

LIVE FENCING: AN ECOFRIENDLY BOUNDARY WALL IN BHADRAK DISTRICT OF ODISHA, INDIA

Taranisen PANDA^{1*}, Nirlipta MISHRA²,
Bikram K. PRADHAN¹, Rajballav MOHANTY³

¹ Department of Botany, Chandbali College, Chandbali, Bhadrak- 756133, Odisha, India

² Department of Zoology, Chandbali College, Chandbali, Bhadrak- 756133, Odisha, India

³ Plot No. 1311/7628, Satya Bihar, Rasulgarh, Bhubaneswar, Odisha, 751010

Abstract

*Live fencing, an age old and traditional practice, commonly found in rural areas of Bhadrak district, Odisha, India, but its importance remains unexplored and not yet documented. Exploratory surveys conducted in Bhadrak district, indicated that traditional farmers have vast knowledge about their live fencing practices and the species used. A total of 61 plant species belonging to 53 genera under 24 families are used by the people as biofencing, besides food, timber, fuel wood, medicine etc. Two groups of species are observed on the fence. The first groups of species (*Ipomoea carnea*, *Bambusa arundinacea*, *Bougainvillea spectabilis* etc.) are used primarily for protection and the second groups of species (*Annona squamosa*, *Borassus flabellifer*, *Moringa oleifera* etc.) are utilized for medicine, fruits and vegetables. Some promising fence species of this region are *Acacia nilotica*, *Annona squamosa*, *Bambusa arundinacea*, *Bambusa vulgaris*, *Borassus flabellifer*, *Casuarina equisetifolia*, *Erythrina indica*, *Euphorbia tithymaloides*, *Ipomoea carnea*, *Jatropha curcas*, *Pandanus fascicularis*, *Pilosocereus arrabidaei* and *Vitex negundo*. This traditional biofencing practice is playing an important role in biodiversity conservation.*

Keywords: APG III; Biofencing; Biodiversity conservation; Economic uses; Indigenous knowledge.

Introduction

Live fencing or biofencing or green fencing is a way of establishing a boundary by planting a line of tree or shrubs at relatively closed spacing and by fixing threads (made from jute or petiole of palm or plastic wire) to them. If cattle and wildlife are to be kept outside more upright double or triple row of dead sticks can be tied to the thread [1, 2]. Live fences are frequent in India separating crop fields, pastures, households, and farm boundaries and forming intricate networks of plant cover across rural landscapes. Not only do live fences occur across areas that are biophysically diverse, with different elevations, ecological life zones, and soil types, but they also occur in areas with distinct cultures, land use histories and agricultural production, notably vegetable plantations, pastures and home gardens [3,4]. In some agricultural regions, where conversion to agriculture has been high, live fences constitute the most prevalent form of tree cover remaining in the landscape. Mainly two types of live fencing are in practice: 1) Permanent boundary wall and 2) Biofencing. Aside from their protective function, biofencing provides bee forage, provide shade, and control dust. They are less expensive and more useful than fences made of wood, barbed wire, or stone masonry. The

* Corresponding author: taranisenpanda@yahoo.co.in

ecological and productive role of biofencing is well studied [5, 6]. Intensive studies concerning biofencing from different parts of the world have earlier been highlighted [7-10] but there is remarkably little information about the live fences in India. For instance, Pujarini (1998) [11] recorded 42 plants used for fencing and making boundaries either live or dried state in Gujarat. Borkataki et al. (2008) [12] reported 26 plant species traditionally used by the people of Nogaon district of Assam. Recently, Dinesh et al (2013) [13] enumerated 18 biofencing plants in Andhra Pradesh. Similarly, Sharma and Devi (2013) [14] documented 61 species of live fencing plants in Himachal Pradesh. But reports about biofencing in Bhadrak district of Odisha, India are still lacking. Biofencing is a common phenomenon in and around almost each rural household of the district. From time immemorial, the people of Bhadrak district have been using different plant species for fencing to protect their cultivated lands and home gardens. As a step in this direction, an attempt is made in this article to investigate the abundance, diversity and distribution of traditional biofencing plants in Bhadrak district of Odisha, India. The main objective of this paper is to understand the biofencing systems as practiced by rural people in the region, and to provide a base for further scientific studies.

Materials and Methods

Study site

Odisha is the ninth largest state of India by area and the eleventh largest by population. It is located in the east coast of India ($17.48^{\circ} - 22.34^{\circ}\text{N}$ and $81.24^{\circ} - 87.29^{\circ}\text{E}$) with the Bay of Bengal forming its eastern and south eastern frontiers. Despite severe population pressure and utter disregard for its protection for decades, it still boasts of 5.72 million ha. of forests which constitutes around 36.73% of the geographic area of the state. The vegetation found in this region is tropical moist deciduous forest type [15]. Obviously the Odishan people have not only depended on this rich floristic resources to fulfill all their basic needs, but it has also influenced the faith, belief, rituals, customs, art, craft, sculpture and other finer expressions of human mind and creativity of this region from time immemorial.

Bhadrak district ($20^{\circ} 43' - 21^{\circ} 13'\text{N}$ and $86^{\circ} 6' - 87^{\circ} \text{E}$) is located in Northeast Odisha. It spreads over 2505 km² having 1.507 million inhabitants (2011 Census). Four other districts namely Balasore, Kendrapara, Jajpur and Koenjhar surround Bhadrak district while a part is bounded by the Bay of Bengal (Fig. 1). The district covers about 1.61 % of the total land area of the state and contributes 3.59 % of the state's population. About 86.66 % of the inhabitants are villagers and the people are engaged in agricultural practices as their primary occupation. Being situated in close proximity to Bay of Bengal, the district is characterized by periodic earth tremors, thunder storms in the rains and dust storms in April and May. Some of the flora which grow in abundance in the region are: *Acacia nilotica* (L.) Delile., *Anacardium occidentale* L., *Annona squamosa* L., *Artocarpus heterophyllus* Lam., *Averrhoa carambola* L. *Azadirachta indica* A. Juss., *Bambusa vulgaris* Schrad., *Bombax ceiba* L., *Borassus flabellifer* L., *Butea monosperma* (Lam.) Taub., *Cassia fistula* L., *Crataeva nurvata* (Buch.) Ham., *Ficus benghalensis* L., *Ficus religiosa* L., *Gmelina arborea* Roxb., *Mangifera indica* L., *Mimusops elengi* L., *Morinda citrifolia* L., *Phoenix sylvestris* (L.) Roxb., *Polyalthia longifolia* (Sonn.)Thw., *Pongamia pinnata* (L.) Pierre., *Pterocarpus marsupium* Roxb., *Samanea saman* (Jacq.) Merr. J. Wash., *Spondias mangifera* Willd., *Streblus asper* Lour., *Syzygium cumini* (L.) Skeels., *Tamarindus indica* L. and *Terminalia arjuna* (Roxb.ex DC.) Wight & Arn.

Data collection

Extensive field surveys (June 2014-May 2016) were carried out to document and enlist the live fencing plant species following established and standard procedures [16, 17]. The information was obtained through a combination of tools and techniques of structured questionnaires, complemented by free interviews and informal conversations [17, 18] and

personal observation. The information regarding the live fencing plant species has been gathered mostly from local farmers, elderly and knowledgeable persons.

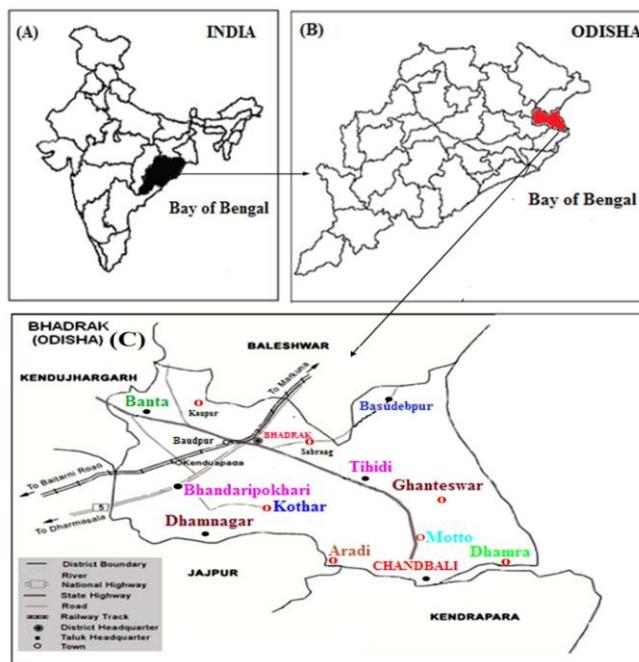


Fig. 1. Location of the Odisha state in the eastern region of India (a), map of Odisha state showing the Bhadrak district (b) and the study area showing different blocks of the Bhadrak district (c)

Personal interviews and group discussions carried out in the local language revealed specific information about the plants, which were further compared and authenticated by crosschecking [19]. The economic uses of these species if any were discussed with the local people. Samples of recorded herbs, twigs of shrubs, climbers and trees were identified using relevant flora [20, 21]. During field study, some of the field characters on live fencing such as rooting ability, soil requirements, growth rates, wind susceptibility, durability, susceptibility to pests, and wood quality were recorded. Similarly, for the management aspect (preparation of stakes, seasonality of management and planting distances), as well as the roles of live fences within the farming system (value as forage, firewood, timber and medicine, provision of shade to cattle, and their effects on soil) information's were collected and noted. The plant species are enumerated and arranged as per Angiosperm Phylogeny Group III Classification [22]. The voucher specimens were deposited in the herbarium of the Department of Botany, Chandbali College, Chandbali. The live fencing plants were represented alphabetically according to their scientific names, family, local name if any, habit and uses.

Results and Discussion

The present study recorded 61 plant species belonging to 24 families under 53 genera which are being used as live fence (Table 1; Fig. 2). As per APG III classification, these taxa are distributed in 8 superorders and 20 orders. 37.7% of the species are reported from the superorder Fabids, 22.95% from superorder Lamids, 14.75% from superorder Lamids and 11.48% from superorder Commelinids. Order Fabales (11), Lamiales (9) and Malphigiales (8) account for about 45.9% of the species in the district. Among the documented plant species, the

family Fabaceae is frequently represented with a total of 11 species followed by Euphorbiaceae (8 species) and Verbenaceae (5 species). Twelve families were monospecific.



Fig. 2. *Clerodendrum inerme* (L) Gaertn. (a), *Euphorbia tithymaloides* L. (b), *Gliricidia sepium* (Jacq) Kunth ex Walp. (c), *Pilosocereus arrabidae* (Lem.) Byles & Rowley (d)

Fences are both homogenous as well as heterogeneous types in Bhadrak district but heterogeneous fencing is most commonly seen surrounding crop fields. All cultivated lands are surrounded by fence to prevent entry of domestic and wild animals. Presence of thorns, spines, pickles, strong soil binding roots and profuse branching are the important characteristics of biofencing plants which is effective in preventing the entry of wild animals to the agricultural field and homestead [11, 23]. Seven plant species i.e. *Acacia nilotica* (L.)Willd., *Albizia lebbek* (L.) Benth., *Bambusa arundinacea*(Retz.)Willd., *Bambusa vulgaris* L., *Borassus flabellifer* L., *Casuarina equisetifolia* L. and *Phoenix sylvestris* Roxb. (L.) are used both in live and dried conditions. Some of the species like *Euphorbia tirucalli* and *Jatropha curcas* are preferred for biofencing due to their unpalatability to cattle. Similarly, *Acacia nilotica*, *Lantana camara*, *Pandanus fascicularis* and *Pilosocereus arrabidae* make their presence as they form impenetrable thickets. While, *Bambusa* sp. acts as wind breakers and also increase the firmness of the fences. House fencing is often supplemented with flowering plants and fruit yielding climbers which also support in livelihood of poor farmers [24]. Moreover the large trees planted along the boundary act as wind breakers, thereby reducing the rate of evaporation from the field and barren land formation. Informants also indicated that, shade from live fences is important for cattle, reducing heat stress, particularly in the dry season, and providing a more comfortable environment for domestic animals particularly cattle. Villagers plant trees mainly for household consumption. In Bangladesh, trees are mainly planted by farmers for the purpose of household consumption in the form of fruits, firewood, etc. [25]. The recorded plant species have been attributed to three different life forms (Fig. 3a). An important characteristic of the biofencing is the predominance of shrubs (62.3%) followed by trees (36.1%). Enumerated plant species in the biofencing include those supplying food, fuel wood, shade, rituals, household products and medicine, among which majority are indigenous [26]. Five major plant use categories were identified in biofencing plants. Figure 3b shows the number of species in each use category, with the dominant one being the medicine category, followed by tooth brush, fuel wood and miscellaneous.

Table 1. Plant species used for biofencing in Bhadrak district of Odisha, India

Sl. No	Botanical name, family & local name	Habit/habitat/domestication	Form of use
1.	<i>Acacia nilotica</i> (L.)Willd. (Fabaceae) 'Babul'	Medium sized tree in plains and rural areas.	Live fencing. Tender shoot axis is used as tooth stick.
2.	<i>Agave americana</i> L. (Asparagaceae)	A common ornamental shrub.	Live fencing.
3.	<i>Albizia lebeck</i> (L.) Benth. (Fabaceae) 'Sirish'	A common wasteland tree.	Live fencing.
4.	<i>Alangium salvifolium</i> (Linn.f.)Wagn (Cornaceae) 'Ankula'	A small tree commonly found in wasteland and in hedges.	Live fencing. Shoot is used as tooth stick. Powered bark is used as tooth powder to get relief from pyorrhea.
5.	<i>Annona reticulata</i> L. (Annonaceae) 'Atta'	A common tree.	Live fencing. Root decoction is taken as a febrifuge to relieve toothache. Ripen fruits are edible.
6.	<i>Annona squamosa</i> L. (Annonaceae) 'Neuwa'	A common tree.	Live fencing. Ripen fruits are edible.
7.	<i>Areca catechu</i> L. (Arecaceae) 'Gua'	A common cultivated tree.	Live fencing. Fruits are used for various ritual purposes.
8.	<i>Atylosia cajaniifolia</i> Haines. (Fabaceae)'Banaharada'	Wild shrub.	Live fencing. Shoot bark is chewed to get relief from caries infection and toothache.
9.	<i>Bambusa arundinacea</i> (Retz.)Willd. (Poaceae)	A common tree.	Live fencing.
10.	<i>Bambusa vulgaris</i> L. (Poaceae)'Baunsa'	A medium sized plant.	Live fencing The young shoot is used as tooth stick.
11.	<i>Barleria prionitis</i> L. (Acanthaceae)'Daskerenta'	A common roadside and wasteland shrub.	Live fencing. Juice extracted from whole plant is taken orally with honey in equal proportions to cure pyorrhea.
12.	<i>Bauhinia variegata</i> L. (Fabaceae) 'Kanchana'	A common tree.	Live fencing. Flowers are edible.
13.	<i>Bombax ceiba</i> L. (Malvaceae) 'Simili'	A wasteland tree.	Live fencing. Thorn paste with cow milk is applied on pimples.
14.	<i>Borassus flabellifer</i> L. (Arecaceae) 'Tala'	A tall tree. Common in wasteland and boundaries of cultivated fields.	Live fencing. The leaves are used for thatching huts, making brushes, weaving mats, brushes, baskets, brooms, fans, hats, umbrella and other indigenous products. Fruits are edible.
15.	<i>Bougainvillea spectabilis</i> Willd. (Nyctaginaceae) 'Kagajaphula'	Common shrub in hedges and gardens.	Live fencing.
16.	<i>Breynia retusa</i> (Denn.) Alston (Euphorbiaceae) 'Jajangi'	Bushy shrub planted on village hedges.	Live fencing The shoot axis is used as tooth stick.
17.	<i>Butea monosperma</i> (Lamk.) Taub.(Fabaceae) 'Palasa'	A tree in hills and plains.	Live fencing. Powder of shoot bark is used as tooth powder for pyorrhea and gum affection.
18.	<i>Caesalpinia bonduc</i> (L.) Roxb. (Fabaceae) 'Gila'	A common cultivated shrub.	Live fencing.
19.	<i>Calamus rotang</i> L. (Arecaceae) 'Beta'	Shrub.	Live fencing. Root paste is used for piles.
20.	<i>Calotropis gigantea</i> R.Br. (Apocynaceae) 'Arakha'	A tall wasteland shrub.	Live fencing. The shoot axis is used as tooth stick to check and cure caries infection and pyorrhea.
21.	<i>Calotropis procera</i> (Ait.) R.Br.(Apocynaceae) 'Sweta Arakha'	A tall wasteland shrub.	Live fencing. The shoot is used as tooth stick to check and cure caries infection and pyorrhea.
22.	<i>Cassia fistula</i> L. (Fabaceae) 'Sunari'	A medium sized tree.	Live fencing. Leave paste is applied externally for rheumatism.
23.	<i>Casuarina equisetifolia</i> L. (Casuarinaceae) 'Jhaun'	A tall branched tree.	Live fencing.
24.	<i>Citrus limon</i> (L.) Burm.f. (Rutaceae) 'Lembu'	A common cultivated shrub.	Live fencing. Fresh fruit juice is taken orally for indigestion
25.	<i>Clerodendrum inerme</i> (L.) Gaertn. (Verbenaceae)	A common wasteland shrub.	Live fencing. The powdered leaves mixed with camphor and garlic is used for muscular as well as rheumatic pain.
26.	<i>Clerodendrum phlomidis</i> L. f. (Verbenaceae) 'Donkari'	A common wasteland shrub.	Live fencing.
27.	<i>Duranta repens</i> L. (Verbenaceae)	A branched thorny shrub.	Live fencing. Stem is used as tooth stick.
28.	<i>Erythrina indica</i> Lam. (Fabaceae) 'Paladhua'	A common wasteland tree.	Live fencing. Leaf juice is prescribed for deworming.
29.	<i>Euphorbia antiqorum</i> L. (Euphorbiaceae)	A common wasteland shrub.	Live fencing.
30.	<i>Euphorbia nivulia</i> Buch.-Ham. (Euphorbiaceae)	A common wasteland shrub.	Live fencing.

31.	<i>Euphorbia tirucalli</i> L. (Euphorbiaceae) 'Dangalsiju'	A common shrub.	wasteland	Live fencing. The shoot paste is tied over the affected part for rheumatism in domestic animals.
32.	<i>Euphorbia tithymaloides</i> L. (Euphorbiaceae) 'Khasrsiju'	A wild shrub.		Live fencing.
33.	<i>Ficus hipsida</i> L.f. (Moraceae) 'Dimbiri'	A small tree.		Live fencing. Tender shoot is used as tooth stick for dental care and protection.
34.	<i>Gossypium herbaceum</i> (L.) Mast. (Malvaceae)	A wild and cultivated shrub.		Live fencing.
35.	<i>Gliricidia sepium</i> (Jacq.) Kunth ex Walp (Fabaceae)	A wild shrub.		Live fencing.
36.	<i>Hibiscus rosa-sinensis</i> L. (Malvaceae), 'Mandara'	A common shrub ornamental garden plant.		Live fencing. Flower is used in various rituals.
37.	<i>Ipomoea carnea</i> Jacq. (Convolvulaceae) 'BadaKalama'	A wild shrub.		Live fencing.
38.	<i>Jatropha curcas</i> L. (Euphorbiaceae) 'Baigaba'	A common shrub in wasteland.		Live fencing. Tender stem is used as tooth stick to protect teeth, remove bad breath against pyorrhea.
39.	<i>Justicia adhatoda</i> L. (Acanthaceae) 'Basanga'	A bushy shrub used for fencing and decoration.		Live fencing. Stem is used as tooth stick to cure gum affection.
40.	<i>Justicia gendarussa</i> Burn.f. (Acanthaceae) 'Kalabasanga'	Shrub.		Live fencing.
41.	<i>Lantana camara</i> L. (Verbenaceae) 'Nagabairi'	A wasteland shrub.		Live fencing. Stem is used as tooth stick for the dental care.
42.	<i>Lawsonia inermis</i> L. (Lythraceae) 'Manjuati'	Shrub.		Live fencing. Juice extracted from root with rice water is given to cure jaundice.
43.	<i>Moringa oleifera</i> Lam. (Moringaceae) 'Sajana'	Tree.		Live fencing. Gum is applied over the bone fractured part.
44.	<i>Musa paradisiaca</i> L. (Musaceae) 'Kadali'	Cultivated shrub.		Live fencing. Feeding of rice husk with banana is useful to cure diarrhoea in cattle.
45.	<i>Nyctanthes arbor-tristis</i> L. (Oleaceae) 'Gangasiuli'	A wild shrub.		Live fencing. Leaf decoction mixed with honey is prescribed to cure fever.
46.	<i>Opuntia dillenii</i> Wight & Arn. (Cactaceae) 'Nagapheni'	A wasteland shrub.		Live fencing.
47.	<i>Pandanus fascicularis</i> Lam. (Pandanaaceae) 'Kia'	A wasteland shrub.		Live fencing. The stilt root is used as tooth stick.
48.	<i>Phoenix sylvestris</i> Roxb.(L.) (Arecaceae) 'Khajuri'	A monocot unbranched tree.		Live and dried stems are used as fencing. Ripen fruits are edible.
49.	<i>Pilosocereus arrabidae</i> (Lem.) Byles & Rowley (Cactaceae) 'Deulisiju'	A wild shrub.		Live fencing.
50.	<i>Polyalthia longifolia</i> (Sonn.) Thw. (Annonaceae) 'Debdaru'	A wild tree.		Live fencing.
51.	<i>Pongamia pinnata</i> (L) Pierre. (Fabaceae) 'Karanja'	A tree species common in coastal plains and hills.		Live fencing. Shoots are used as tooth stick to check bad breath.
52.	<i>Prosopis juliflora</i> (Sw) DC (Fabaceae) 'Phala Babula'	Common tree in village periphery		Live fencing. Tender shoots is used as tooth stick.
53.	<i>Ricinus communis</i> L. (Euphorbiaceae) 'Jada'	A wild shrub.		Live fencing. Seed oil is applied topically to treat inflammation on limbs.
54.	<i>Sansevieria roxburghiana</i> Schult. & Schult. (Asparagaceae)	A wild herb.		Live fencing.
55.	<i>Streblus asper</i> Lour. (Moraceae) 'Sahada'	Common tree in village periphery.		Live fencing. Shoots are used as tooth stick for dental care and to cure gum boils.
56.	<i>Synadenium grantii</i> Hook f. (Euphorbiaceae)	Shrub.		Live fencing.
57.	<i>Tabernaemontana coronaria</i> (Jacq) Willd. (Apocynaceae) 'Tagara'	Cultivated shrub.		Live fencing.
58.	<i>Thevetia nerifolia</i> Pers.ex Steud. (Apocynaceae) 'Koniya'	A wild shrub.		Live fencing.
59.	<i>Vernonia cinerea</i> (L.) Less. (Asteraceae) 'Poksunga'	A small bushy shrub.		Live fencing. Leaf paste is used to cure piles.
60.	<i>Vitex negundo</i> L. (Verbenaceae) 'Begunia'	A small bushy shrub.		Live fencing. Tender shoots are used as tooth stick. Decoction of leaf is taken for fever and cough.
61.	<i>Zizyphus oenoptia</i> (L.) Mill. (Rhamnaceae) 'Kanakoli'	A wild shrub.		Live fencing. Root paste is used for healing of wounds. Ripen fruits are edible.

Fourteen species are used for tooth brush. Prominent among them are *Acacia nilotica* (L.)Willd., *Bambusa vulgaris* L., *Calotropis gigantea* R.Br., *Jatropha curcas* L., *Justicia adhatoda* L., *Lantana camara* L., *Pongamia pinnata* (L) Pierre.and *Streblus asper* Lour. The present report on the use of plants for dental care draws support from earlier studies [27-29] in different parts of India. Most important plant species for edible purpose include *Annona*

reticulata L., *Annona squamosa* L., *Borassus flabellifer* L., *Citrus limon* (L.) Burm.f., *Mimusops elengi* L., *Musa paradisiaca* L. and *Phoenix sylvestris* Roxb.(L.). Some of the studied plants are also frequently used for food purposes in India and Odisha [2, 30-33]. Most preferred plant species for the management of various ailments are *Cassia fistula* L., *Euphorbia tirucalli* L., *Justicia adhatoda* L., *Mimusops elengi* L., *Moringa oleifera* Lam. *Ricinus communis* L., *Pongamia pinnata* (L.) Pierre. and *Vitex negundo* L. Similar plant use is recorded earlier in different parts of India [34-36], indicating the importance of traditional medicine in the treatment of various ailments in Bhadrak district. Two species in the present study is used for various household articles. The stem of *Borassus flabellifer* L. provides strong timber material useful for construction [37-39]. The leaves are used in a variety of artifact construction. For example, for making mats, umbrellas, toys, huts and other household utility products [37]. The pulp is mixed with flour and used to make several edible preparations [40]. Similarly, the leaves of *Phoenix sylvestris* Roxb. (L.) are used in many religious and socio-cultural functions in the district. This plant provides a multitude of useful products such as handicrafts and mats, screens, thatching and fencing materials, baskets, crates, fuel wood, and house brooms and is the main subsistence resource for the poorest people [41]. The important timber and fuel yielding plant species recorded in our study are *Albizia lebeck* (L.) Benth., *Alsotonia scholaris* (L.) R.Br., *Bambusa vulgaris* L., *Casuarina equisetifolia* L., *Polyalthia longifolia* (Sonn.)Thw. and *Pongamia pinnata* (L) Pierre. The diverse patterns of use of different plant species in the study area show that rural people have a high level of indigenous knowledge. The results of preference ranking for four selected threats against the availability of plant species in the study area shows that agricultural expansion is the first ranking threat (most detrimental), followed by urbanization, fuel wood collection and overgrazing. In addition to the above mentioned threats the respondents mentioned that limited government support for species conservation and the gradual waning of the existing traditional systems and coping mechanisms due to external intervention are among the main reasons behind the neglecting of local knowledge and tree management and conservation systems.

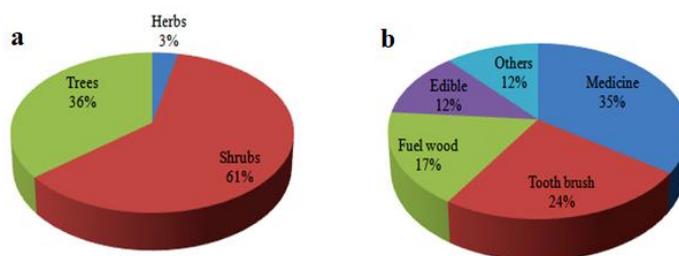


Fig. 3. Life form analysis (a) and the diversity of economic uses (b)

In all areas of the district, most farmers harvested the branches of established live fences to use as material for establishing new live fences or increasing the tree density within existing fences. Forage for cattle is an important product, particularly because many of the common live fence species such as *Gliricidia sepium* and *Erythrina indica* are nitrogen-fixing species that provide forage that is of high nutritive quality and available in the dry season when grass is scarce [42, 43]. Thus these traditional fences are time tested, easily affordable, easy to construct and play an important role in the conservation of many plants [24]. Litter from fencing plants accumulates at the base making soil fertile. Fencing plants attract birds, butterflies, insects, ants and is considered as promising sites to locate the seedlings of species which are dispersed by birds [44]. Therefore, fencings around them provide good sites for maintenance rather conservation of some important wild species. Live fences are abundant and conspicuous features in all rural areas of the Bhadrak district and have fulfilled a range of social, economic and ecological functions: acting as barriers to animal movement and sources of fodder,

firewood and fruits, while also serving as habitat, providing resources, acting as corridors for wildlife conservation and play important role in ethnobotany and ethno medicines [12, 45]. The technique of management and high diversity of live fences reflect the wisdom of traditional culture and ecological knowledge that have evolved over the years. ‘Conservation through use’ [46] approach in live fences is an element of a complementary conservation strategy. There is an urgent need to strengthen and document such traditional systems of natural resource management for economic viability, ecological sustainability and social acceptability.

Conclusion

The present study demonstrates the important productive and ecological roles of live fences within rural areas of Bhadrak district, Odisha, India. The multiple benefits illustrate traditional biofencing practices have great potential to reduce environmental degradation, serve agronomic functions, and also enhance the conservation of biodiversity. Current research focuses on identifying the best combinations of different growth forms to make more efficient biofencing structure and function, with an aim to attain optimum productivity and profitability with reduced economic risks.

References

- [1] P.R. Choudhuri, P. Rai, U.S. Pattanaik, R. Sitaram, *Live fencing practices in the tribal dominated eastern Ghat of India*, **Agroforestry Systems**, **18**, 1997, pp. 41-53.
- [2] S. Mishra, P. Vasudevan, S. Prasad, *Biofencing : an ecofriendly boundary wall*, **Journal of Scientific and Industrial Research**, **70**, 2011, pp.727-731.
- [3] J.D. Sauer, *Living fences in Costa Rican agriculture*, **Turrialba (IICA)**, **29**, 1979, pp. 225–261.
- [4] G. Budowski, *Living fences in tropical America, a widespread agroforestry practice*, **Agroforestry: Realities, Possibilities and Potentials**, (Editor: H.L. Gholz), Springer, Heidelberg, 1987, pp. 169–178.
- [5] J.R.G. Baudry, H. Bunce, F. Burel, *Hedgerows: an international perspective on their origin, function and management*, **Journal of Environment Management**, **60**, 2000, pp. 7–22.
- [6] E.J.P. Marshall, A.C. Moonen, *Field margins in northern Europe: their functions and interactions with agriculture*, **Agriculture, Ecosystem and Environment**, **89**, 2002, pp. 5–21.
- [7] G. Budowski, R. Russo, *Live fence posts in Costa Rica: a compilation of the farmer’s beliefs and technologies*, **Journal of Sustainable Agriculture**, **3**, 1993, pp. 65–85.
- [8] A.J.F. Villanueva, R.R. Sanchez, C.F.O. Carrete, H.L. Mena, *Establishment of different tree species for live fences on the Nayarit coast*, **Tecnica-Pecuaria-en-Mexico**, **34**, 1996, pp. 64-70.
- [9] D. Le Coeur, J. Baudry, F. Burel, C. Thenail, *Why and how we should study field boundary biodiversity in an agrarian landscape context*, **Agriculture, Ecosystems and Environment**, **89**, 2002, pp. 23–40.
- [10] C.A. Harvey, N. Tucker, A. Estrada, **Live Fences, Isolated Trees and Windbreaks: Tools for Conserving Biodiversity in Fragmented Tropical Landscapes?** (Editors: G. Schroth, G.A.B. Fonseca, C.A. Harvey, C. Gascon, H.L. Vasconcelos and A.M.N. Izac.), *Agroforestry and Biodiversity Conservation in Tropical Landscapes*, Island Press, Washington, DC, 2004, pp. 261–289.
- [11] B.L. Punjani, *Role of Plants in field fencing in Tribal areas of district Sabarkantha (North Gujarat)*, **Ethnobotany**, **10**, 1998, pp. 56-60.

- [12] S. Borkataki, M. Chutia, S.K. Borthakur, *Ethnobotany of Biofencing among teagarden and ex- teagarden communities of Nagaon District of Assam*, **Indian Journal of Traditional Knowledge**, **7**(4), 2008, pp. 666-668.
- [13] V. Dinesh, S.K. Bembrekar, P.P. Sharma, *Traditional use of biofencing plants in indigenous folklore of Nizamabad district ,Andhra Pradesh,India*, **International Journal of Pharmaceutical and Chemical Sciences**, **2**(3), 2013, pp. 1491-93.
- [14] P. Sharma, U. Devi, *Ethnobotanical uses of biofencing plants in Himachal Pradesh, Northwest Himalaya.Pakistan*, **Journal of Biological Science**, **16**(24), 2013, pp. 1957-1963.
- [15] H.G. Champion, S.K. Seth, **A Revised Survey of the Forest Types of India**, Manager of Publications, New Delhi, 1968, pp. 16-17.
- [16] S.K. Jain, **Glimpses of Indian Ethnobotany**, Oxford and IBH Publishing Co, New Delhi, 1987, pp. 231-241.
- [17] G.J. Martin, **Ethnobotany: A Methods Manual**, Chapman and Hall, London, UK, 1995, pp. 102-104.
- [18] H.P.Huntington, *Using traditional ecological knowledge in science: Methods and applications*, **Ecological Application**, **10**, 2000, pp. 1270-1274.
- [19] A.B. Cunningham, **Applied Ethnobotany: People, Wild Plant Use and Conservation**, Earthscan Publishing Ltd., London, UK, 2001.
- [20] H.H. Haines, **The Botany of Bihar and Orissa**, Adland and Son, West Newman Ltd., London, UK, 1925.
- [21] H.O. Saxena, M. Brahmam, **The Flora of Orissa**. Vol. I-IV, Orissa Forest Development Corporation, Bhubaneswar, 1996.
- [22] APG III, *An update of the angiosperm phylogeny group classification for the orders and families of flowering plants*, **Botanical Journal of the Linnean Society**, **161**(2), 2009, pp. 105-121.
- [23] R.B. Chhetri, *Ethnobotany of bio-fencing in Dhulikhel region in Nepal*, **Ethnobotany**, **17**, 2005, pp. 176-178.
- [24] P.K. Subrahmanya, K. Raveendran, *Traditional plant fencing and its conservatory nature in Kasaragod District, Kerala, India*, **Ethnobotanical Leaflets**, **14**, 2010, pp. 681-686.
- [25] M.A. Salam, T. Noguchi, M. Koike, *Understanding why farmers plant trees in the homestead agroforestry in Bangladesh*, **Agroforestry Systems**, **50**, 2000, pp. 77-93.
- [26] R.R.B. Leakey, A.B. Temu, M. Melnyk, P. Vantomme, **Domestication and Commercialization of Non-timber Forest Products in Agroforestry Systems**, FAO, 1996.
- [27] J. Singh, S. Narain, *Ethnomedicinal account of Sonbhadra district*, **Journal of Phytological Research**, **20**(2), 2007, pp. 255-264.
- [28] K.P. Saxena, S. Roy, *Allium species: The potent medicinal herbs*, **Journal of Phytological Research**, **20**(2), 2007, pp. 303-308.
- [29] U. Jain, M. Chauhan, *Important herbal wealth of tribal people of Pali (Rajasthan)*, **Journal of Phytological Research**, **22**(1), 2009, pp. 143-150.
- [30] K.N. Reddy, C. Pattanaik, C.S. Reddy, V.S.Raju, *Traditional knowledge on wild food plants in Andhra Pradesh*, **Indian Journal of Traditional Knowledge**, **6**(1), 2007, pp. 223-229.
- [31] S.D. Rout, *Ethnobotany of diversified wild edible fruit plants in Similipal Biosphere Reserve*, **Ethnobotany**, **19**, 2007, pp. 137-139.
- [32] S. Binu, *Wild edible plants used by the tribals in Pathanamthitta district, Kerala*, **Indian Journal** [33] P.P. Sharma, R.J. Savant, *Some less-known plants parts as supplementary foods*, **Inter Multidisciplinary Research Journal**, **2**(12), 2012, pp.12-13.
- [34] R.D. Girach, A. Aminuddin, M. Brahma, M.K. Mishra, *Observations on ethnomedicinal plants of Bhadrak district, Orissa, India*, **Ethnobotany**, **9**, 1997, pp. 44-47.

- [35] S. Sankaranarayanan, P. Bama, J. Ramachandran, P.T. Kalaichelvan, M. Deccaraman, *Ethno botanical study of medicinal plants used by traditional users in Villupuram district of Tamil Nadu, India*, **Journal of Medicinal Plants Research** **4**, 2010, pp.1089-1101.
- [36] A. Sinhababu, A. Banerjee, *Ethno-botanical Study of Medicinal Plants Used by Tribals of Bankura Districts, West Bengal, India*, **Journal of Medicinal Plants Studies**, **1**, 2013, pp.98-104.
- [37] A. Kovoor, **The Palmyra Palm: Potential and Perspectives**, FAO Plant Production and Protection Paper, FAO, 1983.
- [38] H.N. Jagadish, K. Damodaran, S. A. Padmanabhan, B.S. Swathanarayana, X. Francis, S.Z.M. Kamal, H.G. Reddy, **Studies on Palmyra Wood**, IPIRTI Res. Rep. 69. 1993.
- [39] D. Depommier, *The tree behind the forest: ecological and economic importance of traditional agroforestry systems and multiple uses of trees in India*, **Tropical Ecology**, **44**(1), 2003, pp. 63-71.
- [40] T.A.,Davis, D.V. Johnson, *Current utilization and further development of the Palmyra(Borassus flabellifer L. Arecaceae) in Tamil Nadu State, India*, **Economic Botany**, **41**, 1987, pp.247-266.
- [41] M.P. Rana, M.S. Islam, *The role of palm husbandry in the rural economy of the south-eastern region of Bangladesh*, **iForest**, **3**, 2010, pp. 39-43.
- [42] J. Beer, **Experiences with fence line fodder trees in Costa Rica and Nicaragua**, In: J. Beer, H.W. Fassbender, J. Heuveldop (eds.), **Advances in Agroforestry Research**, CATIE Technical Series. CATIE, Costa Rica, 1987, pp. 215–222.
- [43] B. Frank, E. Salas, *Biomass dynamics of Erythrina landecolata as influenced by shoot-pruning intensity in Costa Rica*, **Agroforestry Systems**, **57**, 2003, pp. 19–28.
- [44] M.V. Gokhale, S.S. Shaikh, N.S. Chavan, *Ensete superbum (Roxb) Cheesm: Potential plant species for ecorestoration programme*, **International Journal of Usufruct Management**, **11**(1), 2010, pp. 90-93.
- [45] B.A. Jadeja, N.K. Odedra, M.B. Shilu, *Plants used as fencing in Porbandar District of Gujrat*, **International Journal of Agricultural Science**, **3**(1), 2007, pp.174-176.
- [46] P.B. Eyzaquirre, O. F. Linares, *A new approach to the study and promotion of homegardens*. **People and Plants Handbook: Issue 7: Growing Diversity – People and Plant Genetic Resources**, WWF-UNESCO-RBG, Kew, 2001, pp. 30–33.

Received: April 12, 2017

Accepted: June 02, 2018