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# Sustainable Forage Production from Alternate Land Use System

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**A B S T R A C T**

Sustainable forage production is inevitable in order to meet fodder demand of rising Indian livestock population and also to enhance the livestock productivity. The prime reasons for poor livestock productivity in India are scarcity of fodder, poor and insufficient nutrition, hormonal inequity, low productive breeds, diseases and pest attack etc. **S**ustainable fodder production must focus on round the year supply of nutritious fodder to livestock in adequate amount. Utilization of wastelands, grasslands, degraded lands, community lands, fallow lands, barren lands etc. for tree-based forage production system is one of the viable option for sustaining quality fodder supply to livestock. This can be achieved by integrating fodder trees, fodder shrubs, fodder grasses and fodder legume species in silvipastoral form, utilization of field bunds and interspaces of orchard and plantation for fodder production, growing fodder tree on grasslands and pasture lands, establishing fodder banks etc.

## Introduction

Forage crops are important for the effective process of animal production systems. However, production of forage crops should be strategic during a cost-effective and sustainable way. An appropriately managed crop production system, where forages are fed to livestock, features variety of structures that develop sustainability. Forage crops can be utilized to diminish soil erosion and soil compaction, in addition, they also recover the structure and health of the soil. Vigilant management of forage crops production is critical, particularly when integrated with no-till farming. Sustainable forage production is inevitable in order to meet fodder demand of rising Indian livestock population and also to enhance the livestock productivity (Kashyap *et al.*, 2014)..

### Livestock and Fodder Scenario in India

Livestock sector ensure year-round income and act as insurance against failure of agricultural crops. More than 80 per cent of rural families in India depend on livestock for livelihood. However, the current livestock productivity is not up to the mark. The prime reasons for poor livestock productivity in

India are scarcity of fodder, poor and insufficient nutrition, hormonal inequity, low productive breeds, diseases and pest attack etc. Non availability of adequate amount of quality fodder alone account for 50-20% of total loss occur in productivity and growth rate of livestock. The data on current livestock and fodder scenario in India is depicted in Table 1.

The comparative milk production scenario in India, USA and UK is given in Table 2, which shows that the average milk production in India is lagging much behind the developed countries, instead of India has one of the biggest livestock wealth in the World.

India is facing 35.6, 11.0 and 44.0% deficit of green fodder, dry fodder and feed concentrates respectively (IGFRI, 2015). The rising demand for fodder in India for up-coming years is presented in Table 3. The common fodder resource includes grazing lands, grassland, forests, cultivated fodder, agroforestry, trees/shrubs and crop residues. Productivity and area under pasture and grazing land resources are declining rapidly due to overgrazing, land degradation, climate change, invasion of weed and habitat fragmentation. Only 5% of total gross cropped area in India is devoted to fodder crop cultivation.

## Sustainable fodder production

The probable reason for shortage of fodder in India includes degrading grassland and pastures, overgrazing, deteriorating productivity of fodder resources viz., forests, grasslands etc., reduction of agricultural land and pastures and climate change and land degradation. Therefore, sustainable fodder production must focus on round the year supply of fodder to livestock, quality nutritious fodder production as well as adequate amount of fodder production. The challenges in sustainable fodder production are:

Shrinking agricultural lands: More area under agriculture land cannot be devoted for fodder production.

Declining productivity of land.

Lack of awareness among farmers/livestock keepers regarding importance of quality fodder in sustaining livestock productivity.

Lack of proper policy focusing on grassland management and fodder production.

## Solutions for sustainable forage production

Following are the feasible options for achieving sustainable forage production

## Utilizing alternate lands/non-cultivated lands for fodder production

One of the most reliable solution is utilizing wastelands, grasslands, degraded areas, common property resources, fallow lands, barren lands etc. for the purpose of fodder production. The land use scenario in India is given in Table 4.

## Forage production from non-cultivated land

Utilization of degraded lands/wastelands/grasslands/community land for establishing Fodder tree + Fodder shrubs + fodder grasses + Fodder legume species based alternate land use systems.

Utilization of interspaces of established Orchard and plantation crops.

Forages on bunds.

Fodder banks.

Hortipastures.

Silvopastures.
Fodder tree on grasslands & pasture.

Fodder trees/shrubs as soil conservation hedges.

**Silvopasture**

Among the other means of fodder production, Silvopasture is the most viable option for round the year fodder production on sustained basis.

**Fodder availability from three tier silvopasture system**

**For small ruminants**

Jan to June - 21% (Tree)

Feb to April - 15% (Shrubs)

July to Dec. – 64 % (Green fodder) March-April (Grazing) Grass

**Fodder availability month during Year**

Jan to June: Tree (21%)

Feb to April: Shrubs (15%)

July to Dec: (Green fodder), March to April: (Grazing) (64%)

Jal-kund Size 5x 4x 1.5 m Capacity – 30 m3

30000 litres

2 No. Jal-kund/ha

Water storage/ha= 60000 litres 400 plant/ha Save 3-4 irrigation (Feb to May)

Cost- Rs 6000

Cost of irrigation from water tanker 1 Tanker 4000 litres

No. of plant Irrigated/Tanker = 100 One Tanker cost = Rs. 1000/-

4 tanker/hectare/irrigation Total tanker required for four

irrigation in 1 ha 4x4 = 16 tanker total cost = 16000/ha

**Horti-pastures**

Grass production on orchard floor

Enhanced quality of fruit and fodder production

Aonla based hortipasture system and Guava based hortipasture system are good practicing in India.

**Fodder Bank**

Block of fodder trees, shrubs and legumes crops planted at close spacing to meet out fodder shortage in lean dry period via producing high fodder forage biomass. Mulberry fodder bank with density of 49382 plants per hectare in humid tropics of Kerala have been reported to produce 32.56 t/ha dry following 12 weeks cutting interval.

**Table.1** Current Livestock and Fodder Scenario in India

| Livestock population (millions) | 19th Livestock census | 20th Livestock census |
|---|---|---|
| **Cattle** | 190.90 | **192.49** |
| **Buffalo** | 108.70 | **109.85** |
| **Sheep** | 65.07 | **74.26** |
| **Goat** | 135.17 | **148.88** |
| **Pig** | 10.29 | **9.06** |
| **Mithun** | 0.30 | **0.38** |
| **Yak** | 0.08 | **0.06** |
| **Horses & Ponies** | 0.63 | **0.34** |
| **Mule** | 0.20 | **0.08** |
| **Donkey** | 0.32 | **0.12** |
| **Camel** | 0.40 | **0.25** |
| **Total Livestock** | 512.06 | **535.78** |
| **Change in total population (millions)** | **= 23.72 (4.43%)** | |

Source: Ministry of fisheries, animal husbandry & dairying department of animal husbandry & dairying Krishi Bhawan, New Delhi, 2019

**Table.2** Average milk productivity Scenario

| India | USA | UK |
|---|---|---|
| **2.5 kg/day/animal (Indigenous)**<br>**7.2 kg/day/animal (Cross breed)** | **22 kg/day/animal** | **28 kg/day/animal** |

Source: Ministry of fisheries, animal husbandry & dairying department of animal husbandry & dairying Krishi Bhawan, New Delhi, 2019.

**Table.3** Estimated rising demand for Fodder in India for up-coming years

| Year | Dry Forage | Green Forage |
|---|---|---|
| **2030** | 568.10 | **911.67** |
| **2040** | 594.97 | **954.81** |
| **2050** | **631.05** | **1012.70** |

Source: IGFRI, 2015, IGFRI VISION 2050, Jhansi, U.P. India

**Table.4** Land use scenario in India

| Land use | Area (m ha) | Percent |
|---|---|---|
| **Forest area** | 71.79 | **21.84** |
| **Non-agricultural uses** | 26.88 | **8.73** |
| **Barren & uncultivable wasteland** | 16.99 | **5.2** |
| **Culturable wasteland** | 12.86 | **3.9** |
| **Permanent pastures** | 10.26 | **3.12** |
| **Miscellaneous tree crops** | 3.35 | **1** |
| **Fallow land** | 26.18 | **7.96** |
| **Agricultural Land** | 181.18 | **55.33** |
| **Net Sown Area** | **140.02** | **42.63** |

Source: Directorate of Economics and Statistics, Department of Agriculture, Cooperation and farmers welfare, Ministry of Agriculture and farmers welfare, 2017

**Fig.1** Time to start grazing

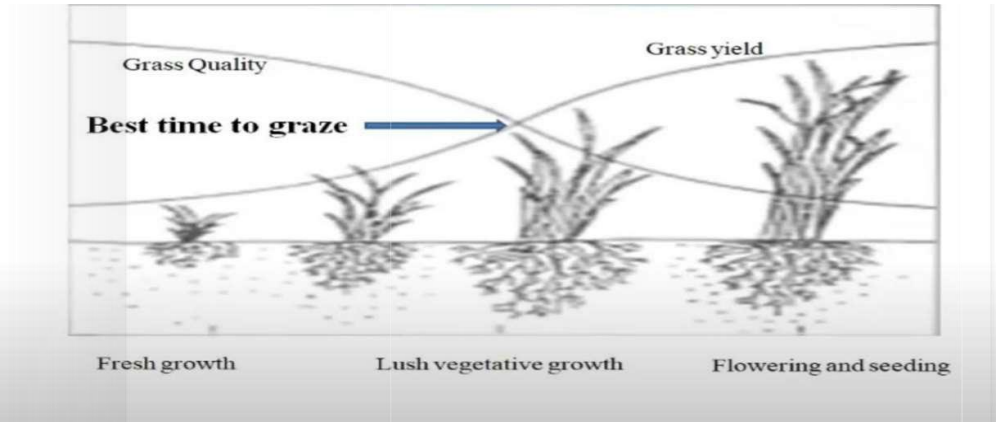



**Fig.2** In-situ water conservation in silvo-pasture system through Jal-kund

**Table.5** State wise pasture grass and legume species

| Zone | State | Name of grass | Name of Legume |
|---|---|---|---|
| **North zone** | Jammu & Kashmir | *Lolium arundinaceum, Dactylis glomerata, Poaalpina* | ***Medicago spp.*** |
| | Uttar Pradesh | *Cenchrus ciliaris, Cenchrus setigerus, Panicummaximum, Chrysopogen fulvus, Pennisetum pedicellatum, Heteropogon contortus, Brachiaria mutica, Dichanthium annulatum, Apluda mutica, Sehima nervosum.* | ***Stylosanthes seabrana, Stylosanthes hamata, Clitoria ternatea, Arachis hypogaea, Desmanthus virgatus.*** |
| | Punjab, Haryana, Delhi, Himachal Pradesh, Uttarakhand | *Cenchrus ciliaris, Panicum maximum, Heteropogon contortus, Apluda mutica, Brachiaria mutica, Poa alpina* | ***Stylosanthes seabrana, Stylosanthes hamata, Clitoria ternatea, Lucerne, Desmanthus virgatus.*** |
| **East zone** | Bihar, Orissa, Jharkhand and West Bengal | *Pennisetum pedicellatum* (Dinanath grass), *Pennisetum polystachion* (Thin napier), *Pennisetum maximum, Heteropogon contortus, Brachiaria mutica, Dichanthium annulatum, Apluda mutica* | ***Stylosanthes seabrana, Stylosanthes hamata, Stylosanthes guianensis, Stylosanthes scabra, Desmanthus virgatus.*** |
| **Central zone** | Madhya Pradesh and Chhattisgarh | *Pennisetum pedicellatum, Cenchrus ciliaris, Pennisetum maximum, Heteropogon contortus, Brachiaria mutica, Dichanthium annulatum, Apluda mutica,* | ***S. seabrana, S. hamata, Clitoria ternatea, Lucerne, Desmanthus virgatus*** |
| **West zone** | Rajasthan, Gujrat, Goa | *Sewan grass, Heteropogon contortus, Brachiaria mutica, Dichanthium annulatum, Cenchrus ciliaris, Panicum antidotale, Dhaman.* | ***S. seabrana, S. hamata, Clitoria ternatea.*** |
| | Maharashtra | *Brachiaria Spp., Cenchrus ciliaris, Panicum maximum, Apluda mutica.* | ***S. seabrana, S. hamata, Lucerne, Desmanthus virgatus.*** |
| **South Zone** | **Andhra Pradesh, Karnataka, Kerala and Tamil Nadu.** | ***Brachiaria Spp., Cenchrus ciliaris, Panicum maximum, Apluda mutica.*** | ***S. seabrana, S. hamata, Lucerne.*** |

**Table.6** State wise fodder tree

| Zone | State | Fodder Tree |
|---|---|---|
| **Northzone** | Jammu & Kashmir | ***Morus alba, Robinia pseudoacacia, Salix alba, Salix babylonica, Populus nigra, Acacia arabica, Albizia spp. Grewia elastica, Ziziphus jujuba, Dalbergia sissoo.*** |
| | Uttar Pradesh | ***Acacia spp. Albizia spp. Ficus spp. Bauhinia spp. Leucaena leucocephala, Azadirachta indica, Dalbergia sissoo, Madhuca latifolia, Ficus infectoria, Morus alba, Ziziphus mauritiana.*** |
| | Panjab, Haryana, Delhi, Himachal Pradesh, Uttarakhand | ***Acacia spp. Albizia spp. Ficus spp. Bauhinia spp. Leucaena leucocephala, Azadirachta indica, Dalbergia sissoo, Madhuca latifolia, Ficus infectoria, Populus deltoides, Ziziphus mauritiana, Grewia optiva.*** |
| **NorthEast zone** | Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura. | ***Acacia auriculiformis, Albizia lebbek, Dalbergia sissoo, Ficus hispida, Gmelina arborea, Albizia chinensis, Leucaena leucocephala, Bauhinia purpurea, Melia azedarach, Morus spp. Bambusa tulda, Azadirachta indica, Gliricidia maculata.*** |
| **Central zone** | Madhya Pradesh & Chhattisgarh | ***Bauhinia purpurea, Acacia albida, Acacia Senegal, Albizia lebbeck, Azadirachta indica, Dalbergia sissoo, Gmelina arborea, Leucaena leucocephala, Morus alba, Ziziphus xylopyrus.*** |
| **West zone** | Rajasthan, Gujrat, Goa | ***Prosopis cineraria, Ailanthus excelsa, Leucaena leucocephala, Prosopis juliflora, Albizia lebbeck, Albizia procera, Dalbergia sissoo, Hardwickia binata, Acacia tortilis, Albizia procera, Diospyros melanoxylon, Melia azedarach, Sesbania grandiflora, Ziziphus nummularia.*** |
| | Maharashtra | ***Acacia albida, Albizia lebbeck, Acacia nilotica, Azadirachta indica, Bauhinia variegate, Bauhinia purpurea, Dalbergia sissoo, Ficus indica, Gmelina arborea, Morus alba, Prosopis juliflora.*** |
| **South zone** | Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. | ***Gliricidia sepium, Ficus spp. Moringa oleifera, Acacia auriculiformis, Azadirachta indica, Acacia nilotica Albizia lebbeck, Acacia tortilis, Ailanthus excelsa, Albizia procera, Dalbergia sissoo, Hardwickia binata., Leucaena leucocephala, Morus alba, Bauhinia racemose.*** |
| **East zone** | **Bihar, Orissa, Jharkhand and West Bengal** | ***Acacia nilotica Acacia lenticularis, Dalbergia sissoo, Azadirachta indica, Moringa oleifera, Gliricidia maculate, Ailanthus excelsa, Sesbania grandiflora, Madhuca latifolia, Ficus racemosa Ficus infectoria, Morus alba.*** |

**Table.7** Fodder availability period of potential fodder trees/shrubs of India

| Species | Period of fodder availability | |
|---|---|---|
| | Leaf fodder | **Pod fodder** |
| ***Acacia nilotica*** | May-February | **May-June** |
| ***Acacia tortilis*** | May-February | **May-June** |
| ***Ailanthus excels*** | May-March | - |
| ***Albizia amara*** | June-March | - |
| ***Albizia lebbeck*** | April-October | - |
| ***Albizia procera*** | July-March | - |
| ***Bauhinia variegate*** | April-November | - |
| ***Dalbergia sissoo*** | February-December | - |
| ***Dichrostachys cinerea*** | June-October | **August-December** |
| ***Ficus glomerata*** | December-April | - |
| ***Hardwickia binata*** | April-January | - |
| ***Leucaena Leucocephala*** | July-December | - |
| ***Melia azedarach*** | Throughout the year | - |
| ***Ziziphus nummularia*** | **Throughout the year** | - |

**Table.8** Foliage quality of some of the important fodder trees of India

| Tree | Crude Protein % | Crude Fiber | Ether Extract | NDF | Ash % | Calcium % | Phosphorus % |
|---|---|---|---|---|---|---|---|
| ***Acacia nilotica*** | 16.90 | 23.90 | 5.5 | 33.10 | 6.60 | - | - |
| ***Ailanthus excelsa*** | 19.87 | 12.82 | 3.53 | 48 | 11.97 | 2.11 | - |
| ***Azadirachta indica*** | 12.40-18.27 | 11.40-23.08 | 2.27-6.24 | 38 | 7.73-18.87 | 0.89-0.96 | **0.11** |
| ***Anogeissus latifolia*** | 9.96 | 25.55 | - | 38.11 | 7.74 | - | - |
| ***Dalbergia sissoo*** | 24.10 | 2.03-4.93 | 12.48-31.97 | 53.88 | 6.44-13.48 | 1.95-2.27 | - |
| ***Prosopis cineraria*** | 14.20 | 22.06 | 4.35 | 43.12 | 6.14 | - | - |
| ***Leucaena*** | 24.20 | 13.30 | 4.40 | - | 10.80 | 1.98 | **0.27** |
| ***Albizzia chinensis*** | 15.08 | 31.64 | 4.39 | - | 5.50 | 1.02 | **0.20** |
| ***Sesbania sesban*** | 25.6 | 21.7 | 6.2 | 32.2 | 10.8 | - | - |
| ***Ziziphus*** | 13.10 | 40.27 | - | 52.42 | - | - | - |
| ***Morus alba*** | 15.00-27.67 | 9.07-15.27 | 2.30-8.04 | - | 14.32-22.87 | 2.43 | **0.24** |
| ***Moringa oleifera*** | 21.87 | 4.5 | 6.5 | 8 | 12 | 3.45 | **0.11** |
| ***Ziziphus xylopyrus*** | 13.20 | 36.07 | - | 53.15 | - | - | - |

**Reference: Kashyap *et al.*, 2014; Nouman *et al.*, 2014**

**Table.9** Scope for Horti-pasture in India

| Types of orchard | Total Area all over India (hectare) | Estimation fodder production green tones | Estimated Fodder production Dry tones |
|---|---|---|---|
| Fruit orchard<br>Plantation | 6506000<br>3744000 | 40662500<br>23400000 | 8132500<br>4680000 |

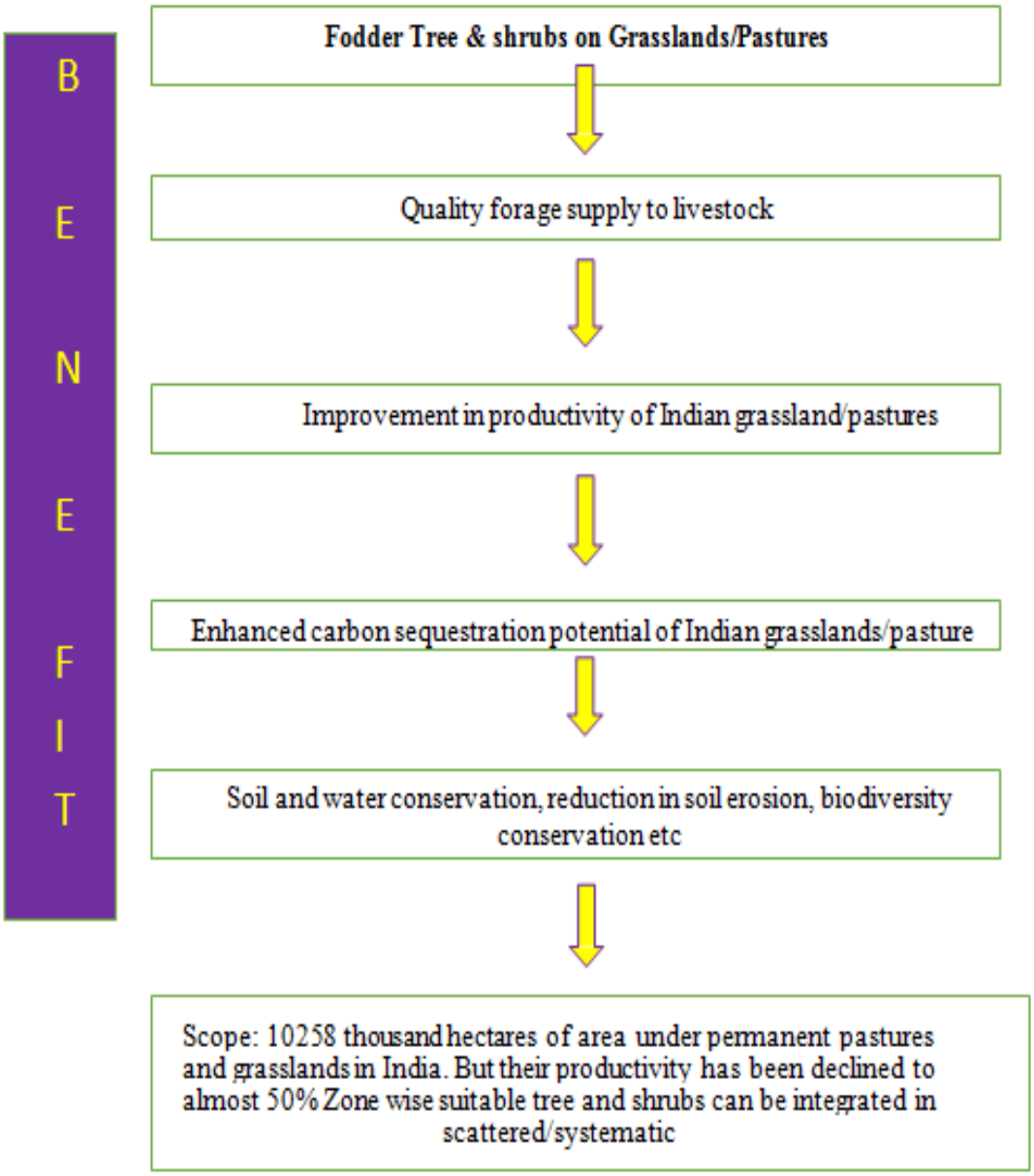
**Table.10** Scope for fodder Bank in India

| Land Use System | Area (in million ha) | Percentage of total geographical area |
|---|---|---|
| Culturable wasteland | 12.86 | 3.9 |
| Barren & uncultivable land | 16.99 | 5.2 |

**Fig.3**

**Fig.4** Single or double rows depending on the width of bunds

**Fig.5**




## Agri-Silvi-pastoral system

*Leucaena leucocephala / Gmelina arborea / Albizia procera* + Guinea grass + cow pea (grown in summer & rainy season) + field pea variety (grow in winter) established in Bihar. The fresh fodder production (tree + grass + crop): 39-45 t/ha (Singh *et al.*, 2008). Such system can be established by integrating suitable fodder trees + grasses with agricultural crops for sustaining fodder supply under various zones of India.

## Fodder on Bunds

Grass production/ tree on bunds Soil and water conservation. The perennial crops: guinea grass, bajra napier hybrid etc.

Tree/shrubs: *Sesbania spp. Gliricidia sepium, Erythrina spp. Acacia spp. Moringa oleifera, Leucaena leucocephala, Azadirachta indica, Ziziphus spp, Grewia optiva, Morus species, Ficus spp.*

**Fodder Yield**

Grass: 1.75-2.50 Kg green fodder per meter bund per cut

4 cuttings: 7.0-11.0 q green fodder per year

Trees: 1.0-2.5 t dry fodder per/ running km (three year rotations) if spacing is 3.0 m

**Benefits of forage based alternate land use system**

Soil and water conservation

Round the year supply of nutritious fodder

Enhanced livestock productivity

Multiple products

Biodiversity Conservation

High economicreturn

Carbon dioxide sequestration

Restoration of degraded lands

**Case study 1: A case study from Missouri (L. Godsey, 2011) The Tomazi Farm**

**210 acres divided into 31 paddocks**

6-9 acres each paddock

84 head cow / calf operation

Rotational grazing system

**Reason for adopting silvopasture**

Improved weight grain in the heat of the summer,

Increased grass acreage without purchasing or renting (put non-productive land into production)

**B/C ratio: 3.12 - 4.08**

**Case study 2: Mahanta S. K. (2013)**

The study was aimed to identify grazing management and silvopasture system for raising small ruminant production in IGFRI, Gwalior Road, Jhansi task to deal with such situation is twofold: (i) improvement of pasture and (ii) Judicious implementation of grazing management.

Studies indicated that body weight gains in lambs and kids were higher when grazed on silvopastoral system over natural grassland. It was observed that improved grazing management practices like rotational or deferred rotational had comparatively better performance over continuous system of grazing in terms of less soil as well as nutrients loss, improved soil fertility status, higher herbage biomass and animal production.

Sustaining round the year quality fodder/forage supply for livestock is utmost important to enhance their productivity. Alternate lands like wastelands, barren lands and grasslands in India can be utilized for establishing tree-based forage production system for sustaining quality fodder supply to livestock sector.

Tree based alternate land use system are also capable of reclaiming degraded lands and providing other tangible and non-tangible benefits. Establishment cost of these system is

very low. There is need to focus on establishing such forage-based land use system on alternate lands in India for sustaining fodder supply.

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