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Green Initiatives for Climate Change Mitigation in Palakkad District of Kerala, India

J Resmi [a*], K Vismaya [b], V Chitra [b], S K Anjana [b] and K.V. Sumiya [a]

[a] Krishi Vigyan Kendra Palakkad, Kerala Agricultural University, Melepattambi PO, Pattambi- 679306, (Kerala), India.
[b] MES Kalladi College, Mannarkkad College P.O., Palakkad - 678 583, Kerala, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Trees and forested ecosystems play a significant role in in meeting global commitments on sustainable development as well as adaptation to climate change and mitigation of its impacts. Aggressive tree planting goals to achieve canopy cover growth targets are a common manifestation to overcome the climate change challenges. Miyawaki forest creation, a method developed by Japanese botanist Akira Miyawaki, involves planting trees per square meter which is intended for intensification of green cover to support local biodiversity. A food forest is essentially a planned and planted forest of food plants that provides a variety of food throughout the year. While both Miyawaki forest and food forest aim to restore ecosystems and enhance biodiversity, they differ in their design, purpose, and management practices. Hence a study on comparative analysis of food

**Corresponding author: E-mail: reshmi.j@kau.in;*

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forests and Miyawaki forests was envisaged to highlight their respective benefits, challenges, and implementation strategies. The present investigation was undertaken on selected institutions of Palakkad district of Kerala namely Krishi Vigyan Kendra Palakkad where Miyawaki forest patch is created at its premises and V T Bhattathiripad College, Sreekrishnapuram where food forest is established. From this study it is understood that Miyawaki forest is reconnecting with the nature by harboring an array of native flora and fauna promoting biodiversity conservation and habitat restoration while *food* forest is reconnecting with nature by providing food source for pollinated server, as a habitat for many animals and it is very ecofriendly because don't require any chemical pesticides. These techniques are highly effective in the establishment of urban forests as well as converting unproductive waste lands into ecological and socially beneficial productive lands.

Keywords: Miyawaki forest; food forest; forest restoration; green spaces.

1. INTRODUCTION

"Forests are the most productive, stable, biodiverse and self-sustaining ecosystems on earth with suitable moisture, temperature, and soil condition. Deforestation and the destruction of ecosystems in the label of development lead to natural disasters and climate change. The creation of forests is a fundamental ecological method for restoring the natural environment. Taking several hundred years to complete the process of forest restoration is too long for us; because we live in a world where industry and urbanization are developing very rapidly, improvement of an alternative reforestation technique that reduces these times could be a useful too" [1].

The concept of "Trees outside Forests" (TOF) designates those trees which grow outside the forest or woodland areas. These are found in diverse formations in the rural and urban landscapes in the country like small woodlots, block plantations, trees along linear features such as roads, canals, bunds, etc. and scattered trees on farmlands, agricultural lands, homesteads, community lands and urban areas. Sacred grove is one such contribution to the concept of TOF, which is a patch of native vegetation (fruits, medicinal, evergreen plants and flora-fauna) planted in a community land for the welfare of villages/area which is maintained by locals [2]. They maintain temperature and water tables of the area and protect water bodies like ponds and lakes. Moreover, it secures local threatened biodiversity and flora-fauna and lead the local people into a movement towards conservation. It is called by different names in different locations. Currently India has approximately 1,00,000 to 1,50,000 sacred groves. These green infrastructure in the concrete-cement grey jungle could be treated as the self-generating and self-sustaining engineered ecosystem [3].

"Kerala is the third most urbanized state in India and also reckoned as the fastest urbanizing state in the country. Urban population has crossed 1 million in 8 Districts. Urban areas account for 78% of carbon emissions and 60% of residential water use. Reduction in vegetation, higher prevalence of dark surfaces with low albedo and increased anthropogenic heat production results in the heat island effect. For the last four years, Kerala has been witnessing a series of natural disasters. It is imperative for the state now to embrace environment restoration methods to avoid another disaster and to rebuild the lost biodiversity. As governments look to new methods for managing sustainability, resilience, and climate goals in their cities, urban forestry has emerged as a novel form of urban green spaces with the potential to not only provide healthy and free food, but also mitigate climate change, support urban ecosystems, and promote holistic wellbeing among residents. As part of this, green patches or urban parks called "Nagaravanams" or "pachathuruthu" which are multi-canopy, close-to-natural forests with species indigenous to the area, are being established in cities across the state. In the long run, these green spaces form biodiversity hotspots of the city and provide many ecosystem services. The biodiversity flourished within urban limits are the assets in terms of environment, economics and socio-cultural aspects. The green spaces with the trees constitute backbone of the green infrastructure which ameliorates the grey space's environmental footprints. Miyawaki forest creation, a method developed by Japanese botanist Akira Miyawaki, involves planting trees per square meter which is intended for intensification of green cover to support local biodiversity" [1]. A food forest is essentially a planned and planted forest of food plants that provides a variety of food throughout the year. While both Miyawaki forest and food forest aim to restore ecosystems and enhance biodiversity, they differ in their design, purpose, and

management practices. Hence a study on comparative analysis of food forests and Miyawaki forests was envisaged to highlight their respective benefits, challenges, and implementation strategies [4].

2. MATERIALS AND METHODS

The present study entitled "Comparative study on biometrics and soil parameters of Miyawaki model forest and food forest in Palakkad district" was carried out at two campus greenery patches on the premises of 2 institutions. Miyawaki model forest unit (experiment plot 1) established at KVK Palakkad of Kerala Agricultural University, Kerala, India representing the Miyawaki model forest and V T Bhattathiripad College, Sreekrishnapuram, Kerala, India representing food forest unit (experiment plot 2) are the institutional study areas. Comparative study on sustainability of these experimental plots were done using 5 research designs through various criteria [5].

3. RESULTS AND DISCUSSION

Miyawaki model forest unit at KVK Palakkad of Kerala Agricultural University is developed under the funded project of Directorate of Climate Change and Environment. Gov't of Kerala. This model conserves native plant species within their natural habitat (Miyawaki *et al*, 1998). Planting of seedlings was done after digging the soil of the entire selected area upto 1m depth and mixing well the standardized growing media in the ratio of 1 kg soil, 4 kg coirpith compost, 2 kg cowdung/ goatmanure/ poultry manure and 5g micronutrient mixture. Mulch was evenly laid out on the soil, in a 5-7 inch layer. The experiment plot area is 871.2 Sq.ft with 40 different species of tree saplings planted randomly which includes flowering, fruiting, ornamental and medicinal trees. No two trees of the same kind are placed next to each other. Totally 188 saplings were planted very closely at a distance of 1 x 1 m^2. It can also be concluded that these native micro forests can offer many ecological and social services, including protecting many pollinators and conserving biodiversity in urban areas [6].

Food-Forest is a concept which has evolved from 'No Till Farming' and is a multi-layer farming practice which utilises the sunlight optimally and avoids manure, pesticides and other conventional farming practices harmful to the crop, soil and environment. It is a mixed farming practice which is an ode to the notions of Palekar, Dhabolkar, Permaculture and Fukuoka method. It is a canopy based farming technique pioneered by the Sreekrishnapuram Jaiva Karshaka Samiti (Organic Farming Society) which over the last few years have proved effectiveness and acceptance among a lot of people. It is a project done in collaboration with Kerala State Bio-diversity Board and Sreekrishnapuram Grama Panchayath. Initially 457 food saplings with 130 tree grafted varieties, medicinal plants millets, grain and oilseeds were planted over 1.25 acres of land. It has a natural composting process as different insects like earthworms, millipedes etc break down the organic waste and the fallen leaves.

3.1 Research Design I Using Indicators

Since the Miyawaki technique is based on the concept of Potential Natural Vegetation (PNV) (Vallejo et al., 2012; Ullah et al., 2023), it deals with the regeneration of a forest by closely planting a variety of tree species, and hence it is best suited for the specified locality irrespective of soil and climatic conditions. The Miyawaki technique of growing forests, also referred to as the potted seedling method, refers to an ecological engineering approach meant for restoring natural forests using the seeds of native trees, on a degraded patch of land.

The concept or notion of food forest is to make the soil alive through composting, live mulching and live shading; maintain diversity through canopy based planting system for food production, conserve water through water harvesting and drip irrigation and controlling pests naturally by ecosystem balance and enhanced fruit production and income through bee keeping.

3.2 Research Design II Using by Visual Observation

Overall health: "Overall health of Miyawaki forest is much better than food forest. Miyawaki unit established at KVK Palakkad is a perfect example for PNR as 37 out of 40 species is indigenous in nature which helps to create balance and maximise density. Moreover, planting of native species in the same area makes maintenance free after three years as well as mingles well with other species including dependant fauna. Native trees are more appropriate than exotics as they are often better adapted to local environmental conditions and more robust during cyclones or susceptible to

high wind speeds. This technique of afforestation has been recommended for eco-forest plantations in urban city settings because of its suitability for rapid growth of thick trees, carbon sequestration, and improved air quality" (Schirone, et al., 2011). In Food forest, there are 43 exotic and 18 indigenous species of tree saplings.

Ground cover on the forest floor: The unique methodology used in Miyawaki Technique is use of natural methods like mulch materials including use of perforation material such as wheat stalk, groundnut shells, corn husk, rice straw or husk, barley stalk, dried grass and dried leaves significantly improve perforation and help the roots to grow. Water retention materials like coco peat and sugarcane stock help the soil retain water and moisture. Species such as earthworms, beetles and other insects feed from the top-down, building soil fertility by pulling the mulch into the ground for it to be broken down by microbes. The more fertile the soil, the more water it holds. Miyawaki forests only need to be maintained for the first two-to-three years, after that weeding and mulching can be stopped here once stabilized, the forest is left to flourish, on its own without further interference. In Miyawaki forest created at KVK Palakkad, 5-7-inch-thick layer of mulch is added to the soil (a minimum of half kg of mulch per tree).

In food forest, a live mulch which act as a cover crop interplanted or under sown with a main crop is intended to serve the purposes of a mulch, such as weed suppression and regulation of soil temperature. These living mulches grow for a long time with the main crops, whereas cover crops are incorporated into the soil. Other benefits of mulches are slowing the growth of weeds, and protecting soil from water and wind erosion. Some living mulches were found to increase populations of the natural enemies of crop pests also. Legumes used as living mulches also provide nitrogen fixation, reducing the need for fertilizer.

Density of tree foliage: In Miyawaki forest, foliage cover more than 80% since the sapling density is maintained at about 3 to 4 plant per sq. m. The number of trees planted here is approximately 30 times more than the number of trees planted through traditional plantation technique. Normally, these forest experiences competitive growth so dense that sunlight cannot reach the ground after eight months. In food forest the density of tree foliage cover between 50% and 80% as saplings are planted with distance by canopy 10 feet.

3.3 Research Design III Using Instruments

Soil biology: The analysis of soil biology in both the forests, from the data it is evident that fungal population was higher in their respective outside areas. There was no difference between the bacterial population in both the forests and their respective control plots. The population of actinomycetes was higher in Miyawaki and food forests and lower in control plots.

Temperature: In Miyawaki forest unit from the data evident that the temperature was higher in outside as compared to Miyawaki inside. Miyawaki forest created at KVK Palakkad has community of plants having trees, shrubs, herbs and climbers. A four layered plantation is created by arranging the dense plantation of 188 individuals covering 36 native plant species in a random pattern so that they grow into different layers. Here the shrubs grow up to 6 feet forming the first layer, trees growing up to 25 feet from the second layer, trees growing up to 40 feet form the third layer and canopy trees form the fourth layer. All the species of plants are arranged in a staggered manner so that similar species of plants are not planted together. Thus, the canopy layer act as a key factor facilitating the cooling effect in Miyawaki model forest demo unit at KVK Palakkad.

In the food forest unit, the exterior temperature was higher than the interior temperature. In this food forest, a shading technique called active shading is used. To do this, the chosen area's soil is planted with millets, grains, oil seeds, flowers, and other plants so that they will grow and provide the essential food items. In addition, the plants shade the land from the sun, lowering the temperature inside the food forest.

Water infiltration rate: "The water infiltration rate in Miyawaki forest is lower than outside and it is eight time quicker inside the forest. The water infiltration rate is lower in food forest inside as compared to outside. It is four times quicker in this forest. In these forests, living and decaying roots create a network of well-connected channels in the soil through which water flows. In addition, organic matter from leaf litter and tree roots improves soil structure, which can increase infiltration rates" as reported by Suzanne and Linda (2018), Panchabhai (2024). Moreover, the

soil structure is improved as soil particles are cemented together by humus, by organic glues created by fungi and bacteria decomposing organic matter, and by polymers and sugars excreted from roots.

3.4 Research Design IV Using Criteria

Socio cultural criteria: Both Miyawaki and food forests provide educational outreach programs, interpretive signage, guided tours, and community events to raise awareness about the value and importance of these forests and green spaces and promote environmental literacy and stewardship among residents and visitors.

Environmental criteria: In the analysis of environmental criteria, in food forest and Miyawaki forest, the water is conserved through drip irrigation. In food forest unit, the soil formation is maintained by mulching and husk burial. In food forest unit, there is high species diversity with connection to green corridors. They can have multiple uses and functions, such as improving environmental quality, providing recreation, and serving as an alternative transportation route (bicycle and foot paths).

In Miyawaki forest unit, the soil formation is maintained only through mulching. Also in Miyawaki forest unit there is high species diversity is observed with undisturbed areas for fauna. Trees help in purifying air by absorbing particulate matter and carbon dioxide gas from the polluted air. This further reduces greenhouse effect and offers a healthy living system to both humans and animals. Secondly, they offer habitat to a wide range of fauna and their conservation. This maintains biodiversity index in the cities.

Economic criteria: Economic criteria is based on economic viability. The Miyawaki technique is capital intensive. It involves digging the earth deep (3-3.5 feet) and getting a source of regular water supply. Then mulching needs to be done; top quality seedlings have to be bought, stick support has to be provided to the young plants. Additionally, cow urine, cocopeat, good quality vermicompost and rice husk are needed to make the soil fertile enough to support the dense vegetation growth. The Miyawaki forest unit established at KVK Palakkad costs Rs 82.66 per Sq. ft. Parikh and Nazrana (2023) also reported that the Miyawaki technique is capital intensive. .According to Reque (2008), “the high costs of the Miyawaki method were still not competitive with the traditional techniques on a large scale, the forest quality achieved would make it a noteworthy tool for protected areas and natural parks, where traditional plantings are not easily accepted because of their aesthetic and ecological impacts”.

“In food forest unit the sustaining livelihood is obtained at Rs 60.85 per Sq. ft. However, for broader impact, food forests need to go beyond the provision of social-cultural and environmental services and enhance their economic viability. There is a need for specific trainings and other measures targeting this deficit. This study appraises the current state of food forests and provides an orientation for food entrepreneurs, public officials, and activists to better understand food forests’ potential for advancing sustainable food systems” [7].

3.5 Research Design V Using Services

Cultural services: In Miyawaki forest, the cultural services include awareness about environment and its conservation, aesthetic sense and inspiration. Miyawaki forest establishes our link back with nature. They are ideal learning ground for young minds. They also fulfill our recreational needs. Different forms, colors and textures changing with each season offer a dynamic character to our society. The Miyawaki forest unit established at KVK Palakkad serve as living classrooms, nurturing environmental awareness, stewardship among students and empower individuals as well as communities to take action for conservation and sustainability.

“In food forest, the cultural services include recreation, social connection and cultural heritage. Nonmaterial benefits people obtain from ecosystems, such as cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, recreation and ecotourism. The food forests have the potential to provide healthy food, sufficient livelihoods, environmental services, and spaces for recreation, education, and community building” [7].

Provisionary services: In food forest, provisionary services include food and medicinal products. This study appraises the current state of food forests and provides an orientation for food entrepreneurs, public officials, and activists

to better understand food forests potential for advancing sustainable food systems.

In Miyawaki forest, provisional services include plants growing rapidly, increasing soil and forest-biodiversity, increasing carbon sequestration, increasing forest resilience and gathering genetic information [8].

Regulating services: The Miyawaki forest provide the regulating services as it can help to mitigate the effects of climate change. Trees absorb carbon dioxide from the atmosphere, and by planting a dense forest using the Miyawaki method, carbon sequestration is increased, which can help reduce the effects of global warming.

"The regulating services given by food forest include habitat, pest regulation, agriculture productivity and water regulation. Community food forests introduce people to a wide variety of food-producing plants and improve their ability to identify and harvest them. In food forest plays a natural pest control system. Food forests use natural predators to get rid of pests. Predatory insects have a permanent home (a natural ecosystem) and abundant food sources (nectar rich flowers) in a food forest" [9].

Supporting services: Miyawaki forest provide cooling atmosphere, air purification and reduced carbon content. Through transpiration process, it cool surroundings by releasing water vapor into the air through their leaves. Trees and vegetation also provide cooling through evaporation of rainfall collecting on leaves and soil. It also increases carbon capture, pollution filtration and produces an area more resilient to flooding and landslides [10].

The food forest provide supporting services as nutrient cycling, photosynthesis and soil formation. They also protects soils and moderates harsh climates, for example, by cooling the air, reducing wind speeds and giving shade. Trees and other vegetation intercept particles and gaseous pollutants and thus help reduce air pollution. The level of biodiversity of urban green areas is often surprisingly high, representing nature and the "wild" close to where people live.

4. CONCLUSION

Trees and forested ecosystems play a significant role in in meeting global commitments on sustainable development as well as adaptation to climate change and mitigation of its impacts. Aggressive tree planting goals to achieve canopy cover growth targets are a common manifestation to overcome the climate change challenges. From this study it is understood that Miyawaki forest is reconnecting with the nature by harboring an array of native flora and fauna promoting biodiversity conservation and habitat restoration while food forest is reconnecting with nature by providing food source for pollinated server, as a habitat for many animals and it is very ecofriendly because don't require any chemical pesticides. Miyawaki forest can be raised on unproductive waste land, fallow or degraded forest land and in virtually all agro-climatic zones and can converting these lands into ecological and socially beneficial productive lands. Food forest can be created in agricultural land, or we can create it in homestead. Both are financially sustainable and more remunerative than traditional agricultural practices being currently followed.

CONFERENCE DISCLAIMER

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DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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