Livelihood diversification in cold arid desert of Indian Himalaya: urgent need of transforming traditional agroforestry system with emphasis on adoption of herbal farming

Jitendra S. BUTOLA*1, A.R. MALIK2, J.A. BABA2

1Herbal Research and Development Institute, Mandal-Gopeshwar, Chamoli (Uttarakhand), India
2Regional Agricultural Research Station/KVK (SKUAST-K), Stakna-Leh 194 101 Ladakh, (Jammu & Kashmir), India

Abstract: Agroforestry is a science which has the potential to contribute to the improvement of rural livelihood. Due to capacity of its various forms, it offers multiple alternative and opportunities to the farmers to enhance farm production and income, while protecting the agricultural environment. The local inhabitants of Ladakh region, a Cold Arid Desert, have their traditional Agroforestry system which plays an important role in meeting diverse subsistence needs particularly in xeric condition occurs during prolonged winter season. In our study, we assessed potential of traditional Agroforestry system in present livelihood perspectives. The present article stressed upon development of an integrated Agroforestry system to provide sustainable livelihood and environmental security maintaining present standard of living in Ladakh region.

Keywords: Livelihood; Agroforestry; Cold desert; Herbal farming; Himalaya.

Indian Cold Deserts fall under Himachal Pradesh (Lahaul & Spiti and Kinnaur districts), Jammu & Kashmir (Leh and Kargil districts), Uttarakhand, Sikkim and Arunachal Pradesh. The Ladakh region (Figure 1), one of the most elevated (2,900 m to 5,900 m asl) and coldest (-30°C to -70°C) of the earth. It covers more than 70,000 square km geographical area of Jammu and Kashmir, India and lies between 31° 44’ 57” - 32° 59’ 57” N latitude and 76° 46’ 29” - 80° 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 blowing winds 40-60 km/hr 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, high percentage of stones and granules, low water holding capacity, high bulk density and low soil fertility may be due to result of uneven distribution of plantation or sparse vegetation.

Figure 1: Over view of cold desert Ladakh (Photo: Dr. A.R. Malik).
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5,750,000 plants of Willow and Popular. These are main source of fuel wood and fodder. Otherwise the requirement of fuel wood during winters when temperature goes down up to -30°C is met through 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 a source of fuel wood in the valley. According to an estimation, every year these species are contributing 400 tonnes of leaf litter to ground and thus, being great source of organic carbon and responsible for sequestration of more than 75,000 tonnes of carbon (Kumar et al., 2009).

Figure 2: Traditional agroforestry system in cold arid desert, Ladakh (Photo: Dr. A.R. Malik).

In wild plants, Seabuckthorn (Hippophae rhamnoides L.), a multipurpose thorny shrub which the villagers use for food, fuel, fodder, medicine and for fencing their fields (Figure 3), 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 region. 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 kitchen garden is also well established tradition of the region.

Traditional agroforestry system

Traditional agroforestry system (Figure 2) of the region exists in the form of agri-silviculture system that is the combination of agricultural crops with boundary plantations of Willow (Salix spp.) and Popular (Populus spp.) species. The Nubra valley is covered with more than 5,750,000 plants of Willow and Popular. These are main source of fuel wood and fodder. Otherwise the requirement of fuel wood during winters when temperature goes down up to -30°C is met through 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 a source of fuel wood in the valley. According to an estimation, every year these species are contributing 400 tonnes of leaf litter to ground and thus, being great source of organic carbon and responsible for sequestration of more than 75,000 tonnes of carbon (Kumar et al., 2009).

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Figure 3: Live fence of Hippophae rhamnoides plantation (Photo: Dr. A.R. Malik).

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 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 include 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.

Major setback in traditional agroforestry system

- Choice of farmers are limited for trees component, i.e., only Willow and Poplar
- Research-extension linkages are poor and therefore, local people are not aware of propagation and plantation techniques of newly introduced tree species as well as agricultural crops.
- Incentives and subsidies from line departments are lacking for agroforestry development.
- Lack of integrated sustainable multi-disciplinary approach.
- Research strategies are either in-effective or insufficient for the region.
- Shifting of local people from agriculture to seek opportunities in other enterprises and eco-tourism activities.
- Moisture and temperature limitations: water availability is restricted due to very low precipitation in the region.
- Climatic uncertainties.

Prospects and Potential of Agroforestry for enterprises development

Herbal farming

Diversification in present cropping system seems to be the need of the day to cope up with the ever increasing demand for variety of products and assured income. The region has great medicinal plants diversity. Cultivation of medicinal plants with existing agroforestry systems is a viable option. Wherever markets are established, medicinal plants are remunerative alternative intercrops to the traditionally grown annual crops. Economically viable and highly demanded medicinal herbs like Aconitum heterophyllum Wall. ex. Royle, Arnebia euchroma (Royle) Johnst, Artemisia maritima L., Dactylorhiza hatagirea (D. Don) Soo (Fig-
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Majority of these species being native to Himalaya are well adapted to local climatic conditions and therefore, can be intercropped with local tree species. However, the selection of species will depend on the size and intensity of its canopy shade, tree spacing and management, especially pruning of branches and nature of the medicinal plants, i.e., their light/shade, moisture and nutrient requirements. The planted trees may benefit from the inputs and management given to the intercrops. Demand of unprocessed material and finished herbal products is very high even in local areas due to presence of tourists and defence personnel. Besides, there is a well developed ‘Amchis System of Medicine’ in the region which includes a number of herbs for curing various diseases of over 60% tribal population. Due to low availability of certain wild medicinal herbs in the study area ‘Amchis’ have to travel far and wide in search of such species. Besides, the Field Research Laboratory, Leh, the world’s highest research laboratory of Defence Research and Development Organization (DRDO), has also formulated certain high value medicated herbal products in the past few years. Cultivation of medicinal herbs will meet the raw material demand and reduce the over-exploitation pressure from natural populations.

*Salix spp.* are already well planted in the fields. Plantation of *H. rhamnoides* and *Juniperus* spp. in the boundaries of cultivated fields will be fruitful. Hardy medicinal and fruit trees can be grown in community lands in villages and degraded lands. The soil fertility is improved by planting sustainable native agroforestry tree species. *H. rhamnoides* is sparsely present in traditional agroforestry system which further can be augmented through plantation at appropriate distance and place. *Juniperus macropoda* Boiss is a high value medicinal and aromatic plant and a prominent source of Juniper oil. Local people use its fruit and leaves for making aromatic sticks (*Dhoop*). Natural regeneration of the species is negligible due to different biotic disturbances, such as increasing population pressure, grazing, fire and also due to lack of scientific knowledge of propagation. Besides these, collection of any part of the plant for research purpose is prohibited by local Buddhist Monks (Lamas) that adds fuel to fire for its large scale propagation. There is a dire need to develop propagation, multiplication and plantation techniques of this species to harness its potential for socio-economic and ecological development of the region.

**Dairy farming**

Due to various reasons including lack of grazing areas as well as availability of grazing areas for short period of time and lack of green fodder, dairy farming is very restricted in the region. Moreover, adverse climatic conditions...
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