Biofencing: A Holistic Approach to Biodiversity Conservation and Ecological Integrity - A Case Study from Palakkad District, Kerala, India.

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Abstract

The primary purpose of biofences or live fences is to regulate the movement of animals and people by serving as a physical barrier. Besides its main function as living barrier the bio fences act as tools for biodiversity conservation by providing habitat for native species and increasing connectivity in the landscape. Extensive field explorations were carried out in various villages of Palakkad District, Kerala State, India to collect data of plants that are components of biofences. The present study revealed that village people of Palakkad District are using about 132 plants belonging to 43 families as components of biofences either live or in dried form. This includes 34 herbs, 30. Shrubs, 37 climbers and 31 trees. The dominating family was found to be Malvaceae followed by Euphorbiaceae. The rapid developments in villages and towns are paving stones to the fast diminishing of biofencing, that in turn cause the loss of biodiversity of plants, small birds and animals.

Key words: Biodiversity, Conservation, Biofuels, Species richness, Biofencing, Socio-economic impact, Climate change mitigation, Sustainable agriculture

1. Introduction

The transformation of human society from nomadic mode of life to settled one is very much closely associated with the beginning of agriculture. To protect the crop fields and home stead from grazing animals and other intruders the human beings has raised a protective way by utilizing locally available biological material and that is the biofencing (Mishra *et al*., 2010). Most of the plants selected for such fences are non-browsable or thorny and hardy plants. However, many other plants including climbers will be established along the fences, reinforcing them. Many butterflies, other insects and lizards find food and shelter in the hedges. Birds come for food, roosting and nesting in the live fences. Live fence is actually an ecosystem by itself. Because of the change in life style and security implications, in many places the live fences have been replaced by non-biological type of fences and walls. This has resulted in the disappearance of a unique ecosystems, the bio fence. The role played by the live hedges in enriching the biodiversity by providing habitat for native species and increasing connectivity in the landscape (Leon and Harvey, 2000), ensuring availability of medicinal plants and green manure, controlling pests, conservation of natural resources and integrity of the ecosystem, regulation of regional atmospheric temperature, etc. (Leon and Harvey 2000; Waran, 2001)should be evaluated. Biofencing perform a crucial role in micro economic system of the rural community. Biofencing is closely related to various socio-cultural events of farmer community in village area(Budowski and Russo, 1993). This study was intended to explore the floristic composition in the study area and evaluate the eco-economical and socio-cultural role of bio fences.

2. Materials and Methods

Study Area

Palakkad, the largest district in Kerala is taken as study area (Fig:1). Palakkad district is located in the central Kerala and is one of the socially and economically backward districts in Kerala state. It lies between 10º 21' North and 11º 14' North latitudes and 76º 02' East and 76º 54' East longitudes. Palakkad district covers an area of 4475.8 sq.km and has a total population of 2809934 as per census 2011. The district experiences humid and sub humid climate. The district receives an average annual rainfall of 2171 mm. Nearly 90 % of the total annual rainfall is received during South west and Northeast monsoon seasons. The Bharathapuzha and Siruvani with their tributaries drains the entire district. About 45% of the total geographical area is cultivated and nearly 86% of the net sown area is irrigated. Paddy, coconut, vegetables, fruits, rubber and spices and condiments are the major crops cultivated in the district. (Premakumar *et al*., 2015).

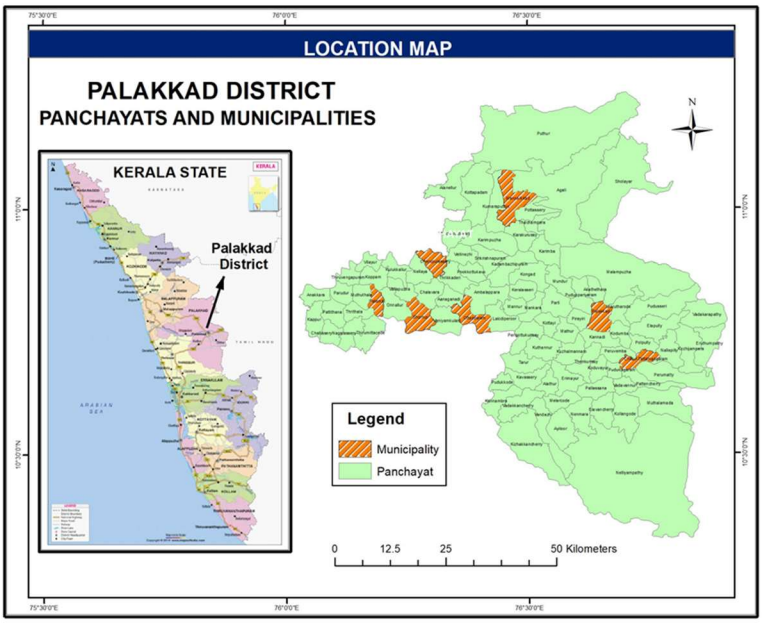

Fig 1: Study area

This study focused on the angiosperm diversity on the bio fences of Palakkad District of Kerala State. Extensive field trips were carried out to different villages of Palakkad district. Personal observation on purpose and the process of construction of these fences were done and recorded. Diversity of plants and animals present in each fence in the study area studied and recorded. The tendencies in replacing the traditional system construction of fence with modern means of fencing were also studied. Information regarding different aspect of biofencing onspecies richness, socio-economic status of the local community, cultural heritage and identity of the society etc. in the study area were collected through personal interview with the villagers. Plants were collected, made into herbarium and identified by using floras (Hooker, 1892 –1897; Gamble and Fischer 1915 - -1936; Manilal and Sivarajan,1982; Mathew, 1984; Ramachandran and Nair,1988; Gopalakrishna Bhat,2003; Anil Kumar *et al*; 2005).

3. Result

From present study it is clear that the village people are using a total of 132 plant species belonging to 43 families, either live or in dried state for fencing. The different plants located in the bio fence and its neighboring area, their family, local name, habit is listed in table 1to 4. The plants with thick foliage cause obstruction to sight of cattle, thereby preventing grazing. *Justicia adhatoda* L, *Duranta erecta* L., *Euphorbia tirucalli* L., *Hibiscus rosa-sinensis* L., *Jatropha* spp., *Justicia gendarussa* Burm.f., *Pedilanthus tithymaloides* (L.) Poit., are preferred due to their unpalatability to cattle. *Hultholia mimosoides* (Lam.) Gagnon & G.P. Lewis., *Lantana camara* L., *Mucuna pruriens* (L.) DC., *Pandanus* spp. make their presence as they form impenetrable thickets. *Bamboos, cacti, Jatropha*

spp., *Pandanus* spp. and *Vitex negundo* L. prevent soil erosion. *Bambusa arundinacea* (Retz.) Roxb., *Bombax ceiba* L., *Ceiba pentandra* (L.) Gaertn., *Pandanus* spp.,and *Vitex negundo* L. act as wind breakers and also increase the firmness of the fences. Ornamental plants are often planted along these fences to impart attraction to eyes while in some areas these were supplemented with many fruits yielding climbers to make them economically important

Table 1: Herbs in traditional fences.

Sl.No	BOTANICAL NAME	FAMILY	IMPORTANCE
1.	*Barleria cristata* L.	Acanthaceae	Ornamental
2.	*Ruellia prostrata* Poir.	Acanthaceae	Medicinal
3.	*Achyranthes aspera* L.	Amaranthaceae	Medicinal
4.	*Ouret lanata*(L.) Kuntze	Amaranthaceae	Medicinal
5.	*Cyathula prostrata* (L.) Blume	Amaranthaceae	Weed
6.	*Colocasia esculenta*(L.) Schott	Araceae	Wild relative
7.	*Chromolaena odorata* (L.) King & Robins	Asteraceae	Medicinal
8.	*Emilia sonchifolia*(L.) DC. ex DC.	Asteraceae	Medicinal
9.	*Cyanthillium cinereum* (L.) H.Rob.	Asteraceae	Weed
10.	*Xanthium strumarium* L.	Asteraceae	Weed
11.	*Ipomoea pes – caprae* (L.) R.Br.	Convolvulaceae	Weed
12.	*Acalypha indica*L.	Euphorbiaceae	Weed
13.	*Euphorbia hirta* L.	Euphorbiaceae	Weed
14.	*Pedilanthus tithymaloides* (L.) Poit.,	Euphorbiaceae	Ornamental
15.	*Senna tora* (L.) Roxb.	Fabaceae	Medicinal
16.	*Grona triflora* (L.) H. Ohashi & K. Ohashi	Fabaceae	Weed
17.	*Tephrosia purpurea* (L.) Pers.	Fabaceae	Medicinal
18.	*Mesosphaerum suaveolens* (L.) *Kuntze*	Lamiaceae	Weed
19.	*Leucas aspera*(Willd.) Link	Lamiaceae	Weed
20.	*Leonotis nepetifolia* (L.) R.Br.	Lamiaceae	Weed
21.	*Hibiscus subdariffa* L.	Malvaceae	Medicinal
22.	*Hibiscus shizopetalus*(Dyer) Hook.f.	Malvaceae	Medicinal
23.	*Melochia corchorifolia*L.	Malvaceae	Fiber
24.	*Sida rhombifolia* L. *ssp. alnifolia* (L.) Ugbor	Malvaceae	Medicinal
25.	*Sida acuta* Burm. f.	Malvaceae	Medicinal
26.	*Triumfetta rhomboidea*	Malvaceae	Weed
27.	*Waltheria indica* L.	Malvaceae	Weed
28.	*Plumbago zeylanica* L.	Plumbaginaceae	Medicinal
29.	*Spermacoce pusilla* Wall.	Rubiaceae	Weed
30.	*Chassalia curviflora*(Wall.) Thw.	Rubiaceae	Medicinal
31.	*Knoxia sumatrensis*(Retz.) DC.	Rubiaceae	Weed
32.	*Physalis minima* L.	Solanaceae	Weed
33.	*Solanum americanum* Mill.	Solanaceae	Weed
34.	*Laportea interrupta* (L.) Chew.	Urticaceae	Weed

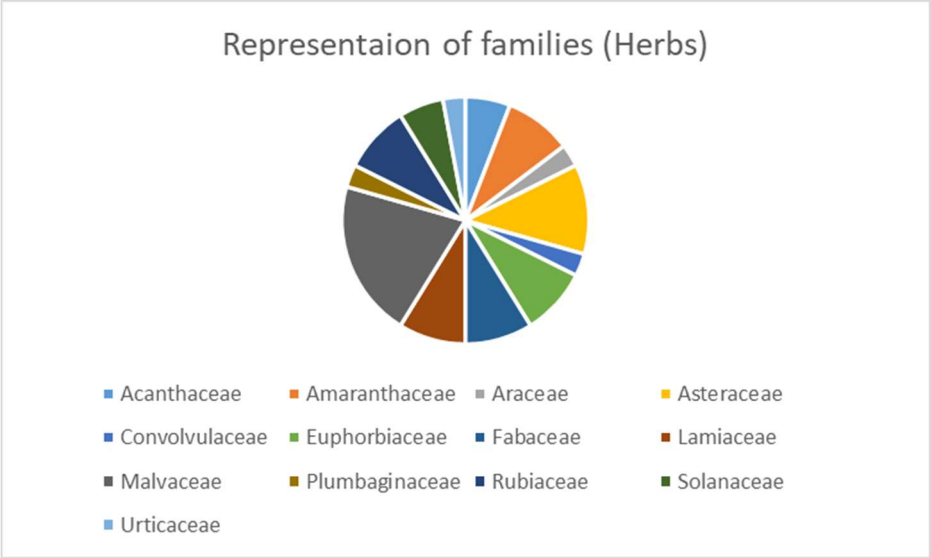

Fig 2: Representation of families (Herbs)

Table 2: Shrubs in traditional fences.

Sl.No	BOTANICAL NAME	FAMILY	IMPORTANCE
1.	*Justicia adhatoda* L	Acanthaceae	Medicinal
2.	*Justicia gendarussa* Burm.f,	Acanthaceae	Medicinal
3.	*Justicia betonica* L.	Acanthaceae	Medicinal
4.	*Thunbergia erecta*(Benth.) Anders.	Acanthaceae	Ornamental
5.	*Carissa carandas* L.	Apocynaceae	Edible
6.	*Tabernaemontana divaricata* (L.) R. Br.	Apocynaceae	Ornamental
7.	*Cascabela* thevetia (L.) Lippold	Apocynaceae	Ornamental
8.	*Opuntia dillenii* (Ker Gawl.) Haw.	Cactaceae	Weed
9.	*Acalypha fruticosa* Forssk.	Euphorbiaceae	Medicinal
10.	*Euphorbia tirucalli* L.	Euphorbiaceae	Ornamental
11.	*Jatropha curcas* L	Euphorbiaceae	Biodiesel
12.	*Jatropha heynei* Balakr.	Euphorbiaceae	Biodiesel
13.	*Jatropha multifida* L.	Euphorbiaceae	Ornamental
14.	*Bauhinia tomentosa* L.	Fabaceae	Ornamental
15.	*Gliricidia sepium* (Jacq.) Walp.	Fabaceae	Weed
16.	*Volkameria inermis* L.	Lamiaceae	Ornamental
17.	*Clerodendrum indicum*(L.) Kuntze	Lamiaceae	Weed
18.	*Vitex negundo* L.	Lamiaceae	Medicinal
19.	*Abutilon indicum*(L.) Sweet	Malvaceae	Weed
20.	*Hibiscus rosa-sinensis* L.	Malvaceae	Ornamental
21.	*Bougainvillea spectabilis* Willd.	Nyctaginaceae	Ornamental
22.	*Pandanus kaida* Kurz.	Pandanaceae	Ethnobotanical
23.	*Bambusa bambos* (L.)Voss	Poaceae	Ethnobotanical
24.	*Breynia androgyna* (L.) Chakrab. & N.P.Balakr..	Phyllanthaceae	Leafy vegetable
25.	*Ziziphus oenopolia* (L.) Mill.	Rhamnaceae	Edible
26.	*Ziziphus mauritiana* Lam.	Rhamnaceae	Edible
27.	*Glycosmis pentaphylla*(Retz.) DC.	Rutaceae	Medicinal
28.	*Solanum torvum* Sw.	Solanaceae	Medicinal
29.	*Duranta erecta* L.	Verbenaceae	Ornamental
30.	*Lantana camara* L.	Verbenaceae	Weed

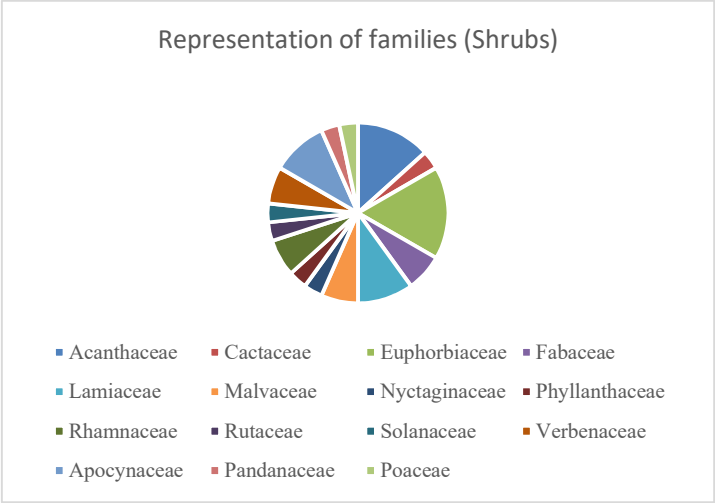

Fig 3: Representation of families (Shrubs)

Table 3: Climbers in traditional fence.

Sl.No	BOTANICAL NAME	FAMILY	IMPORTANCE
1.	*Pergularia daemia* (Forssk.) Chiov.	Apocynaceae	Weed
2.	*Gymnema sylvestre*(Retz.) R.Br. ex Sm.	Apocynaceae	Medicinal
3.	*Hemidesmus indicus* (L.) R. Br.	Apocynaceae	Medicinal
4.	*Cynanchum annularium* (Roxb.) Liede & Khanum	Apocynaceae	Medicinal
5.	*Ichnocarpus frutescens* (L.) W.T.Aiton	Apocynaceae	Medicinal
6.	*Tylophora asthmatica* (L. f.) Wight & Arn.	Apocynaceae	Medicinal
7.	*Wattakaka volubilis* (L.f.) Stapf	Apocynaceae	Medicinal
8.	*Aristolochia indica* L.	Aristolochiaceae	Medicinal
9.	*Gloriosa superba* L.	Colchicaceae	Medicinal
10.	*Ipomoea obscura* (L.) Ker Gawl.	Convolvulaceae	Medicinal
11.	*Diplocyclos palmatus* (L.) C.Jeffrey	Cucurbitaceae	Medicinal
12.	*Benincasa hispida* (Thunb.) Cogn.	Cucurbitaceae	Edible/Medicinal
13.	*Coccinia grandis*(L.) Voigt	Cucurbitaceae	Edible/Medicinal
14.	*Luffa cylindrica* (L.) M.Roem.	Cucurbitaceae	Edible/Medicinal
15.	*Cucumis maderaspatanus* L.	Cucurbitaceae	Medicinal
16.	*Momordica dioica* Roxb. ex Willd	Cucurbitaceae	Medicinal / WR
17.	*Dioscorea alata* L.	Dioscoreaceae	Edible
18.	*Dioscorea pentaphylla* L.	Dioscoreaceae	Wild relative
19.	*Dioscorea wallichii* Hook. F.	Dioscoreaceae	Wild relative
20.	*Abrus precatorius* L.	Fabaceae	Medicinal
21.	*Clitoria ternatea* L.	Fabaceae	Medicinal
22.	*Centrosema molle* Mart. ex Benth.	Fabaceae	Weed
23.	*Hultholia mimosoides* (Lam.) Gagnon & G.P. Lewis	Fabaceae	Weed
24.	*Mucuna pruriens* (L.) DC	Fabaceae	Medicinal
25.	*Vigna umbellata* (Thunb.) Ohwi & H.Ohashi	Fabaceae	Wild relative
26.	*Vigna vexillata* (L.) A.Rich.	Fabaceae	Wild relative
27.	*Vigna radiata* (L.) R.Wilczek	Fabaceae	Wild relative
28.	*Cyclea peltata*(Burm.f.) Hook.f. & Thomson	Menispermaceae	Medicinal
29.	*Cissampelos pareira* L.	Menispermaceae	Medicinal
30.	*Tinospora cordifolia* (Willd.) Hook.f. & Thomson	Menispermaceae	Medicinal

31.	*Jasminum grandiflorum* L.	Oleaceae	Ornamental
32.	*Passiflora foetida* L.	Passifloraceae	Weed
33.	*Piper nigrum* L.	Piperaceae	Medicinal
34.	*Antigonon leptopus* Hook &Arn.	Polygonaceae	Ornamental
35.	*Cardiospermum halicacabum* L.	Sapindaceae	Medicinal
36.	*Cayratia pedata*(Lam.) Juss ex Gagnep.	Vitaceae	Weed
37.	*Cissus quadrangularis* L.	Vitaceae	Wild relative

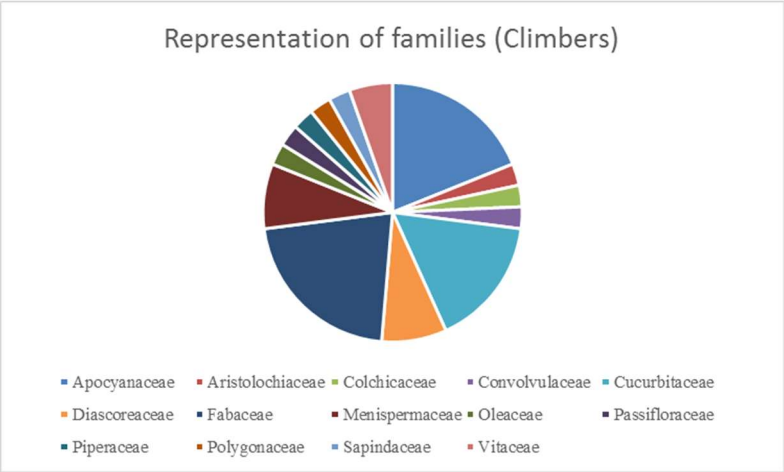

Fig 4: Representation of families (Climbers)

Table 4: Trees in traditional fences

Sl.No	BOTANICAL NAME	FAMILY	IMPORTANCE
1.	*Annona reticulata* L.	Annonaceae	Edible
2.	*Annona squamosa* L.	Annonaceae	Edible
3.	*Polyalthia longifolia*(Sonn.) Thwaites	Annonaceae	Ornamental
4.	*Holarrhena pubescens* Wall. Ex G.Don	Apocynaceae	Medicinal
5.	*Wrightia tinctoria* (Roxb.) R. Br	Apocynaceae	Medicinal
6.	*Cascabela thevetia* (L.) Lippold	Apocynaceae	Medicinal
7.	*Borassus flabellifer* L.	Arecaceae	Edible
8.	*Trema orientale* (L.) Blume	Cannabaceae	Wood
9.	*Carica papaya* L.	Caricaceae	Edible
10.	*Alangium salvifolium* (L.f.) Wangerin	Cornaceae	Weed
11.	*Manihot carthaginensis ssp. glaziovii* (Muell-.Arg.) Allem	Euphorbiaceae	Medicinal
12.	*Cassia fistula* L.	Fabaceae	Ornamental
13.	*Delonix regia* (Hook.) Raf.	Fabaceae	Ornamental
14.	*Erythrina variegata* L.	Fabaceae	Wood
15.	*Pterocarpus marsupium* Roxb.	Fabaceae	Wood
16.	*Tamarindus indica* L.	Fabaceae	Edible
17.	*Premna tomentosa* Willd.	Lamiaceae	Wood
18.	*Tectona grandis* L.f	Lamiaceae	Wood
19.	*Strychnos nux-vomica* L.	Loganiaceae	Medicinal
20.	*Bombax ceiba* L.	Malvaceae	Fiber & wood
21.	*Ceiba pendandra* (L.) Gaertn	Malvaceae	Fiber & wood
22.	*Thespesia populnea* (L.) Sol. ex Corrêa	Malvaceae	Medicinal / Wood
23.	*Azadirachta indica* A. Juss	Meliaceae	Medicinal
24.	*Melia azedarach* L.	Meliaceae	Medicinal

25.	*Morus alba* L.	Moraceae	Edible
26.	*Streblus asper* Lour.	Moraceae	Medicinal
27.	*Syzygium cumini* (L.) Skeels	Myrtaceae	Edible
28.	*Bridelia retusa* (L.) A. Juss	Phyllanthaceae	Wood
29.	*Morinda coreia*Buch.-Ham.	Rubiaceae	Medicinal
30.	*Limonia acidissima* Groff	Rutaceae	Medicinal
31.	*Santalum album* L.	Santalaceae	Medicinal

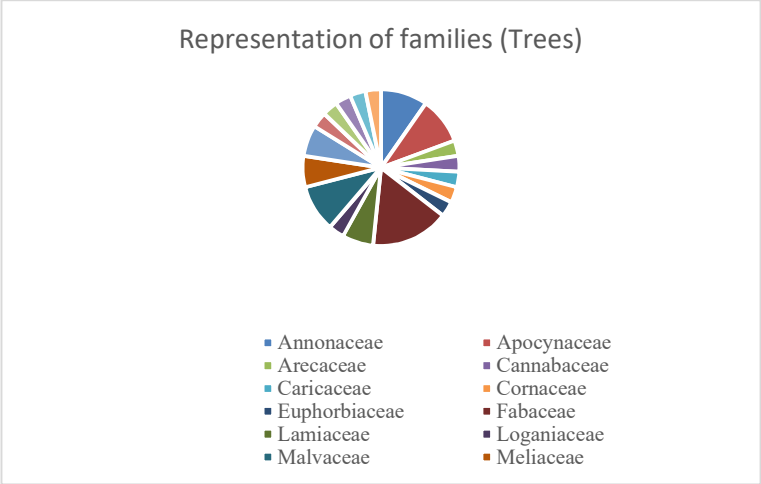

Fig 5: Representation of families (Trees)

4. Discussion

A living fence, which was traditionally referred to as a hedgerow, is a type of hedge that is durable and dense enough to perform the same functions as a manufactured fence, such as ensuring privacy, security, and controlling livestock or protecting crops. However, it also provides a range of biological and agricultural benefits that cannot be achieved by manufactured fence (Choudhary *et al*., 1997) .Bio fences, which were previously a significant aspect of Kerala's scenery, are rapidly being replaced by barbed wire and concrete fences due to the social and economic transformations brought about by land reform regulations in 1964. Despite serving for centuries, bio fences are now viewed as undesirable flora (Chandrashekara *et al.,* 1997). Owners nowadays prefer to enclose their properties with a wall or with barbed wire. With the pressure on land tightening, planters and farmers also tend to remove all "unproductive" clumps of greenery around their fields. This is the result of an average citizen's inability to understand the significance of bio fence.

The value of floristic diversity conserved by the bio fence cannot be measured in terms of money. We could identify 34 species of herbs belonging to 13 families (Table 1), 30species of shrubs belonging to 15 families (Table 2),37 species of climbers of 14 families Table (3), and 31species of trees of 18 families (Table 4) from the study area. The dominating family among the herbaceous group was Malvaceae and that of shrubs was Euphorbiaceae. Out of 37 climbers 22% are coming under the family Fabaceae. Among the tree members also, Fabaceae is the most represented family. Most these plants are medicinally very important and on the verge of extinction. The traditional fences have multiple benefits, including conserving plants with spines and creating impenetrable thickets that would have otherwise disappeared. Additionally, the large trees planted along the boundary help reduce evaporation from the field and prevent barren land formation by acting as wind breakers. These fences are affordable, easy to construct, and have been proven effective over time. However, replacing these live fences with nonliving artificial ones can result in the degradation of the biological treasure and flora biodiversity that has been conserved for thousands of years by the local community.

The diminishing bio fences in Kerala have severely impacted the survival of various small animals and birds. These bio fences are essential habitats for creatures like mongoose, rabbits, rats, and even the endangered tree frog. Birds such as babblers, tailorbirds, mynahs, magpies, and sparrows rely on these bio fences for breeding and foraging for food like worms, berries, and nectar. However, the rapid development in towns and cities of Kerala has

led to the destruction of bio fences, making them a scarce resource. Unfortunately, this trend has now spread to villages as well, resulting in more than 50% loss of bio fences in Kerala over the last 20 years. (Chandrashekara *et al*., 1997) .

Creating a living fence can be considered as an ideal instance of "edge habitat" that contributes significantly to the ecological diversity of a homestead. The presence of such a fence can attract a range of species such as insects, spiders, toads, snakes, birds, and mammals, which can find food and habitat in it. As a result, a natural balance may emerge, which can prove beneficial for us. (Das and Das, 2005).Bio fencing promotes the conservation of biodiversity by providing a habitat for various species of plants, insects, and birds. These plants act as a food source and provide shelter for insects and birds, thus creating a diverse ecosystem (López *et al*., 2018).

The bio fence, which is constructed using various plant species, has several functions besides providing fencing. It can serve as a source of food, fuel wood, and medicines. Certain types of protein rich fodder trees can provide more protein per unit than alfalfa, making them highly productive sources of livestock feed. Livestock can also benefit from the shade provided by a dense living fence. Adding leguminous and nitrogen-fixing species to the fence can increase soil nitrogen levels in the root zone, which can be harvested as leafy cuttings for use in mulches and composts (Kumar *et al*., 2013). Living fences can play a significant role in enhancing the microclimate by acting as windbreaks, which protect livestock and crops from wind stress, soil drying, and wind erosion. For instance, a six-foot high hedge can provide these protective benefits up to 100 yards downwind (Harvey *et al*., 2004). Some researchers suggest that a field sheltered by a living fence can retain more CO_2 at ground level, which can boost the productivity of pasture plants or crops and result in higher yields. Bio fencing helps to mitigate climate change by reducing the amount of carbon dioxide in the atmosphere. Plants absorb carbon dioxide during photosynthesis, reducing its concentration in the atmosphere (Oteng *et al*., 2000).

The use of bio fences can have a positive impact on soil quality. Bio fencing helps in soil conservation by reducing soil erosion, improving soil fertility, and preventing soil degradation (Samra *et al*., 1999). The roots of the plants used in bio fencing help to bind the soil together, thus preventing soil erosion. Additionally, the plants' leaf litter acts as natural fertilizer, improving soil fertility (Prasad, 2010). They contribute to the accumulation of humus in the soil by breaking down leaf litter and shedding root hairs, which helps to compensate for the loss of top growth caused by pruning or grazing. When planted along contour lines, hedges can also prevent soil erosion during rainfall on slopes and improve the infiltration of rainwater, thereby increasing the groundwater level.

Living fences have a longer lifespan compared to man-made fences because they can last as long as the natural lifespan of the species utilized, which can even reach hundreds of years. Certain suitable species of plants can also easily regenerate new shoots if the main trunk is cut through the process of coppicing. As a result, the fence can renew itself without difficulty after damage, and can be managed to produce wood for various purposes like fence posts, fuel, construction, and tool handles (Samra *et al*., 1999). A living fence adds a distinctive aesthetic value to the environment. While artificial fences may lack attractiveness and require additional plants to conceal them, they are only stationary features in the landscape. In contrast, a living fence can bloom with flowers during spring, yield colorful fruits in summer, display vibrant hues in autumn, and showcase an intricate geometric design in winter (Mishra *et al*., 2011).

Bio fences are still present in the countryside and suburban regions of northern Kerala (Subrahmanya and Raveendran, 2010). However, they are gradually disappearing from the urban and semi-urban areas of central Kerala, and the rate of their disappearance is even more alarming in the southern district. Palakkad is the only district in Kerala where hedgerows are still abundant. In the face of development, important decisions must be made regarding the value placed on hedgerows versus highways, the survival of hedges on unused plots during housing development, and the preservation of hedgerows as a resource for present and future biodiversity.

5. Conclusion

Bio fencing is an important technique for sustainable agriculture and environmental conservation. Its benefits include soil conservation, biodiversity conservation, climate change mitigation, and cost-effectiveness. In order to protect the valuable diversity of plant and animal life in natural fences, such as hedges, significant

conservation measures must be taken. Neglected fences must be restored and surviving ones defended. It is not reasonable to rely on farmers and planters to maintain these fences solely because ecologists recognize their importance. Instead, a comprehensive approach is necessary to effectively conserve bio fences.

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Conflicts of Interest

The authors declare no conflicts of Interest.

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