per cent; their economic contribution could 35 per cent; and their integral contribution to local food supply is 32 per cent (Figure 2).

On account of this, it can be inferred that this type of dynamic and alternative type of traditional management practice helps to continue and conserve the indigenous agrobiodiversity and sustainable ecosystem management (Elmqvist *et al.*, 2004).

Gender specific learning of agro-biodiversity management indicates that most of the agricultural operations are performed by the women who are the real backbone of livelihood and local economy (Figure 3).

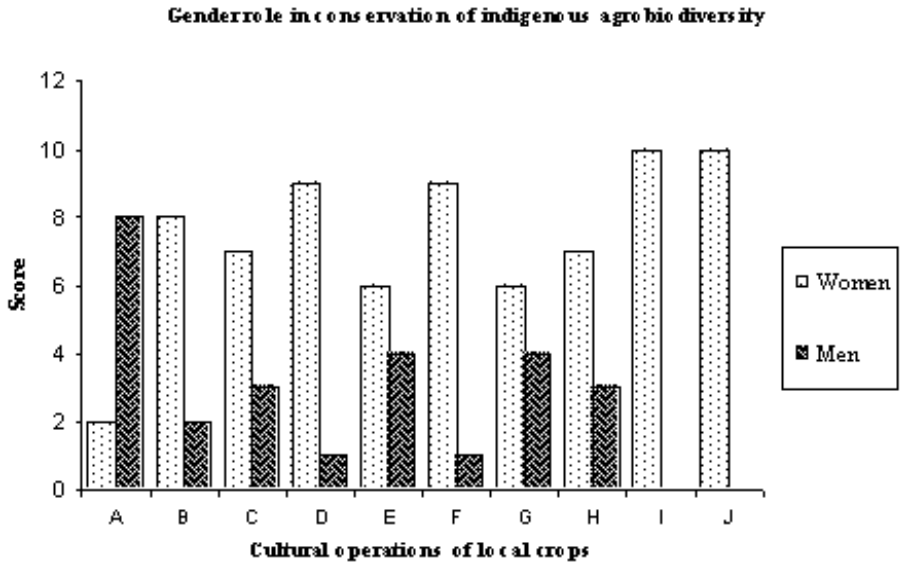

Fig 3 A=land preparation, B=seed selection, C=seed sowing, D=weeding, E=irrigation, F=harvesting, G=threshing, H=winnowing, I=grading of seeds, J=preservation of seeds

The harvesting of crops is done by a group of women called *Lakpa* (indigenous institution). They share the workload and it reduces the time necessary for doing the agricultural operations. Besides, it also creates a knowledge network for sharing common ideas related to agriculture management and exchanging seeds of local crops. According to the norm of this institution, no one will accept any wage. Instead, each will be offered a variety of indigenous foods including a special offer of local beer (made of finger millet and barley) by the farmer who is the host. If groups

of women are harvesting the crops of a *Gaon Burha*, then according to his pride he will offer *Rakshi* and *Lohpani* (a good quality of local beer made of indigenous varieties of barley, finger millet and maize). Along with this, they also get special food added with yak ghee to reduce the feeling of exhaustion.

The ecological edges existing in the area play a pivotal role in sustaining the culture, food habits and flows of indigenous information for process of vertical learning. Earlier, the *Monpa* were more dependent on Tibet for consumable products. They were, for example, accustomed to using dried fish, but this tradition has eroded gradually because of the influence of factors, such as changing food habits. Customarily dried fish is mixed with local beer (*Chhang*) made of indigenous rice to make its taste softer. Dried fish is also added in the *Cchurpi,* made from indigenous soybean and *Yer* (local spice plant) and offered to the guests to show the honour and pride.

3.5 Agricultural diversification and natural resources

In response to the growing demand from urban areas for fruits and nuts such as apple, pear, peach, plum, apricot, persimmon, kiwifruit and walnut, some male farmers started diversifying the species of fruit trees planted in the upper ecosystem of valleys, especially in Dirang. They have more than eight species of fruit trees in their fields – a radical change from the traditional apple, plum, peach and pear. It is not unusual to find several varieties of species (early maturing to late maturing varieties), chosen by farmers with a view to minimising risks. Some farmers are skilled at grafting fruit trees, even grafting different species on one tree. For instance, combinations of apples and pears and of peaches and apple can be found. Another interesting extension of traditional practice is the grinding of local cereals into flour with the aid of the indigenous grinding wheel that is powered by flowing water. The same water is redirected for the irrigation of vegetables and other cash crops. This is also used for the supplementary irrigation to grow a range of fruit trees and some vegetables on uneven land. Ultimately this traditional way of designing, planning, patterning and using the local available resources leads to the diversification process which helps to reduce risks and assures sustainable livelihood.

The tribal economy is basically subsistence in character and based on underdeveloped agriculture. Consequently productivity is low. The local tribe attaches great importance to their traditional values, morals and institutions. Most of them have an egalitarian ethos with a great concern for their community. Resources are, to some extent, owned by the community as a whole. Hence, the decision on the use of available local resources is made by the community and not by the individual.

Skills developed over centuries by tribal are suited to the particular environment and ecosystem in which they live and operate the agricultural practices. Given the traditional skill endowments, the tribal members are slow to accept new skills.

Successive governments in Arunachal Pradesh have initiated substantial development programmes. The traditions, ethics, community interests, and values related to *Jhum* (some extent) were the prime concerns in all initiatives related to NRM during past. The practice of shifting cultivation was found to be ecologically stable and sustainable when the fallow period was about 15-20 years. Recently deforestation, soil erosion and fertility decline problems have become severe as the fallow period is decreased upto 7-8 years. This is the result of pressures by ever mounting population on the land and the local fruit crops (apple, peach, plum, kiwi fruit, etc). There is insufficient time for the replacement of soil fertility through natural processes. Due to frequent changing of site of whole ecosystem, shifting cultivation is largely responsible for deposition of silt in the rivers of adjoining areas and there is a continuous regression of valuable forest species. This kind of trend of using natural resources poses a serious threat to biodiversity and sustainability (Nsolomo and Chamshama, 1990).

3.6 Indigenous gardens: sources of nutrition and food security

Home gardens found near the areas of habitation play an important role for the conservation of vegetables, medicinal plants, agro-forestry and fruit trees. In fact, they sustain the health and nutritional security of the *Monpa* tribe. Home gardens provide easy access (particularly during the rainy seasons) to a variety of resources the communities need regularly, such as food, fuel wood, fodder and medicines. In Dirang, plum, apple and peach trees, grown in home gardens of poor people, were cited as major sources of income. Radish and *Lai patta* (*Brassica* spp.) growing in home gardens add up to the stock relied on by communities for income and general livelihood security.

Livestock (poultry, ducks and pigs) are also reared near home gardens and are fed by local weeds, *Colocasia* and byproducts of garden. *Timbur* (*Xanthoxylum* spp, a spice) is grown in small scale in home gardens. Annual crops, for example like maize, beans, chillies and amaranths are grown as intercrop and mixed crop in the home gardens where there are perennial fruit trees. These fruit trees provide support to the vines of beans, cowpea and the like. The size and location of gardens are decided on the basis of family size, number of animals, food habit and local market where the surplus produce is sold. The size and number of home gardens in the area is declining. This is largely as a result of rapid immigration. Consequently there is a marked shift in land-use patterns from gardening to house construction.

3.7 Using microenvironments and sustaining local forest

Local farmers are experienced in sustainable planning of land (FAO & UNEP, 1999) and using the microenvironment for crop production, agro-biodiversity conservation and sustainable livelihood (Singh, 2003e). Valley bottoms are used by the *Monpa* as a microenvironment for the production of annual and perennial crops in hilly mountainous areas of Dirang and Tawang. Maize, soybean, rice, beans and some vegetables are produced during the rainy season. However, using the new techniques of stream water for irrigation has made the bottom parts of the valley fields more useful for producing vegetables, maize and beans in dry season in patches where there are fertile soils. The growing importance of cash crop farming in both Dirang and Tawang, is dependent on nearby forest-soils and stream water. Whereas intensive farming of fruit crops in hilly forest has a direct adverse impact on forest resources (deforestation). Studies indicate that competition for expanding lands leads to reducing the forest cover (Allaway and Cox, 1989) while increasing the dependency on home gardens for vegetable production has also indirect impacts on forest resources. In both Dirang and Tawang hilly agricultural and horticultural fields have emerged from cleared forest land. The importance of hilly forest fields on cash and food crop production is not sustainable in the long run. It leads to the degradation of ecosystems at lower altitude. One such sign of stress on forest land is the declining yield of many local crops and frequent changes of cultivation sites. A study on natural resource use patterns also indicates the similar result (Nuwamanya, 1994).

3.8 Community knowledge, indigenous institution and sustaining natural resources

Diverse bamboo species *viz. Mai* (most frequently used and available in plenty), *Maichu* (thorny), *Maith* and *Phakso* (used as firewood) plays a pivotal role in income generation and subsistence economy of the *Monpa* tribe. Many local trees like *Shingchu* and *Shingmai* are used for cooking (because they burn for a long time) and are conserved by means of individual initiatives. Pine trees are used to extract oil and manufacture incense sticks (*Dhup*). Looking to the importance and local value of pine species, the religious priest, *Lama* (priest) plays an active role in domestication of pine species around *Gompa* for use in various religious activities. Earlier, aquatic biodiversity, such as blue green algae, fish, frog, snails, crab, prawn, etc. played a pivotal role in the food security of local people, but their population has gradually declined due to various anthropogenic factors. In the experience of a village wise man, the local supply of fish, particularly in small rivers, was abundant in the 1960s. However, over-exploitation due to increasing population has led to gradual extinction of some species.

Local rivers are sources of food, medicines and materials for house construction. Looking to this importance, community members have decided to impose rules through indigenous institution *Chhopa* to limit the access. The violation of these rules is likely to invite the imposition of fines. When there is over-exploitation of fish, shrimp, crabs and frogs, lands around the hills, stones on the river banks, forest trees and wild animals, the *Gaon Burha* files a case before the *Chhopa.* The accused is called up to give an explanation. If he is found guilty, a fine of Rs. 2000 - Rs. 20 000 is imposed. If the guilty person is unable to pay the fine, it is passed on to his close relatives.

The *Chhopa* reserves the right to reduce the fine according to the capacity of the guilty person. It can also determine the amount of the fine in terms of varying degrees of guilt. For example, if a person is accused of cutting a private tree, then he/she is fined one cow. Size and age of cow is decided according to the nature, productivity and age of a particular tree. The money from the fine is used by the community in the leadership of *Gaon Burha* in social welfare and managing natural resources like plantations on community land, hillsides and roadsides to avoid landslides, etc. This ethical instinct has forced the *Monpa* tribe in preserving the biodiversity and natural resources.

An indigenous institution called *Mila* is formed with the homophilous resource-based *Monpa* women for the collection of ethnic fruits, vegetables, timber and other products from forests. To sustain forest resources under the *Mila* system, there are several rules which assure that access to the forest will be in the form of groups, instead of individuals. Nobody is expected to pluck or harvest the forest products in surpluses. The harvest is determined by the women themselves and is based on family size. If someone is found guilty of transgression, the matter is again taken to the *Gaon Burha* where the guilty person is fined. In the regulatory process, on the main entrance gate of forests, one informal watchman is appointed occasionally by the community to regulate and monitor the access of forest based products.

Customary use and food habit does not ban the hunting of deer, pigs and wild boar from nearby forests. It is performed exclusively for personal consumption by the local people. The religious philosophy of local tribe does not permit them to sell the meat of hunted animals. However, sometimes greed is powerful in breaking the cohesive force of religious ethics. Local norms of society regulate hunting by allowing these activities, only at times of culturally specified community festivals and other occasions. According to this norm there will be rotational hunting in different directions of the forest. After the agreed hours, the hunter has to return back and hunting is no longer allowed. Any violation of this arrangement would invite a fine. An informal institution consisting of elder hunters monitor the activities of its members and enforce the social sanctions in case of no-use of rule. A strong sense of ethics in respect of

this norm thus helps to sustain wildlife. In this regard one *Gaon Burha* (75 years age) has shared his own ethics as follows:

> If the wild animals do not harm to any one then why they must be killed? Is it necessary to play game with wildlife? Are only the wild lives are the sources of non-vegetarian foods? Without eating the wildlife and non-vegetarian food can't a man survive?

From this ethic, it may be learnt that the overexploitation of wildlife should be avoided and alternative management with judicious use of wildlife is required to meet the needs of a local tribe (Norton-Griffiths and Southey, 1993, 1995 and Norton-Griffiths, 1995). It could be inferred that applying rotational use, social norms and monitoring through informal institutions are different kind of modes for conserving and sustaining the natural resources which are more sophisticated than any formal rules and policy (Berkes, 1998; Berkes, 1999 and Elmqvist *et al.*, 2004).

3.9 Community knowledge and forest conservation

The *Monpa* tribe of Tawang and Dirang still follow an old tradition in which both community forests and private forests are conserved on community land as well as private land. From this forest, they collect the leaves of pine and *Paisang* which are rich sources of organic manure in the indigenous agricultural system. The leaves are collected and kept at the bottom of a local hut. The hut is double-storied. The first story is used for habitation whereas a mixture of the leaves of pine and *Paisang* and the excreta of human and pigs is allowed to decompose in the ground story of the hut. The manure, thus formed, is called *Permang*. Most of the *Monpas* live in temperate zones where water scarcity is a problem. Hence, instead of wasting more amount of water in toilet, they use the green leaves of *Paisang* as tissue paper. It is agreed that *Monpa* do not cut or pluck the leaves of *Paisang* trees, being aware of its value for local use. Only fallen leaves are collected and utilized as mulch. The dry wood is used as firewood and it burns for a longer time.

During the 1930s and 1950s the problem of deforestation was not severe, but after the 1960s the new generation started with activities that led to deforestation in an effort to become rich instantly. This trend has created problems such as landslides and soil erosion. This has been responsible for the loss of some potentially fertile agricultural lands. As a rule, the village committee, headed by the *Gaon Burha,* is authorized to restrict the deforestation. They can use voluntary workers to control soil erosion and land slide by planting many local shrubs and trees, but with the passage of time, cultural erosion, population pressure and easy availability of transport, the rate of forest cutting has been increased significantly.

After 1989, the *Marwari* businessmen (natives of Rajasthan State of India) have started business on the local spices, medicinal plants and timber

of some of the trees species which has led to overexploitation. Looking to the changing scenario and rapid deforestation, most members of the village community, headed by *Gaon Burha,* have now designed new rules. Now the villagers only enter the forest in groups to collect firewood. It is confined to a particular day of the month. Even the quantity of firewood for each member of the group is prescribed under this rule.

3.10 Informal social Institutions and the conservation of natural resources

Many studies indicate that religion, belief and local communities' spiritual values have a strong influence on the sustainable management of forests, lands, water and crop management (Donnelly-Roark, 1998; Sibanda, 2004 and Steiner, 2004). On the occasion of worship (related to the crop, animals and vegetation) the local *Lama* carries the statue of the Lord *Buddha* and some religious books, which are read in favour of natural resources, crops and animals. This happens three times a year i.e. during winter, summer and the rainy season. The worship is called *Chhoskar* and people believe that without these ceremonies they cannot do agricultural operations. The religious occasion is celebrated both at community and individual level for the welfare of the animals, availability of forest products and getting higher productivity from crops.

Performing the rituals, worship and customs of Buddhist religion implies that the people have to conserve more than eight varieties (of three species) of local pine. For the domestication of local tree species, *Lamas* (priests) issue a notice to collect the seedlings and cuttings from forests on a particular day and time. The Buddhist religion plays a pivotal role, even during different agricultural operations. For instance, before harvesting the local maize, special religious permission need to be taken from the village *Lama*. If this is not done the people believe that the subsequent crops will suffer from many diseases.

Only after the harvest, the members of the community drive the animals for grazing into the maize fields. This takes place on a common and pre-decided date. If someone violates this social norm then he/she will be fined by the agricultural priest called *Bonpu*. Even though a field is privately owned, grazing is not allowed before the *Kakun Torban*, a festival in which ethnic food made from local maize is worshipped. Only after worshipping is done by the agricultural priest, the first harvest of maize is taken out to make *Kakun* (an ethnic food made after crushing the boiled maize grains) and grazing is allowed thereafter. Thus, these unconventional but promising sources of innovation for sustaining and managing natural resources with the help of communities and institutions contribute substantial portion (Berkes and Folke, 1998; Olsson and Folke, 2001). Therefore, strengthening local social institutions would play an

important role to adopt these practices towards new purposes in dynamic and sustainable NRM (Berkes *et al.*, 2000).

3.11 Indigenous biodiversity and livelihood: conservation perspective

We do not have evidence of the amount of household income from timber forest resources. Respondents have however indicated that buying wood for fuel and charcoal for energy and timber for house construction were the major forms of use. This clearly suggests that, there is a section of the local tribe whose major source of income is dependent on supplying [through selling] timber forest resources. There are variations between the manner in which men and women use these resources. They tend to rank preferred species, but there are similarities in terms of their dependence on these resources. Livelihood dependence on forest resources in some of the areas is not sustainable. This is because of over-utilization of resources. This makes timber forest species more vulnerable, not only to excessive use, but also to extinction.

In many communities, it is well reported that land is used for deriving socio-cultural and spiritual identity and local practices are based on a sense of harmony with the natural environment. This resulted in sustainable land use and management practices (Elmqvist *et al.*, 2004 and Steiner, 2004).

Land in reserved forests and public forests constitute the most important support for land shortages experienced by many households. Of late, land in the public forests has been cleared for farming. It is the only vacant land available in the area. The clearance of land in public forests has extended into the purposes of growing commercial fruit crops. The lack of formal land ownership (mainly clans residing on the land considered as public and private), complicates the problems of land management around the forest areas. Interviews with some young persons and influential informants showed that these landlords are not aware of any village institutions neither do they think that the institutions are responsible for deciding on any issues concerning their land. Among others, uncontrolled bushfires are associated with the tendency of absentee landowners to light fires when attending their farms and leaving the burning fires unsupervised. The forest land provides an alternative strategy to cope up with the ever-growing needs and insecure households.

Indigenous medicinal plants provide a major stay for ensuring health and security of households. The forest resources have been relied on to provide requisite medicines to the communities. Access to forest medicinal plants is mainly by means of collection from nearby forests, and purchases from traditional healers and, at times, traditional birth attendants. Most traditional healers were found to be the social workers in the community

and do not take any remuneration. They have a supernatural fear in the knowledge that the art of healing has been given to them by the God for welfare of the society – not as the source of income generation. If they are continuing this art and wisdom with remuneration, very soon the plants concerned for curing a particular disease and the art of curing will be eroded from certain localities. Medicinal plants from the forest are not only important for direct consumption, but also provide income to sustain the livelihoods of some sections of the communities. Non-woody forest resources are also identified as major sources of livelihood in the survey sites. While respondents in all the sites made efforts to conceal the importance of non-woody forest resources in supporting their livelihoods, there is ample evidence to suggest that in two rural based sites of Dirang and Tawang, specific categories of non-woody forest species constituted an important element to cope up with seasonal stress in livelihoods.

Uses of non-woody forest resources are mainly of two types; direct consumption and income generation. Non-woody forest species commonly used for direct consumption and income generation include vegetables, mushroom, medicinal plants, roots and tubers. Mushroom is the major source of protein for members of the *Monpa* tribe in areas where there are no other types of protein available in the form of meat. Respondents' knowledge about prices of various mushroom species was clear evidence of the use of these plants. Forest mushroom was not shown to be a major source of protein among some rich *Monpa* tribe members on the pretext that instead yak meat and pork were considered an important source of meat protein in the area. There are variations between communities in respect of the importance attached to the types of uses of local products generated from ecosystem. Among members of the *Monpa* this might be due to ecological variations and edges.

3.12 Alliances and natural resource conservation

Alliances are generated by the overlapping interests (Glaser and Oliveira, 2004). For Dirang and Tawang, overlapping conservators' and users' interests (and therefore the actual and potential alliances in the management of natural resources) focus in on some of the major themes. Central and state government agencies, NGOs, scientists and other donor agencies profess an interest in forests and rivers, common land and local agro-biodiversity conservation. This sometimes coincides with the requirements of commercial producers, businessmen and also subsistence needs of local communities. These interests are in conflict with strict conservation interests that distance themselves from primary needs and aim to protect the natural resources by prohibiting communities' utilization of ecosystems. The non-effective enforcement of legislation, related to the management and conservation of natural resources of Dirang and Tawang, make allies among environmental agencies,

commercial producers and excessive exploiters of the environment. The illegal use of forests, rivers and the injudicious widespread *Jhuming* (shifting cultivation) has raised local livelihood concerns and generated a demand for the rules that excluded non-tribals and over-exploiters. The local communities and their leaders are opposed to the centralistic and bureaucratic approach of state government. The demand for users' rights and the management of natural resources form part of their quest for autonomous government at district and rural level, as they seek increased active participation and the sharing of funds for their location specific development.

Persons, more concerned with political spheres of influence, head the major stakeholder alliances related to the management and use of local resources. These stakeholder alliances also include local influential community members with their respective business agendas as client constituencies and close relatives of ruling politicians. This finding is in agreement with that of Glaser and Oliveira (2004).

4. Conclusions and policy implications

From the above discussion it can be concluded that community knowledge plays an important role in food security, resource management and environmental and biodiversity conservation. There is no doubt that the communities realise the importance of natural resources and its management. Community initiatives are site specific in their approach, and varied in their origin. Methods of access, regulations, monitoring and management of natural resources differ from site to site. Conservation and sustainable use in community conserved areas is often for longer-established than in government managed protected areas, yet they are often neglected or not recognised in official conservation system. Community efforts are about not only conservation but also regulated access to the conserved resources. By taking a de facto control over natural resources where such control is largely not allowed and demonstrating effective management; the community conservation efforts meet the survival of poorest people. Natural systems such as forests, woodlands, grasslands, rangelands and rain-fed zone resources, used directly to generate income, food and subsistence livelihoods. The timely contribution of villagers for the upkeep and maintenance of existing ecosystem and overall conservation of natural resources, including local breeds of livestock and agricultural crops (Singh, 2003f), needs to be a part of an integrated research and development arena.

In many areas, traditional ways of resources management have broken down in response to the process of acculturation, globalization, modern development, inappropriate policies and malpractices in government and non-government organizations, and a host of threats from wider

economic and political forces. The net result of this has been degradation of resources and collapse of ecosystem's services.

Hence, for enhancing the sustainability of existing natural resources, a comprehensive participatory approach needs to be adopted using the local institutions, people's experiential wisdom and their active participation (Salam *et al.*, 2005). Policy makers and NGOs as partners can help in making the community more self-reliant and responsible towards natural resources (Figure 4). Formation of cooperative societies and strong marketing network for local products generated from existing ecosystem and establishing a strong linkage within community are the major intervention points to maintain the equilibrium and dynamics of sustainability of natural resources and livelihoods.

The knowledge holding community needs to ensure that their knowledge systems and practices are supported and recorded and that they are not locked out of the research agenda of the major institutions. In this regard agricultural extension services and the direction of research and development should take account of community knowledge. Other social and economic policies should support to enable community knowledge and their technologies (practices) in continuing and sustaining natural resource management systems and livelihoods. Natural resources management institutions has the capacity to cope up with changes through adaptive learning which in turn leads to the stability of management and an ability to cope up with surprise or sudden shocks which further increases the resilience of ecosystem. The task of agricultural development through community-based natural resource management is so complex and formidable that it needs imaginative and concerted effort and well designed thrust supplemented with anthropological and socio-physical approach. Simultaneously, there has been a growing recognition that local economic concerns and local institutions play a central role in natural resource management; hence most strategies, policies and projects for nature's conservation now should involve and benefit local communities in some ways (McNeely, 1992).

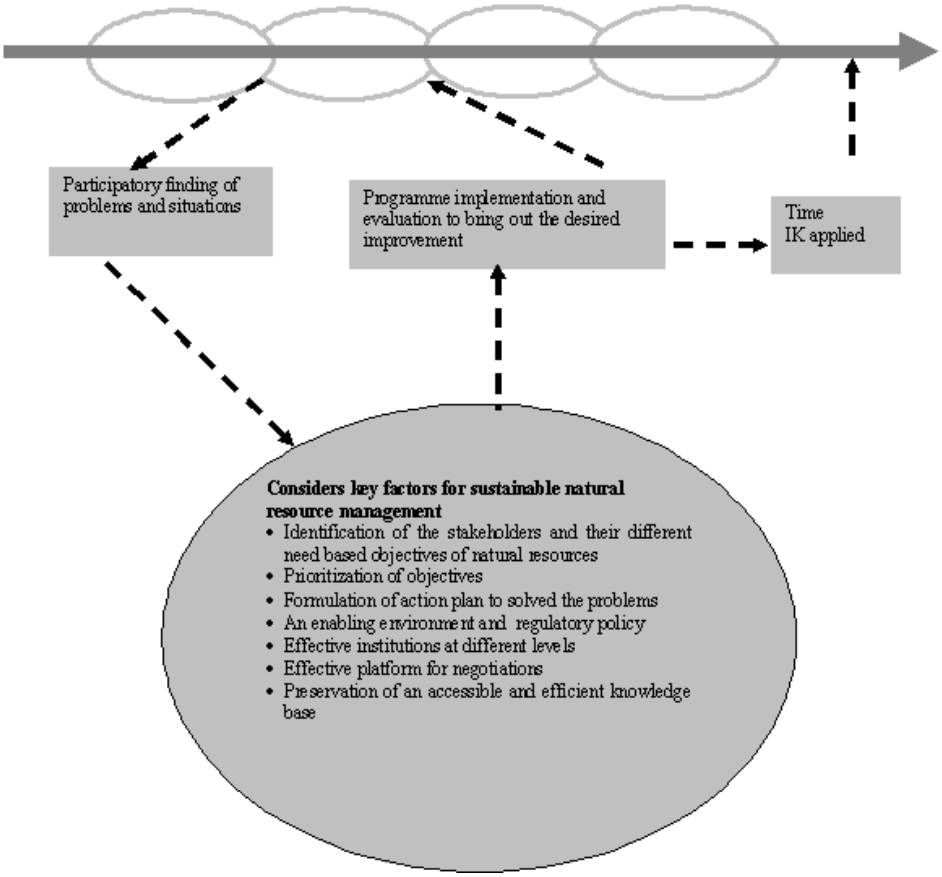

Fig 4 Basic structure of an IK-based sustainable natural resource management and development process

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