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Need and Development of Best Agroforestry Models for State of Uttarakhand: via Domestication of Agroforestry Trees

Chandra Shekhar Sanwal [1], Vivek Pandey[2*]

[1]Sanwal, Uttarakhand Forest, Divisional Forest officer, Haldwani.
[2]Uttarakhand Forest, Chief Working Plan Officer, Uttarakhand, India.

***Corresponding Author:** Vivek Pandey, Uttarakhand Forest, Chief Working Plan Officer, Uttarakhand, India.*

ABSTRACT

The paper highlights the need of best agro forestry practices suited under different agro climatic zones of the state for developing best agro forestry models for Uttarakhand. Also to meet the demands of hilly people for food, fodder, firewood and timber in the present scenario of increasing availability of fallow and cultural wastelands, new interventions are proposed to enhance the productivity of existing land-use systems for food and nutritional security of the hilly people of the state.

Thus to make the best use of available land based on its supporting ability for fulfilling the socio economic needs of hilly people pilot studies or participatory on-farm researches are the urgent requirements to harness the potential of agro forestry models in the state.

Keywords: *Agro forestry Models, Socio-Economic Needs, Potential of Agro forestry*

INTRODUCTION

Although the agro forestry is an age old practice yet science of agroforestry is new. Agro forestry practices are highly specific and specialized. To adopt it on one's land, one has to have a specific prescription with a complete package of operations. As it involves management of crops, livestock and trees so sound knowledge of agriculture and forestry for integrated administration is the obvious requirement. Through agroforestry it is feasible to produce food and wood while at the same time conserving and rehabilitating ecosystems. In the country, forestland is only 23 per cent of the total geographical area, which is not enough to establish 33 per cent green cover. In addition, all of this 23 per cent area is not suitable to plant trees, as it is rocky and heavily degraded. However, achieving the national target of 33 per cent green cover will be possible only through agroforestry that is, planting trees on farm or agricultural lands.

Hills cover major part of Uttarakhand State that cover approximately 90 per cent of the geographical area. The total forest area under various classes of the forest is 37999.53 Km^2, which is 71% of the total geographical area (Uttarakhand forest statistics, 2013-14). A majority of the area of the state is under forests and wastelands thus leaving behind only a small amount of land (about 12 %) for cultivation. Further anomalies like shift in monsoon patterns, landslides, cloud bursts and drying up of natural springs have resulted into the practice of hill agriculture as uneconomical one which is relevant in most of the mountain regions of the state. Today mountains are witnessing migration at a very large scale and lands turning up barren. Presently out of the total reported area of 5672636 ha in the state, cultural wastelands and fallow land occupy 438183 ha which is about 8 per cent of the total area (Uttarakhand at a glance, 2012-13). In such a scenario agro forestry as a multiple use concept of land management is capable of meeting the present challenge of shortage of fuel wood, fodder, environment degradation, protection of watersheds, improvement of wastelands and agriculture land.

There is ample scope of improvement of these culturable fallow lands by adopting improved agro forestry systems viz., agrisilvicultural, agrisilvipastoral, hortsilvicultural, hortisilvipastoral, energy plantations and multiple use vegetative cover, vegetative check dams and stream bank plantations. The present paper highlights various agro forestry practices (Table1) to introduce domestication of

agroforestry trees for developing best agroforestry models for the Terai -Bhabar regions and the lower, mid and higher Himalayan regions in the state of Uttarakhand.

Table1. *Existing Agro forestry systems found in different agro climatic zones of Uttarakhand.*

Zone	Agroforestry system	Agricultural crop	Tree Species
Terai & Bhabar Upto 750m	Agrisilviculture Agrihorticulture	Wheat, Maize, Paddy, Soyabean, Gram, Lentil, Mustard, Sugarcane, Urd, Pea, Okra, Garlic, Onion, French bean, Cauliflower, Cabbage etc.	**Forestry Sp:** Eucalyptus, Poplar, Shisham etc. **Horticulture Sp:** Mango, Litchi etc.
Shivalik (Sub temperate mid hills 750-1500m)	Agrisilviculture Agri-hortisilviculture Silvipastoral	Rice, Wheat, Maize, Mustard, Pea, Barley, Mandua, Jhingora, Pearl millet, Urd, Mung, French bean, Cabbage etc.	**Forestry Sp:** Bhimal, Toona, Sehtoot, Kachnar, Khirak, Chura, Chir etc. **Horticulture Sp:** Pear, Plum, Apricot etc. **Grasse Sp:** *Apluda mutica, Chrysopogon Sp., Heteropogon, Agrostis, Thameda anathera, Arundinella nepalensis, Digetaria decumbense, Panicum coloratum, Chloris gayana, Bracharia decumbens, Pennisetum clandastymum, Setaria, sphacelata, Pennisetum orentalis, Pennisatum flaccidium* etc.
Lesser Himalayas (Temperate high hills 1500-2500m)	Agrisilviculture Hortiagriculture Hortisilviculture Silvipastoral	Wheat, Maize, Barley, Mandua, Jhingora, Pearl millet, Pea , French bean, Cabbage, Ramdana, Potato, Buckwheat etc.	**Forestry Sp:** Pangar, salix, Banj, Kharsu, Moru, Buransh, Poplar, Thuner, Raga, Deodar, Kafal etc. **Horticulture Sp:** Apple, Walnut, Pear, Apricot, Almond etc. **Grasse Sp:** *Aragrostis spp, Bromis intermis, Festuca arundinacea, Dactylus glomerata, Festuca, Kobretia, Cymbopogon distans, Chrysopogon royleanus, Dandhonia cachemyriana, Digetaria decumbense, Festuca arundinacea, F.pretensis Kobretia, Panicim repens, Setaria anceps, Chrysopogon serrulatus, Lolium multiflorum, Pancium cladystymum, Chloris gayana, Poa annua, Lolium vigidum, Arundinalla nepalensis, Phleum pretense, Poa annua* etc.
Higher Himalayas (Dry Temperate zone above 2500m)	Agrisilviculture Hortisilviculture Silvipastoral	Wheat, Barley, Potato, Buckwheat etc.	**Forestry Sp:** *Hippophae*, Betula, Salix etc. **Horticulture Sp:** Apple, apricot, Almond, etc. **Grasse sp:** *Danthnia cachemyriana, Koeleria cristata, Calamagrotis emodensis, Festuca lucida, Brachypodium sylvaticum, Trisetum spicatum, Andropogon tristis, Phleum alpinum, Agrostis munroana, Deschampsia caespitose Hilictotrichon virescens and Deyeuxia pulchella.*

Existing Agro Forestry Systems in Different Agro Climatic Zones

Agro forestry in real sense is the back bone of cultivation system of the Uttarkhand. The state has been divided into four agro climatic zones. Agroforestry has its own role to play in all these zones. There are structural as well as functional changes in the agro forestry systems in different zones.

Terai and Bhabar Zone (Up to 750 M)

This zone consists of plains, terai and bhabar areas. Out of these, terai zone is intensively cultivated because of fertile soil and plenty of irrigation water. Agroforestry systems in terai zone are well developed and are of commercial nature. In the last two decades, Poplar and *Eucalyptus* based agroforestry systems have played a major role in augmenting the economy

of the farmers in terai region and are common amongst the farmers. With intensive management of these fast growing species, the farmers are getting up to Rs. 40,000 to 45,000 per acre per year against approximately Rs. 12,000 to 15,000 from rice-wheat rotation. Many agricultural crops viz. wheat, black gram, rape seed, lentil, coriander, tomato cabbage, sugar beet, sweet potato, potato, spinach, brinjal, fenugreek, knol-khol, turnip, strawberry, onion, lettuce, celery, garlic, etc can be profitably grown with poplar up to 8 year old plantations. Some other crops like pea, chilly, berseem, chickpea can be grown with poplar up to 4 years. Few crops like sugarcane, maize, sorghum, soybean and menthe can suitably be grown only up to two years.

Taungya system is also one of the important agroforestry systems of this region. Since 1962, big farmers have taken taungya system to establish poplar in terai region. The following combinations were followed.

Trees	Associated agricultural crops and yield (kg/ha)
Shorea robusta, Tectona grandis, Acacia catechu, Dalbergia sissoo, Eucalyptus spp. Populus spp.	Maize (946), rice(862), soybean, wheat (380), chick pea (447), rape seed (392)

In the western circles especially in the terai east, terai central and terai west forest divisions the departmental and leased taungya were very common and prevalent from the year 1990 to 2008 which were considered very beneficial from economic point of view to both the farmers as well as the forest departments. However, from the year 2009 onward the taungya system of raising these plantation were put to an end by the government of India order dated 29th December 2008 while considering agriculture crop as non forestry activity and eventually the violation of Forest conservation act 1980. Now such plantations are raised solely by the forest department without raising any agricultural crops.

In this zone, agrihorticulture systems are also well developed. Fruit trees viz. *Mangifera indica* (Mango) and *Litchi chinensis* (litchi) are most commonly grown by the farmers. *Psidium guajva* (Guava), *Prunus persica* (Peach), *Pyrus communis* (Pear), *Artocarpus integerifolia* (Jack Fruit), *Carica papaya* (Papaya), *Citrus sp* (lemon, kagzi lime, orange, chakotra, galgal, mosumbi etc) are also of common occurrence on farmer's field. Wheat, Maize, Soya bean, Lentil, Sugarcane, Mustard, rainy season vegetables, winter vegetables, and leguminous crops like Bengal crop, Barseem, peas, black gram and green gram are usually grown as intercrops with these fruit trees in initial years. Sometimes, filler trees like peach, papaya, plum, guava etc are also grown in between mango trees. However, these filler trees are generally uprooted after 8-10 years before any competition set in. Besides these well managed agroforestry systems, sometimes marginal farmers also retain some of the trees like *Dalbergia sissoo* (shisham), *Leucaena leucoephala* (Subabul), toon (Toona ciliate), dek (Melia azedarach), *anthocephalus kadamba* (Kadam), *Holoptelea integerifolia* (kanju), *Adina cardifolia* (haldu) on their farm for meeting the need for fuelwood , fooder and small timber.

Recently, after Eucalyptus and Poplar based agroforestry systems, Salix trees are increasingly being adopted by the farmers due to slash in the poplar prices.

Case Studies1. Salix and Coffee based Silvi-horticulture system in terai region of Uttarakhand

Looking to the commercial value of coffee plantations and to diversify the prevalent agroforestry systems based on monoculture of *Eucalyptus* and Poplar, a trial was done to introduce and establish the coffee plantations in terai region of Uttarakhand, under trees of *Salix alba* for developing Salix based Silvi-horticulture system. Research was undertaken to find out the effect of Salix spacing and fertilizer doses on the growth and quality of coffee under shallow water table conditions. The field experiment was conducted during 2002-2003 in the agro forestry research block, Patharchatta of G.B. Pant University of Agriculture and Technology, Pantnagar and quality of coffee was determined in the laboratory of Food Science and Technology department of G.B.P.U.A. &T., Pantnagar. The coffee powder prepared from the coffee plantation grown in terai region of Uttarakhand was subjected to chemical analyses for testing the quality of coffee with respect to moisture, carbohydrate, protein, fat, total ash, nitrogen, potassium and polyphenol and compared with the coffee powder procured from market.

All growth character of coffee plantation was recorded higher under 10x5 Salix spacing and

N+P+K fertilizer dose was found best for optimum growth of coffee plantations. Chemical analysis and sensory evaluation of coffee indicated its liking by the panellists when it was compared with the coffee powder procured from the Chickmagalur (Karnataka). Thus, the establishment of coffee plantation in Salix based agro forestry system offered a good scope for the adoption of coffee as potential crop for the farmers and growers of terai region of Uttarakhand (***Sanwal et al. 2011***).

Case Studies2. Introduction of Melia Composita as a Potential Agroforestry Species in Terai Region of Uttarakhand.

Melia composita is commonly known as Burma Neem is fairly large, deciduous and fast growing tree. It grows upto a height of 20m and straight cylindrical bole of 9m. The tree is commonly found in the Eastern Himalayas particularly in the states of Sikkim, North Bengal, Assam, Khasi Hills, and Orissa. Due to its wide distribution, the tree is capable of withstanding wide range of climatic conditions. The tree is cultivated in the arid, semiarid and semi moist areas. Due to its fast growth and multiple uses, it is emerging as a most potential tree for growing under agro-forestry plantation in the North-Western states of India.

Further to promote the agroforestry in the line of National Agroforestry policy 2014the Uttarakhand government has already released the tree list exempted from any transit pass and fee (Table 2).

Table2. *List of tree exempted from Transit Pass in Uttarakhand*

Sl. No.	Name of Tree Speices	Botanical Name
1	All species of Eucalyptus	*Eucalyptus spp.*
2	All species of Popular except Pahari Peepal	*Poplus spp.* (except Populus ciliata)
3	Majnu/Willow	*Salix spp.*
4	Exotic pine	*Pinus spp.* (except P. roxburghii & P. wallichiana
5	Surai	*Cupressus spp.* (except Cupressus torulosa)
6	Silver oak	*Grevillea robusta*
7	Bottle brush	*Collistemon spp.*
8	Robinia	*Robinia pseudacacia*
9	Paulownia	*Paulownia spp.*
10	Subabul	*Leucaena leucocephala*
11	Paper mulberry	*Broussonetia papyrifera*
12	Jacaranda	*Jacaranda mimosaefolia*
13	All Wattle species except Khair	*Acacia spp.* (except Acacia catechu)
14	Peach	*Prunus persica*
15	Apple	*Malus domestica*
16	Pear	*Pyrus communis*
17	Guava	*Psidium gujava*
18	Kadamb	*Anthocephalus cadamba*
19	Bakain	*Melia spp.*

Ref: *Uttarakhand Timber and Other Forest Products Transit Rule, Dated-06.02.2014*

Case Studies3. Bamboo Based Agri-Silvicultural System for Terai and N-W Himalaya Region of Uttarakhad.

In terai region of Uttarakhand, suitability of land and climate, large holding size, huge market for bamboo wood, fast returns than other tree species, regular income after four years, and easy cultivation favours large scale cultivation of bamboo from the land where other crops fail to perform. High yielding genotypes of bamboo species viz., *Bambusa balcooa, B. tulda, B nutan, D. asper* in terai region and *Dendrocalamus hamiltoni* in low and mid hills under block plantation of 5m x 5m and on boundary at the spacing of 5m or 3m were introduced. Intercrops like wheat, soybean, rapeseed, bean, mustard are grown successfully for first two years.

The total cost of cultivation in bamboo based system is about Rs. 1, 10,000/-. Output in terms of net profit per unit area is Rs. 1, 80,000/- to 2, 00,000/- ha-1 yr-1 after four years of age. The overall net income per hectare per year with bamboo based system rose from Rs. 95,000/- to Rs. 2, 00,000/- ha-1 yr-1 after four year under irrigated condition. Bamboo based plantation helps farmers to get high and higher and regular returns on their investment. Industries have fast access to raw material. It is also useful in their daily and agricultural pursuits. It also protects

soil from erosion therefore highly preferred in river command areas.

Recently the Government in a landmark initiative has promulgated the Indian Forest (Amendment) Ordinance 2017 to exempt bamboo grown over non forest areas from the definition of tree, thereby dispensing with the requirement of felling or transit permit for its economic use. Hence the need and development of bamboo based agroforestry systems hold a high potential in different parts of the Uttrakhand.

Shiwalik Region (750-1500 M)

Agroforestry systems in this sub tropical zone are traditional and are less developed. In this zone, agrisilviculture, agrihorticulture, silvipastoral and agrisilvipastoral systems are generally found. The agriculture crops are grown as per the season, rotation and needs of the farmers. Fodder trees are grown on field bunds and homesteads generally for meeting the farmers own requirement without any geometric arrangement. Bhimal (*Grevia optiva),* khirak (*Celtis australis*), Kachnar (*Bauhinia variegate*) and kimar (*Morus serrata*) are most important tree species of this zone. These, these species are generally harvested for the fodder and fuel wood after 5-7 years of planting. Among these trees, *Grewia optiva* provides excellent fodder in winters when no other green fodder is available. While Kimar and Khirak are lopped in summer to rainy season. There is no regular management of all the above trees species. However, with efficient management practices like pollarding, yield of fodder and fuelwood can be certainly increased. In addition to above trees, shisham (*Dalbergia Sissoo*), khair (*Accacia catechu*), dhak (*Butea monosperma*), siris (*Albizia lebbek*), simal (*Bombax ceiba*), bamboo (*Dendrocalamus strictus*), subabul (*Leucaena leucocephala*), tuni (*Toona ciliata*), bakain (*Melia azedarach*), harar/behra (*Terminalia spp.*), Timla (*Ficus roxburghii),* Mangiri (*Ficus palmata) etc.* are also retained by the farmers (Bhatt & Rawat, 1993; Singh and Gautam, 2004).

Fruit trees viz., apricot (Prunus armeniaca), plum (Prunus saliciana) and peach (Prunus pessica) are also grown by medium scale farmers in this zone. About 250 trees/ha are generally planted. These trees commence the production after five years of plantation. Intercropping of beans and peas are taken for two to three years. However, low chilling varieties of peach can be intercropped up to six years.

In this zone many new silvipastoral systems have been developed after years of research. These technologies are well suitable and highly profitable. Some of the important recommended combinations are: *Leucaena leucocephala* + *Chrysopogon fulvus / Eulaliopsis binata, Dalbergia Sissoo* + Bhabar grass, *Albizia lebbeck* + Bhabar grass or other grasses, *Grevia optiva* + fodder grass in steep slopes etc (Narain *et.al* 1998).

Case Studies4. Productivity enhancement of Chirpine forest through intervention of medicinal plants: an opportunity for livelihood security of forest dependent communities

To improve the productivity and check fire hazards of Chir pine forests, an intervention of economically important medicinal plants was undertaken by forests by associating seven of the naturally growing medicinal and aromatic herbs to improve the productivity of these forests. The concept of minimum tillage and appropriate topographical aspect was adopted to introduce native grasses and medicinal herbs in the under storey of degraded forests. The former aimed at minimizing disturbance to the forest floor and the latter to suit the appropriate microclimate of the particular herb. Seven herbs namely Lemon grass (*Cymbopogon flexuous*), Sweet basil (*Ocimum basilicum*), Akarkara (*Spilanthes acmella*), Kaunch (*Mucuna pruriens*), Ashwagandha (*Withania somnifera*), Kantkari (*Solanum khasianum*) and Kalmegh (*Andrographis paniculata*) were selected having reviewed their natural habitats and growth conditions. The trial was conducted for two consecutive years and to everyone's surpise out of seven medicinal plants four medicinal plants namely Akarkara, Kaunch, Kantkari and Kalmegh were found to be economically viable due to better yield and healthy financial returns. *Spilanthes acmella, Mucuna pruriens* and *Solanum khasianum* produced maximum yield when grown on northern aspect with net returns of Rs. 34,639, 15,567 and 2879 respectively per hectare in a growing season of four to six months depending on the species (*Sanwal etal, 2011, 2013, 2015, 2017*). While *Andrographis paniculata* gave highest yield with net returns of Rs. 5833 per hectare when grown on western aspect. Thus a Chir pine based innovative Silvi-medicinal system was introduced in the Indian Himalayan Region.

The outcome of the research has the potential to utilize the under storey of Chir pine forests, which occupy 3943 km² area in Uttarakhand (15.25% of the total forest area) and other Himalayan states.

Case Studies5. Need and Development of Agro-Forestry Systems for Livelihood Security in Man-Monkey Conflict Areas.

Rhesus like a wide range of food, including roots, shoots, leaves, fruits even grasses. In India, 86% of the total rhesus monkey population resides near human habitations and monkey menace is prevalent in many parts of the country. Conflicts often occur when non-human primates raid crops and compel local farmers to give up the farming. Hence monkeys are considered pests in the areas of massive agriculture, horticulture and other plantations since they damage the crops and orchards. Hence there is a need to develop tree and crop based systems which are not liked by the monkeys but are economically viable. For this purpose after a series of surveys a trial was conducted to plant screened trees and crop species not liked by monkeys in the medicinal and aromatic tree conservation and development centre of Sharda range of Haldwani forest division. Spices based agro forestry system was considered as one of the best systems for ensuring livelihood security in man-monkey conflict areas of the region (*Sanwal et al. 2016).*

Lesser Himalayas (1500 to 3000 m)

The major practice in the field is line planting on the terrace risers. It is reported that intercropping a young apple orchard with grasses and legumes under rained conditions for one year can give yields of green grass varying from 24,000 to 31,000 kg/ha and those of legumes varying from 24,000 to 26,700 kg/ha and millet and peas as the best cropcomibnations with apple.

In agrisilviculture system, forest trees viz. *Quercus* spp (banj, moru and kharsu), *Aesculus indica* (Pangar), *Robinia, Alnus,* are retained by the farmers for meeting the basic needs of fuelwood, fodder and small timber. Generally, the trees are not planted in any systematic manner and no attention is given to spacing to get full density per unit area. These primitive practices are of not economic importance. However, using appropriate technologies, agro forestry can contribute to sustained production of crops and livestock, on these lands.

In this zone, silvipastoral systems are more commonly found where lopping of trees and grazing of grasses by nomadic graziers is a common practice. People have the right to graze their animals and collect the fodder, fuel wood and timber for their needs. The forests and civil soyam land in this zone suffer from high grazing pressure. Sattered trees are generally found on these lands. However, fodder tree species are now being taken under Joint forest management programmes and Van Panchayat forests for improvement of these lands.

Higher Himalayas (>300m)

This dry temperate zone is mainly dominated by the grasses viz., *Danthnia cachemyriana, Koeleria cristata, Calamagrostis emodensis, Festuca lucida, Branchypodium sylvaticim, Trisetum spicatum, Andropogon tristis, Phleum alpinum, Agrostis munroana, Deschampsia aespitose, Helictotrichon virescens* and *Deyeusia pulchella.* In addition shrubs and trees like *Hippophae salicifolia, H tibetiana* (chharma/chuk), wild apricot, *Betula utilis* are also found. The tree species are heavily lopped for fodder and fuelwood. So the Silvipastoral system and Silvi-horticultural systems are needed to be strengthened for harnessing the real potential of Agroforestry systems.

Case Studies 6. Restoring/ Planting Seabuckthorn in High Altitude Areas Like Mana, Niti, Bhyundar and High Altitude Areas in Uttarakashi Etc (Hippophae Rhamnoides And H. Salicifolia).

Seabuckthorn is specific to certain high altitude areas and as such there is a scope to improve the quality of the areas already under seabuckthorn in specific sites under Seabuckthorn. Further areas already under this spp. have not been properly managed so far and hence are degraded. Keeping in view, the proven high potential of seabuckthorn in environmental conservation, health protection and economic augmenting of Himalayan States, activities under this sub mission in Green India Mission can aim to bring 1000 hectares of land area in the state under seabuckthorn cultivation (selected watersheds esp in vulnerable areas around river banks and hill slopes), community mobilization for plantation of sea buckthorn and commercialisation of sea buckthorn products.

Dovetailing with Schemes and Programmes Like Green India Mission

For promoting technically feasible, socially acceptable and economically viable agroforestry systems in the state many multipurpose tree species (MPTS) and shrubs can be incorporated in the ongoing programmes and schemes like integrated watershed development programme, Mahatma Gandhi national rural employment scheme, National Horticultural Mission and Green India Mission, JICA etc. Agro-forestry in plains and Agro-horticulture in the hills of Uttarakhand hold good potential not only for meeting up the day to day requirements but also for sequestering carbon, lowering soil erosion, improving soil health and good economic return. Activities like plantations of commercially viable, short rotation, multipurpose species like Eucalyptus, Poplar, Melia, Salix, etc. and suitable horticulture species (for hilly regions) on farm boundaries, railway tracks, canal banks, etc can be promoted to improve the green cover. For promoting such activities, establishment of Quality Planting Material production centres/ nurseries and Training programs and Extension activities (setting up of farmer's field schools etc.) are the immediate requirements.

Case Studies 7. Silk cultivation in Forest areas for people living in and around the forest areas

Tusser cultivation in forest areas which can be termed as "Van Silk Cultivation", with active participation of local communities could be one such area which can earn benefit for them and help conservation and protection of forests by reducing their dependency on forests. Vanya silk cultivation can be allowed on *Terminalia arjuna* (Arjun), *Terminalia tomentosa* (Asan), *Shorea robusta* (Sal), *Syzygium cumini* (Jamun), *Quercus leucotricophora* (Ban Oak), Q. *Serrata, Q himalayanan* etc. (*MoEF No. 2-1/2003-FC (Pt III) dated 07.06.2004*)

Need for Pilot Studies and Participatory on Farm Research

There is an urgent need for running the pilot projects for the adoption of best available research in the market. It should involve the open interaction between researchers, farmers and extension workers. The researchers should give the farmers ample opportunity to express their own approach to the new technology without foregoing their own role as active research partners. One of the key requirements for participatory on-farm research is to identify successful farmer as innovator for the on farm experiment. Forest department can work as facilitator in the eventual extension of successful new technology development even in remote and inaccessible hilly part of the state. Also with a view to initiate domestication of agroforestry trees through scientific interventions, the hilly areas have to be identified in the prominent districts the state of Uttarakhandand so that the productivity of such lands can be enhanced by introducing native variety of tree, shrubs, grasses, medicinal and aromatic herbs etc.

Conclusion

Participatory research and extension through successful pilot projects in one way will expand agroforestry potential areas in a situation when complex conditions force the hilly people to migrate in plains. Successful hill agroforesty systems and some other models like sericulture, apiculture, etc. hold enormous potential for sustainable growth of the hilly regions. Participatory research will allow the farmers to participate in research and related stakeholders to take part in local land use experiments and their interpretation and large scale implementation. All these agroforestry systems can not only provide diverse products but also help in terrace stabilization, moisture conservation, soil improvement and reduction of biotic pressures on existing forest resources and drudgery. These can be put into practice by facilitating increased participation of industries dealing with agro forestry produce and offering incentives to farmers for adopting agro forestry.

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