TAMIL NADU VETERINARY AND ANIMAL SCIENCES UNIVERSITY

HANDBOOK ON AGROFORESTRY MODELS IN TAMILNADU FOR LIVESTOCK INTEGRATION

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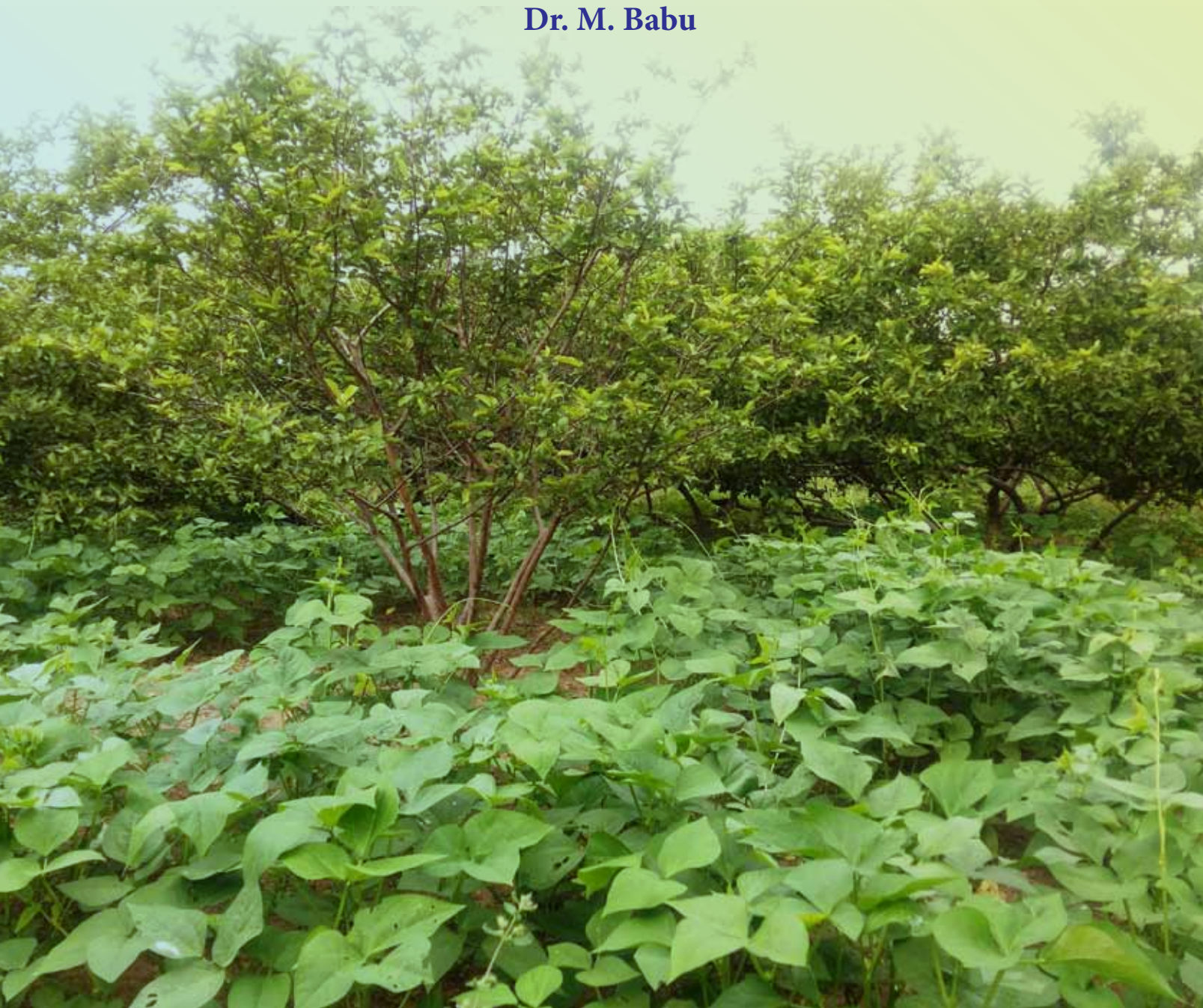

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FOREWORD

Feeding livestock with tree fodder is a traditional practice in India. Livestock productivity can be augmented with grazing supplemented with fodder and tree fodder. Agroforestry is an age old concept wherein the resources of soil, water, biomass and livestock are integrated by recycling for mutual benefit. Different Agroforestry models *viz.,* silvipasture, hortipasture, hortisilvipasture, agrisilvipasture yield grass, fodder, fruits and the returns are from all products. Integrating livestock with these Agroforestry models would enhance soil fertility, check soil erosion and augment livestock productivity.

Tamil Nadu Veterinary and Animal Sciences University (TANUVAS) is actively engaged in propagating Agroforestry models establishment with livestock integration for more than two decades. The All India Co-ordinated Research Project (AICRP) on Agroforestry implemented by TANUVAS in the Institute of Animal Nutrition, Kattupakkam funded by Indian Council of Agricultural Research (ICAR) through Central Agroforestry Research Institute (CAFRI), Jhansi has yielded many meaningful and adoptable results.

This Handbook on Agroforestry models in Tamil Nadu for livestock integration contains salient findings and adoptable recommendations stands testimony to the effort of TANUVAS scientists. I compliment them and thank the Indian Council of Agricultural Research, Central Agroforestry Research Institute, Jhansi for their continued support. I am happy that this handbook is released during the Annual meet organized by the agency in Srinagar in July 2015.

Place : Chennai – 600 051
Date : 25.06.2015

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Foreword

Agroforestry with livestock integration has been a traditional land and livestock management practice in India. Agroforestry systems for livestock integration include silvipasture, hortipasture, agrisilviculture, hortisilvipasture. These systems ensure year round fodder production to livestock. As livestock production systems depend on the availability of quality fodder, agroforestry systems integrated with livestock ensure availability of quality fodder. Tree and shrub / grass components of agroforestry models depend on the agroclimatic conditions prevailing in the region. Thus Tamil Nadu state having seven agroclimatic zones has diverse tree / grass / legume components in the agroforestry models. The Central Agroforestry Research Institute in collaboration with IFGTB, Coimbatore (ICFRE) and AICRP on AF coordinating centre at FCRI, Mettupalaym (TNAU) have identified and disseminated information about suitable agroforestry systems for different region of Tamil Nadu. Agroforestry will also play very effective role in socio - economic upliftment with livelihood and nutritional security and income generation of farmers.

I am pleased to note that AICRP – Agroforestry, Kattupakkam centre, the only centre under AICRP on AF working on integration of live stock in different agroforestry systems has brought out a handbook on Agroforestry models suitable for Tamil Nadu for the benefit of farmers / scientists for their knowledge empowerment on Agroforestry techniques for integration of livestock.

I am sure this handbook with pertinent information on various agroforesty models supported with appropriate photographs will help farmers / institutions who want to implement agroforestry systems in their land. Information relating to nutritive value, carrying capacity of models, different products that could be produced from tree fodder is also presented that will benefit livestock producers.

(S K Dhyani)

CHAPTER

1 INTRODUCTION

Agroforestry is a dynamic, ecological based, natural resource management system that, through integration of trees on farms and in agricultural landscape, diversifies and sustains production of agricultural and its related commodities, for increased social, economic and environmental benefits, for land users at all levels (ICRAF). It is a land use management system in which trees or shrubs are grown around or among crops or in pastureland.

Agroforestry can be advantageous over conventional agricultural and forest production methods. Agroforestry enhances the ecosystem through carbon storage, prevents deforestation, leads to biodiversity conservation and soil and water conservation. When adapted on a large scale, agroforestry enables agricultural land to withstand extreme weather conditions (floods and droughts) and climate change.

Varied benefits can be obtained through the implementation of various Agroforestry models. They include

- Increased production of tree products such as fodder, farm-grown fuel wood, fruits, gums, etc.
- Multifunctional site use i.e crop production and animal grazing.
- Restoring the soil fertility for food crops.
- Cleaner water through reduced nutrient and soil runoff.
- Counters global warming.
- Reduces deforestation.
- Reduces or eliminates the need for insecticides, herbicides, etc.,
- Production of diverse farm outputs leading to improved human nutrition.
- Drought resistant ability – ensures availability of fodder even during drought.
- Provides employment to rural and urban population through production of varied products, products for industrial application and value addition.

India is the first country in the world to come out with a National Agroforestry policy which is aimed at not just increasing tree cover, but providing multiple livelihood and environmental benefits.

CHAPTER

2 AGROFORESTRY MODELS FOR LIVESTOCK INTEGRATION

Various agroforestry models are there suiting different needs. Livestock integration is possible only in certain models. Brief description on Agroforestry models suited for livestock integration is given below.

Silvipasture *(Trees and pastures)*

The production of trees combined with pasture is referred to as Silvipasture. Trees and shrubs are used for fodder production to meet the fodder fodder needs of livestock or trees may be grown in the pasture for timber / fuel wood / to improve the soil quality.

Plate 1 Silvipasture (Trees and pastures integrated with animals)

Agri silvipasture *(Trees, crops and pastures / animals)*

The production of trees combined with annuals and pastures is referred Agrisilvopasture. The annuals generally are crops for human consumption. Pasture crops are integrated with the annuals for fodder purpose.

Plate 2 Agri silvipasture (Trees, crops and pastures / animals)

Home Gardens *(Trees, crops and animals)*

Home gardens are land use systems involving management of multipurpose trees and shrubs in association with annual and perennial agricultural crops and livestock within the compounds of individual houses. Home gardens are a general feature in the southern states of India.

Plate 3 Home Gardens (Trees, crops and animals)

Hortipasture *(Fruit trees and pasture / animals)*

The practice of growing fruit-trees in association with fodder grasses / legumes is known as hortipasture.

Plate 4 Hortipasture (Fruit trees and pasture / animals)

Boundary Plantations *(Trees in boundary)*

The practice of growing trees in field boundaries is known as boundary plantations. The fodder from trees is utilized for feeding livestock.

Plate 5 Boundary Plantations

CHAPTER

3 TREE MANAGEMENT IN AGROFORESTRY SYSTEMS

Management of tree components at suitable age and interval is of vital importance in an agroforestry system. Given below are the generalized management practices for trees in agroforestry systems.

Propagation - Trees and shrubs can be propagated either from seeds or stem cuttings. Certain species like *Leucaena* is cultivated from seeds on the other hand *Gliricidia*, is easily established from stem cuttings or seeds.

Plate 6 Establishment through stem cuttings

The seeds of leguminous tree species usually have a hard seed coat. Hence, these seeds require some form of treatment for water imbibition and germination. Treatment with hot water, chemical agents or mechanical scarification can be carried out to increase the germination ability.

Table 1 Suggested pretreatment for some fodder tree seeds

Tree species	Treatment
Acacia nilotica	Soaking for 30 minutes in concentrated sulphuric acid followed by overnight soaking in water
Acacia leucophloea	Soaking for 30 minutes in concentrated sulphuric acid followed by 4 minutes soaking in water at 80^{0}C
Ailanthes excelsa	Soaking in water for 3 days
Albizia lebbeck	Soaking in water at room temperature for 24 hours (or) soaking for 30 seconds in water raised to a temperature of 80^{0}C
Leucaena leucocephala	Soaking for 30 seconds in water raised to a temperature of 80^{0}C (or) soaking for 5 minutes in concentrated sulphuric acid.
Bauhunia sp.	Soaking for 12 minutes in water raised to a temperature of 80^{0}C (or) soaking for 45 minutes in concentrated sulphuric acid.
Thepesia populunea	Removal of seed coat

Stem sections should be planted fresh within 3 days after cutting and the exposed ends of the stem should be waxed or covered with vaseline, mud,dung or polythene to minimize evaporation. An oblique angle is to be maintained while planting in order to increase the terminal bark area from which the roots emerge.

The nurseries for fodder trees can be prepared in polythene bags. The polythene bags are filled with 2 part soil + 1 part farmyard manure. If farmyard manure is not available, for each bag 2 g of NPK (15:15:15) could be used.

Plate 7 Fodder tree nursery

Fertilizer requirement - A basal application of N: P2O:K2O at the rate of 20:50:30 kg/ha is recommended.

Harvesting - During the first to three years of establishment, foliage is to be harvested only once or twice a year. In humid climates where emphasis is on fodder production, short cutting intervals of 8–10 weeks appear suitable, while longer interval of 12–14 weeks is recommended for the drier environment. Seasonal effect exists on regrowth and total biomass yield, therefore to ensure adequate all-year round supply of fodder for livestock , a pruning interval of 8 weeks during wet and 12 weeks during dry season can be practiced.

Several different harvest methods like coppicing, pollarding, lopping, pruning and thinning are advocated as cutting technologies for trees.

Coppicing - It is one of the most widely used methods, in which individual trees are cut at base usually between 15-75 cm above ground level. New shoots develop from the stumps. For pole and fodder production 2-3 sprouts should be allowed to grow. For exclusive fodder production, the tree can be coppiced very frequently. *Subabul* and *Gliricidia* are examples of good coppiciers.

Pollarding - All the branches including top of the tree are removed at a height of 1.5 meters above ground level. This system is used for the management of live fences, hedgerows in alley farming. *Subabul, Gliricidia, Erythrina indica, Mulbery,* Neem, etc., respond well for pollarding.


Plate 8 Pollarding

Lopping - In this system most of the branches providing thick shade are removed. Excessive and indiscriminate lopping of fodder trees should be avoided. The lopping is advised at 1/3rd level annually for medium and large sized trees.

Plate 9 Lopping

Pruning - Removal of small branches and stems from fodder shrubs is called pruning.

Thinning - It is a traditional forestry practice followed to maintain desirable trees by eliminating the poorly grown trees and retaining the desired trees so as to improve the growth of retained trees by reducing competition for light and nutrients.

Forage yield documentation – On harvesting the yield of fodder from trees / grasses / legumes can be documented by weighing.


Plate 10 Forage yield documentation

CHAPTER

4 BIOMASS YIELD AND NUTRITIVE VALUE OF TREE FODDERS

Regardless of the production systems of fodder trees, biomass / foliage yield is affected by factors such as tree species, density of planting and harvesting management, i.e., age at first harvest, height and frequency of cutting and season of harvest.

A high variability in the nutritive value of fodder trees exists and this could be attributed to species variability, plant age, plant part, harvesting regimen, season and location. The digestibility of tree fodder depends on the lignifications of plant tissue which in turn depends on the age of the plant. As plant age increases the lignin content increases and digestibility decreases.

Table 2 Common fodder trees of Tamil Nadu with their biomass yield on Dry Matter basis (MT/ha) and their nutritive value (%DMB)

S. No.	Botanical name	Tamil name	Biomass yield on Dry Matter basis (MT/ha)	Crude protein (%)	Crude fibre (%)	TDN (%)
1.	*Acacia nilotica*	Karuvel	0.5 – 2.0	12	28	45
2.	*Acacia leucophloea*	Velvel	0.5 – 2.0	14	25	45
3.	*Acacia planifrons*	Kudaivel	0.5 – 2.0	9.6	22	45
4.	*Ailanthes exelsa*	Perumaram	3.0 - 4.5	6.0	23	63
5.	*Albizia lebbek*	Vagai	1.0 – 2.0	16	18	50
6.	*Albizia amera*	Vengai	2.0 – 3.0	15	20	50
7.	*Azardirachta indica*	Vembu (neem)	-	6	27	55
8.	*Bahunia sp*	Mandharai	1.5 – 2.5	17	22	55
9.	*Dalbergia sisso*	Sissu	-	17	25	50
10	*Erythrina indica*	Kalyana murungai	1.0 – 2.0	26	12	60
11.	*Ficus bengalensis*	Alla maram	-	12	27	52
12	*Hardwickia binata*	Aachan	-	10	26	50
13.	*Gliricidia sepium*	Eru Maram	2.0-15.0	22	25	65
14.	*Inga dulci*	Kodukapuli	2.0 – 4.0	20	25	55
15.	*Milligtonia hortensis*	Maramalli	-	6	20	62
16.	*Leucaena leucocephala*	Subabul	2.0-20.0	21	24	68
17.	*Lannea coromandalica*	Otiyan	-	4	18	65
18.	*Sesbania sesban*	Sithagathi	2.0 -10.0	24	28	65
19.	*Sesbania grandiflora*	Agathi	2.0 -10.0	22	27	65
20.	*Thespesia populnea*	Poovarasu	-	11	20	60

Tree fodders are rich in minerals compared to fodder crops. The mineral content of tree fodders are variable depending upon tree species, age of the tree, stage of lopping, season of lopping, soil mineral profile, soil pH, etc. The calcium to Phosphorus ratio is wide in tree fodders hence necessitates supplementation of phosphorus while being fed to animals by way of supplementing with bran.

Table 3 Mineral content of common fodder trees of Tamil Nadu

S. No.	Botanical name	Tamil name	Calcium (%)	Phosphorus (%)	Magnesium (%)	Iron (ppm)	Zinc (ppm)	Copper (ppm)
1.	*Acacia nilotica*	Karuvel	2.80	0.52	11.28	-	58.68	12.64
2.	*Acacia leucophloea*	Velvel	2.29	0.41	12.08	257.44	15.41	10.79
3.	*Acacia planifrons*	Kudaivel	2.45	0.04	11.28	335.42	58.68	12.64
4.	*Albizia lebbek*	Vagai	3.04	0.04	13.50	887.76	6.97	11.70
5.	*Azardirachta indica*	Vembu (neem)	2.13	0.04	-	-	16.28	6.71
6.	*Bahunia sp*	Mandharai	2.90	0.03	10.55	-	-	-
7.	*Dalbergia sisso*	Sissu	2.65	0.03	13.39	323.37	95.76	11.73
8.	*Erythrina indica*	Kalyana murungai	2.40	0.04	16.18	-	38.3	8.17
9.	*Ficus bengalensis*	Alla maram	2.33	0.04	10.78	300.24	18.72	11.24
10.	*Hardwickia binata*	Aachan	9.75	0.02	9.81	1462.00	56.73	10.66
11.	*Gliricidia sepium*	Eru Maram	2.47	0.27	14.98	-	26.64	8.84
12.	*Inga dulci*	Kodukapuli	3.23	0.06	13.30	-	30.37	16.84
13.	*Milligtonia hortensis*	Maramalli	2.35	-	15.15	-	-	-
14.	*Leucaena leucocephala*	Subabul	2.29	0.06	12.33	253.38	11.71	32.61
15.	*Lannea coromandalica*	Otiyan	2.25	-	14.86	-	17.3	6.36
16.	*Sesbania grandiflora*	Agathi	2.20	0.05	13.87	226.71	23.55	9.57
17.	*Thespesia populnea*	Poovarasu	4.03	0.06	14.01	260.02	53.44	16.13

CHAPTER

5 AGROFORESTRY MODELS FOR LIVESTOCK INTEGRATION IN TAMIL NADU

Tamil Nadu is classified into seven agroclimatic zones based on climate, physical and ecological characters. Different agroforestry models for livestock integration exist in the different agroclimatic zones.

Agroforestry Systems for livestock integration in North Eastern zone of Tamil Nadu

This zone includes the following districts Chennai, Kanchipuram, Thiruvallur, Cudallore, Vellore, Thiruvannamalai and Vilupuram. Some of the common agroforestry models adopted for livestock integration in this zone is given below.

Three-tier Agroforestry model

Tree species
Gliricidia sepium
Leucaena leucocephala

Understorey grass / legume
Stylosanthes hamata
Sorghum bicolor

Plate 11 Three-tier Agroforestry model

Plate 12 Hortisilvipasture

Hortisilvipasture

Tree species
Moringa oleifera
Leucaena leucocephala
Mangifera indica

Understorey grass / legume
Sorghum bicolor

Silvipasture

Tree species
Gliricidia sepium

Understorey grass / legume
Crotalaria juncea

Plate 13 Silvipasture

Plate 14 Hortipasture

Hortipasture

Tree species
Cocus nucifera
Psidium guajava

Understorey grass / legume
Stylosanthes hamata

Silvipasture

Tree species
Sesbania grandiflora

Understorey grass / legume
Bajra Napier hybrid grass

Plate 15 Border Plantation

Agroforestry models for livestock integration in North Western zone of Tamil Nadu

This zone includes Dharmapuri, Krishnagiri, Salem and Namakkal districts. Some of the common agroforestry models adopted for livestock integration in this zone is given below.

Agrisilvipasture

Tree species
Leucaena leucocephala
Moringa oleifera

Understorey grass / legume
Dolichos biflorus

Plate 16 Agrisilvipasture

Plate 17 Silvipasture

Silvipasture

Tree species
Azadirachita indica

Understorey grass / legume
Stylosanthus sp

Hortipasture

Tree species
Cocus nucifera

Understorey grass / legume
Cenchrus ciliaris
Megathyrsus maximus

Plate 18 Hortiipasture

Agroforestry Systems in Western zone of Tamil Nadu

This zone includes Erode, Coimbatore, Karur, Dindigul and Theni districts. Some of the common agroforestry models adopted for livestock integration in this zone is given below.

Plate 19 Silvipasture

Silvipasture

Tree species
Sesbania sesban

Understorey grass / legume
Stylosanthes hamata

Hortisilvipasture

Tree species
Mangifera indica

Understorey grass / legume
Bajra Napier hybrid grass

Plate 20 Hortisilvipasture

Plate 21 Hortipasture

Hortipasture

Tree species
Cocus nucifera

Understorey grass / legume
Desmanthus virgatus

Agroforestry systems in Hilly zone of Tamil Nadu

This zone includes The Nilgiris, Shevroys, Elagiri javadhu, Kolli, Anamalai, Palni and Podhigai Hill ranges. Some of the common agroforestry models adopted for livestock integration in this zone is given below.

Agrisilvipasture

Tree species
Acacia melanoxylan
Chamaecytisus palmensis

Understorey grass / legume
Pennisetum clandestinum

Plate 22 Silvipasture

Plate 23 Hortipasture

Hortipasture

Tree species
Pyrus pyrifolia

Understorey grass / legume
Pennisetum clandestinum

Agroforestry systems in Southern zone of Tamil Nadu

This zone includes Ramanathapuram, Tirunelveli, Madurai, Pudukottai (part of the district), Sivagangai, Virudhunagar and Thoothukudi. Some of the common agroforestry systems adopted in this zone is given below.

Plate 24 Silvipasture

Silvipasture

Tree species
Leucaena leucocephala

Understorey grass / legume
Cenchrus ciliaris
Stylosanthes hamata

Agrisilviculture

Tree species
Leucaena leucocephala

Understorey grass / legume
Crotalaria juncea

Plate 23 Agrisilviculture

Plate 23 Hortipasture

Hortipasture

Tree species
Mangifera indica

Understorey grass / legume
Desmanthus virgatus
Megathyrsus maximus

Agroforestry systems in Cauvery delta zone of Tamil Nadu

This zone includes Tiruchirapalli (part of district), Perambalur (part of district), Pudukottai (part of district), Thanjavur, Nagapattinam and Thiruvarur. Some of the common agroforestry systems adopted in this zone is given below.

Hortipasture

Tree species
Cocus nucifera

Understorey grass / legume
Sorghum bicolor
Bajra Napier hybrid grass

Plate 24 Hortipasture

Plate 25 Silvipasture

Silvipasture

Tree species
Leucaena leucocephala
Gliricidia sepium

Understorey grass / legume
Stylosanthes scabra

Agroforestry systems in High rainfall zone of Tamil Nadu

This zone includes Kanyakumari district. Some of the common agroforestry systems adopted in this zone is given below.

Plate 26 Agrisilviculture

Silvipasture

Tree species
Lannea coromondalica

Crop
Oryza sativa

Silvipasture

Tree species
Leuceana leucocephala
Gliricidia sepium

Understorey grass / legume
Stylosanthes hamata

Plate 27 Silvipasture

CHAPTER

6 VALUE ADDED PRODUCTS FROM TREE FODDER

High quality silage could be prepared from tree fodder using additives such as 0.5% salt, 1% molasses and non protein nitrogen sources such as urea at 0.5 to 1 %. Tree fodder can be lopped dried and stored as hay. From dried tree fodder complete feed block, extruded feed, tree leaf meal and tree leaf meal incorporated antheleminthic salt licks can be prepared.

Plate 28 Neem silage

Plate 29 Gliricidia hay

Plate 30 Complete feed block incorporating tree fodder

Plate 31 Extruded feed incorporating tree fodder

Plate 32 Tree leaf meal

Plate 33 Tree leaf meal incorporated anthelminthic salt lick

CHAPTER

7 ANTI NUTRITIVE FACTORS IN TREE FODDERS

Tree fodders contain high levels of deleterious compounds that make them unpalatable or harmful to livestock when consumed in large amounts. Some of the common antinutritional factors in tree fodders include mimosine, or its metabolite 3-hydroxy-pyridone (DHP), tannins and saponins.

S.No.	Botanical name	Tamil name	Antinutritional factor (%)
1.	*Acacia nilotica*	Karuvel	Tannin 9 - 10
2.	*Acacia leucophloea*	Venvel	Tannin 8 - 9
3.	*Acacia planifrons*	Kudaivel	Tannin 9 - 10
4.	*Ailanthes exelsa*	Perumaram	Tannin 2 - 8
5.	*Albizia lebbek*	Vagai	Tannin 7 - 9 Saponins 0.5 -1
6.	*Albizia amera*	Vengai	Tannin 7 - 9 Saponins 0.5 -1
7.	*Azardirachta indica*	Vembu (neem)	Azadirachtin 0.02
8.	*Bahunia sp*	Mandharai	Tannin 10 - 14
9.	*Dalbergia sisso*	Sissu	Tannin 6 - 7
10.	*Erythrina indica*	Kalyana murungai	
11.	*Ficus bengalensis*	Alla maram	Tannin 3 - 4
12	*Hardwickia binata*	Aachan	Tannin 11
13.	*Gliricidia sepium*	Eru Maram	Tannin 2 - 3
14.	*Inga dulci*	Kodukapuli	Tannin 5 - 8
15.	*Milligtonia hortensis*	Maramalli	
16.	*Leucaena leucocephala*	Subabul	Tannin 9 - 11 Mimosine 2 - 6
17.	*Lannea coromandalica*	Uthyan	Tannin 3 - 5
18.	*Sesbania sesban*	Sithagathi	Tannin 8 - 11 Saponin 0.5 - 1
19.	*Sesbania grandiflora*	Agathi	Tannin 8 - 11 Saponin 0.5 - 1
20.	*Thespesia populnea*	Poovarasu	Tannin 8 - 9

A number of methods can be used to overcome toxicity problems. Wilting, drying and dilution with other feeds are some of the methods.

CHAPTER

8

FEEDING EXPERIMENTS IN LIVESTOCK

To evaluate a feed it is essential to carry out feeding experiments. The feed can be evaluated by carrying out any of the trials listed below.

1. **Palatability trial** – This trial is to check the extent to which the feed / fodder under test is palatable.

Plate 34 Palatability trial

2. **Digestibility trial** – This trial is to determine the digestibility of nutrients in the feed or fodder.

Plate 35 Digestibility trial

3. Metabolic trial / Balance studies – This trial is carried out to check the extent to which a nutrient is retained in the animal system.

3. **Growth trial -** It is a trial conducted to check the extent to which the feed / fodder supports growth.

Plate 36 Growth trial

4. **Reproductive trial -** It is a trial carried out to check the extent to which a feed or fodder has an impact on the reproduction of animals.

Plate 37 Reproductive trial

5. **Lactation trial -** It is a trial carried out to check whether the feed or fodder affects the milk yield or its composition.

Plate 38 Lactation trial

CHAPTER

9 DETERMINING DIGESTIBILITY OF FEED / FODDER

The digestibility of nutrients in feed / fodders can be determined by conducting digestion trial. The requirements for conducting digestion trial are experimental animals (adult, same sex preferably male and comparable body weight),metabolism stall (a place to house the animal having facilities for separate collection of urine and fecal matter), weighing balances, sample collection containers and experimental feed / fodder.

Procedure: The feed / fodder whose digestibility is to be determined is collected / and stored. A pre experimental feeding or adaptation period for 2 to 4 weeks is first carried out. During this period the test feed / fodder is fed to the animal as a sole feed or a component of a ration. This is necessary to adapt the animal to the new type of feed / fodder and also to clear the digestive tract from the previous feed. The adaptation period is followed by collection period, which is for 5 to 10 days. The weights of the animals are recorded at the start of the period. The experimental feed / fodder is fed as a sole fed. Feed intake is recorded daily by maintaining records on the amount of feed / fodder offered to the animals and the amount of feed / fodder left over. Samples of feed / fodder offered and left over are collected and processed for further analysis. Faeces voided are collected every 24 hours, weighed and sample taken for proximate analysis.

Plate 39 Dung collection

Urine voided is also collected if metabolism studies are to be carried out. Samples of feed / fodder and faeces are analyzed in laboratory for their proximate principles viz., moisture, crude protein, crude fibre, ether extract and nitrogen free extract so as to determine their content in the feed or fodder consumed or feces voided. Using these information the digestibility coefficient or per cent digestible nutrient or Total digestible nutrient (TDN) present in the feed is calculated using the formula given below.

$$\text{Digestibility Coefficient} = \frac{(\text{Nutrient intake} - \text{Nutrient excreted})}{\text{Nutrient intake}} \times 100$$

$$\text{Per cent Digestible nutrient} = \frac{(\text{Nutrient intake} - \text{Nutrient excreted})}{\text{Feed intake}} \times 100$$

TDN (%) = % digestible crude protein + (% digestible ether extract2.25 ⊠) + % digestible crude fibre + % digestible nitrogen free extract.

In ruminants, roughage can be given to the animals as the sole item of diet. Concentrate feeds, however, may cause digestive disturbances if given alone and their diestibility is often determined by giving them in combination with a roughage of known digestibility. Thus the digestibility of concentrates (feeds with low crude fibre) can be found out only by the method of difference. In this method the digestibility of any standard roughage is determined first as explained earlier. A second trial is conducted with the same animals, where the concentrate whose digestibility is to be determined is fed to the animals along with the same standard roughage. The digestibility coefficient of the roughage alone is calculated. The digestibility coefficient of concentrate is determined by substracting the digestibility of nutrient in roughage from digestibility of nutrient in combined rations.

Marker / Indicator method of determining digestibility

In grazing animals it is difficult to measure the feed intake or faeces output, or both. In these animals digestibility can still be measured, if there is present in the feed some substance which is known to be completely indigestible. If the concentrattions of this marker / indicator in the feed and in small samples of the faeces of each animal are determined, the ratio between these concentrations gives an estimate of digestibility.

$$\text{Digestibility coefficient of nutrient} = 100 - \left(100 \times \frac{\%\text{ indicator in feed}}{\%\text{ indicator in faeces}} \times \frac{\%\text{ nutrient in the faeces}}{\%\text{ nutrient in the feed}}\right)$$

The ideal specification of an indicator / marker are: It should be totally indigestible, it should not have any pharmacological action on the digestive tract, it should be inert in the digestive system, it must remain uniformly distributed in the digesta, it should pass through the digestive tract at a uniform rate and should be voided entirely, it should be readily be determined chemically, and preferably be a natural constituent of the feed / fodder under test. Lignin, silica, acid insoluble ash fullfill these conditions and are therefore used as markers / indicators.

CHAPTER

10 LIVESTOCK FEEDING METHODS ADOPTED IN AGROFORESTRY MODELS

Stall feeding

Tree fodders are lopped and stall fed to livestock. This system of feeding is also referred to as cut and carry system or zero grazing.

Plate 40 Stall feeding of cow with tree fodder

Plate 41 Stall feeding of sheep with tree fodder

Plate 42 Stall feeding of goats with tree fodder

Plate 43 Stall feeding of rabbits with tree fodder

Grazing / Browsing

The animals are allowed into the agroforestry systems and are allowed to graze or browse the fodder available.

Plate 44 Cattle grazing in silvipasture

Plate 45 Goats browsing in silvipasture

Plate 46 Sheep grazing in silvipasture

Using tree leaf meal in concentrate mixture of livestock

The tree fodder lopped is dried, ground and incorporated in concentrate mixture at varying levels in replacement of conventional feed ingredients. This helps to reduce cost of concentrate feed and maintaining the desired nutritive value.

Plate 47 Goats feeding tree leaf meal incorporated concentrate mixture

Plate 48 Buffalo calves feeding tree leaf meal incorporated concentrate mixture

Example of Tree Leaf meal based concentrate feed

Ingredients	Inclusion level (%)
Tree leaf mix	30
Yellow maize	28
Wheat bran	10
Deoiled rice bran	10
Soya bean meal	14
Sunflower oil cake	5
Mineral mixture	2
Salt	1
DCP%	14
TDN%	70
Cost (Rs.)	15.00

CHAPTER

11 LEVEL OF FEEDING FODDERS FROM AGROFORESTRY MODELS

Plate 49 *Leuceana leucocephala*

For large ruminants 5 - 8 kg and small ruminants 2 - 3 kg could be fed per day.

Plate 50 *Inga dulce*

For small ruminants 2 - 3 kg could be fed per day.

Plate 51 *Gliricidia sepium*

For large ruminants 3 - 5 kg and small ruminants 1 - 2 kg could be fed per day.

Wilting in shade for 5 hours is essential for feeding the animals.

Plate 52 *Erythrina indica*

For rabbits 0.3 to 0.4 kg could be fed per day

Plate 53 Bajra napier hybrid grass

For large ruminants 20 - 25 kg and small ruminants 3 - 4 kg could be fed per day.

Plate 54 Fodder sorghum

For large ruminants 20 - 25 kg and small ruminants 3 - 4 kg could be fed per day.

Antinutritional factor: Cyanic acid (young leaves)

Plate 55 Guinea grass

For large ruminants 20 - 25 kg and small ruminants 3 - 4 kg could be fed per day.

Plate 56 *Cenchrus ciliaris*

For large ruminants 20 - 25 kg and small ruminants 3 - 4 kg could be fed per day.

Plate 57 *Desmanthus virgatus*

For large ruminants 4 - 5 kg and small ruminants 0.5 - 1 kg could be fed per day.

Plate 58 *Stylosanthus hamata*

For large ruminants 4 - 5 kg and small ruminants 0.5 - 1 kg could be fed per day.

CHAPTER

12 CARRYING CAPACITY OF DIFFERENT AGROFORESTRY MODELS

S.No.	Agroforestry model	Tree and fodder component	Carrying capacity
1.	Silvipasture	*Leucaena leucocephala* *Gliricidia sepium* *Cenchrus ciliaris*	***Leucaena leucocephala*** can replace 20 % of green fodder and can hold 6 -7 cows per year per hectare without adverse effect on its milk yield and composition in dairy animals ***Gliricidia sepium*** can replace 15 % of green fodder and can hold 14 -15 cows per year per hectare without adverse effect on its milk yield and composition in dairy animals.
2.	Hortipasture	*Cocos nucifera* *Psidium guajava* *Desmanthus virgatus* *Stylosanthes hamata* *Crotolaria juncea* *Cenchrus ciliaris*	***Desmanthus virgatus*** Can hold 70 calves fed at 2 kg /calf/day apart from reducing the requirement of concentrate feed by 37.5% ***Stylosanthes hamata*** Can hold 60 adult ***sheep / goats*** per year fed at 1kg /day /animal. ***Crotolaria juncea*** Can hold 12 -14 adult ***sheep / goats*** per year fed at 1kg /day /animal or 50 -55 ***rabbits*** per year fed at 0.25kg /day /animal. ***Cenchrus ciliaris*** can hold 4 cattle or 16 sheep / goats per year.
3.	Hortisilvipasture	*Leucaena leucocephala* *Mangifera indica* Fodder sorghum (CoFS 29)	The fodder produced in this model could support 36 calves for a year when fed at 8 kg/day/animal.

CONCLUSION

Agroforestry a means of sustainable agriculture, helps to mitigate climate change, is a source of additional revenue to farmers also protects environment and provides livestock with superior feed / fodder especially during periods of scarcity thereby augmenting their productivity.

Agroforestry with livestock integration solves the problem of fodder shortage and helps in the production of value added livestock products or designer livestock products. Tree fodders are rich in nutrients some of which protected from rumen degradation hence are of great value in feeding ruminants. A wider, newer dimensional research is needed to further the concepts of Agroforestry. Moreover the Indian Government has come out with the National Agroforestry Policy which deals with with pratice of intergrating trees, crops and livestock on the same plot of land. Hence it becomes mandatory to popularize agroforestry among farmers.

This book is compilation of 20 years of research on Agroforestry at Institute of Animal Nutrition, Kattupakkam. This book will serve as a guide to farmers of Tamil Nadu who are interested in adopting agroforestry systems with livestock integration.

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