Abstract

Introduction

Food insecurity and poverty have been affecting the livelihood of the rural poor since ages and posing major challenges to the sustainable development of many developing countries in Asia. Indeed, due to climatic, land and soil degradation and increasing population pressure with limited resources, agricultural production in the developing countries has seldom matched the needs of the people. For this reason, in many countries, there has been greater recognition of the need for more sustainable agricultural practices.

In such a situation, agroforestry or woody perennial-based mixed species production systems has the potential to arrest land degradation and improve site productivity through interaction with trees, soil, crops and livestock and thereby partly restore the degraded lands. Agroforestry is also a potential option for improving rural livelihood and enhancing integrated management of the natural resource base. As per the definition, "Agroforestry is a collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit".

Conscious efforts on system management, policy adjustments and accurate knowledge are therefore imperative to ensure adoption of agroforestry among the farming community. Since knowledge about agroforestry is very limited in Iran and is still a new concept at the academic and institutional levels, identification of traditional systems is necessary to develop a basis for such studies.

Research objectives

The objectives of this study were:

1. To study the prevalent agroforestry systems in Iran and the objectives of establishing these systems.
2. To study the role of agroforestry systems in soil and water conservation and environmental improvements.
3. To study the impact of agroforestry systems on food security and supply of various products for home consumption such as fodder and fuelwood, income and employment generation.
4. To identify the participation of rural families in this sustainable land use system particularly that of women, whose right to land is insecure.
5. To identify various models, methodologies and strategies adopted for implementation of agroforestry systems in other regions and to suggest methods which are more effective in sustainable development.
6. To assess the socio-economic value of traditional systems, compare them with modern agroforestry systems in the world and recommend sustainable systems of agroforestry for socio-economic development of the rural population in Iran.
The background and perspective of Agroforestry in Iran

Agroforestry land-use technologies are neither new to Iran nor to the world. This sustainable land use system has been traditionally practiced for many years by villagers in almost every part of the country. Since Iran is located in the arid and semi arid zone and has a poor forest cover (less than 10%), tree farming plays a major role and reduces pressure on natural forests.

A review of traditional agroforestry systems in Iran revealed that while many systems used natural forests and woodlands in their existing condition and livestock were generally free-grazing, the local people may have moved periodically from one area to another. This resulted in a blend of agricultural activities with agroforestry systems and cultivation of crops on forest lands by clearing the bushes. In almost all the practices, the tree component has generally been natural forest, frequently modified by regular burning or fruit orchards.

Despite extensive research in agroforestry throughout the world and existing varieties of traditional agroforestry systems in Iran, little research has been done so far and no local information is available either for the scientific sector or for the farming communities who are the backbone of the rural economy.

Methodology

With a view to review and improve the agroforestry systems in Iran, the province of Kohgiluye-va-Boyerahmad (where rural communities are poor and dependent on forest resources for their livelihood) was selected for the study. To capture the latest trends in agroforestry systems practiced all over the world and to recommend some improvement in traditional agroforestry systems in Iran, a region with similar geographical and ecological characteristics in India was selected. The criteria for area selection were based on climatic conditions, intensity of research and development in the field of agroforestry, comparative socio-economic conditions and tangible differences in the progress of agroforestry systems in India as compared to Iran. Uttarakhand was the State selected from India which is located on the same latitude as Kohgiluye-va-Boyerahmad in Iran.

To fulfil the objectives of this study, extensive travel was undertaken throughout the country, especially in the province of Kohgiluye-va-Boyerahmad and critical systems and their characteristics were recorded. A detailed schedule was prepared and used for interviewing the local people, experts and managers. During the last stage, the data was analysed with the application of SPSS and Excel softwares. GIS software was also applied for visuals and maps.
Some of the comparable characteristics of selected areas in Iran and India are presented in Table 1:

**Table 1: Comparative agro-ecological conditions of the study areas in Iran and India**

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Iran (K&amp;B)</th>
<th>India (UL)</th>
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</thead>
<tbody>
<tr>
<td><strong>Map</strong></td>
<td><img src="image" alt="Map Iran" /></td>
<td><img src="image" alt="Map India" /></td>
</tr>
<tr>
<td><strong>Geography</strong></td>
<td>Between 29°49’ to 31°28’ N latitude and between 49°53’ to 51°54’ E longitude</td>
<td>Between 28°43’ to 31°27’ N latitude and between 77°34’ to 81°02’ E longitude</td>
</tr>
<tr>
<td><strong>Topography</strong></td>
<td>Located along the Zagros mountain ranges, unevenness could be observed in nearly 80% of the province</td>
<td>Lies on the south slope of the Himalaya range and steep slopes, inward slopes and valley lands form almost 90% of the area</td>
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<tr>
<td><strong>Soil</strong></td>
<td>Lime sand stone and conglomerate&lt;br&gt;Sandy and limy marls and gypsum&lt;br&gt;Grey and green shells</td>
<td>Sandy to sandy loam&lt;br&gt;Alluvial sandy soil&lt;br&gt;Brown forest soil&lt;br&gt;Red to dark black clay</td>
</tr>
<tr>
<td><strong>Vegetation</strong></td>
<td>• <strong>Highest elevations:</strong> conifer forests&lt;br&gt;• <strong>High mountainous zone, 2000-3500 m:</strong> covered with dense forests of <em>Quercus persica</em>, <em>Pistacia atlantica</em> and <em>Crataegus azarollus</em>&lt;br&gt;• <strong>High hilly zone, 1500-2500 m:</strong> sparse forests of <em>Quercus persica</em> and <em>Pistacia atlantica</em>.&lt;br&gt;• <strong>Hilly zone, 1000-2000 m:</strong> sparse forests of <em>Quercus persica</em>, <em>Amygdalus orientalis</em> and <em>Zizyphus spinachristi</em> in the form of short trees and shrubs&lt;br&gt;• <strong>Plains, 200-1000 m:</strong> covered with very sparse vegetation and some scattered trees of <em>Zizyphus spinachristi</em>, <em>Zizyphus nummularia</em> and <em>Amygdalus scoparia</em>.</td>
<td>• <strong>Highest elevations:</strong> ice and bare rock&lt;br&gt;• <strong>between 3000-3500 and 5000 m:</strong> tundra and alpine meadows to shrublands below&lt;br&gt;• <strong>3000-2600 m:</strong> conifer forests&lt;br&gt;• <strong>2600 to 1500 m:</strong> Himalayan broadleaf forests&lt;br&gt;• <strong>Below 1500 m:</strong> drier Terai-Duar savanna and grasslands belt, and the Upper Gangetic Plains moist deciduous</td>
</tr>
<tr>
<td><strong>Forests</strong></td>
<td>More than 40% of the province is covered with forests (659836 ha) which are of two major types: Mountainous and hilly stands</td>
<td>The actual forest area in the state is 1.539 million ha, about 35% of the state area (which includes, dense forest of 0.236 million ha, medium 0.810 million ha and poor 0.493 million ha). Forests are important sources of fuelwood, fodder, timber and other major and minor forest produce.</td>
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<tr>
<td><strong>Climate</strong></td>
<td>Average temperature is 35°C and -11°C in warm and cold season respectively with an average of precipitation of about 600-700 mm annually. On the whole, it can be said that the south and western parts of the province are <strong>dry and warm</strong> while the north and eastern parts are <strong>humid and moderate</strong>.</td>
<td>There are wide fluctuations in temperature, due to variations in altitude from 36°C during summer and 0°C or even below during winter. The winter rains are brought about by western disturbance and the summer rains by summer monsoon winds with an annual average of 1300-1500 mm</td>
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<tr>
<td><strong>Population Density</strong></td>
<td>This province has a population of 635000 of which 52% lives in rural areas. 40.9/km² (106/sq mi)</td>
<td>The state has a population of approximately 8.48 million. 158/km² (409/sq mi)</td>
</tr>
<tr>
<td>Attributes</td>
<td>Iran (K&amp;B)</td>
<td>India (UL)</td>
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<tr>
<td>Landuse pattern</td>
<td>Animal husbandry is the major source of livelihood under the sedentary and nomadic systems followed by agriculture which is the most important subsistence for the inhabitants. Out of the total landholdings; - 35% are less than 1 ha which form about 2.3% of the total cultivated area. While about 15% are between 1 to 2 ha covering 3.7% of the cultivated area - 23% are between 2 to 5 ha in size, covering 13.5% of the total cultivated area - 27% are more than 5 ha constituting about 80.5% of the total cultivated area</td>
<td>Subsistence agriculture interlinked with animal husbandry and forestry is the primary source of livelihood for more than 70% of the population; 70% of landholdings are less than 1 ha, 26% are between 1 to 4 ha and 3% are above 4 ha in size</td>
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<tr>
<td>Crops</td>
<td>Wheat, Barley, Paddy, Maize, Peas, Beans, Lentil, Vetch, Broad bean, Water melon, Cucumber, Cantaloupe, Musk melon, Honeydew melon, Tomato, Onion, Potato, Eggplant, Squashes, Alfalfa, Clover, Sorghum, Sugar beet, Sesame, Sunflower, Colza</td>
<td>Wheat, maize, paddy, soybean, gram, lentil, mustard, sugarcane, turmeric, ginger, chili, black gram, ricebean, pigeon pea, pea, okra, garlic, onion, capsicum, French bean, cauliflower, cabbage, rice, barley, mandua (finger millet), jhangora (white millet), pearl millet, green gram (mung), ricebean, ramdana (amaranth), potato, buckwheat</td>
</tr>
<tr>
<td>Orchards</td>
<td>- Cold zone: Apple, Pear, Quince, Sour cherry, Cherry, Plum, Peach, Nectarine, Apricot, Mirabelle, Almond, Walnut, Grape - Tropical zone: Date palm, citrus (Orange, Tangerine, Lime, Sweet lemon, Grapefruit, Sour orange), pomegranate, fig, jujube</td>
<td>- Tropical zone: Mango, litchi, guava, jack fruit, papaya, aonla (Indian gooseberry), citruses (lemon, kagzi lime, orange, chakotra, galgal, mosambi, etc.) - Cool zone: Apple, walnut, pear, apricot, almond, pistachio, plum</td>
</tr>
</tbody>
</table>

**Results and discussion:**

Agroforestry is the mainstay of the cultivation system in Uttarakhand. The State has been divided into four agro-climatic zones. There are structural as well as functional variations in the agroforestry systems in various zones.

The study showed that the prevalent agroforestry systems in Kohgiluye-va-Boyerahmad, are agri-silvicultural, agro-silvopastoral and silvopastoral systems. These traditional systems can be classified into 4 groups based on agro-ecological adaptability.

Agro-ecological characteristics can be used as a basis for planning agroforestry systems. Moreover, agroforestry systems in similar ecological zones in different geographical regions, are structurally (in terms of the nature of species components) similar. Table 2 shows the agroforestry systems in similar agro-climatic zones in the study areas of Iran and India.
Table 2: Comparative agroforestry systems in the study areas of Iran and India

<table>
<thead>
<tr>
<th>Similar Agro-ecological zones</th>
<th>Agroforestry systems</th>
<th>Iran (K&amp;B)</th>
<th>India (UL)</th>
</tr>
</thead>
</table>
| **India**: Tarai and Bhabar zone (up to 1000 m) | Agroforestry systems are rare and only appear in the form of citruses and date palm orchards and grasses in the understorey. | • Intensively cultivated because of fertile soil and plenty of irrigation water  
• All the agroforestry systems are well developed and commercial  
• Poplar-based agroforestry systems have a major role in the region  
• Taungya \(^1\) system is very common in this area | |
| **Iran**: Dry temperate zone (200-1000 m) | | |

| **India**: Subtropical zone (1000 to 1500 m) | Croplands are located under forest cover with low productive rainfed cereals. | • Agroforestry systems in this zone are more traditional and less developed  
• In this zone, agrisilviculture, agrihorticulture, silvopastoral and agrosilvopastoral systems are generally found.  
• The agricultural crops grow well seasonally and rotationally  
• Fodder trees are grown on field bunds and homesteads  
• Silvopastoral systems have been developed recently | |
| **Iran**: temperate zone (1000-2000 m) | | |

| **India**: Cool temperate zone (1500 to 2400 m) | Rainfed cultivation with cereals under forest cover is a productive way of agriculture in this area. | • Silvopastoral, agrisilviculture and agrihorticulture systems are mainly prevalent in this zone  
• The major practice in the field is line planting of fruit trees on the terrace which are inter-cropped with beans or peas  
• Silvopastoral systems are more commonly found in this area  
• Planting fodder trees is the major plan for this zone | |
| **Iran**: Cool temperate hilly zone (1500-2500 m) | | |

| **India**: Dry temperate zone (more than 2500 m) | The orchards consist of various fruit species. High productive agriculture underneath the trees is the notable characteristic of this area which should be noted for improved agroforestry in future. | • This zone is mainly dominated by the grasses although scattered shrubs and trees are also found  
• The tree species are heavily lopped for fodder and fuelwood  
• The main agroforestry systems are Agrisilviculture, hortisilviculture and silvopastoral | |
| **Iran**: High mountainous zone (2000-3000 m) | | |

Taking into consideration the components and other geographical and socio-economic conditions, agroforestry systems in similar agro-climatic zones of India can be recommended for the study area in Iran.

\(^1\) Combined stand of woody and agricultural species during early stages of establishment of plantations
The challenges of Agroforestry in Iran

If agroforestry is deemed as a "desirable" land use system for Iran, policy makers need to understand the principal constraints for its wider adoption and should be aware of the scope to overcome these constraints. For organisational convenience, the challenges in Department are grouped into technical, socio-economic and political issues with the following constraints:

A. Technical Constraints: Scientific research, concepts, applicable knowledge, training;

B. Socio-economic Constraints: Land tenure, tree tenure, landuse systems, incentives, risks, farmers, household, markets, subsidies, credits, transportation, water, seeds, germplasm, processing and marketing of agroforestry products and services, price, restrictions, property rights, access to agroforestry inputs;

C. Political Constraints: Institutional, services, infrastructure, organisational reforms, supervision, agro-industrial development, community organisation at the local level, regulatory and financial environment, management, Government support, resources, extension organisations, NGOs.

To overcome these constraints and ensure adoption of agroforestry by the rural communities, the following steps are required:

- Improve technical and practical knowledge about agroforestry.
- Improve productivity of the existing lands using agroforestry systems.
- Efficient conservation of land, soil and water through agroforestry interventions.
- Decrease technological input in sustainable agriculture.
- Improve the socio-economic conditions of rural life through promotion of agroforestry.
- Provide loan and subsidies to facilitate investment in agroforestry and increase the economic condition of farmers.
- A well developed market network is required to win the confidence of the farmers.

Recommendations

Improvement of notable Agroforestry systems in Iran

Considering the enumerated agroforestry systems in both the study areas and significant development made by agroforestry in India, a number of proposals to improve the methodology and implementation of agroforestry practices are presented in Table 3:
Table 3: Scope for improvement in agroforestry systems in Iran based on the experiences in India

<table>
<thead>
<tr>
<th>Agroforestry system</th>
<th>Status in Iran</th>
<th>Status in India</th>
<th>Recommendations for improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees on rangeland or pastures</td>
<td>A sparse combination of indigenous forest trees and nomadic livestock in forest areas</td>
<td>Multipurpose trees and shrubs of fodder value. The major output is fodder for livestock production and sometimes wood.</td>
<td>Method, species</td>
</tr>
<tr>
<td>Multipurpose woody hedge rows</td>
<td>A sparse combination or boundary plantation of tree species and agricultural crops and nomadic or sedentary livestock</td>
<td>This is mainly a soil conservation function ensuring food, fodder and fuelwood.</td>
<td>Method, species</td>
</tr>
<tr>
<td>Taungya</td>
<td>A dense combination or strip plantation of fruit trees and agricultural crops in farmlands or degraded forest area</td>
<td>The practice consists of land preparation, tree planting, growing agricultural crops for 1-3 years until the shade becomes too dense and then repeating the cycle in a different area.</td>
<td>Indian system has scope for improvement by introducing fruit species.</td>
</tr>
<tr>
<td>Home gardens</td>
<td>A dense combination of fruit trees, agricultural crops and sedentary livestock</td>
<td>Many species of trees, bushes, vegetables and other herbaceous plants are grown in dense and in random or spatial and temporal arrangements. Most home gardens also support a variety of animals. Fodder grass and legumes are also grown to meet the fodder requirement of cattle.</td>
<td>Method, species</td>
</tr>
<tr>
<td>Multipurpose trees on crop lands</td>
<td>A sparse combination of forest species or strip plantation of trees with agricultural crops</td>
<td>The primary role of this system is production of various tree products and the protective function includes fencing, social values and plot demarcation. This is being performed in all ecological regions especially in subsistent farming.</td>
<td>Method, species</td>
</tr>
</tbody>
</table>

Improvement of agroforestry systems based on Sustainable Development

Earlier, based on one-dimensional vision, absolute removal of livestock from the forest areas or monoculture systems for agriculture was advisable in natural resource management. The complex blend of productive systems in natural resources, in addition to increasing the sustainability and production, makes them responsive to various necessities. These are:

- To generate employment through apiculture, pisciculture and mushroom cultivation;
- Include various methodologies to increase forage production in rangelands and forest grounds;
- Identify methods to increase the foliage in fodder trees;
- Ensure cooperation from farmers to restore forest through establishment of multipurpose trees and shrubs;
- Application of agroforestry systems to reduce the effect of competition among components and to maintain livestock and plants in a single landuse system;
- To preserve rural and tribal culture, customs and aesthetic aspects of nature to improve the eco-tourism.
Consequently, there are two basic points: one is application of the power of nature to solve its issues and the other is use of a complex and sustainable landuse system for conservation of nature, which is agroforestry.

Scope for adopting agroforestry systems in Iran

a. **Agricultural lands**
   There is scope for adopting improved agroforestry systems even under the traditional farming systems based on the land productivity, adaptability of plant species, demand and marketing potentials, profitability and fulfilment of various service functions. Livestock being a critical source of income for small land holders, livestock development can be an integral component of agroforestry to ensure better value for forage produced in the system. There is further scope to support the agroforestry production system with backward and forward linkages.

b. **Rangelands**
   Using a participatory approach, adopt improved silvopastoral systems, energy plantation, multiple use vegetative cover, vegetative check dams, stream bank/shelter belt plantations and watershed development.

c. **Forest lands**
   To support income generation activities and improve small scale industries based on the principles of Community Forest Management and develop multipurpose trees, medicinal herbs/shrubs plantation, improved silvopastoral systems, energy plantations and non-timber forest product species.

**Suitable multipurpose trees for Iran:**

Table 4 shows some of the fast growing and MPTS either indigenous or exotic species, which are perennial components in Indian agroforestry systems and can be included in agro-climatic zones in Iran.

**Table 4: Tree species suitable for Iran**

| Fast growing tree species | Acacia mearnsii, Acacia nilotica, Acacia Senegal, Acacia tortilis, Ailanthus altissima, Ailanthus excelsa, Albizia lebbeck, Albizia procera, Albizia saman, Bambusa arundinacea, Calliandra calothyrsus, Casuarina equisetifolia, Cedrela toona, Colophospermum mopane, Enterolobium cyclocarpum, Grevillia robusta, Leucaena leucocephala, Melia azedarach, Parkinsonia aculeata, Paulownia tomentosa, Pithecellobium dulce, Populus deltoides, Prosopis cineraria, Robinia pseudoacacia, Sapindus trifoliatus, Seshania grandiflora, Seshania seshan, Tectona grandis, Terminalia arjuna |
| Other MPTS | Acacia catechu, Achara sapota, Anacardium occidentale, Annona reticulata, Annona squamosa, Artocarpus heterophyllus, Averrhoa carambola, Azadiracta indica, Carica papaya, Dalbergia sissoo, Dendrocalamus strictus, Derris indica, Dichrostachys cinerea, Emblica officinalis, Ficus religiosa, Gliricidia sepium, Grewia optiva, Madhuca indica, Mangifera indica, Moringa oleifera, Morus alba, Musa paradisiaca, Nepheleium lappaceum, Psidium guajava, Sesbania grandiflora, Shorea robusta, Syzygium cumini, Tamarindus indica, Terminalia arjuna, Zizyphus mauritiana |
Productivity improvement in traditional agroforestry systems in Iran

Following are some of the national plans for sustainable development to improve agroforestry systems in the area:

- Agro-silvopastoral systems in enclosed forests or rural conventional territories;
- Tree farming norms and their improvement in northern part of Iran;
- The national programme of local forestry for sustainable development of rural communities;
- Transfer of abandoned agricultural lands to sustainable and productive systems;
- Afforestation and forest rehabilitation through Tooba (transfer of right of land exploitation by tree plantation).