Design and development of multifunctional agroforestry for family farming

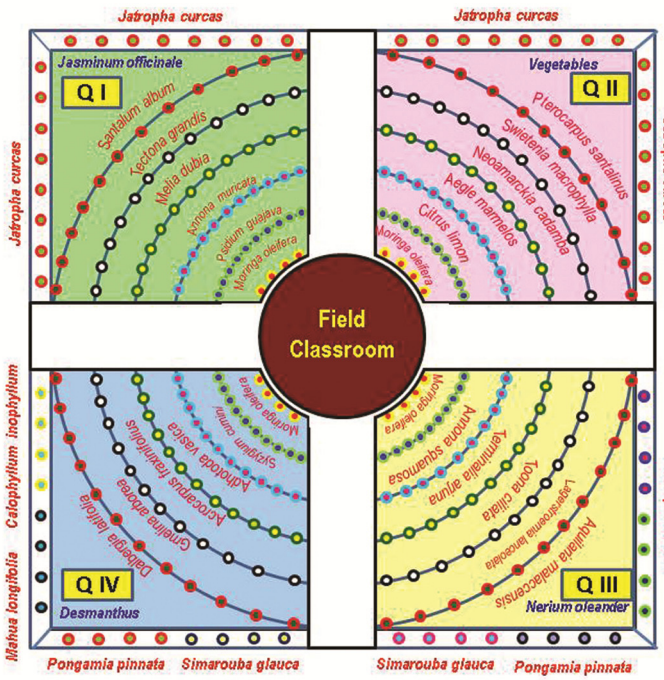
According to the Global Action Plan on the United Nations Decade of Family Farming 2019–2028, we all are living in the decade of family farming[1]. This Action Plan aims to shed new light on what it means to be a family farmer in a rapidly changing world and highlights more than ever before, the important role farmers play in eradicating hunger and shaping our future of food. In family farming, agroforestry is a sustainable option for achieving food security and to earn income. Since the inception of agroforestry, organized research has been based on improved systems. It is also noticed that, over the years, emphasis on the study of indigenous systems has been sidelined or ignored[2]. Some agroforestry systems have been 'forgotten' or 'downtrodden'. The agroforestry concept has been changing each and every decade since 1970s. During earlier decades, agroforestry was seen as a different form of land use. Later it got impoverished with science and technological interventions, but now it is seen as a tool for transforming the lives of millions of people through multidimensional approach.

Therefore, there is a need to maximize food production while supporting natural ecosystems and at the same time develop a sustainable model especially to suit the need of small farmers to augment productivity and profitability. In recent years, new concepts such as integrated farming systems, domestication of high-value native plants, and urban and peri-urban agroforestry have emerged. In continuity with the newly emerged agroforestry systems, multifunctional agroforestry is the area of attraction, especially in terms of obtaining multifaceted benefits. The concept of multifunctional agroforestry recognizes agroforestry as a multi-output activity producing not only commodities (food, wood/timber, fibres, flowers, agrofuels, medicinal products and ornamentals), but also non-commodity outputs such as environmental services (nutrient cycling, soil formation and retention, carbon sequestration, pollination, water quality and regulation), landscape amenities and cultural services (agroforestry tourism, walking, educational and scientific knowledge, spiritual value, meditation, etc.; modified from ref. 3). Such a multifaceted land-use system has not had systematic research to assess the different services provided by the tree and associated crop and animal components, especially for small land holding system. Against this backdrop, in 2018, the Forest College and Research Institute, Tamil Nadu Agricultural University (TNAU), India conceived and designed a circular multifunctional agroforestry model in an area of 0.75 acres (11.32°N, 76.39°E), located in the sylvan surroundings of the Nilgiris, Tamil Nadu. The reason behind adopting such a model is to accommodate more number of multi-utility (fruit, medicinal) trees, crops and grasses that cater to the needs of small farmers.

The model incorporated 24 tree species and 8 intercrops. Based on their provisioning services, the tree species are established in six concentric circles. The entire circle is diagonally divided into four equal sections (quadrats) and intercrop components are raised in the quadrats. Figure 1 shows the design and components of the model. The model also includes two goats and one cow to cater to the basic domestic needs of a family. The selection of tree and crop components varies depending upon availability of local species and prevailing climatic condition of the area. Determining agroforestry design is the first step when adding agroforestry practices on farm lands. Landowner goals, direction and position of land, species selection, soil type, water availability and many other key factors are the crux for successful implementation. The design of multifunctional agroforestry system in this study was done in such a way that the outer circle occupying more number of trees, followed by the circles becoming narrower. It consists of six circles and the espacement between circles is 5 m. Each circle of tree species within the model has its own importance, viz. high-value timber circle (sixth), timber circle (fifth), plywood (fourth), medicinal value (third), fruits (second) and moringa (first) circle. The spacing between trees in the sixth, fifth and fourth, circle of trees is 3 m and in the remaining circle, the spacing is 1 m. This model is especially designed for small and marginal farmers, who can earn a daily income of Rs 400–900 per day. In other words, the seasonal calendar of multifunctional agroforestry shows that there is continuous yield and income from one of the components throughout the year (Table 1). After 3–6 months of development, the annual crop components starts generating income and after one year, the entire model becomes functionally active to generate income on a monthly basis to the farmers. The capital and management can be owned completely by a family, but consumption can be partially on farm and the remaining for income generation. In terms of output, there are multiple deliverables and this helps even in adverse climatic conditions. The functionality and its economic impact are monitored from the inception of the model and will bring good database for promoting multifunctional agroforestry system in a long-term approach.

The model focuses on family farming consisting of four members. So the farmer's preferences and needs are given utmost importance in this model. However, the ecological processes takes their own space and time in the long-term, both in terms of sustainability and diversity (insects, butterflies, birds and soil biota). One of the main advantages of tree diversity within each type of tree utility is the chance of lower risk of income failure. This system more closely mimics the functionality of nature; thus it can become more stable and resilient in future. It also serves the purpose of 'making profit' for family farming and provides a wide range of ecosystem services.

The rapid growth in population, declining size of land holdings, and irregular and erratic weather pattern are increasing stress on agricultural crops. Most farmers having small and marginal lands are not able to meet their daily requirements from agricultural crops alone. Under such conditions, multi-functional agroforestry aims to be production-oriented and also focuses on conservation goals, thereby performing both functions (production and conservation) which will be highly resilient even under adverse conditions. However, the challenge is to strike the right balance between these goals at the plot/farm level, and also in



Tree species	Number of trees
Quadrat I	
Moringa oleifera	4
Psidium guajava	10
Annona mucronata	11
Melia dubia	11
Tectona grandis	12
Santalum album	12
Intercrops (Flowers)	
Jasminium officinale	72
Jasminium grandiflorum	104
Quadrat II	
Moringa oleifera	4
Citrus lemon	6
Aegle marmelos	11
Neolamarckia cadamba	11
Swietenia macrophylla	11
Pterocarpus santalinus	12
Intercrops (Vegetables)	
Quadrat III	
Moringa oleifera	4
Annona squamosa	10
Terminalia arjuna	10
Toona ciliata	11
Lagestromia lanceolata	12
Aquilaria malaccensis	12
Intercrops	
Nerium oleander	28
Murraya koenigii	350
Quadrat IV	
Moringa oleifera	4
Syzygium cuminii	11
Adhotoda vasica	12
Acrocarpus fraxinifolius	12
Gmelina arborea	12
Dalbergia latifolia	12
Intercrops	
CO 3 Guinea grass	303
Desmanthus	
Border	
Jatropha curcas	50
Calophyllum inophyllum	5
Simaouba glauca	10
Pongamia pinnata	10
Madhuca longifolia	5
Total plants	1174

Figure 1. Layout of multifunctional agroforestry.

Table 1. Multifunctional agroforestry portfolio of different intercrops for small farmers

Intercrops	January	February	March	April	May	June	July	August	September	October	November	December
Jasminium officinalum												
Jasminium grandiflorum												
Bhendi												
Chilli												
Brinjal												
Onion												
Curry leaf												
Nerium												
Desmanthus												
Guinea grass												
Moringa oleifera												

adopting management practices and selecting key species that accelerate ecological processes. Since access to labour and knowledge is a common constraint across most contexts, systems need to be simple enough and appropriately sized to be manageable, yet complex enough to ensure that the key ecosystem functions desired are maintained over time. Under such circumstances, National Agroforestry Policy (2014) guidelines gives some relief, since farmers are now opting to cultivate trees on their lands. Moreover, it is the need of the hour to bring new models that are suited to local climatic conditions for attaining food security and achieving sustainability.

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