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# REGENERATION PATTERN OF TREES IN SACRED GROVES – A COMPARATIVE STUDY

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**ABSTRACT** Sacred groves are the relics of original vast gregarious forest vegetation which are safeguarded by the society or local people in the name of worship of deities. In many parts of India, sacred groves are representative of surviving examples of climax vegetation. The richness, health and sustainability of natural forest mainly depend on the diversity, distribution and regeneration pattern of trees than any other plant groups in the ecosystem. Evaluating the regeneration pattern of trees, their diversity and distribution in the area would be useful in understanding the stability and richness of vegetation. The present study analyzed the regeneration pattern of selected sacred groves (Sankulangara sacred grove and Palliyana sacred grove) and its adjacent disturbed non-sacred grove lands. The tree regeneration analysis done in the selected sacred groves revealed that greater seedling and sapling densities with reverse J-shaped curve exhibited by good proportion of the total tree species. This implies satisfactory regeneration behavior of these tree species. So, it is necessary to continue the protection of such groves by providing additional support from government bodies and NGOs for joint management to address the conservation activities very efficiently to be sustainable for the future.

**KEYWORDS :** Climax vegetation, Conservation, Natural forest, Plant diversity, Regeneration, Tree species

## INTRODUCTION

The richness, health and sustainability of natural forest mainly depend on the diversity, distribution and regeneration pattern of trees than any other plant groups in the ecosystem. However, during the course of time, different man-made disturbances and activities like over exploitation of forest resources particularly for timber and the deforestation practices for various developmental activities have resulted in the degradation of majority of the forest area. Be the forest area large or small as patches, trees form the major structural and functional basis in maintaining the ecosystem balance in the area and they can serve as indicators of changes and disturbance pressures affecting landscape (Jayakumar & Nair, 2013). Evaluating the regeneration pattern of trees, their diversity and distribution in the area would be useful in understanding the stability and richness of vegetation. This study was undertaken to assess the regeneration status of trees in view of degree of protection and disturbance in the selected sacred groves and non-sacred grove lands to predict what would be the status of tree species composition in future and why it should be so.

## OBJECTIVES

- To assess the regeneration pattern of trees in selected sacred groves and its adjacent disturbed non-sacred grove lands.
- Comparative study of regeneration pattern of trees in selected study sites.

## MATERIALS AND METHODS

Two sacred groves are selected for detailed study – Sankulangara sacred grove SN puram and Palliyana sacred grove Vatanapally Thrissur District, Kerala and its adjacent disturbed non-sacred grove lands. Regeneration studies of trees in sacred groves and adjacent disturbed non-sacred grove lands are carried out based on the method followed by Induchoodan (1998) and Uma Shankar (2001). The selected study areas are divided in to approximately four equal divisions and all the tree species having girth at breast height (GBH) less than 10 cm in each division are considered for the study. The regeneration status of each tree species is analyzed through enumeration and their classification according to the height growth stage as follows

1. Seedling stage
Tree growth height class 1 - less than 20 cm in height
Tree growth height class 2 - 20 to 40 cm in height

2. Sapling stage
Tree growth height class 3 - 41 to 100 cm in height
Tree growth height class 4 - greater than 100 cm in height
The height growth class1 and 2 are considered as early seedling stage and late seedling stage respectively while height growth class 3 and 4 are considered as early sapling stage and late sapling stage respectively.

## RESULTS AND DISCUSSIONS

### A) Sankulangara sacred grove and disturbed non-sacred grove land

The data on regeneration pattern of different tree species in the Sankulangara sacred grove is shown in the table 1. The tree species like *Aphanamixis polystachya, Cinnamomum malabathrum, Hopea ponga, Vateria indica, Artocarpus hirsutus, Hydnocarpus pentandrus, Mimusops elengi, Olea diocia, Persea macrantha, Caryota urens, Holigarna arnottiana, Tabernaemontana alternifolia, Quassia indica* and *Vitex altissima* exhibited normal conventional regeneration pattern. In these species, the representation of tree in early seedling growth stage is comparatively higher and progressive reduction in regenerate density towards the late sapling growth stage. The tree species such as *Adenanthera pavonina, Aporosa cardiosperma, Areca catechu, Carallia branchiata, Garcinia gummi-gutta, Litsea coriaceae, Pinanga dicksonii* and *Sterculia guttata* showed irregular regeneration pattern. In these cases, the tree species representation is not following either an ascending or descending order in the regenerate density from first to last height growth class. Instead, it is observed that the pattern is not consistently increasing or decreasing. Another regeneration pattern observed in the study is incomplete or discontinuous regeneration pattern. This includes representation of tree either in seedling stage or in the sapling stage or both but lack of representation in one or more height growth class. The tree species found belonging to such category include *Pouteria campechiana* (upto 20cm height class-seedling stage), *Ficus amplissima, Ficus benghalensis,*

*Ficus drupaceae, Saraca asoca, Syzygium hemisphericum* & *Terminalia catappa* (upto 40cm height classes -seedling stage), *Chrysophyllum cainito* & *Syzygium lanceolatum* (above 40cm-100cm height growth class-sapling stage) and *Xanthophyllum arnottianum* (above100cm height growth class-sapling stage). Besides all these, the trees such as *Ficus religiosa, Strychnos nux-vomica, Terminalia bellirica* and *Vitex pinnata* showed no regeneration, not even a single seedling represented in any of the height growth classes considered for the study.

**Table 1: Regeneration pattern of trees in Sankulangara sacred grove**

| SI NO | NAME OF SPECIES | FAMILY | TREE GROWTH CLASSES | | | | |
|---|---|---|---|---|---|---|---|
| | | | Seedling stage | | Sapling stage | | Adult trees |
| | | | <20cm | 20-40 cm | 41-100 cm | >100 cm <10cm GBH | >10cm GBH |
| 1 | *Adenanthera pavonina* | Leguminosae | 3 | 4 | 3 | 3 | 3 |
| 2 | *Aphanamixis polystachya* | Meliaceae | 28 | 12 | 8 | 6 | 12 |
| 3 | *Aporosa cardiosperma* | Euphorbiaceae | 9 | 8 | 7 | 9 | 16 |
| 4 | *Areca catechu* | Arecaceae | 3 | 4 | 3 | 3 | 4 |
| 5 | *Artocarpus hirsutus* | Moraceae | 72 | 42 | 24 | 21 | 30 |
| 6 | *Carallia branchiata* | Rhizophoraceae | 3 | 4 | 2 | 3 | 3 |
| 7 | *Caryota urens* | Arecaceae | 43 | 22 | 8 | 6 | 32 |
| 8 | *Chrysophyllum cainito* | Sapotaceae | 0 | 0 | 2 | 4 | 4 |
| 9 | *Cinnamomum malabatrum* | Lauraceae | 18 | 9 | 8 | 4 | 14 |
| 10 | *Ficus amplissima* | Moraceae | 8 | 3 | 0 | 0 | 11 |
| 11 | *Ficus benghalensis* | Moraceae | 12 | 4 | 0 | 0 | 1 |
| 12 | *Ficus drupaceae* | Moraceae | 5 | 3 | 0 | 0 | 4 |
| 13 | *Ficus religiosa* | Moraceae | 0 | 0 | 0 | 0 | 1 |
| 14 | *Garcinia gummi-gutta* | Clusiaceae | 6 | 6 | 7 | 5 | 9 |
| 15 | *Holigarna arnottiana* | Anacardiaceae | 26 | 19 | 11 | 9 | 14 |
| 16 | *Hopea ponga* | Dipterocarpaceae | 93 | 50 | 38 | 31 | 101 |
| 17 | *Hydnocarpus pentandrus* | Flacourtiaceae | 40 | 29 | 18 | 13 | 24 |
| 18 | *Litsea coriacea* | Lauraceae | 3 | 2 | 4 | 2 | 5 |
| 19 | *Mimusops elengi* | Sapotaceae | 28 | 21 | 13 | 11 | 12 |
| 20 | *Olea diocia* | Oleaceae | 25 | 17 | 7 | 3 | 19 |
| 21 | *Persea macrantha* | Lauraceae | 22 | 9 | 8 | 2 | 6 |
| 22 | *Pinanga dicksonii* | Arecaceae | 9 | 5 | 5 | 8 | 9 |
| 23 | *Pouteria campechiana* | Sapotaceae | 16 | 0 | 0 | 0 | 1 |
| 24 | *Quassia indica* | Simaroubaceae | 34 | 20 | 7 | 5 | 27 |
| 25 | *Saraca asoca* | Leguminosae | 3 | 1 | 0 | 0 | 2 |
| 26 | *Sterculia guttata* | Sterculiaceae | 6 | 5 | 2 | 5 | 4 |
| 27 | *Strychnos nux-vomica* | Loganiaceae | 0 | 0 | 0 | 0 | 1 |
| 28 | *Syzygium hemisphericum* | Myrtaceae | 6 | 2 | 0 | 0 | 2 |
| 29 | *Syzygium lanceolatum* | Myrtaceae | 0 | 0 | 2 | 6 | 4 |
| 30 | *Tabernaemontana alternifolia* | Apocynaceae | 22 | 11 | 6 | 3 | 12 |
| 31 | *Terminalia bellirica* | Combretaceae | 0 | 0 | 0 | 0 | 1 |
| 32 | *Terminalia catappa* | Combretaceae | 10 | 3 | 0 | 0 | 1 |
| 33 | *Vateria indica* | Dipterocarpaceae | 42 | 35 | 20 | 18 | 31 |
| 34 | *Vitex altissima* | verbenaceae | 21 | 18 | 8 | 4 | 8 |
| 35 | *Vitex pinnata* | Verbenaceae | 0 | 0 | 0 | 0 | 2 |
| 36 | *Xanthophyllum arnottianum* | Polygalaceae | 0 | 0 | 0 | 4 | 17 |
| **Total (Height class wise)** | | | **616** | **368** | **221** | **188** | **447** |

The result of the tree regeneration study conducted in the disturbed non-sacred grove land at S.N.Puram is shown in the table 2. The regeneration pattern exhibited by majority of the tree members is mostly incomplete in nature. Tree species like *Briedelia retusa, Carallia branchiata* (40cm-100cm), *Ailanthus triphysa, Anacardium occidentale, Artocarpus heterophyllus, Cinnamomum verum, Garcinia gummi-gutta, Mangifera indica, Terminalia catappa, Vitex altissima* (40cm-above 100cm), *Areca catechu, Swietenia macrophylla, Tectona grandis* (above 100cm) are belonging to this kind of regeneration pattern. *Tabernaemontana alternifolia* is the only tree species which exhibited the normal regeneration pattern. Tree species like *Artocarpus hirsutus* and *Hydnocarpus pentandrus* exhibit complete but irregular regeneration pattern. The tree species *Cocos nucifera* and *Annona squamosa* showed no regeneration.

**Table 2: Regeneration pattern of trees in the disturbed non-sacred grove land**

| SI NO | NAME OF SPECIES | FAMILY | TREE GROWTH CLASSES | | | | |
|---|---|---|---|---|---|---|---|
| | | | Seedling stage | | Sapling stage | | Adult trees |
| | | | <20cm | 20-40 cm | 41-100 Cm | >100 cm <10cm GBH | >10cm GBH |
| 1 | *Ailanthus triphysa* | Simaroubaceae | 0 | 0 | 1 | 1 | 2 |
| 2 | *Anacardium occidentale* | Anacardiaceae | 0 | 0 | 2 | 2 | 2 |
| 3 | *Annona squamosa* | Annonaceae | 0 | 0 | 0 | 0 | 1 |
| 4 | *Areca catechu* | Arecaceae | 0 | 0 | 0 | 2 | 13 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | *Artocarpus heterophyllus* | Moraceae | 0 | 0 | 3 | 2 | 2 |
| 6 | *Artocarpus hirsutus* | Moraceae | 2 | 3 | 1 | 2 | 2 |
| 7 | *Briedelia retusa* | Euphorbiaceae | 0 | 0 | 2 | 0 | 1 |
| 8 | *Carallia branchiata* | Rhizophoraceae | 0 | 0 | 1 | 0 | 1 |
| 9 | *Cinnamomum verum* | Lauraceae | 0 | 0 | 1 | 4 | 2 |
| 10 | *Cocos nucifera* | Arecaceae | 0 | 0 | 0 | 0 | 16 |
| 11 | *Garcinia gummi-gutta* | Clusiaceae | 0 | 0 | 1 | 2 | 2 |
| 12 | *Hydnocarpus pentandrus* | Flacourtiaceae | 9 | 4 | 4 | 7 | 3 |
| 13 | *Mangifera indica* | Anacardiaceae | 0 | 0 | 1 | 2 | 1 |
| 14 | *Swietenia macrophylla* | Meliaceae | 0 | 0 | 0 | 1 | 1 |
| 15 | *Tabernaemontana alternifolia* | Apocynaceae | 12 | 9 | 5 | 2 | 5 |
| 16 | *Tectona grandis* | Verbenaceae | 0 | 0 | 0 | 2 | 1 |
| 17 | *Terminalia catappa* | Combretaceae | 0 | 0 | 1 | 3 | 1 |
| 18 | *Vitex altissima* | Verbenaceae | 0 | 0 | 2 | 2 | 1 |
| **Total (Height class wise)** | | | **23** | **16** | **25** | **34** | **57** |

### B) Palliyana sacred grove and disturbed non-sacred grove land

The details of regeneration pattern of tree species in the Palliyana sacred grove are given in the table 3. The tree species like *Aphanamixis polystachya*, *Artocarpus hirsutus*, *Cinnamomum malabatrum*, *Hydnocarpus pentandrus*, *Holigarna arnottiana*, *Persea macrantha*, *Pongamia pinnata*, *Vitex altissima*, *Caryota urens*, *Mimusops elengi*, *Olea diocia*, *Sterculia guttata*, *Tabernaemontana alternifolia* and *Quassia indica* exhibited normal regeneration pattern. The data indicates large number of tree species such as *Adenanthera pavonina*, *Aporosa cardiosperma*, *Areca catechu*, *Anacardium occidentale*, *Briedelia retusa*, *Diospyros malabarica*, *Garcinia gummi-gutta*, *Streblus asper*, *Litsea coriacea*, *Syzygium cumini* and *Vateria indica* exhibited irregular order in the regeneration pattern.

The incomplete regeneration pattern is exhibited by tree species like *Alstonia scholaris*, *Ficus benghalensis*, *Saraca asoca* (upto 40cm height), *Strychnos nux-vomica*, *Syzygium caryophyllatum*, *Xanthophyllum arnottianum* (40cm-above 100cm height) and *Polyalthia longifolia* (upto 100cm height) *Chrysophyllum cainito* (21cm-above 100cm height). The tree species *Ficus religiosa* and *Terminalia bellirica* showed no representation of seedling in any of the height growth classes (no regeneration).

**Table 3: Regeneration pattern of trees in Palliyana sacred grove**

| SI NO | NAME OF SPECIES | FAMILY | TREE GROWTH CLASSES | | | | |
|---|---|---|---|---|---|---|---|
| | | | Seedling stage | | Sapling stage | | Adult trees |
| | | | <20 cm | 20-40 cm | 41-100 cm | >100 cm <10cm GBH | >10cm GBH |
| 1 | *Adenanthera pavonina* | Leguminosae | 6 | 3 | 5 | 3 | 8 |
| 2 | *Alstonia scholaris* | Apocynaceae | 9 | 1 | 0 | 0 | 1 |
| 3 | *Anacardium occidentale* | Anacardiaceae | 2 | 3 | 1 | 4 | 7 |
| 4 | *Aphanamixis polystachya* | Meliaceae | 28 | 13 | 9 | 3 | 22 |
| 5 | *Aporosa cardiosperma* | Euphorbiaceae | 5 | 1 | 4 | 3 | 10 |
| 6 | *Areca catechu* | Arecaceae | 4 | 2 | 3 | 2 | 9 |
| 7 | *Artocarpus hirsutus* | Moraceae | 34 | 15 | 8 | 7 | 23 |
| 8 | *Briedelia retusa* | Euphorbiaceae | 3 | 1 | 3 | 2 | 4 |
| 9 | *Caryota urens* | Arecaceae | 26 | 11 | 6 | 3 | 13 |
| 10 | *Chrysophyllum cainito* | Sapotaceae | 0 | 2 | 8 | 12 | 10 |
| 11 | *Cinnamomum malabatrum* | Lauraceae | 17 | 12 | 4 | 3 | 15 |
| 12 | *Diospyros malabarica* | Ebenaceae | 4 | 6 | 3 | 5 | 2 |
| 13 | *Ficus benghalensis* | Moraceae | 3 | 1 | 0 | 0 | 1 |
| 14 | *Ficus religiosa* | Moraceae | 0 | 0 | 0 | 0 | 1 |
| 15 | *Garcinia gummi-gutta* | Clusiaceae | 7 | 3 | 5 | 9 | 12 |
| 16 | *Holigarna arnottiana* | Anacardiaceae | 32 | 18 | 9 | 5 | 20 |
| 17 | *Hydnocarpus pentandrus* | Flacourtiaceae | 28 | 17 | 11 | 8 | 20 |
| 18 | *Litsea coriacea* | Lauraceae | 3 | 7 | 3 | 4 | 12 |
| 19 | *Mimusops elengi* | Sapotaceae | 28 | 9 | 5 | 4 | 13 |
| 20 | *Olea diocia* | Oleaceae | 18 | 14 | 8 | 4 | 10 |
| 21 | *Persea macrantha* | Lauraceae | 25 | 15 | 9 | 5 | 16 |
| 22 | *Polyalthia longifolia* | Annonaceae | 9 | 5 | 1 | 0 | 3 |
| 23 | *Pongamia pinnata* | Leguminosae | 17 | 11 | 7 | 3 | 19 |
| 24 | *Quassia indica* | Simaroubaceae | 31 | 13 | 9 | 7 | 14 |
| 25 | *Saraca asoca* | Leguminosae | 5 | 1 | 0 | 0 | 1 |
| 26 | *Sterculia guttata* | Sterculiaceae | 15 | 12 | 8 | 5 | 19 |
| 27 | *Streblus asper* | Moraceae | 5 | 7 | 4 | 6 | 4 |
| 28 | *Strychnos nux-vomica* | Loganiaceae | 0 | 0 | 0 | 2 | 3 |
| 29 | *Syzygium caryophyllatum* | Myrtaceae | 0 | 0 | 1 | 3 | 5 |
| 30 | *Syzygium cumini* | Myrtaceae | 9 | 2 | 5 | 3 | 11 |
| 31 | *Tabernaemontana alternifolia* | Apocynaceae | 10 | 6 | 5 | 2 | 4 |
| 32 | *Terminalia bellirica* | Combretaceae | 0 | 0 | 0 | 0 | 2 |
| 33 | *Vateria indica* | Dipterocarpaceae | 9 | 3 | 5 | 4 | 3 |
| 34 | *Vitex altissima* | Verbenaceae | 27 | 11 | 7 | 5 | 16 |
| 35 | *Xanthophyllum arnottianum* | Polygalaceae | 0 | 0 | 1 | 2 | 8 |
| **Total (Height class wise)** | | | **419** | **225** | **157** | **128** | **341** |

The tree regeneration study conducted in the disturbed land at Palliyana site showed *Gliricidia sepium* and *Garcinia gummi-gutta* are the two tree species which exhibited a normal pattern of regeneration (table 4). The tree species *Anacardium occidentale*, *Artocarpus hirsutus* and *Lannea coromandelica* followed irregular order in the regeneration pattern. The majority of the tree species in the disturbed land exhibited incomplete or discontinuous regeneration pattern. This includes *Terminalia catappa*, *Vitex altissima* (40cm-above 100cm), *Mangifera indica* (upto 20cm and above 100cm), *Cocos nucifera*, *Areca catechu*, *Azadirachta indica* (above 100cm). Representation of tree species in any of the height growth classes is not recorded by *Tectona grandis*.

**Table 4: Regeneration pattern of trees in the disturbed non-sacred grove land**

| SI NO | NAME OF SPECIES | FAMILY | TREE GROWTH CLASSES | | | | |
|---|---|---|---|---|---|---|---|
| | | | Seedling stage | | Sapling stage | | Adult trees |
| | | | <20cm | 20-40 cm | 41-100 cm | >100 cm <10cm GBH | >10cm GBH |
| 1 | *Anacardium occidentale* | Anacardiaceae | 4 | 2 | 1 | 3 | 2 |
| 2 | *Areca catechu* | Arecaceae | 0 | 0 | 0 | 3 | 13 |
| 3 | *Artocarpus hirsutus* | Moraceae | 5 | 1 | 2 | 6 | 2 |
| 4 | *Azadirachta indica* | Meliaceae | 0 | 0 | 0 | 2 | 3 |
| 5 | *Cocos nucifera* | Arecaceae | 0 | 0 | 0 | 7 | 14 |
| 6 | *Garcinia gummi-gutta* | Clusiaceae | 9 | 5 | 3 | 2 | 2 |
| 7 | *Gliricidia sepium* | Leguminosae | 15 | 7 | 3 | 2 | 4 |
| 8 | *Lannea coromandelica* | Anacardiaceae | 7 | 1 | 3 | 4 | 2 |
| 9 | *Mangifera indica* | Anacardiaceae | 1 | 0 | 0 | 3 | 1 |
| 10 | *Tectona grandis* | Verbenaceae | 0 | 0 | 0 | 0 | 1 |
| 11 | *Terminalia catappa* | Combretaceae | 0 | 0 | 5 | 2 | 1 |
| 12 | *Vitex altissima* | verbenaceae | 0 | 0 | 3 | 2 | 1 |
| **Total (Height class wise)** | | | **41** | **16** | **20** | **36** | **46** |

The analysis of regeneration pattern of tree species in the selected disturbed non-sacred grove lands revealed, majority of the tree species showed incomplete regeneration pattern. This is about 72.22%, 50%, of total tree species in the disturbed lands respectively at Sankulangara, Palliyana study sites. Tree species with no regenerate representation in all the height growth classes are 11.11% in Sankulangara, 8.33% in Palliyana, However, good or fairly good regeneration pattern are followed by only 16.67% of tree species in the disturbed land at Sankulangara, 41.67% at Palliyana. The tree species *Tabernaemontana alternifolia* at Sankulangara and *Garcinia gummi-gutta* and *Gliricidia sepium* at Palliyana site are the only species which exhibited normal regeneration pattern. The analysis of sum total of regenerate density from height growth class1 to height growth class 4 in disturbed lands revealed comparatively higher regenerate density recorded either in the later growth stage of sapling (class 4) or in the early growth stage of seedling (class 1) and lower regenerate density recorded in between these two classes. This indicates non-sustainable regeneration pattern exist in disturbed non-sacred grove lands and clearly revealed high anthropogenic disturbances.

The observations done in the selected sacred grove lands revealed those tree species with good or fairly good regeneration pattern are generally the dominant tree species in the area. However, the phytosociological data of tree species analysed in the disturbed lands revealed, *Cocos nucifera* and *Areca catechu* are the dominant tree species, though their regeneration status is very poor or not even represented a single regenerate in any of the height growth classes. This clearly revealed high human interference in the area and comparatively higher values of phytosociological data of these tree species in the disturbed land which may be the result of human cultivation as part of agriculture.

## Conclusion

The tree regeneration analysis done in the selected sacred groves revealed that greater seedling and sapling densities with reverse J-shaped curve exhibited by good proportion of the total tree species. This implies satisfactory regeneration behavior of these tree species. However, considerable reduction in the seedlings and saplings density in the selected non-sacred grove lands with incomplete regeneration or even total absence of regenerate representation is exhibited by majority of the tree species. This indicates poor regeneration status. The higher regenerate density with good regeneration status of majority of the tree species recorded in the studied sacred groves is due to protection and conservation of these groves by the local communities based on their religious beliefs. However, the opposite situation in the regeneration process observed in the selected non-sacred grove lands is due to the lack of protection and high anthropogenic disturbances. The study suggests it is necessary to continue the protection of such groves by providing additional support from government bodies and NGOs for joint management to address the conservation activities very efficiently to be sustainable for the future.

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