Technical Specification: Mango and Tamarind trees for Dry Lands

System: **Mango and Tamarind** for Dry Land
Variation: Mango, Tamarind, Jack Fruit, Jamun, Old Mango
Pongemia, Neem and Acacia Auriculiformis as wind break and for fuelwood

Summary
In dry land areas of North Kolar District, Karnataka, agro-forestry is a suitable system of land management. Marginal farmers grow fruit trees and fast growing fuel wood species as wind breaks on the bunds. Depending on the soil type, soil depth, water availability for the particular plot, and management capability of the farmer family, various fruit trees are suitable.

Mango (grafted and old variety), Tamarind, Jack Fruit, and Jamun trees are planted in rows at a distance of 6 metres. Pongemia, Neem, and Acacia Auriculiformis are planted as windbreak trees for fuelwood, timber and fodder for browsing by small livestock. Intercropping is carried out for the first 12 years.

Ecology
Agroforestry is a symbiosis of tree growing, crop production and livestock raising where each component is beneficial to the other. Trees are selected on the basis of maximum benefits in terms of production as well as soil fertility. In the present case, the local varieities of Mango, Tamarind, Jack, Jamun and Pongemia and Neem are suited to the poor soil and low rainfall conditions of Gudibanda taluk, Kolar District. Farmers are also encouraged to dig farm ponds for catching the 4 - 5 flash floods which bring upto half the annual rainfall on their plots. This water management is an important element for plant survival. In the absence of farm ponds, farmers irrigate their plots with water from borewells.

Whatever agroforestry systems in Gudibanda taluk there may have been have been degraded through years of land partitioning and cash crop cultivation of groundnuts. Timber extraction and charcoal production have also ruined old Tamarind stands. Farm trees are often in poor form due to indiscriminate lopping for fire wood. But good examples of individual Mango trees and Tamarind "toops" (stands) may still be found.

The following are the important parametres for productivity for the chosen species:[1]

Mango

High	600-1200masl; deep, well-drained loamy soil, good sub-soil needed; min temp > 0ºC > 38 ºC, rainfall > 800mm/yr. It does best in comparatively dry regions which receive good rains from June to September followed by a more or less dry spell in subsequent periods. The quantum of rainfall is not as important as its distribution.
Medium	Boulders at 8 – 12 ft depth as there are in Gudibanda taluk negatively affects productivity.
Low	Rain during flowering and fruit-setting (February to April) is harmful. Mineral nutrition of mango plants is an important management practice to achieve good productivity of fruit and growth of trunk.

Tamarind

High	600-1200masl, sandy soil, min temp >0ºC, rainfall > 500mm/yr. Forest tree native to South India. Thrives in dry conditions. Attains 20m+ height after 10 years. Hybrid varieties require protective irrigation during establishment.
Medium	Stony or shallow soils negatively affect growth
Low	Prolonged temp > 40ºC

Management objectives

[1] Fruit Growing, J.S. Bal, Kalyani Publ., New Delhi, 1997

The system is managed primarily for fruit. Intercropped legumes and groundnuts are harvested for the first 10 years or so. Fuelwood, fodder, and some timber may be taken in moderation which are assumed not to make a substantial difference to the total standing biomass or the carbon flows of the plot.

Products

Fruit from Mango, Tamarind, Jack Fruit and Jamun.
Fuelwood from Pongemia and Neem.
Stakes and poles from Acacia Auriculiformis.
Fodder from ……..
Small amounts of oil seed from Pongemia and Neem.

Hindupur 30 km from Varlakonda and other project plots is the largest Tamarind market in India. Mangos from Kolar District are sold all over South India.

Other benefits
Home garden agro-forestry has a value in providing income security compared to groundnut cropping which is highly dependent on suitable rainfall. It also prevents soil degradation and desertification. Biodiversity may increase once tree species and other flora establish - and fauna may increase. Soil conservation is improved on the slopes especially if farm ponds are added to the total management plan. Old variety Mango will stand for over 100 years and will provide a variety of benefits including fruit, twigs, and leaves for increasing the organic matter and the carbon content of the soil.

Income
With 100 Mango trees per acre the yield will be 500 - 1000 fruit per tree during years 10 - 20; 1000 - 3000 fruit per tree in the years 20 - 40. A first grade fruit weighs 300 gr. An income of Rs 8’000 to 10’000 after 5 years can be expected.
($ 250 - 400 p.a.)

Management practices
Establishment: 15 man days /acre, 380 seedlings
Maintenance: 150 man days per year
Total cost: Rs 4000 excluding labour.

Establishment:

The pits should be dug and filled with red earth, sand and manure. Irrigation channels should be dug and wind breaks should have been planned one or two years before. Irrigation, training, hoeing, weeding and staking to protect against high winds have to be carried out at regular intervals. Grafted plants should be kept free of branching upto at least 75 cm height. As little pruning as possible should be done. Intercultivation is necessary to control Mango mealy bug in November and December. Mangos grow well even in poor soils due to their deep root system. But during the non-bearing period N P K should be applied.

Between the trees in the centre of the plot, legumes, millet and groundnuts are planted in rows upto the 12th year. Thereafter intercropping will probably cease. As Tamarind does not allow such annual crops to come up under its shade, Tamarind is placed at the edge and the corners of the field. The suitable hybrid varieties of Mango are Ratnagiri Alfonso, Benisha, H 13, and Mallika. Suitable Hybrid Tamarind varieties are Urigam, and local Red Tamarind varieties. The Jack Fruit and Jamun trees are placed suitably in the centre of a hexagon of Mangos, and the Old Variety Mangos are planted on the bund between the Neem and Pongemia and left to grow to their natural massive height.

Planting Density
In this Land Use System 100 Mango trees, 10 Tamarind trees, 10 Jack Fruit, 10 Jamun and 10 old variety Mango are planted in rows at a distance of 6 metres.

Pongemia, Neem, and Acacia Auriculiformis are planted as windbreak trees for fuel and fodder at 2.5 m spacing in 2 rows along the bunds, giving a total of 220 trees.

Harvesting/replanting
The trees are removed in the following cycles:

Mango grafted	100% every 40 years	fuelwood
Tamarind	100% every 40 years	???
Jack	100% every 80 years	???
Jamun	100% every 30 years	???
Old Variety Mango	100 years +	

Neem, Pongemia and Acacia Auriculiformis will be coppiced for fuel wood, and the leaves and twigs cut for mulch.

Carbon Sequestration

Baseline

Baseline line assessment is made on the assumption that the land would not be in use at all, and would be severely degraded with minimal soil cover and no trees except as counted in the baseline assessment of the individual plot. It is assumed that even where farmers have access to a borewell, they do not have the cash to develop their land. The baseline carbon for degraded land is assumed to be 16.4 tC/ha. This figure is based on unpublished research carried out by the Centre for Ecological Science in Bangalore.

Where farmers already have trees planted on their land the baseline for above ground biomass is assumed to be the number of trees present divided by the final planting density. (*Note when counting trees already present fuelwood species on bunds are not included – see comment below*)

Carbon storage potential

The carbon storage potential is the increase in biomass due to the growth of the trees over 100 year period taking into account the rotation period for each of the species.

The average carbon sequestration potential over 100 years is assumed to be 36.4 tC/ha (i.e. 20 tC/ acre over a deg added land baseline). This fugure is based on unpublished research carried out by the Centre of Ecological Science in Bangalore (see annex 2 for a description on this research and results). The actual research resul;ts predict a standing carbon stock of 50 tC/ha for mango plantations and 306 tC/ha for Tamarind. This latter figure is considered somewhat large and so a conservative estimate of 50 tC/ha has been assumed for the long term average.

As the bund planting (Neem, Pongemia and Acacia Auriculiformis) will be coppiced for fuel wood, and the leaves and twigs cut for mulch, the total standing biomass of these trees on the bunds has not been considered.

Monitoring indicators

Monitoring targets are based on the number of main plot trees planted (i.e. excluding bund planting which is assumed to have a low carbon value and has not been included in the carbon sequestration potential). The final density will be 160 trees per acre.

Year 1	110	(80% trees planted at 85% survival)
Year 2	136	(100% trees planted at 85% survival)
Year 3	160	(100% trees planted at 100% survival

Later monitoring targets will be based on the growth of the trees.

Additional Comments

This technical specification has been written after consultation with farmers locally, and after 1 years experience of managing a agro-forestry carbon offset project. It is currently under development and the carbon offset potential of the LUS described has to be verified over the coming year through biomass sampling of all chosen species.

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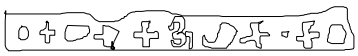

Dry Land Agro-Forestry

Mango, Tamarind, Jack Fruit and Neem trees for Reclamation of Private Wastelands.

System: **Dry Land Agro-Forestry**

Variation: Mango, Tamarind, Jack Fruit, Neem
With Jamun, Seedling Mango, Pongemia Pinnata, Hardwickia Binata, Butea monosperma, and Agave on the boundary.

Summary:
In dry land areas of North Kolar District, Karnataka, agro-forestry is a suitable system of land management. Marginal farmers can grow **40 fruit trees per acre** and fast growing fuel wood species as wind breaks on the bunds. Depending on the soil type, soil depth, water availability for the particular plot, and management capability of the farmer family, various fruit trees are suitable.

Mango (grafted and seedling variety), Tamarind, Jack Fruit, and Jamun trees are planted in rows at a distance of 6 metres. Pongemia, Neem, Acacia Auriculiformis, Butea and others are planted as windbreak trees and for fuelwood, timber and fodder for browsing by small livestock. Intercropping is carried out for the first 12 years and even thereafter intercropping can be continued provided farmers are taught how to prune the fruit trees judiciously.

Ecology:
Agroforestry is a symbiosis of tree growing, crop production and livestock raising where each component is beneficial to the other. Trees are selected on the basis of maximum benefits in terms of production as well as soil fertility. In the present case, the local varieties of Mango, Tamarind, Jack, and Pongemia and Neem are suited to the poor soil and low rainfall conditions of Gudibanda taluk, Kolar

District. Farmers are also encouraged to dig farm ponds for catching the 4 - 5 flash floods which bring upto half the annual rainfall on their plots. This water management is an important element for plant survival. In the absence of farm ponds, farmers irrigate their plots with water from Borewells if available, but otherwise 2 irrigation with water from a tractor tanker are sufficient and thereafter the trees survive on their own. Any additional watering from Bindigas (water pots) carried from which ever nearest water source is an added bonus and will serve the trees well.

Whatever agroforestry systems in Gudibanda taluk there may have been have been degraded through years of land partitioning and cash crop cultivation of groundnuts. Timber extraction and charcoal production have also ruined old Tamarind stands and other stands of endemic local trees such as Hardwickia, Red Sander and what may have been available in the past. Farm trees are often in poor form due to indiscriminate lopping for fire wood. But good examples of individual Mango trees and Tamarind “toops” (stands) may still be found.

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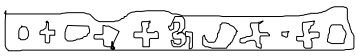

The following are the important parametres for productivity for the chosen species:[1]

Mango

High	600-1200masl; deep, well-drained loamy soil, good sub-soil needed; min temp > 0ºC > 38 ºC, rainfall > 800mm/yr. It does best in comparatively dry regions which receive good rains from June to September followed by a more or less dry spell in subsequent periods. The quantum of rainfall is not as important as its distribution.
Medium	Boulders at 8 – 12 ft depth as there are in Gudibanda taluk negatively affects productivity.
Low	Rain during flowering and fruit-setting (February to April) is harmful. Mineral nutrition of mango plants is an important management practice to achieve good productivity of fruit and growth of trunk.

Tamarind

High	600-1200masl, sandy soil, min temp >0ºC, rainfall > 500mm/yr. Forest tree native to South India. Thrives in dry conditions. Attains 20m+ height after 10 years. Hybrid varieties require protective irrigation during establishment.
Medium	Stony or shallow soils negatively affect growth
Low	Prolonged temp > 40ºC

Management objectives:
The system is managed primarily for fruit. Intercropped legumes and groundnuts are harvested for the first 12 years without pruning of branches, and with pruning thereafter. Fuelwood, fodder, and some timber may be taken in moderation
which are assumed not to make a substantial difference to the total build up of carbon and organic matter in the soil. Part of the management objective is to increase the standing biomass in order that the small farmers may benefit from income from sale of carbon sequestration services to the global environmental community, once the financing mechanisms are in place. In the mean time the main purpose is to improve the livelihoods of the poorest of marginal dry land farmers who are too poor to improve their own small holdings and will benefit from small investments for long term increased income on their own farms.

Products:
Fruit from Mango, Tamarind, Jack Fruit and Jamun.
Fuelwood from Pongemia and Neem.
Stakes and poles from Acacia Auriculiformis.
Fodder for small livestock from Neem and Harwickia Binata
Oil seed from Pongemia and Neem

[1] Fruit Growing, J.S. Bal, Kalyani Publ., New Delhi, 1997

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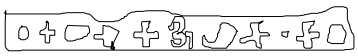

Oil seed cake from Neem for fertiliser.

Hindupur 30 km from Varlakonda and other project plots is the largest Tamarind market in India. Mangos from Kolar District are sold all over South India.

Other benefits:
Home garden agro-forestry has a value in providing income security compared to groundnut cropping which is highly dependent on suitable rainfall. It also prevents soil degradation and desertification. Biodiversity may increase once tree species and other flora establish - and fauna may increase. Soil conservation is improved on the slopes especially if farm ponds are added to the total management plan. Seedling variety Mango will stand for over 100 years and will provide a variety of benefits including fruit, twigs, and leaves for increasing the organic matter and the carbon content of the soil. Nutrition of the children of poor families will increase if they can pick fruit from their own orchards.

Income:
With 40 trees per acre the yield will be 500 - 1000 fruit per tree during years 10 - 20; 1000 - 2000 fruit per tree in the years 20 - 40. A first grade fruit weighs 300

gr. Second grade fruit can be expected from dry land agro-forestry in Gudibanda taluk, weighing 200 gr.

20 Mango trees per acre x 400 fruit per tree after 6 years = 8000 fruit = 1600 kg of Mango x Rs 3/kg = Rs 4800
+
10 Tamarind trees per acre x 100 kg per tree after 6 years x Rs 5 = Rs 5000
+
5 Jack Fruit trees, 10 fruit per tree, Rs 50 per fruit = Rs 2500 per annum after 6 years

It is assumed that the rest of the produce from the orchard will not be sold. The intercrop will also be used for the home.

An income of Rs 4800 + 5000+2500 = **Rs 12300 after 6 years** can be expected.
This assumes a certain dedication and consistency in maintenance by the women agriculturalists who are trained to look after the trees, and it assumes continuous support and monitoring by WSD.

Management practices:
Establishment: 40 pits dug with JCB mechanical digger.
Maintenance: 100 man days per year weeding, intercropping, watering, watch and ward.

Establishment:
The pits should be dug deep with the mechanical digger, and filled with red earth, sand and manure if possible. Irrigation channels should be dug and wind breaks should have been planned one or two years before. Irrigation, training, hoeing, weeding and staking to protect against high winds have to be carried out at regular intervals. Grafted plants should be kept free of branching upto at least 75 cm height. As little pruning as possible should be done. Intercultivation is necessary to control Mango mealy bug in November and December. Mangos grow well even in

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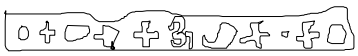

poor soils due to their deep root system. But during the non-bearing period N P K should be applied.

Between the trees in the centre of the plot, legumes, millet and groundnuts are planted in rows upto the 12th year. Thereafter intercropping may continue with pruning of trees. As Tamarind does not allow such annual crops to come up under its shade, Tamarind is placed at the outer rows and the corners of the field.

The suitable hybrid varieties of Mango are Ratnagiri Alfonso, Benisha, H 13, and Mallika. Suitable Hybrid Tamarind varieties are Urigam, and local Red Tamarind

varieties. The Jack Fruit trees are placed suitably in the centre of a hexagon of Mangos, and the Old Variety Mangos are planted on the bund between the Neem and Pongemia and left to grow to their natural massive height.

Planting Density:
In this Land Use System 20 Mango trees, 10 Tamarind trees, 5 Jack Fruit, are planted in wide rows to allow intercropping, and 1 each Neem, Butea, Pongemia and Hardwickia and 1 seedling Mango are planted on the boundaries.

Depending on extra tree availability, Pongemia, Neem, and Acacia Auriculiformis are planted as optional extra windbreak trees for fuel and fodder at 2.5 m spacing in 2 rows along the bunds.

Harvesting/replanting:
The trees are removed in the following cycles:

Mango grafted	100% every 40 years	for timber
Tamarind grafted	100% every 40 years	for timber
Jack	100% every 80 years	for timber
Neem	100% every 100 years	for timber
Seedling Variety Mango	100% every 200 years +	
Others	As required	

Neem, Pongemia and Acacia Auriculiformis will be coppiced for fuel wood, and the leaves and twigs cut for mulch.

Carbon Sequestration:

Baseline:
Baseline line assessment is made on the assumption that the land would not be in use at all, and would be severely degraded with minimal soil cover and no trees except as counted in the baseline assessment of the individual plot. It is assumed that even where farmers have access to a borewell, they do not have the cash to develop their land. The baseline carbon for degraded land is assumed to be 16.4 tC/ha. This figure is based on unpublished research carried out by the Centre for Ecological Science in Bangalore and WSD.

Where farmers already have trees planted on their land the baseline for above ground biomass is assumed to be the number of trees present divided by the

final planting density. (*Note when counting trees already present fuelwood species on bunds are not included)*

Carbon storage potential:
The carbon storage potential is the increase in biomass due to the growth of the trees over 100 year period taking into account the rotation period for each of the species.

The average carbon sequestration potential over 100 years is assumed to be 26.4 tC/ha (i.e. 10 tC/ acre over a degraded land baseline). This figure is based on unpublished research carried out by the Centre of Ecological Science in Bangalore and WSD. The actual research results predict a standing carbon stock of 50 tC/ha for Mango plantations and 30.6 tC/ha for Tamarind with much higher density planting. This latter figure is considered somewhat large for the degraded land conditions in Gudibanda Taluk, and so a conservative estimate of 26.4 tC/ha has been assumed for the long term average.

As the bund planting (Neem, Pongemia and Acacia Auriculiformis) will be coppiced for fuel wood, and the leaves and twigs cut for mulch, the total standing biomass of these trees on the bunds has not been considered.

Monitoring indicators:
Monitoring targets are based on the number of main plot trees planted (i.e. excluding bund planting which is assumed to have a low carbon value and has not been included in the carbon sequestration potential). The final density will be 40 trees per acre.

Year 1	27	(80% trees planted at 85% survival)
Year 2	34	(100% trees planted at 85% survival)
Year 3	40	(100% trees planted at 100% survival

Later monitoring targets will be based on the growth of the trees.

Additional Comments:
This technical specification has been written after consultation with farmers locally, and after 1 years experience of managing a agro-forestry carbon offset project. It is currently under development and the carbon offset potential of the LUS described has to be verified over the coming year through biomass sampling of all chosen species.

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