Traditional practice of leaf litter harvesting and utilization by farmers in west-central Bhutan: Paving the way for sustainable management

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ABSTRACT: Forest is an important resource for the farmers in soil fertility management and crop production in Bhutan. The tradition of leaf litter harvesting from the forests has been in practice since time immemorial. However, the continuous leaf litter harvesting has raised concerns on the sustainability of the leaf litter forests (Sokshing). There is a paucity of information about harvesting practices, utilization and management of forests. Hence, the present study was aimed at generating information on how farmers perceive, utilize and manage leaf litter forests. Data were collected from two sub-districts Nahi and Limbukha in west-central Bhutan involving a total of forty farmers, using questionnaires and semi-structured interviews, focus group discussions and personal observations during field visits to the forests. The study found that despite having access to chemical fertilizers, soil fertility management for the farmers is mainly based on the use of leaf litters as farmyard manure (FYM). Given the labour intensive nature of FYM production, aggravated by labour shortages, farmers still preferred FYM over chemical fertilizers. *Quercus griffithii*, *Q. lanata* and *Pinus* spp. were the main leaf litter tree species in the studied areas; *Quercus* spp. being the most preferred by farmers. The complete removal of litters from the leaf litter forests as revealed by farmers will not only have negative effects on nutrient cycling in the leaf litter forests but also render the exposed ground vulnerable to erosion. During litter harvesting farmers' clearing the regenerations in leaf litter forests as found in the present study, will exacerbate the already thinly populated litter forests resulting in declining productivity and ultimately the sustainability of leaf litter forests. Traditional practice of leaf litter harvesting will continue for perpetuity for the mountain farmers, therefore, sustainable management practices will have to be found and put in practice based on participatory approaches.

Keywords: Forests, FYM, Oak, Pine needles, Soil fertility

Introduction

Eighty percent of the Bhutanese population depend on small scale mountain farming and livestock rearing for their livelihoods (Gurung et al., 2006). In Bhutan, the forest land owned by the government, with the right given to the farming community to collect the leaf litters for agricultural purposes is called 'Sokshing' ('sok' literally meaning leaf litter and 'shing' meaning tree). The tradition of harvesting leaf litters from the forests for agricultural use has been in practice for decades in the life of a Bhutanese farmer. Leaf litters from the forests are used for the purposes of livestock bedding and farm yard manure (FYM) production. Leaf litters are kept as animal bedding ranging from few months to almost a year. The decomposed leaf litters are applied to the field as manure. FYM and mineral fertilizers are the two main sources of plant nutrients used by farmers in Bhutan, however FYM is the single most important source of plant nutrients with 139,000 Mt applied to cereals and horticultural crops in 2000 (Chhetri, 2003).

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Farmers not only depend on forests for leaf litters but also for livestock feed, construction materials, agricultural implements, raw materials for wood-based industries and non-wood forest products (Gautam, 2009). To meet the nutrient demand of the crops especially for the resource poor farmers, the use of organic materials would be an inevitable practice for a long time to come (Satyanarayana et al., 2002). Depending on the agro-ecological zone, leaf litters of broadleaf-deciduous, evergreen-conifers and mixed broadleaf-conifers are used. The major leaf litter trees used by the farmers are, *Schima wallichii* and *Castanopsis indica* in wet tropics (altitude 200-800 meter above sea level (m asl)); *Alnus nepalensis*, *S. wallichii* and *Quercus griffithii* in foot hills (altitude 600-2500 m asl); *Pinus roxburghii*, *Q. griffithii, Q. lanata and P. wallichiania* in dry valleys (altitude 800-2600 m asl); and *P. wallichiania* and *Q. semecarpifolia* in high areas (altitude 2700-3500 m asl) (Roder et al., 2003). Misra et al.(2008) reported the use of *Quercus* spp., *Acer oblongum*, *Aesculus indica*, *A. nepalensis* and *Juglans regia* by farmers in middle hills in Garhwal in Uttar Pradesh, India. Bracken ferns and crop residues mainly paddy straws are also used along with the leaf litters for FYM. In Thailand too, for lowland paddy, organic residues like rice straw, green manures and tree leaf litters are used (Kaewpradit et al., 2009).

Bhutan is often praised for its pristine environment, with 64.35% of the country still under forest cover, however, there are concerns on sustainability. Long term litter harvesting severely depletes the forest of its soil nutrients and the tree productivity. The traditional use of forests as a source of nutrients for agriculture is likely to deplete the fertility of the forest soils with negative ecological effects (Roder, 1990). Low productivity of the leaf litter forests was already an issue for some farmers in Lingmutheychu watershed in west-central Bhutan (Renewable Natural Resources Research Centre and National Soil Services Centre, 2001). Considering the huge dependence on forest resources by farmers and the paucity of information on utilization and management of the leaf litter forests demanded an investigation. Therefore, the present study aimed at generating information on the harvesting practice, utilization and management of leaf litter forests by farmers in the two sub-districts in west-central Bhutan. While not providing in-depth information, the findings from this study should serve as preliminary information as a basis for further investigation of the leaf litter forests in any country.

Materials and Methods

Study areas

Study was conducted in 2011 in two sub-districts, Nahi in Wangdiphodrang and Limbukha in Punakha districts in west-central Bhutan. These two areas were selected mainly because of the differences in forest cover, population and spatial distribution of households, and expected difference in leaf litter use and management resulting from the aforementioned differences.

Survey of farming community

Prior to carrying out the study, a preliminary meeting was held with the district headman, extension agents and the forestry officials from the two sub-districts to brief them on the survey.

Data were collected using questionnaires and semi-structured interviews, and focus group discussions. The questionnaires and semi-structured interviews were conducted with the local farmers while the focus group discussions consisted of village elders and local government officials from each sub-district. Forty farmers were involved in the study, twenty from each sub-district. Data on the number of household members, number of family labours involved in leaf litter harvesting practices, changes in the sub-districts in the last twenty-five years, type and number of animals raised, type and size of land holdings, crops grown, use of chemical fertilizers and leaf litters, reasons for their choice of materials for soil fertility, harvesting non-wood forest products, leaf litter harvesting (frequency of harvesting, changes in forest users, quantity of leaf litter harvested, etc) and management practice of leaf litter forests were gathered.

Field visits to the forests

Field visits to leaf litter and natural forests (undisturbed forests where leaf litter is not harvested) along with the farmers and forestry officials were made and data on the conditions of the forests were collected based on visual observations during the visits.

Chemical analysis

Leaf litters of oak and chir pine were analysed for total carbon (C) (Walkley and Black) and nitrogen (N) (micro-Kjeldahl) at the Department of Plant Science and Agricultural Resources laboratory, Khon Kaen University, Thailand. Oak had 32.63% total C and 0.86% N while in chir pine it was 39.91% total C and 0.52% N.

Data analysis

Data were analysed using statistical package SPSS 16. Percentages, ranges, means and standard errors (M±SE) are presented. Qualitative data analysis was based on understanding the situations, decision makings, causes and effects on leaf litter management by the farmers.

Results and Discussion

Description of study areas - Nahi and Limbukha

Nahi lies at an altitude ranging from 1200 to 3600 m asl and has cool sub-tropical to temperate climate with annual rainfall ranging from 700 to 800 mm. It has an area of about 65 km^2, of which almost 90% is under forest cover. Limbukha lies at an altitude ranging from 1200 to 3000 m asl with sub-tropical to warm temperate climate and annual rainfall ranging from 800 to 900 mm. Its area is about 25.6 km^2, 77% of which is covered with forest. In both the sub-districts, broadleaf and conifer forests are found depending on the altitude. Though smaller in area Limbukha has higher population of 1828 people compared to 1179 in Nahi. In addition, the households in Limbukha are mostly clustered but in Nahi, they are scattered deep into the valley and up the higher slope.

Table 1 Characteristics of the households in the two sub-districts (Mean±SE)

Items	Nahi (N=20)	Limbukha (N=20)
Population in the sub-district*	1179	1828
Number of households*	143	182
Number of members per household	6±1.01	4±0.42
Female respondents (%)	30	80
Male respondents (%)	70	20
Wetland per household (ha hh^{-1})	0.81±0.25	1.11±0.24
Dryland per household (ha hh^{-1})	0.47 ±0.15	0.73±0.17
Number of cattle per household	6±1.16	8±1.52
Number of poultry birds per household	5±1.20	-
Number of pigs per household	2±0.50	1±0.33
Number of horses per household	-	2±0.47

Sources: sub-district offices

Farm household descriptions

All the interviewed farmers in both the studied areas have been living in the villages since their ancestors' time. Household characteristics are summarised in **Table 1**. Limbukha farmers owned larger land area (dryland plus wetland) (1.84±0.38 ha) compared to Nahi farmers (1.28± 0.30 ha). All the farmers raised cattle mainly for milk, cheese, manure and draught power. Number of cattle was higher in Limbukha ranging from 4 to 20 (8.30±1.52) and 3 to 14 (6±1.16) per household in Nahi. In both the studied areas, paddy is the main crop followed by wheat, maize, potato, chilli, mustard, and other vegetables. The main household income is through the sale of rice, potato, chilli, maize and seasonal vegetables grown on farm as well as harvested from the forests. Farmers in both the studied areas are self sufficient in rice with estimated 410 kg yr^{-1} per person at Limbukha and 331 kg yr^{-1} per person at Nahi (Countrystat-Bhutan, n.d.). Based on the survey, the main developmental changes in the last 25 years were construction of farm roads, access to good water supply, electricity, school and basic health units. Agricultural developments were seen in the improved extension services, access to good quality seeds, seed treatments, pests and diseases control, and improved irrigation facilities. The main problem for the farmers is emerging labour shortage since more people moved to urban areas for a better life; due to this problem some farmers had to reduce the number of cattle in the farm. The other problem is crop damage by wildlife especially wild pig and deer.

Leaf litter forests or 'Sokshing'

Tradition of harvesting leaf litters from the forests has been in practice since many generations in the Bhutanese farming systems. Based on the survey, at Nahi only a small proportion (20%) of the farmers owned leaf litter forests or 'Sokshing' and the area ranged from 0.20 to 0.40 ha (0.30±0.10). Majority (80%) of them harvested leaf litters from natural forests. At Limbukha all farmers had leaf litter forests and the area ranged from

0.10 to 0.81 ha (0.46±0.06). Based on the field observations in the leaf litter forests at Nahi, the main leaf litter trees were *Quercus* spp., and *Pinus* spp., while at Limbukha, they were *Quercus* spp., *Pinus* spp., and *Castanopsis* sp. Oak leaves or *sisi* (*Quercus* spp.) in local terms and pine needles or *tongphu* (*Pinus* spp.) were the dominant litters, available in abundance in both the studied areas. Activity calendar of the farmers in the two sub-districts is shown in **Figure 1**. Most of the farmers harvest leaf litters during winter when there are no farm activities and the demand for farm labour is less. For those who carry out farm activities during this time especially growing potato, wheat and mustard harvest lesser amount of leaf litters. According to the farmers they harvest around 20-30 kg of leaf litters per basket per person.

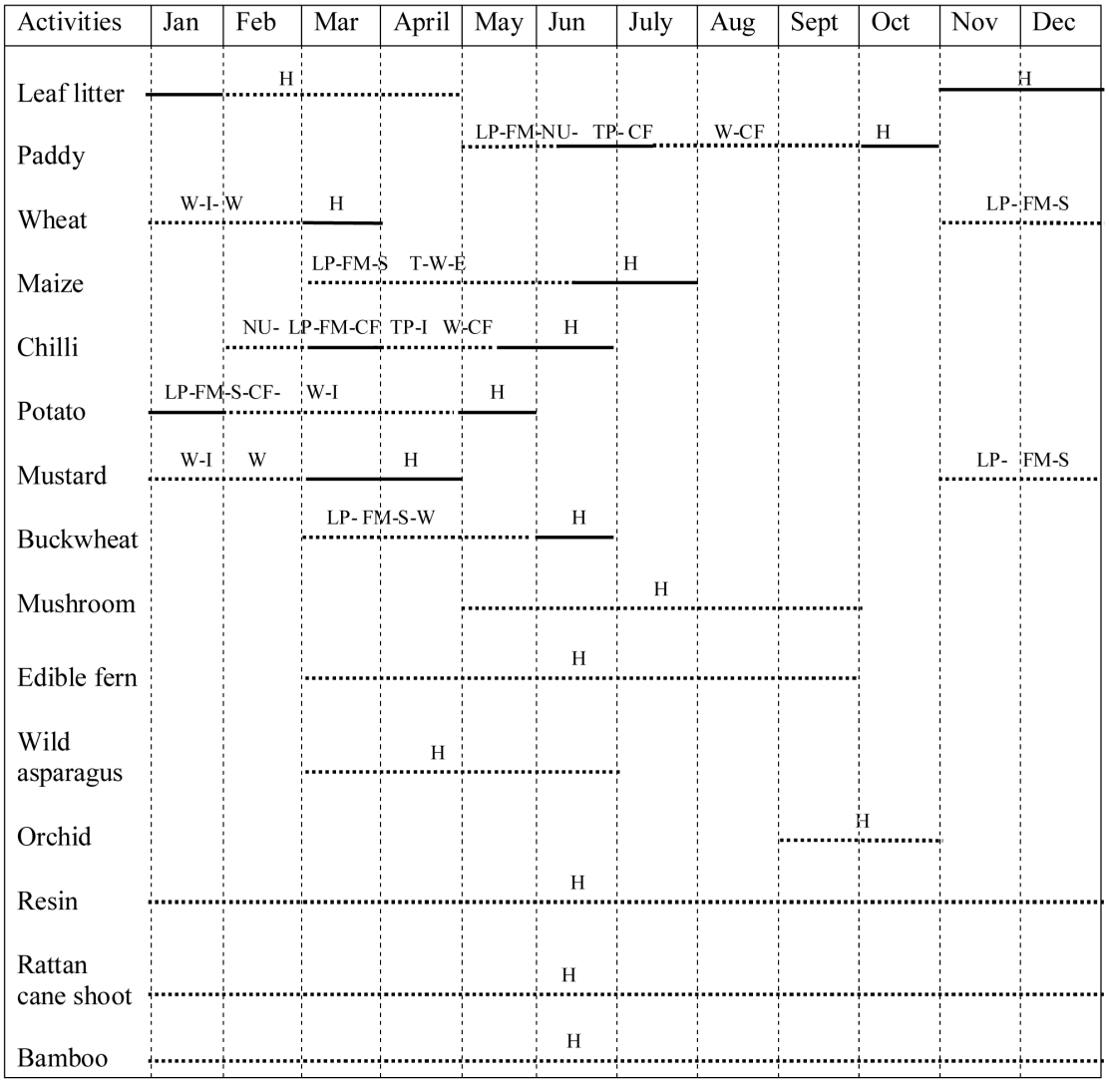

Figure 1 Activity calendar of the farmers at the study areas, Nahi and Limbukha (N=40). LP- land preparation, S-sowing, NU-nursery, TP-transplanting, CF-chemical fertilizer, W-weeding, FM-manure, I-irrigation, T-thinning, E-earthing, H-harvesting, ····· = anytime, ——— = regular.

Based on the survey, a small proportion of farmers about 20% in both the studied areas harvest leaf litters weekly especially those living near the forests. The harvested leaf litters are put in cattle shed as animal bedding for composting. Depending on the availability, different types of plant litters are used for making FYM **(Table 2)**. From the survey, at Nahi, 50% of the farmers use oak as the main component of FYM and the rest use pine needles. At Limbukha, all the interviewed farmers use oak as the main component of FYM. Among the types of leaf litters, oak is the most preferred by the farmers in both the studied areas. Farmers' opinion was that oak is easy to decompose and gives more yield compared to other leaf litters. Pradhan (2002) and Renewable Natural Resources Research Centre and National Soil Services Centre (2001) also reported that the farmers preferred broadleaf oaks than pine needles and paddy straws. Rate of decomposition of the litters depend on the litter quality, one of them is C:N ratio of the litters. C:N ratio in oak is much lesser (37.94) compared to chir pine (76.75) (analysed at KKU) and paddy straws (83) (Kaewpradit et al., 2008). Lower C:N ratio of oak led to faster decomposition and mineralisation of the nutrients. Leaf litters from broadleaf had less recalcitrant materials, faster decay rate and faster release of N compared to conifers (Yang et al., 2004).

Use of FYM

FYM is used in variety of ways; farmers usually pile manure in the fields and plough into the soil during land preparation. It is also used as mulch and burnt in the fields. Burning of manure is practiced in fields located far from the settlements, though burning helps in rapid release of nutrients N, P, K, most of C and N are also lost (Roder et al., 2003). FYM is applied to all the crops, mainly in paddy, chillies and potatoes, the quantity applied depend on the crops grown. Usually 5 to 7 t ha^{-1} of FYM is applied. Some farmers use FYM to control weeds and pest attack in chillies which is a high income crop in Bhutan. When chillies reach 5 cm height, soil is lightly hoed and FYM is applied. Based on the survey, 70% of farmers at Limbukha and 30% of farmers at Nahi use chemical fertilizers but in small quantities; mainly urea, suphala (mixed fertilizer, 15:15:15) and herbicides along with FYM application. Nonetheless, in both the studied areas all farmers prefer leaf litters (FYM) over chemical fertilizers and they mentioned various reasons for their preference **(Table 3)**. One of the main concerns of the farmers from the continuous use of chemical fertilizers was soil hardening and difficulty in ploughing. Pilbeam et al. (2005) reported that the farmers in mid-hills of Nepal preferred to use FYM in combination with chemical fertilizers instead of using chemicals alone since continuous use of chemical fertilizers led to soil hardening, made ploughing difficult, reduced soil fertility and caused a decline in crop productivity. Few farmers about 10% at Limbukha prefer to use chemical fertilizers since FYM production is labour intensive. During the interview with the farmers, it was evident that they are not applying the recommended chemical fertilizer doses, indicating unbalanced nutrient use (Dorji, 2008). Urea is commonly used in almost all the crops, because of the cheaper cost of urea (Nu.379.00 per 50 kg bag; 1US$=Nu.49.50=Baht 30.93) compared to suphala (Nu.734.65), single super phosphate (Nu. 428.00), diammonium phosphate (Nu.821.50), and muriate of potash (Nu.432.00) (Druk Seed Corporation, 2010). There is a need to make the farmers aware on the recommended fertiliser use for different crops.

Table 2 Leaf litter harvesting and use by the farmers in the two studied areas

	Leaf litter use (N=40)
Years of harvesting leaf litters	5 to 80 years
Number of family labour involved in leaf litter harvesting	3 hh^{-1}
Time of leaf litter harvesting	November to April
Source of leaf litters	Leaf litter forest (Sokshing) and natural forests
Area of leaf litter forest (range)	0.10 to 0.81 ha
Walking distance to the forests	5 to 60 minutes
Type of leaf litters	*Quercus* spp., *Pinus* spp., *Castanopsis* sp., Bracken ferns
Quantity of leaf litters harvested per basket	20 to 30 kg
Tools used for leaf litter harvesting	Wooden rake, sickle, hoe, stick (tree branch)
Components of FYM	Pine needles, paddy straw and cow dung
	Oak leaves, paddy straw and cow dung
	Oak leaves, pine needles, paddy straw, ferns and cow dung
	Oak leaves, paddy straw, ferns and cow dung
	Oak leaves, pine needles , paddy straw and cow dung
Place of storing the harvested leaf litters	Cattle shed, open field, under tree, constructed wooden shed
Duration of storing the harvested leaf litters	1 to 12 months

Table 3 Reasons mentioned by farmers for their preference of leaf litters (FYM) over chemical fertilizers in the two studied areas

Reasons	Percent farmers (%)	
	Nahi (N=20)	Limbukha (N=20)
Available in nature, no need to purchase	20	60
Improves soil quality ('black, soft and porous')	70	30
FYM performs more than one function but chemical fertilizers can be used only to give high yield	20	50
Continuous use of chemical fertilizers hardens soil and makes ploughing difficult	70	70

Harvesting non-wood forest products (NWFP)

Besides harvesting leaf litters, based on the survey, 80% of the farmers at Nahi and 40% farmers at Limbukha harvested NWFP mostly from natural forests. The NWFP are mushrooms, edible ferns, wild asparagus, orchids, rattan cane shoots, bamboo and resins. These products fetched them good income. Given the thick forests and lesser settlements at Nahi compared to Limbukha, higher proportion of farmers at Nahi (80%) depended more on forests for NWFP. A small proportion of farmers, 20% at Nahi and 10% at Limbukha, mentioned that the competition for NWFP was high as more people chose these products due to their good market value.

Forest floor in the leaf litter forests

During the field visits it was observed that litters from leaf litter forests consisted of the dominant *Quercus* spp. in both the studied areas whereas in the natural forests there were mixed species of trees and other vegetations. According to farmers, regenerations in the leaf litter forests are removed at the time of litter harvesting for easy collection of leaf litters. It was also observed that the leaf litter forests had no litter layer accumulation on the forest floor, in contrast to 15-19 cm thick layer in the adjacent natural forests. In the leaf litter forests, there is complete removal of leaf litters from the forest floor during litter harvesting. Therefore, there is no source of nutrient inputs through decomposition of litter layers on the forest floor. Annually farmers harvest about 2.94-3.11 t ha^{-1} of litters from the leaf litter forests in west-central Bhutan (Chhetri, personal communication, March 15, 2012). Gimmi et al (2008) also reported an annual litter harvest of about 2-3 t ha^{-1} in a few communities in the Swiss canton of Valais. Substantial amounts of nutrients are removed as a result of litter harvesting; total quantity of 20.57 to 25.47 kg N ha^{-1}, 5.88 to 7.76 kg P ha^{-1}, 12.93 to 14.91 kg K ha^{-1} and 92.58 to 93.42 kg Ca ha^{-1} are removed annually from the leaf litter forests during litter harvesting (Chhetri, personal communication, March 15, 2012)

Farmers' perception and management of leaf litter forests

Based on the survey, 90% of farmers at Nahi and 70% farmers at Limbukha mentioned that the leaf litters are sufficient. Presence of forests nearby and people migrating to urban areas for better opportunities were some of the reasons for the availability of sufficient leaf litters. Only 30% of farmers at Limbukha mentioned the leaf litters are not sufficient. According to them this was due to less area of leaf litter forests and young trees. They also mentioned that the trees in the leaf litter forests have become weaker over the years and they often died. Similar observations were made during the field visits, the leaf litter forests had fewer number of trees compared to the adjacent natural forests, and this must be the reason for insufficient leaf litters. Based on the survey, a small proportion of farmers from Nahi (30%) and Limbukha (20%) mentioned that the 'Sokshing' users were decreasing due to farm labour shortage and the resultant decrease in cattle holdings. This trend of declining household labour and fewer cattle in a household would tempt more people to opt for inorganic fertilizers (Norbu and Floyd, 2004).

Similar management practices were followed by the farmers in both the studied areas. Farmers protect the leaf litter forests by avoiding tree felling and reduced grazing. However, tree stumps observed during the field visits in both leaf litter and natural forests indicated illegal felling. All leaf litter forests had a clean forest floor without any litter layer unlike the natural forests. For easy harvesting of leaf litters farmers clear (either uprooting or cutting) all regenerations which reduces competition for nutrients for the standing trees in the leaf litter forests, but adversely affect the plant populations. In fact the regenerations especially of the preferred species should be allowed to grow since the number of trees is already low in the leaf litter forests. Wangchuk (2001) suggested a rest period for rehabilitation and new plantations to be carried out in leaf litter forests. However, in the current areas, new plantations may not be necessary since vigorous regenerations were observed. If the current practice of clearing the young vegetations and

complete removal of leaf litters during litter harvesting continues, over a period of time the leaf litter forests are going to be depleted. This situation in turn will encourage people to encroach the natural forests (which are already happening in some ways).

Community forestry in the country has become an important part of the national forest policy since its establishment in 1990s (Royal Government of Bhutan, 2010). There are two community forestry at Nahi and five at Limbukha and few more are in the process of establishment (Nado and Yeshey, personal communication, January 10, 2012). Only 10% of the surveyed farmers at Nahi were members of the community forestry user group. Though the community forestry allows everyone equal access to community forest resources, according to the farmers they still prefer to have their own area of 'leaf litter forests' or 'Sokshing' near their settlements. Frequent raking caused soil disturbances by exposing the roots and damaging the regenerated vegetations, killing soil fauna and made the floor vulnerable to erosion (Bhutan Soil Survey Project, 1999). The manners of using the tools by farmers during litter harvesting do not seem appropriate. Based on the survey, 90% of the farmers at Limbukha and 40% farmers at Nahi harvested quickly (deep raking) to complete the work fast and cover more area. This could expose the roots of the trees and also make the soil vulnerable to erosion. Only 30% of the farmers at Nahi were aware of the negative impacts of continuous and improper harvesting, they specifically mentioned soil erosion as the main negative impact. None of the farmers at Limbukha seem to be aware of the negative impacts.

Conclusions

At Limbukha more farmers (70%) use chemical fertilizers compared to Nahi (30%), this indicates that there is more farm labour shortage at Limbukha than Nahi. This is also an indication that more people are migrating to urban areas from Limbukha than Nahi. However, the leaf litter use and its management are similar in both the studied areas. Although labour shortage is one of the main problems faced by the farmers, farmers still chose to use leaf litters than chemical fertilizers as they also are aware of the long term benefits of using FYM in improving the soil quality. Farmers perceive that the trees in the leaf litter forests are weakening over the years and often die. Though majority of farmers mentioned that there is sufficient leaf litters; however, opinions on the sufficiency and the trend in the number of users are divided based on the differences in farm resources such as labour, capital and off-farm activities. Substantial quantities of nutrients are removed annually through litter harvesting; this is likely to have negative effects on the nutrient cycling in the leaf litter forests. Field observations show that leaf litter forests are not managed well and there is a need to revive these forests. The present practice of managing the leaf litter forests by clearing the regenerations is not sustainable; regenerations of the preferred species should be encouraged to increase the plant populations in the leaf litter forests. The findings from this study should serve as preliminary information for further investigation on current management of the leaf litter forests and their concerned conditions. Long term research needs to be conducted on a larger scale across the country to elucidate the different leaf litter forest management practices and to formulate sustainable management practices based on participatory approaches.

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