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REVIEW ARTICLE **OPEN ACCESS**

Problems and Prospects of Agro-forestry Systems in NE India- A review

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ABSTRACT

Acceleration in human and livestock population growth necessitated acquisition of more and more land under cultivation. The area under agriculture and forest has been reduced drastically due to population pressure and this has resulted in a wide gap between demand and production of agricultural and forest products viz. food, fodder, vegetables, fuel wood, timber medicines etc. Hence, an interest in agroforestry has therefore become necessary in order to encourage sedentary. Agroforestry is of great importance in recent times primarily because of meeting the diversified needs of people and for sustaining the frazzle ecosystem for generations to come. Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. About 80% of the people of north-east (NE) India are directly or indirectly concerned with agriculture. Farmers, in this region, are generally small holders and thus, an attempt with agroforestry practices can result an increase in their earnings without endangering the fragile ecosystem (Gogoi, 2015). In the NE region, trees are deliberately integrated with the crop and livestock production system (Chauhan and Dhyani 1990). A number of crops like maize, ginger, pineapple, coffee, and vegetables are grown with tree species such as Pinus kesiya, Alnus nepalensis, Schima wallichii, Pyrus communis, Prunus domestica, Areca catechu etc. (Rao and Bhattacharyya, 2005). Though different problems such as lack of knowledge, credit facilities, saplings availability etc., were present in this region, prospects are available. Different agroforestry models are available in respect to the different locations are need to be studied through different researches. So, an effective strategy based on agroforestry with scientific introduction of suitable tree species with crops on farm lands require not only for feeding the increasing population but also for conservation of land resources for the future generations to come as well as creation of different opportunities for the youths of N.E. India.

Key Words: Agroforestry, N-E region, Fuel, Fodder, Livestock production

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INTRODUCTION

Agriculture is backbone of our country with 145 M ha area is under cultivation & about 80% people lives on agriculture. Per capita availability of land declined from 0.48 ha (1951) to 0.14 ha (2000) and will be reduced to 0.08 ha by 2020.>30% of entire energy requirement of our country is meet by trees and woody shrubs, but we are cutting trees fastly to meet our other needs. At present, rate of deforestation is 1.5 M ha/year and per capita forest availability is 0.09 ha (world average is 1.6 ha).

Livestock population 0.6 billion and India is world's highest milk producing country. Agricultural and forestry productivity is decreasing day by day. Thus, there is remotest possibility of increasing forest and agricultural area separately. The only answer is to integrate. We have different problems related to soils & agricultural production system which are mentioned below:

- Climate Change related problems *viz.* drought, flood etc.
- Crop failure
- Sand casting due to various types of erosion such as water and wind.
- River bank erosion

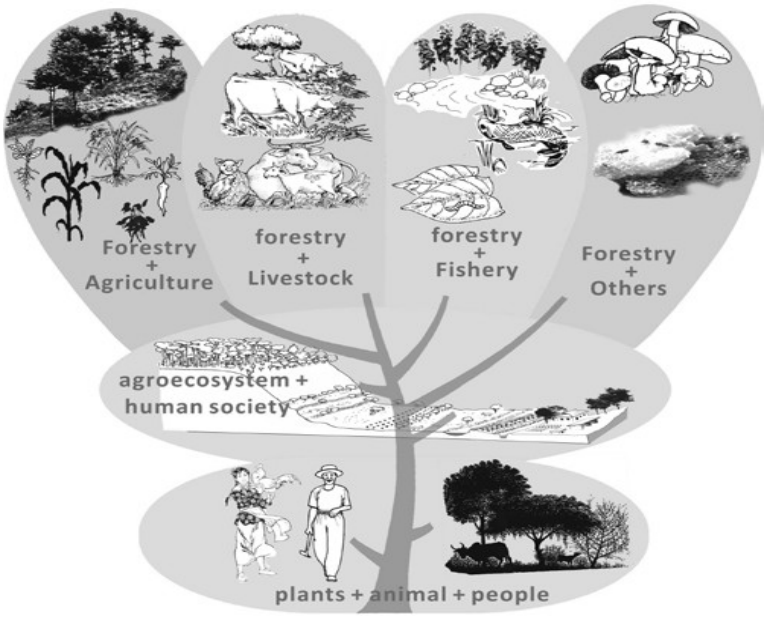


Fig.1 Agroforestry is an integrated dynamic system

In this figure various integrations are shown with different agro a forestry practice which finally leads to a successful plant + animal + people integration.

What is Agroforestry?

Agroforestry is a land use systems and technology where woody perennial plants (tree, shrubs, herbs etc.) are deliberately introduced in the same land management practices, along with the agricultural crops and/or livestock, in a spatial temporal sequence (ICRAF).

AGROFORESTRY PRACTICES

- **Alley Cropping**: Alley Cropping is planting rows of trees at wide spacings with a companion crop grown in the alleyways between the rows.
- **Silvo-pasture**: It is the practice of combining forestry and grazing of domesticated animals in a mutually beneficial way. Advantages of a properly managed silvopasture operation are enhanced soil protection and increased long-term income due to the simultaneous production of trees and grazing animals.
- **Forest Farming**: It is the cultivation of high-value specialty crops under the protection of a forest canopy that has been modified to provide the correct shade level. Crops like ginseng, shiitake mushrooms, and decorative ferns are sold for medicinal, culinary, and ornamental uses.
- **Riparian Forest Buffers**: A riparian forest buffer is a planned combination of trees, shrubs, grasses and forbs planted along a stream or river. It can include many different species and perform several different functions.
- **Windbreaks**: A windbreak (shelterbelt) is a plantation usually made up of one or more rows of trees or shrubs planted in such a manner as to provide shelter from the wind and to protect soil from erosion.
- **Multi storied Farming**: *Multistoried* cropping are multi-layer cropping and multi-tire cropping. It is one kind of intercropping. *Growing* plants of different height in the same field at the same time is termed as *multistoried* cropping. It is mostly practiced in orchards and plantation crops for maximum use of solar energy.

AGROFORESTRY SYSTEMS: Different agro forestry systems are

i) **Agri-silviculture:** Agri-silviculture is a production technique which combines the growing of agricultural crops with simultaneously raised and protected forest crops. A similar practice involving forest villagers and tribesmen is known as the "taungya system" in Asia.

ii) **Silvipastoral system:** (Tree+ pasture/animal) The production of woody plants combined with pasture is referred to as *Silvipastoral system*. The trees and shrubs used primarily to produce fodder for livestock. This *system* is needed in dry area to meet the fodder demand throughout the year.

iii) **Agrisilvipastoral system:** (Tree Crops + Grain crops + animals) This is the system in which the forest tree crops for fodder like Anjan, Subabhul, Babhul, Tamrind, Hadga and Khejedi etc. are taken with

intercrops of grasses like Stylo, Burssem, Haemeto are taken for fodder purpose as well as the food grain crop like Wheat, Rice, Jowar etc. are taken in between the strips of forest tree species. The forest tree species are planted at 10 to 12 m distance and in the lines the grasses and food grains are cultivated as intercrop.

iv) **Horti-silviculture system:** This system is defined as growing of trees and fruit trees or ornamental trees or vegetables/flower together in same lands at the same time. This system is common in home gardens.

v) **Agri-horticulture system:** It is a land management system in which agricultural crops are grown on spa ce between two rows of fruit tree species. Integration of fruit crops in croplands is referred to as *agri-horticultural* land use *system* of Agroforestry.

vi) **Agrihortisilviculture system:** In this system, in addition to arable crops, MPTS (Multi-Purpose Tree Species) like Subabul, are grown along with fruit trees like ber and aonla. The MPTS , besides providing green fodder and fuel wood annually, also protect the fruit trees from hot winds in the summer and cold winds in the winter and improve the soil by virtue of their nitrogen-fixing abilities. It is possible to grow 100to 400 fruit trees per hectare along with arable and also with MPTS like Subabul(200 to400per hectare)which are planted in between the fruit trees.

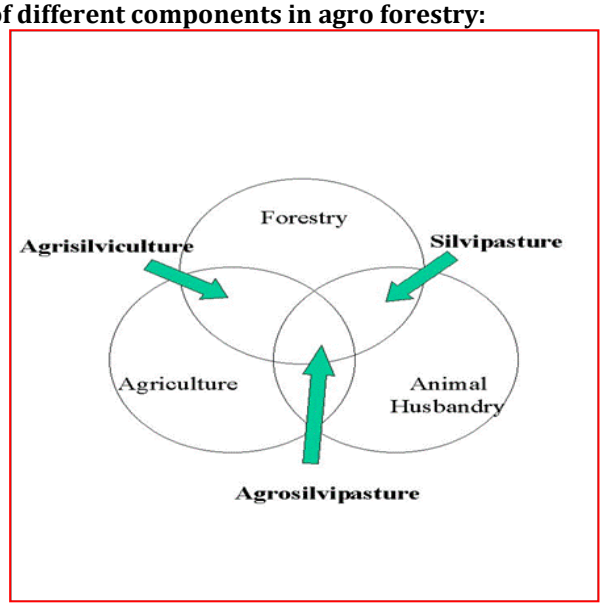
vii) **Multipurpose forest tree production** (other specialized agroforestry systems): *Multipurpose trees* are *trees* that are deliberately grown and managed for more than one *output*. They may supply food in the form of fruit, nuts, or leaves that can be used as a vegetable; while at the same time supplying firewood, add nitrogen to the soil, or supply some other combination of multiple outputs. "*Multipurpose* tree" is a term common to agroforestry, particularly when speaking of tropical agroforestry where the tree owner is a subsistence farmer.

viii) **Apiculture with trees:** In this system various honey (nector) producing trees frequently visited by honeybees are planted on the boundary of the agricultural fields.

ix) **Aquasilviculture or Aquaforestry:** It is a management strategy that combines and harmonizes fish production and mangrove development. In this system various trees and shrubs preferred by fish are planted on the boundary and around fish ponds.

x) **Agrisilviaquaculture:** In paddy field, fish can easily be reared by planting trees on field bunds or boundary. A land management system followed in high rainfall areas which involve rearing of fish in fields and planting of trees on bunds or boundary.

Interrelationship of different components in agro forestry:



(Source: Gill and Roy, [5])

Objectives of agro forestry:

- To utilize the available farm resource properly
- To maximize per unit production of food, fodder, fuel
- To optimizing-biological and physiological resources
- To maintain the ecological balance
- To check soil erosion, conserve soil moisture and
- increase the soil fertility

Benefits of Agroforestry:

Agroforestry- Maximizes production

- Efficient utilization of solar energy
- Efficient utilization of nutrients
- Sustains the scarce resources for future generations

Soil productivity improvement:

- ✓ Addition of carbon in soil
- ✓ Release and recycling of nutrients
- ✓ The rate of infiltration of soil water is 3 to 5 times more in forest soil
- ✓ Reduction of loss of soil (erosion) through root binding
- ✓ Improves physical condition of soil
- ✓ Nitrogen fixation
- ✓ More microbial associations
- ✓ Moderating the effect of extreme acidity and alkalinity
- ✓ Utilize waste and degraded land, improve environment
- ✓ Provide employment opportunities
- ✓ Increase farm income

Benefits of Silvopasture:

* Income from Annual fodder
* Long-Term Timber Income
* Lower Animal Stress
* Reduce Wildfire Risk
* Wildlife Benefits
* Visually Pleasing
* Carbon Sequestration: *It* describes long-term storage of *carbon* dioxide or other forms of *carbon* to either mitigate or defer global warming and avoid dangerous climate change. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels.

Negative interaction;

☼ Competition for light

☼ Competition for moisture and nutrients

☼ Allelopathy effect

☼ Others, like soil disturbance etc.

Tree species to be chosen for agroforestry:

a) They should be amenable to early wide spacement.

b) They should tolerate relatively high incidence of pruning, i.e., their photosynthetic efficiency should not decrease with heavy pruning.

c) They should be light branching in their habit.

d) They should be tolerant to side shades.

e) Their phenology, particularly with reference to leaf flushing and leaf fall, should be advantageous to the growth of the annual crop in conjunction with which they are being raised.

f) The rate of litter fall and litter decomposition should have positive effects on the soil.

g) Their root systems and root growth characteristics should ideally resulting exploration of soil layers that are different to those being tapped by agricultural crops.

Purpose of plantation in Agro forestry:

◆ Social Needs: fire woods, fodder, timber, fruits etc.

◆ Industrial Needs: The Forest Policy of 1988, provides that industries should meet their raw material needs from agroforestry.

◆ Environmental Protection:

- conserve the soil and water.
- improved in nutrient cycling
- favourably modify the micro-climate in the area.
- maintain the ecological balance.
- withstand adverse condition.

◆ Land Use Needs: According to capability classification land class V, VI, VII and VIII should necessarily be put under trees.

Useful Tree Species of N.E India:

Based on the research findings and field observations, the following tree species have been recommended for agro-forestry, under Indian conditions including North-eastern region are:

Fodder cum Fuel wood species:

1. Amara (*Albizia amara*)
2. Corol tree (*Erythrina sp*.)
3. Gliricidia (*Gliricidia sepium*)
4. Anjan (*Hardwickia binata*)
5. Subabul (*Leucaena leucocephala*)
6. Madras thorn *(Pithecellobium dulce*)
7. Shevari (*Sesbania sesban*)

FUEL WOOD AND TIMBER SPECIES:

1. Babul (*Acacia nilotica*)
2. Siris (*Albizia lebbeck*)
3. White Siris (*Albizia procera*)
4. Neem (*Azadiracta indica*)
5. Casuarina (*Casuarina equisetifolia*)
6. Shishum (*Dalbergia sissoo*)
7. Bamboo (*Dendrocalamus strictus*)
8. Pongamia(*Derris indica*)
9. Horse bean (*Parkinsonia aculeata*)
10. Portia (*Thespesia populnea*)

SOFTWOOD AND PULPWOOD SPECIES:

1. Tree of Heaven (*Ailanthus excelsa*)
2. Dhup (*Ailanthus tryphysa*)
3. Silk cotton (*Bombax ceiba*)
4. White Albizia (*Paraserianthes falcataria*)
5. Poplar (*Populus deltoides*)

Fruit and Vegetable Species:

1. Ramphal (*Annona reticulata*)
2. Custard apple (*Annona squamosa*)
3. Jack fruit (*Artocarpus heterophylus*)
4. Amala (*Emblica officinalis*)
5. Drum stick (*Moringa oleifera*)
6. Ber (*Zizyphus mauritiana*)

HEAVY RAINFALL AND HIGH WATER TABLE:

1. Bamboo (*Dendrocalamus strictus*)
2. Arjun (*Terminalia arjuna*)
3. Eucalyptus (*Eucalyptus grandis*)
4. Porita (*Thespesia populnea*)
5. Pongamia (*Derris indica*)
6. Sesbania (*Sesbania sesban*)
7. White siris (*Albizia procera*)
8. Casuarina (*Casuarina equisetifolia*)
9. Silk cotton (Bombax ceiba)

DRY AREAS:

1. Babul (*Acacia nilotica*)
2. Amara (*Albizia amara*)
3. Custard apple (*Annona squamosa*)
4. Neem (*Azadiracta indica*)
5. Dassod (*Cassia siamea*)
6. Horse bean (*Parkinsonia aculeata*)
7. Khejdi (*Prosopis cineraria*)
8. Ber (*Zizyphus mauritiana*)
9. Agave spp.

WELL MANAGED IRRIGATED AREAS:

1. White siris (*Albizia procera*)
2. Casuarina (*Casuarina equisetifolia*)
3. Shishum (*Dalbergia sissoo*)

4. Gliricidia (*Gliricidia sepium*)
5. Anjan (*Hardoickia binata)*

Table.1 Tree species suitable for Agroforestry system in Assam

Sl. No.	Tree species	Remarks
(i)	Bamboo(*Bambusa tulda, B.balcooa, Dendrocalamus strictus*, etc) TN: Banh	As boundary plantation, mixed in homestead, or in block in upland / medium land situation. Most dominant species
(ii)	*Gmelina arborea* Trivial Name: Gamari	As boundary plantation, mixed in homestead, block plantation or in dyke of fish pond. Mostly in upland / medium land situation
(iii)	*Shorea robusta* Trivial Name: Saal	As boundary plantation, mixed in homestead, block plantation or in pond dykes by general farmers. In block plantation in hill slopes / high lands by Govt. Deptts.
(iv)	*Lagerstroemia flos-reginae* Trivial Name: Ajar	As parkland plantation or block plantation; mostly confined to periodically inundated areas
(v)	*Trewia nudiflora* Trivial Name: Bhelkor	As parkland cultivation or block plantation; mostly confined to periodically inundated areas. As road-side plantation by Govt. Deptts.
(vi)	*Anthocephalus cadamba* Trivial Name: Kadam	Mostly as parkland cultivation and in homestead as mixed
(vii)	*Albizia procera* Trivial Name: Koroi	Mostly as parkland cultivation or as mixed in homestead in upland and midland situation

(Source: ZREAC, Rabi, 2012-13)

Constraints and problems of Agroforestry Systems:

- Scarcity of saplings of suitable tree species
- Seasonal occurrence of plant and animal diseases
- Inadequate compensation for destroyed crops
- Lack of credit facilities
- Inadequate education on tree tenure
- Crop destruction by felling timber species on farms.
- Poor marketing system
- Lack of knowledge on logging regulations/ procedures
- Inadequate harvesting & processing techniques
- Lack of knowledge regarding value added product
- Laws restricting harvesting, transporting & sale of trees
- Lack of assured financial support for popularizing agro-forestry
- Lack of proper transfer of technology , trained manpower, infrastructure & funds
- Identification of suitable species
- Nursery development

Problems of Agroforestry in NE India:

1. **High Rainfall:** The region falls under high rainfall zone. The region is characterised by difficult terrain, wide variations in slopes, altitude, land tenure systems and diverse cultivation practices

2. **Soil erosion**: More than 70 per cent of total geographical area of the region is covered by hills and about 3 million hectare is estimated to be under soil erosion hazard as a result of practice of *Jhum cultivation*

In Assam alone, 83.2 per cent of area are suffered from erosion. i.e.

Area suffered by the intensity of erosion are -

Slightly : 35.30%,
Moderate : 37.70%,
Severe : 10.00%
Very severe: 0.30%

3. **Natural calamities like drought, flood, hail storm etc**
4. **Fragmented land holdings**
5. **Low availability of agri-inputs**
6. **Socio-economic status of the people**: The region is dominated by the tribal population and the development of agriculture and production of food grains in the region is highly depends upon the custom, culture and the food habit of the local people

Thus, increasing the yield of crop in such a complex system and in an environmentally positive manner is a challenge in a place like NE region of India.

Prospects of Agroforestry:

- Practice of mixed cropping
- Knowledge on tree importance
- Presence of nurseries
- NG0s involvement in promoting agroforestry
- Plantation of Fruit trees for subsistence and income reducing the cost of farm inputs
- Increasing homestead garden through proper management
- Inclusion of apiculture, sericulture in the agroforestry system

Agroforestry Models In North-Eastern States of India:

- Agri-Silviculture: (crops + trees)
- Agri-Horticulture: (crops + fruit trees)
- Silvi-Pasture: (trees + fodder crops)
- Horti- Pasture: (fruit trees + fodder crops)
- Agri-Horti-Silviculture: (crops + fruit trees + trees)
- Homestead Agroforestry : (may be the mixtures of crops,vegetables, fruit trees, fodder crops and trees)

Table.2 Few Agroforestry Models for Assam

Sl. No.	Specific nature	Tree species	Intercrops	Seedlings/ bigha
1.	Boundary plantation	Sisu, Titachapa, Gomari	Any field/ horticultural crop	75 – 150
2.	Boundary plantation	-do-	-do-	20
3.	Dykes of fish pond	Sisu, Arjun	Banana, Assam lemon, Pineapple, fodder	120-150
4.	Plantation in *Jhum* area	Teak, Gomari, Titachapa, Koroi, Sam, Hollock, Bogipoma, Poma,Khokan, Ghoraneem, etc.	Upland rice, maize, vegetables, etc. grown in the area	80
5.	Plantation in *Char-Chapori*	Gomari, Sisu, Siris, Koroi, Moj, *Acacia mangium*, Arjun, Kolajamu, Ximolu	Any field/ horticultural crop	20
6.	*Acacia mangium* based Agroforestry system	*Acacia mangium*	Sesame/BG-Toria/Niger (for 4 years)	45
7.	Jackfruit based Agroforestry system	Jackfruit	a) Ahu rice- BG-Toria/Buckwheat	20

(Source: ZREAC, Rabi, 2012-13)

Table.3 Quantities of N fixed by different tree sp.

Sl. No.	Species	*N* fixed (Kg/ha/yr)
1.	*Acacia mearnsii*	200
2.	*Acacia pennatula*	34
3.	*Casuarina equisetifolia*	40-60
4.	*Prosopis juliflora*	88-132
5.	*Leucaena leucocephala*	224-274

In table 3. quantities of N fixed by different tree species has been shown. Highest N is fixed by *L. leucocephala* tree species which fixed nitrogen of 224-274 kg/ha/year as compared to other tree species mentioned in the table which is due to the fact that it has higher nodular activity in the roots which fixed the atmospheric nitrogen [8].

Table.4 Soil and nutrient loss from different land use system

Land use system	Soil loss(t/ha)	Runoff %	Nutrient Loss	
			N%	K%
Eucalyptus-Bhabar grass	0.07	0.05	0.46	0.50
Areca catechu- forage grass	0.24	2.00	6.97	0.52
Sesame-rapeseed	2.69	20.50	42.50	3.00
Teak-Leucaena- Bhabar	0.43	3.30	2.08	0.55
Poplar-Leucaena	1.54	4.80	5.90	1.10
Cultivated fallow	5.65	23.0	51.30	5.00

In table 4. Soil and nutrient loss from different land use system has been shown. Lowest soil loss of 0.07t/ha, run off per cent of 0.05 % and nutrient losses has been found in eucalyptus – bhabar grass land use system which is due to the root volume and its holding capacity as compared to others [7].

Table.5 Total C storage under agro-forestry systems in different regions of the country

Region	Agro-forestry system and components	Total C storage (t C/ha)
Semi-arid region	Silvi-pastoral system (age 5 years)	
	(Babul)*Acacia nilotica* + natural pasture	9.5-17.0
	Acacia nilotica + established pasture	19.7
	(Sisoo) *Dalbergia sissoo* + natural pasture	12.4
	Dalbergia sissoo + established pasture	17.2
	Hardwickia binata + natural pasture	16.2
	Hardwickia binata + established pasture	17.0
	Acacia/Dalbergia/Prosopis +Desmostacya	6.8-18.5
	Acacia/Dalbergia/Prosopis +Sporobolus	1.5-12.3
Central India	Block plantations (age 6 years) (Gamari)*Gmelina arborea*	24.1-31.1
Arid region(Rajasthan)	Agri-silvicultural system (age 8years)	
	Emblica officinalis+Vigna radiata	12.7-13.0
	Hardwickia binata + Vigna radiata	8.6-8.8
Arid region(Rajasthan)	*Colophospermum mopane+ Vigna radiata*	4.7-5.3
Semi-arid region	Agri-silvicultural system (age 11 years)	
	Dalbergia sissoo + crop	26.0
North-western Himalayas	Silvi-pastoral system	2.17
	Agri-horti-pastoral	1.15
	Horti-pastoral	1.08

In table 5.Total C storage under agro-forestry systems in different regions of the country has been shown. Highest C storage has been found in case of Block plantations in Central India as compared to others which is due to higher C absorption by the plants [3].

Table.6 Mean Plant height (m) of trees under various treatments

Treatment	**Years**						**Mean**
	2000	2001	2002	2003	2004	2005	
Siris sole	3.97	3.03	5.86	7.08	6.33	7.80	5.67
Siris + Barley	2.98	3.00	5.22	7.17	7.35	8.20	5.65
Siris + Chickpea	4.62	4.10	7.37	9.24	8.60	9.80	7.28
Neem sole	2.97	3.50	4.92	7.28	7.05	7.30	5.50
Neem + Barley	3.36	3.73	5.05	7.29	7.10	7.55	5.68
Neem + Chickpea	3.32	3.76	5.42	6.92	6.10	7.55	4.94
Shisham sole	4.77	5.26	6.95	9.04	9.35	9.65	7.50
Shisham + Barley	4.35	4.83	6.03	8.00	8.20	8.75	6.69
Shisham + Chickpea	4.40	4.96	6.44	8.38	8.85	9.25	7.04
Babul sole	4.16	4.70	6.20	10.29	7.90	7.70	6.82
Babul + Barley	4.55	4.83	6.15	8.06	8.05	8.15	6.63
Babul + Chickpea	4.43	5.00	6.29	8.49	7.95	7.80	6.66
C.D. (P = 0.05)	0.47	1.13	1.03	1.60	2.33	1.27	

In table 6.Mean plant height of trees has been shown. Highest plant height of 7.28 m has been found in case of Siris + Chickpea which is due to their compatibility and because of incorporation of the leguminous crop chickpea which fixes the atmospheric nitrogen that is beneficial to the tree [4].

Table. 7 Dry foliage yield (q/ha) of trees under various treatments

Treatment	Years						Mean
	2000	2001	2002	2003	2004	2005	
Siris sole	11.22	2.03	6.27	4.58	16.96	16.21	9.54
Siris + Barley	0.70	0.62	3.62	5.68	15.65	7.05	5.55
Siris + Chickpea	0.85	1.59	9.84	4.00	18.51	10.20	7.49
Neem sole	1.85	1.98	2.78	3.74	13.77	1.75	4.31
Neem + Barley	1.50	2.45	2.93	5.21	13.89	2.67	4.77
Neem + Chickpea	1.30	2.99	2.27	4.62	15.43	2.31	4.82
Shisham sole	7.65	4.55	14.26	7.49	22.74	3.31	10.00
Shisham + Barley	6.86	3.58	8.24	4.70	23.97	2.41	8.29
Shisham + Chickpea	9.71	3.58	11.18	6.71	22.28	2.55	9.33
Babul sole	5.56	3.89	16.94	1.92	15.94	2.89	7.85
Babul + Barley	8.06	3.27	17.01	6.03	17.74	3.03	9.19
Babul + Chickpea	9.67	3.02	17.38	3.79	17.46	2.79	9.01
C.D. (P = 0.05)	2.95	1.71	2.71	1.81	3.47	5.88	

In table 7, dry foliage yield of different trees combination are given. Highest dry foliage yield of 10 q/ha has been found in case of shisham sole which has been due to the less competition as compared to the other trees combination [4].

Table.8 Effect of fast growing species on fruit yield of Mandarin orange

Main plot	Fruit yield of Mandarin(Kg/plant)			
	Eucalyptus	Casuarina	Grevillea	Control
Mandarin on trifoliate rootstock	2.5	7.8	5.1	6.3
Mandarin on citrange rootstock	2.1	10.9	6.8	10.1

In table 8, effect of fast growing species on fruit yield of mandarin orange has been given. Highest yield of mandarin has been found in case of casuarina of 10.9kg/ha due to its fast growing ability and synergism conditions [2].

Table.9 Performance of fruit tree based agrihorti systems in the NEH region

Tree crop	Field crop	Variety of field crop	Trees ha^{-1}	Net return (Rs ha^{-1})
Khasi Mandarin	Groundnut	JL-24	400	4541
	Soybean	Alankar	400	19625
	Turmeric	RCT-1	400	30375
	Ginger	Nadia	400	33416
Guava	Groundnut	JL-24	400	3000
	Soybean	Alankar	400	916
	Turmeric	RCT-1	400	2750
	Ginger	Nadia	400	15791
Assam Lemon	Groundnut	JL-24	400	3500
	Soybean	Alankar	400	2583
	Turmeric	RCT-1	400	1916
	Ginger	Nadia	400	36625

In table .9. Performance of fruit tree based agri-horti systems in the NEH region has been shown. Good performance and higher net returns has been observed in case of khasi mandarin grown tree crop with ginger due to their compatible growth between the two [9].

Table.10 Income from various crops grown with poplars

Poplar with	Yield (kg/ha)	Duration(Months)	Gross income (Rs)	Net income (Rs)
Onion	15,000	5	18,000	7,500
Ginger	11,000	8-9	11,000	3,400
Turmeric	4,000	8-9	14,000	3,900
Mustard	8,800	3-4	2,400	1,400
Berseem	50,000	5-6	5,000	2,400

In table.10, Income from various crops grown with poplar has been shown. Highest net income of Rs.7500 has been found in case of onion grown with poplar due to the higher yield of onion due to the favourable growth conditions [1].

FUTURE THRUST

- Farmers participation and adoptive research need to be increased
- Integrating Agroforestry with sericulture
- Appropriate feed systems with tree fodder for livestock develop for different ecological seasons
- More thrust be given to agroforestry research on dry land farming

CONCLUSION

Agroforestry can support food production, increase the total efficiency and stability of the system in North Eastern region. It holds promise to satisfy all human needs (food, fuel, fodder, timber *etc*.) and it also can act as an insurance against drought, flood and natural calamities those are familiar to north-east region of India. With inclusion of agroforestry with different crop components and livestocks one can be benefitted in terms of monetary as well as ecological sustainability. Thus, area based effective research strategies in North Eastern region is required for meeting the diversified needs of the people as well as for increasing the food production

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REFERENENCES

1. Chandra, J. P. (1998). Development of poplar based agroforestry system. *Indian Journal of Ecology*, *38*(Special Issue), 11-14.
2. Debroy, K. R. (1989). Agroforestry options in indo-gangetic plains. Alternative Land Use Systems For Sustainable Production, 176.
3. Dhyani, S. K., Handa, A. K., Prasad, R., Alam, B., Rizvi, R. H., Gupta, G., ... & Jain, A. (2013). Modeling analysis of potential carbon sequestration under existing agroforestry systems in three districts of Indo-gangetic plains in India. Agroforestry systems, 87(5), 1129-1146.
4. Gill, K. S. (2003). Feasibility of boron fertilization for yield, seed quality and B uptake of canola in northeastern Saskatchewan. *Canadian journal of soil science*, *83*(1), 99-108.
5. Gill, AS and Roy, R. (2012). Agroforestry research situation in India. Agriculture Situation in India 47:345–354.
6. Gogoi, B. (2015). Soil productivity management and socio-economic development through agro-forestry in north-east India.
7. Grewal, R. (1993). Physical management of soils of the tropics: priorities for the 21st century. *Soil science*, *165*(3), 191-207.
8. MacDicken, K. G. (1994). *Selection and management of nitrogen-fixing trees*. Winrock International Institute for Agricultural Development
9. Mohapatra, D., Mishra, S., Singh, C. B and Jayas, D. S. (2011). Post-harvest processing of banana: opportunities and challenges. *Food and bioprocess technology*, *4*(3), 327-339.

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