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Indigenous knowledge on bio-resources management for sustainable livelihood by the cold desert people, trans-Himalaya, Ladakh, India

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The present study is carried out in Ladakh to document the indigenous knowledge on bio-resources management. People here practice various indigenous techniques for storage, use and management of their local resources. Some of the indigenous practices for storage of cultivated crops (*i.e*., food grains, vegetables, and fruits), fuel, fodder and several other bioresources in nutshell are described in this paper. The present study not only established the validity of traditional knowledge but also indicates the urgency to use and keep them in a sustainable mode. Indigenous knowledge if not conserved properly will be seriously threatened under pressure of modernization and especially on account of the apathy among the new generation.

Keywords: Bioresource, Cold desert, Drass, Indigenous knowledge, Ladakh, Nubra valley, Storage, Suru valley, Zanskar.

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Introduction

Indigenous knowledge and practices are of great value in the life of the people living in harsh climatic conditions. Being in practice for the long years they have the characteristics of minimum risk, eco-friendly, economical, environmentally healthy and easily understandable. Such knowledge has continuously been updated or degraded from one generation to another with the passage of time. Indigenous communities are well known for the wise use of limited natural resources and for keeping a healthy state of the environment. The harsh climate (prolonged cold winter) prevailing in this zone always enforces the far-flung inhabitants to search new sources of vital resources like food, shelter, medicine, fodder and fuel[1]. The appropriate storing practice of the available food items and different products from cultivated crops has been explored and tested time and again[2-4]. These practices have led to the development of indigenous methods of storage and utilization of biological resources in cold and harsh climatic conditions.

Documentation of traditional storage practices has importance in developing a strategy for natural resource management and thus, sustainable development of the area. An attempt has been made to document such knowledge in cold desert area of Ladakh region.

Study area

Ladakh, a part of the cold desert, has truly self-sufficient culture and tradition where dependency on natural resources is very high[5]. Despite the remoteness, harsh climatic conditions and aridity, this region is endowed with unique resources: boundless solar energy, clean air and water, rich diversity of wild and domesticated plants and animals, vibrant cultures and rich indigenous knowledge. Indian cold deserts fall under Himachal Pradesh (Lahaul, Spiti and Kinnaur districts), Jammu & Kashmir (Ladakh and Kargil districts), Uttarakhand, Sikkim and Arunachal Pradesh. Ladakh district, one of the most elevated (2,900 to 5,900 m asl) and coldest region (-30 to -70 ^{o}C) of the earth. It covers more than 70,000 km^2 geographical area of Jammu and Kashmir, India and lies between 31^{o} 44’ 57” – 32^{o} 59’ 57” N latitude and 76^{o} 46’ 29” – 80^{o} 41’ 34” E longitude. The region is sparsely populated along the river banks of different valleys namely Indus, Nubra, Changthang, Zanskar and Suru valley. The mean annual precipitation is less than 50 mm, received mostly in the form of snowfall. The region faces fast

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blowing winds 40-60 km/h mainly in the afternoon hours. The soil moisture remains frozen during winters and low relative humidity during the summer months. The region has barren topography. The soils of the region are gravelly and sandy loams on the alluvial fans to sandy and slit clay loams on the Indus plains. Loose sandy loam texture, a high percentage of stones and granules, low water holding capacity, high bulk density and low soil fertility may be due to the result of uneven distribution of plantation or sparse vegetation. The region has a very short growing season as the land remains landlocked for more than 6-7 months every year during extreme winter. Due to small land holdings, local population subsist on limited crops and largely depends on natural resources for meeting diverse subsistence needs which have led to over-exploitation. However, the main source of income is the rearing of Pashmina goats or Changthangi Goat (*Capra aegagrus hircus*), which provide cashmere wool for making well-known Pashmina shawl, and eco-tourism activities. Natural wealth of the region is under various biotic (over-harvesting, grazing, trampling, invasion of alien flora, etc.) and abiotic (natural calamities, habitat fragmentation and degradation through increasing human settlements, climate change, tourism activities like high influx of tourist and army vehicles generate pollutants, increasing unmanaged solid waste, damaging flora while camping, adventurous activities etc., pressures causing high ecological imbalance in the region. According to NAEDB, due to long and severe winter, human population pressure is more than carrying capacity of the vegetation[6].

Materials and Methods

The study is based on the extensive and intensive field surveys conducted in the Ladakh region, a part of the cold desert from 2010 to 2013. In order to collect the data Nubra valley, Suru valley, Drass, Zanskar, Leh and Kargil areas of Ladakh located at different altitudes were selected. Interviews, semi-structured open-ended questionnaire and direct observations were used to gather information on indigenous storage, processing and utilization practices of local bio-resources. The respondents were chosen using stratified sampling in which male and female informants ranging from 30-70 years.

Results

Traditional agroforestry system as the main source of food materials

It is well-known fact that through the development of agroforestry system the pressure on natural resources can be substantially reduced. Recently, the agroforestry has received adequate attention for its enormous potential for carbon sequestration. In Ladakh region, traditional agroforestry system in the form of agri-silviculture system exists since time immemorial[1] which is the combination of agricultural crops with boundary plantations of willow (*Salix* spp.) and poplar (*Populus* spp.) species. The Nubra valley is covered with more than 5,75,000 plants of willow and poplar. These are the main source of fuel-wood and fodder. Otherwise the requirement of fuel-wood during winters when the temperature goes down up to -30 ^{o}C is met through the cutting of dry as well as green plants or collection of fallen twigs in nearby forests. This unsustainable practice of harvesting has posed huge pressure on the wild stock. Almost all the woody species are used as source of fuel-wood in the valley. According to an estimation, every year these species are contributing 400 tonne of leaf litter to the ground and thus, is a great source of organic carbon and responsible for sequestration of more than 75,000 tonne of carbon[7].

In wild plants, seabuckthorn (*Elaeagnus rhamnoides* (L.) A.Nelson of Elaeagnaceae (syn. *Hippophae rhamnoides* L.), a multipurpose thorny shrub, which the villagers use for food, fuel, fodder, medicine and for fencing their fields, is an important species. Being a nitrogen-fixing species, it is planted in Igoo-PHE canal as rehabilitation measures to the soil condition of the area and to support the agricultural crops. The valley portion of Nubra is well vegetated with thickets of seabuckthorn compared to mountain slopes and remaining part of Ladakh district. In lower slopes, the integration of agricultural crops are rarely seen with fruit trees as apple (*Malus pumila* Mill. or *M. sylvestris* (L.) Mill.), apricot (*Prunus armeniaca* L.), peach (*Prunus persica* (L.) Batsch), mulberry (*Morus alba* L.) and walnut (*Juglans regia* L.). Strawberry (*Fragaria vesca* L.) has been introduced in combination with agricultural crops. The raising of some fruit tree species in the kitchen garden is also a well-established tradition of the region.

The land utilization pattern of Leh, Nubra and Nyoma showed that only 2.64 % area is arable and 9.66 % area is under vegetation cover. The lower percentage of arable land is restricted only to flat valleys and in lower slopes where water availability is ensured. In high ridges, the wild plant species depend upon the good amount of snowfall because of an acute scarcity of water on the barren mountains. The traditional crops of the region include barley

(*Hordeum vulgare* L.), grim (*Hordeum aegiceras* Nees ex Royle), wheat (*Triticum aestivum* L.), buckwheat (*Fagopyrum tataricum* (L.) Gaertn. and *F. esculentum* Moench), millets (*Panicum miliaceum* L.) and oat (*Avena sativa* L.). Besides, a chunk of the cropped area is occupied by pea (*Pisum sativum* L.), potato *(Solanum tuberosum* L.*)* and mustard (*Brassica* spp.). *Allium cepa* L., *Allium stracheyi* Baker, *Coriandrum sativum* L. and *Carum carvii* L. are cultivated mostly in kitchen gardens and used as a spice. *Carum carvii* has great demand in the market both for spice and medicinal purposes.

In recent years local farmers have diversified their agricultural crops by including vegetable crops including *Brassica rappa* L., *B. oleracea* L. (both cauliflower and cabbage), *B. nigra* L., *B. caulorapa* L., *Chenopodium album* L., *Cucurbita maxima* Duchesne, *Cucumis melo* L., *Solanum lycopersicon* L., *Solanum melongena* L. and *S. tuberosum* L. under cultivation. They use these crops both for self-consumption and for sale to the government employees including the defence personnel. This adds to their cash income. Besides cultivated crops, some wild plants in the region are used as vegetable which includes *Amaranthus spinosus* L., *Capsella thomsonii* Hooker, *Allium thomsonii* Baker, *Lactuca dolichophylla* Kitam, *Chenopodium foliolosum* Hooker, *Lepidium latifolium* L., *Orobanche hansii* Kerner and *Polygonum aviculare* L. Additionally, many legumes associated with agricultural crops act as valuable sources of fodder and soil enrichment.

As the area is totally closed for almost half of the year and totally cut off from whole state or world during winter period due to heavy snowfall on Zojila (3510 m) and Rothag pass (3978 m), the local inhabitants practices a number of indigenous methods/ techniques for storage, processing, uses and management of their local resources, to cope with the harsh climatic conditions. The process of storage, processing and use of the different bioresources are explained in details which are as follow:

Processing and storage of cultivated food grains

Due to prolong sub-zero temperature during winter, farming activities are done only between March and September. Despite harsh climate condition, people have developed their own farming systems and produce more than enough food for their subsistence[8]. *Hordeum vulgare* (*nas*), *Triticum aestivum* (*tro*), *Pisum sativum* (*rshatma*) and *Fagopyrum tataricum* (*bro*) are the major cultivated millets of the region. These crops are sown in March-April and harvested in August-September. Harvested crops are kept as such in the fields for 8-10 days in order to reduce their moisture content so that processing could be done easily. Seed grains separated through threshing are exposed to sunlight for 4-5 days in order to achieve optimum moisture for storage. Finally, they are collected in jute bags and stored in large wooden boxes locally called '*Zgram*' (Plate 1a-b), made of *Salix* sp. and *Morus alba*. The size of the boxes varies according to the type of the products to be stored. However, the boxes used for food grain storage are generally of 5.0-6.0 m length, 1.5-2.0 m width and 3-4 m height. Beside this, a compartment like small room locally called '*Paa-na*' (in Leh) '*Bangba*' (in Kargil) (Plate 2a) especially prepared by mud inside the house, is also used for this purpose. It has a capacity of storing large quantity grain for long-term preservation. In some areas, particularly in Suru Valley and Kargil, a big sized basket locally called '*Tukuru*', made up of fresh branches of *Salix* sp. is also used for this purpose. It is plastered by mud externally and then food grains particularly wheat and barley are kept and its open top lid is fully packed by mud in order to protect from mice and insect attack and also for long-term storage. However, the wooden boxes, locally known as *Zgrams* are used to store grounded grain materials.

During the month of October – November, the stored grains are consumed and only the required amount is taken out for use. Before consumption, it is properly washed and then sun-dried for a week. After optimum sun drying, it is roasted and finally, grounded with the help of modern or traditional flour mill. The grounded materials are called with different names like *nasfey* or *nanphey (Hordeum vulgare), brofay (Fagopyrum esculantum*), *rshanfay (Pisum sativum*) etc. Barley is also used to make beer locally called '*Chang*' (Plate 1k).

Processing and storage of fruits

Among many fruit yielding trees, apricot is the most demanding and economically important one. Apricot is a small delicious soft fruit of yellowish to orange colour. They contain a pit inside of them and the core of this pit is called the kernel. The kernel is pressed to produce apricot kernel oil. Fresh apricot fruits are locally called as '*Chuli*' and '*Fating*' in dry condition.

It is present in many areas of Ladakh but high quality apricot is most abundant in slightly warm

Plate 1 — a) *Zgram*, a side view,-b) Food grain stored in a *Zgram*, c*)* Sun drying of apricots, d) Separation of low quality apricots, e & f) Apricot seeds threshed to get the kernels for oil production, g) Vegetable storage process, h) Fodder storage in *Foogra,* (a room) , i) Fodder collection from high mountains, j) Fodder left after threshing, k) Barley ready for beer (*Chang*) production

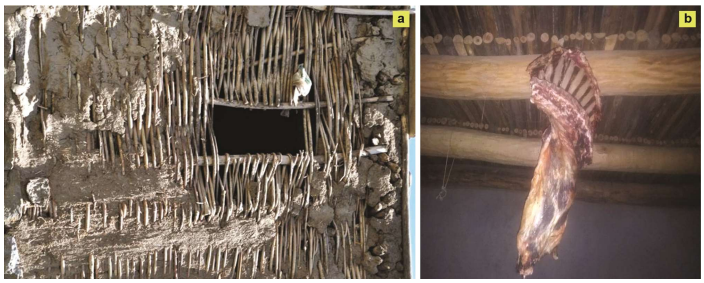

Plate 2 — a) *Paa na* to store grains, b) Animal foods (meat) preserved specially during winter by spreading salts

temperature zones particularly in lower Ladakh like Garkon, Batalik, Hardaas and Kargil.

To maintain the quality of the harvested fruits they are kept in a basket, locally called '*Cheypo*', made of young branches of *Salix* sp. For sun drying, fruits are spread on a special wooden sheet which is made of *Salix* wood and locally called '*Shaq*'. The high-quality apricots having good nutritive value and sweet kernels are dried for 10-12 days. Shrunken and hardened fruits are collected in jute bags and stored in wooden boxes for winter. However, low-quality apricots are directly used for oil extraction. For that

cover of the fruit is separated from the nuts and allowed to sun-dry for 8-10 days (Plate 1c-f). In winters, dried fruit coverings are used as fodder to cattle, sheep and goats. However, nuts with sweet kernel are eaten as such and also exported.

The apricot oil locally called '*Chulimar*'or '*Tsugimar*' has multipurpose use in household and a good market value (up to Rs. 700/L). It is easily absorbed into the skin and does not leave any oily residue on the skin. It is gentle and mild for babies. Apricot kernel oil is also used in lotions, creams, and balms, as well as in soaps. Traditionally, it is extracted through cold press method hence retain the nutritive value of the oil.

Other fruits like apple, pears, mulberry, grapes etc., are also dried and stored. Apples are cut into chips and are allowed to sun-dry for two weeks and afterwards stored in cloth bags and consumed especially by children during prolonged winters. Low quality dried fruits are used as cattle fodder.

Storage of eatables

Plant originated food materials

Due to limited landholding, the coverage area of vegetable cultivation is very less in this region. cauliflower (*Brassica oleracea* var. *botrytis*), cabbage (*Brassica oleracea* var. *capitata*), reddish (*Raphanus sativus*), turnip (*Brassica rapa*), rapeseed mustard (*Brassica napus*), onion (*Allium cepa*), potatoes (*Solanum tuberosum*) are sown as the major crops. Cabbage, cauliflower and other leafy vegetables are cut into small pieces, sun-dry for optimum storage conditions and consumed during winter when there is dearth of food resources **(**Plate 1g, i, k**)**. Beside this, wild plant species like *Taraxicum officinale* (*khorma/han*), *Rumex acetosa* (*shoma*)*, Caparis spinosa* (*kabra*), *Allium carolinianum* (*skochey*), *Cristolea crassifolia, Mentha longifolia* (*phololing*)*, Mentha arvenses* (*phololing*), *Rhodiola* sp. (*rsholo*) etc. are also collected, dried and stored by adopting the aforementioned process.

Potato (*Solanum tuberosum*), carrot (*Daccus carrata*), turnip (*Brassica rapa*), reddish (*Raphanus communis*) etc., are stored in sub-soil underground pits which are prepared in agricultural fields near the houses. In this method, 2-3 m deep pits are dug and the vegetables are kept there in a definite manner and then covered with soil. The covered pits are slightly raised above the soil level in order to identify them later. Sometimes a 5-8 cm thick stick is tagged above the pits so that the pits can be easily recognized during heavy snowfall.

Such traditional methods of storage are very good for a high quantity of storage in a natural manner as the stored material remains safe and healthy even for 5-8 months without using any electrical energy[5]. In some areas, solar houses are built to grow the vegetables, for that people have to depend upon sun light so no longer practised by the inhabitants particularly during heavy snowfall.

Animal originated food materials

Meat is considered one of the major sources of energy to combat against harsh climatic conditions particularly during extreme winter. Goat and sheep are the major sources of meat which is cut into small pieces and dried for the four weeks and then stored at ambient room temperature particularly in kitchen (Plate 2b). Skin and fat portions of these animals are not cut before drying. The wool collected from these animals are used to prepare woollen garments. The outer skin of sheep and goats are used as mattresses.

Processing and storage of fodder

The fodder is obtained from the cultivated crops and grasses cultivated along the margins of cropland. Some fields are used for the production of alfalfa (*Medicago lupilina*). The crops like barley, wheat etc., after harvesting are kept in fields for 5-6 days sun-dry to them and then threshing is done through the indigenous method by cows, bulls, horse, donkeys, yaks, *tzo* and *tzomo*. Usually heavy animals are preferred for this purpose. In some parts of the region, threshing is also done with the help of machines. Afterwards, grains are separated and straw is stored as fodder for livestock in a separate room locally called '*Foogra*' or '*Phugrags*' specially made for the storage of fodder material (Plate 1h-j). The cultivated grasses mostly *Medicago* sp. are also dried and tied into small bundles for storage on the roof of houses. Small twigs, leaves and barks of large trees like *Salix*, *Populus*, *Prunus*, *Juglans*, *Morus* sp. etc., are also used as fodder. Besides these, collection of wild fodder is also done from higher mountains during summer season and stored them after drying. The plants collected from wild include *Cicer songaricum, Cicer microphyllum* (*seri*), *Cremanthodium arnicoides, Heracleum pinnatum* (*spur-ma*), *Meliolotus indicus, Prangos pabularia, Ranunculus* sp., *Artemisia* sp. etc.

Fuel and litter storage

Collection of fuel for winter purpose starts in autumn when people are free from cultivation and harvesting activities. The dried branches of

Salix, Prunus, Populus, Pyrus, Morus species, etc. are used as fuel wood. The inhabitants residing nearby mountain and riverine areas prefer to collect shrubs like *Hippophea rhaminoides, H. tibetianum, Myricaria rosea, Rosa webbianum, R. feotida, Caragana versicolor, Juniperus* sp., *Ribes alpestre, Ribes orientale, Artemisia* sp., etc. Dung cake is also prepared throughout the year and used as fuel particularly in winters.

Other products

Traditional agriculture in Ladakh is based on human labour, animal power and handmade tools. Various animals like *sheep, goat, horse, donkey, yak, cow*, *tzo*, *tszomo* (last two a cross between *yak* and *cow*) are reared by the people of Ladakh to meet their primary needs. '*Yaks'* are reared for buttermilk, cheeses and wool; *sheep* and *goats* for wool and meat. The *horses* and *donkeys* are mainly used for transportation and '*Tzos'* to plough the agricultural fields. The wool derived from the sheep is used for making woollen garments like sweaters, socks, gloves, caps etc. The wool material derived from *goats* and *Yaks* are used in the manufacturing of blankets locally called '*Fiyarba*'. Various agricultural instruments are made from *Salix* sp. and *Juglans* wood.

Conclusion

In the subzero climate, the people of trans-Himalaya practices a range of processing and storage techniques to store and conserve their foods and other items to cope with the environmental conditions. The techniques like storage of potato, reddish, carrot etc., under sub-soil, food grains storage in wooden boxes, preparation of local beer *chang* are very unique and distinctive methods as compared to other parts of the country. These methods can be used in developing low-cost innovative methods of preservations to minimize the post-harvest losses and increased the availability of vegetables during winter months. These techniques can be modified to develop the zero-energy storage of vegetables to further extend the shelf life and quality of food items. Further, more exploration and documentation regarding the conservation management of indigenous knowledge and practices in high land regions is required before it is lost forever. If such knowledge is not conserved timely then due to the advent of modernization, it will be in grave threat and with the passage of time, it will totally vanish.

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