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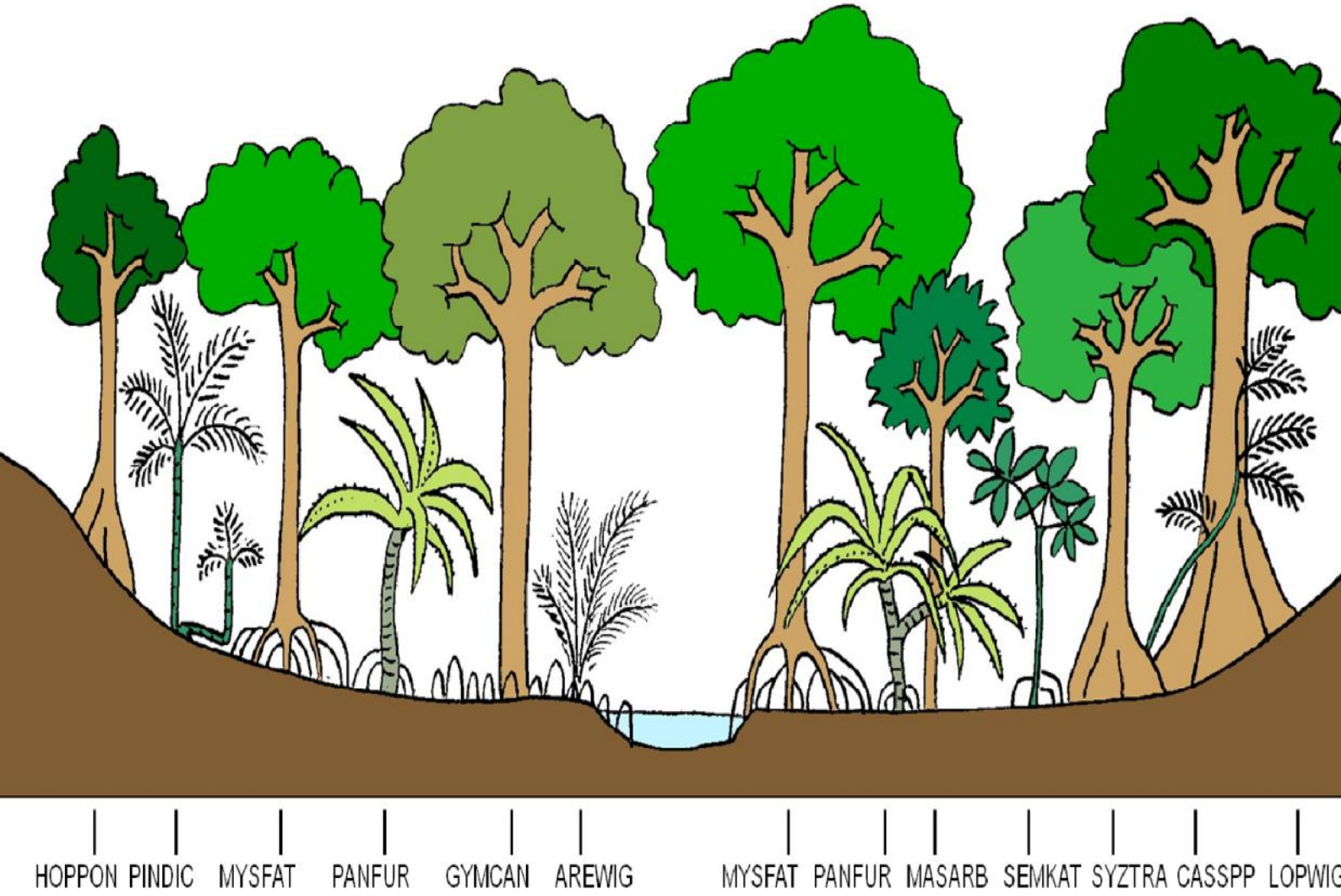
Towards ecological restoration of critically endangered fresh water swamps in central Western Ghats: Blending sustainable cultural practices with scientific methods



Linking fragmented fresh water swamps through restoration of micro-corridors, Central Western Ghats, India

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Towards ecological restoration of critically endangered fresh water swamps in central Western Ghats: Blending sustainable cultural practices with scientific methods

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Summary

Freshwater swamps are one among the globally recognized, critically endangered habitats, prioritized for restoration in the Western Ghats. Some of these swamps are also considered sacred and thus have heritage value. Today many of these ecosystems are being degraded primarily due to human interference. Central to restoring these degraded ecosystems is the participation by communities in restoration actions. Under a project funded by the Critical Ecosystem Partnership Fund (CEPF), we have undertaken the restoration of six degraded patches of freshwater swamps in the central Western Ghats, India adopting a participatory approach. Baseline data on the levels of dependency of local people on swamps and threat were collected and analyzed. The local people were empowered through the creation of village forest committees, swamp restoration committees, and a community trust fund. Communities were also technically empowered to collectively raise nurseries of swamp species for an operation level planting. By revitalizing local traditions of swamp-tree-worship, the restoration was made more inclusive to people. In order to reduce the dependency of local people on swamps, community assets like fuel-efficient ovens, driers and solar lighting systems were installed through CEPF grants and by raising matching grants from other state-departments in villages. Awareness building activities through trainings, workshops, meetings and publications was done.

Key words: Freshwater swamp, ecological restoration, participatory approach, Western Ghats.

1. Introduction

1.1 Fresh water swamps

Fresh water swamp forests elude any simple definition. These are broadly understood as forests in poorly drained depressions inundated with fresh water either permanently or seasonally associated with and often open into river/rivulet. Sometimes ground water levels in swamps lie very close to the ground surface itself. Gore, (1983; Anon, 2005). Mires, marshes and wetlands were brought under the fold of swamps, Cunnigham and Saigo (1990) considered only those wetlands with trees as swamps. Champion and Seth (1968) included under the group 'Littoral and swamp forests' the subgroup of "Tropical Fresh Water Swamp Forest". Fresh water swamps (as tree covered wetlands) are found in the Siwalik, the Dun valley and Brahmaputra valley apart from the Western Ghat regions of South India, specially from the States Karnataka and Kerala (Varghese and Menon, 1999).

In Uttara Kanada district of central Western Ghats these swamps being dominated by members of the Myristicaceae family are known as *Myristica* swamps. The *Myristica* swamps are critically endangered ecosystems in the Central Western Ghats (Vasudeva et al. 2003). These habitats are now reduced to highly fragmented and tiny pockets because of anthropogenic impacts through centuries. Chandran (1997) points out that these habitats have become endangered because of their conversion in to arecanut gardens and fields of summer rice.

We have observed in the field that alterations of natural hydrologic regimes through draining, pollution due to application of pesticides and fertilizers, diversion of stream waters to farmlands, excessive growth of exotic or invasive species, especially in degraded and open swamps, and conversion of swamps and adjoining areas into cultivation as major threats to the swamp ecosystems. . During our field surveys were also observed swamp area conversions into arecanut cum banana plantations. Presence of decayed and dried up stumps of swamp trees associated with such gardens indicate the grave threats swamps have been passing through to almost their near decimation currently calling for urgent action to save them. This situation related to the downfall and near extinction of a primeval ecosystem from the Western Ghats prompted us to initiate the course of activities delineated in this paper aiming at ecological restoration of the Myristica swamps of the Central Western Ghats. As people have been involved in reclaiming swamps for agriculture, as was earlier done by their ancestors, we considered winning their confidence, support and, over and above, seeking

their very partnership itself as an important step needed for the restoration of swamps. Divided in to six parts the paper explains about ecological restoration, methods used for this participatory ecological restoration, results, discussions and finally the conclusion.

1.2 Ecological restoration

Conversion of natural habitats into agricultural and industrial landscapes, and ultimately into degraded land, is the major impact of humans on the natural environment, posing a great threat to biodiversity (Dobson et al 1997). Impacts of long-term habitat conversion may occur over a much longer time scale as individual species become threatened and eventually go extinct. The emerging discipline of restoration ecology provides a powerful suite of tools for speeding the recovery of degraded lands. In doing so, restoration ecology provides a crucial complement to the establishment of nature reserves as a way of increasing land for the preservation of biodiversity (Clewel and Aronson 2007; Jordan et al 1987). Ecological restoration is the process of assisting the recovery and management of ecological integrity. Ecological integrity includes a critical range of variability in biodiversity, ecological processes and structures, regional and historical context and sustainable cultural practices (http:// www.ser.org/definitions.html). Major goal of ecological restoration is that establishment of characteristics of an ecosystem such as biodiversity and ecological function that were prevalent before degradation (Bakker et al 2000; Lamb et al 2005; Diggelen et al 2005).

1.3 Study sites

Uttara Kannada district in the central Western Ghats of Karnataka State, India is the focal work area adopted for restoration of swamps and related studies. The district is bordered by Goa state and Belgaum district in the north, Arabian Sea in the West, Shimoga and Dharwad in the east and Udupi district towards South. Notably, Uttara Kannada it is one of the biggest and densely wooded districts of the Western Ghats (population 140 inhabitants per sq. kilometres) with bounty of natural resources. The district has a variety of forest types ranging from wet evergreen to dry deciduous types, with annual rainfall as the major decisive factor, although the humans here have overwhelming role in changing any kind of natural vegetation. Despite the rising human threats it needs to be stated that of the 10250 km² of its geographical area forests cover almost 8280 km². The cultivation, occupying a minimal part of the land covers only relatively small area of 1200 km² (12%).

Uttara Kannada (lat.13° 55'-15' 31' N and long. 74°09'-75°10' E), a district features a rugged landscape of steeply rising hills of central Western Ghats, parallel to the Arabian Sea, leaving a narrow coastal strip interrupted by promontories and foothills and estuaries of west flowing rivers. The Ghats have average height of 500 m with occasional hills attaining almost 800 m. The annual precipitation is largely confined to the monsoon months of June to September. The average annual rainfall ranges from 3500- 4000 mm along the coast, rising to 4500 mm along the crest line. The quantum of rain declines rapidly down to 1000 mm towards the rainshadow eastern plateau region (District Statistics Bureau, 2011). Four major west flowing rivers descending steeply from the Ghats run their short westward course through the narrow coastal zone and join the Arabian Sea. Our study sites were associated with the basins of three of these rivers namely, Sharavathi, Aghanashini and Bedthi or along their tributaries. Our focal area swamps are demarcated alongside five river/tributary catchments namely Sharavati, Bilgi, Mukthi, Aghanshini and Bedthi (Fig).

2. Methods

a) Identification and mapping of the fresh water swamps using GPS and GIS, through extensive field surveys. Meetings were held with local communities andforest department, for concurrence on selection of critical micro-corridors for restoration to link the fragmented swamp patches.. Using quantum GIS software these points were put into geo-referenced topo-sheets to generate the spatial distribution map of swamps

b) In order to classify the swamps, threat parameters such as average distances from the village settlement, roads, commercial orchards, population density, possibility of land use change, water diversion and area of the swamp were recorded for each of the swamps. Each parameter was scored based on their level of disturbance as 0, 1, 2 and 3 which are considered as threat category scanty, low, minimum (medium) and high respectively and for ecological potential, categorized in the reverse order namely: high, medium, low and scanty. Further combining this ecological potential with threats, the swamps were categorized into four classes. For the ecological potential the median number arrived at were 2.77 and for the threat median were 2.8.

C) Detailed floristic composition studies were conducted in randomly selected swamps by running a line transect of 5 m breadth along the stream course of selected swamp. The species which are indicators of habitat disturbances, and others which are typical to swamps such as

those with specialized modifications for the swampy conditions are treated as facultative and obligatory species respectively.

d) To enable the active participation of local villagers decentralized nurseries were established close to the swamp through community participation for raising typical swamp specific species as well as swamp associated species.

e) Active planting of degraded swamps with swamp and associated species was done during period from 2010-2012. Each plant was tagged with a plate displaying a number and date of planting. These plants were observed for two years to record the survival and growth.

e) Re-wetting of the land was carried out through adopting soil and moisture conservation measures in the degraded swamps

f) Community participation ensured towards restoration and management

3. Results

a) In the process of survey and documentation, one hundred two swamps were identified in the district (Annexure I). In the district this listing is the more comprehensive one as of now. The area of the swamps measured was varied from 0.1 ha to 2.1 hectares with total depression area of about 82 hectares (table 1).

Table 1.Details of swamps in different river catchment area.

	Sharavati	Bedti	Aghanashini	Mukti	Bilgi
Total number of swamps	15	17	25	23	18
Total area of swamp (depression part) in Ha		13	17	22	18
Number of swamps restored	6	0	0	2	1
Average area of swamp (Ha)	0.755 (SDV 0.549)	0.575 (SDV 0.438)	0.65 (SDV 0.382)	0.757 (SDV 0.453)	0.99(SDV 0.422)
Minimum area (Ha)	0.5	0.4	0.1	0.25	0.4
Maximum area (Ha)	2.1	1.5	1.5	2	2

b) The *Myristica* swamps are situated in the catchment areas of three major and two minor rivers of Uttara Kannada district covering a total area of about 82 ha. The study provides for

the first time details of the unique floristic composition of many of these swamps. We recorded altogether 164 species of flowering plants belonging to 126 genera under70 families (Appendix). Of these, 5% (8 species) were obligatory swamp species which included 5 tree species (*Gymnacranthera canarica* (Red Listed as Vulnerable), *Myristica fatua* (Endangered), *Semecarpus kathalekanesis* (recently discovered and extremely rare), *Syzygium travancoricum* (Critically Endangered) and *Mastixia arborea*, *Pinanga dicksonii, and Lophopetalum wightianum*. Shrubs, small trees and herb of one species each respectively were present. Of the rest 35% (58 sp), 49% (80 sp) and 11% (18 sp) were found to be facultative of evergreens with relatively wide choice of habitats including swampy areas, invasive evergreens and deciduous species which appeared probably after instances of man-made fires.

Cluster wise species composition revealed that, Mukthi and Bilgi clusters are with maximum of 87 and 72 species followed by Sharavathi and Aghanashini clusters with 66 and 64 species respectively and least was with Bedthi cluster having 41 species.

The species diversity indices of entire study area were calculated separately for trees and woody, shrubs/climbers and herbs. The Shannon (H') diversity index for entire swamp clusters were 3.23, 2.77 and 2.03 for trees, shrubs and herbs respectively. The Simpson values of 0.08, 0.1 and 0.2 respectively for trees, shrubs and herbs respectively and the highest evenness value recorded was for shrubs (0.48) followed by trees(0.44) and herbs (0.39).

Among the catchments highest Shannon-Weiner value recorded (H') was for Mukthi catchment (3.17) followed by Bilgi (2.99), Sharavathi and Bedthi (2.72 each) and least species diversity was in Aghanashini catchment (2.39).

Of the 70 families of flowering plants Euphorbiaceae was leading (13 species) followed by Rubiaceae (10), Moraceae and Myrtaceae (9 each), Lauraceae (8), Clusiaceae (6) and Mysristicaceae (5). 61 families were represented by less than 5 species. The family Ebenaceae was represented by 6 species all under a single genus *Diospyros*.

c) List of swamps that are classified in to four categories and their characteristics are as follows;

There are 38 different swamps in the (high) threat category and with scanty ecological potential. 18 swamps are with high ecological potential but facing also high threats; out of these18 swamps 6 are in the Bedthi river catchment area. Four swamps are third category having fairly low ecological strength but threats can be considered scanty. Number of swamps that are categorized in the cell having less threats and substantial ecological potential are 33, which fall in the fourth category (annex 3, figure 5).

Obviously the swamps categorized under first category are facing heavy threat. At least fifteen swamps in the extreme left cells are on the verge of extinction. These swamps needed great efforts at restoration. Different steps in the ecological restoration processes to be carefully followed were: soil amendments, re-wetting of the soil, stakeholder involvement, planting larger number of swamp and associated species, establishing or rejuvenating community organizations like Village Forest Committees etc. Moreover larger budgets are required to conserve these swamps. Management plans for the swamps that are categorized as having high threats and more ecological potential (second category of swamps) and low threats and low ecological potential (third category) may be bringing protection measures like reducing the pressure on swamps, sustainable utilization of water resources from the swamps to avoid water diversion, boundary demarcation, reducing the pressure like water diversion and resource use of swamps.

The swamps that fall in the fourth category are obviously much safer compared to others. Though there are 23 swamps in this category of which five swamps fall in the extreme right are safer than the rest. However, conservation and management efforts are required for these swamps as well, for the fact that prevailing anthropogenic forces of degradation in the region act unpredictably and the wear out signs of these swamps are easily perceptible. Activities adopted or recommended for the ones unreachable within the limited scope of the current project are: establishing and rejuvenating the local community organizations for natural resources governance that could take up swamp protection measures, creating community assets like fuel efficient driers and ovens, solar lightings, nursery establishments. Training on value addition and value chain development provided to communities especially women groups for locally available natural products to ensure livelihood security and participation in conservation. Planting of swamp exclusive species may be essential for some of these swamps.

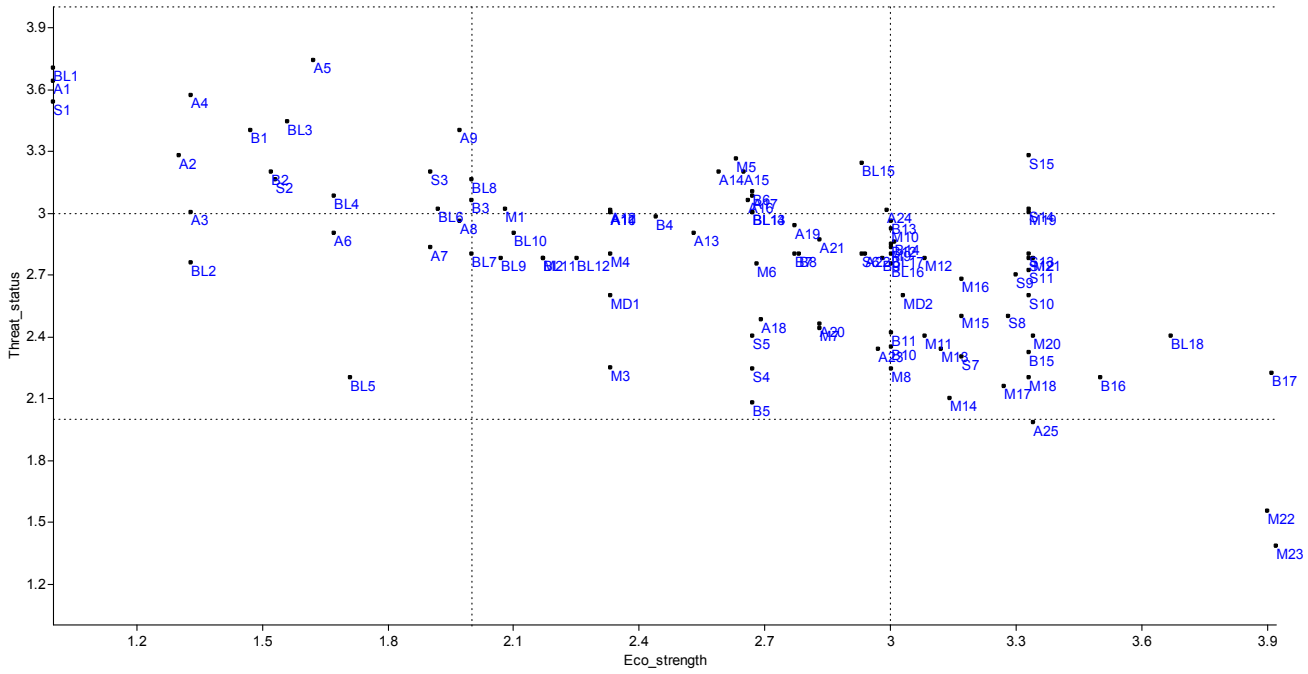

Figure 5. Swamps classified according to their ecological potential and threats.

Nine swamps under the category high threat were considered for the restoration remedial measures adopted were confined to these swamps.

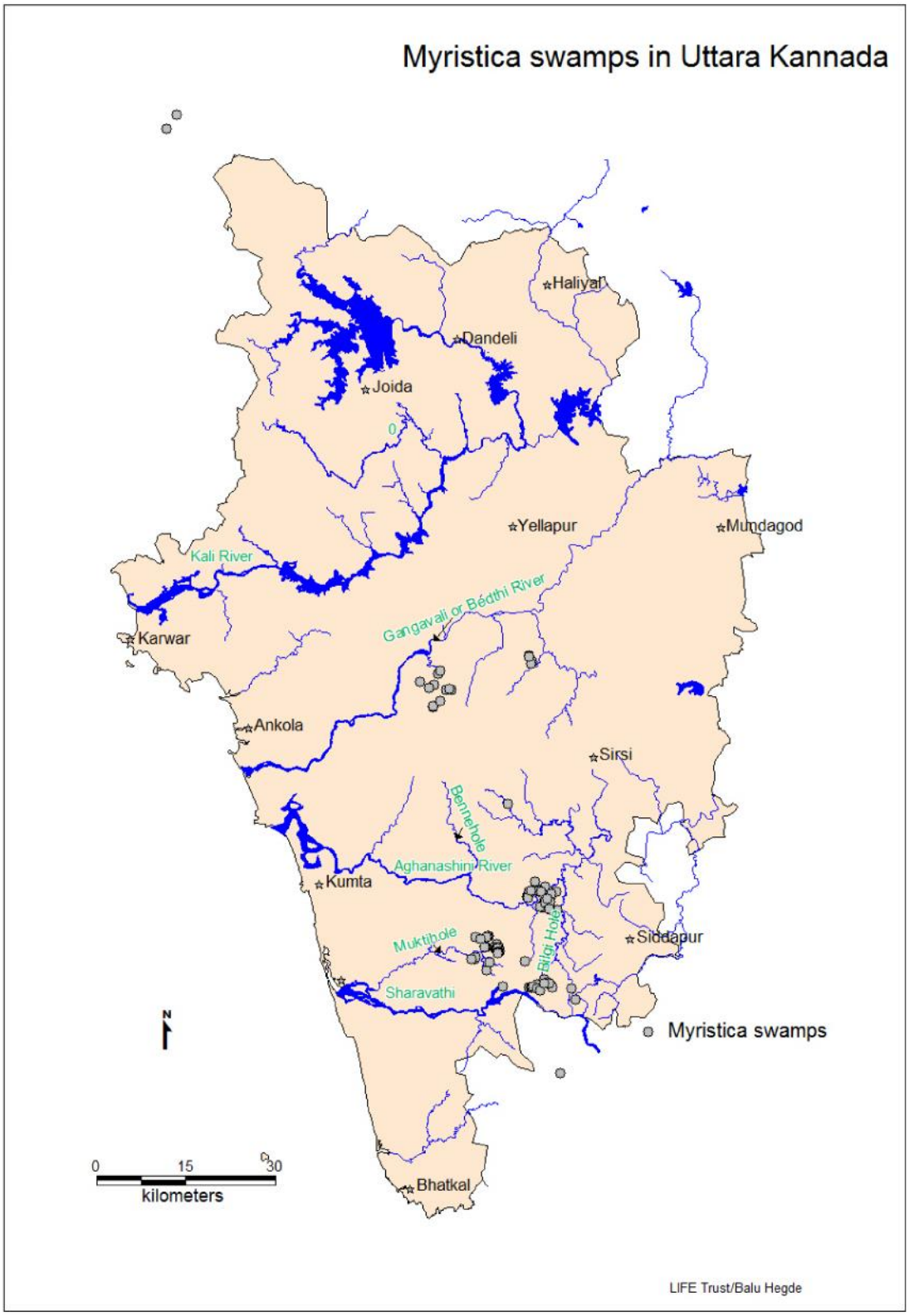

Figure 1.Map of Myristica swamps in Uttara Kannada district of Central Western Ghats.

d) Developing swamp species in the field nursery under community management was found as the most challenging task in the restoration process, a major reason being most of the swampy species having recalcitrant seeds, short lived in their viability. Species selection for restoration had to be made keeping in mind the need for keeping the ecological integrity of the swamps as well as taking into consideration the priorities of the local people for NTFP needs. Altogether 15,000 plants from 43 species were grown in people managed nurseries. Forest department cooperation was also available for raising the nursery stock. Species that are more adapted to the swampy conditions such as *Myristica fatua var. magnifica, Gymnacranthera canarica, Mastixia arborea, Semecarpus kathalekanensis, Syzygium travancoricum, Vateria indica, Arenga wightii* etc. were developed in larger numbers. Eight micro-corridors chosen for linking fragmented swamps were planted with these species with the active involvement of the local people.

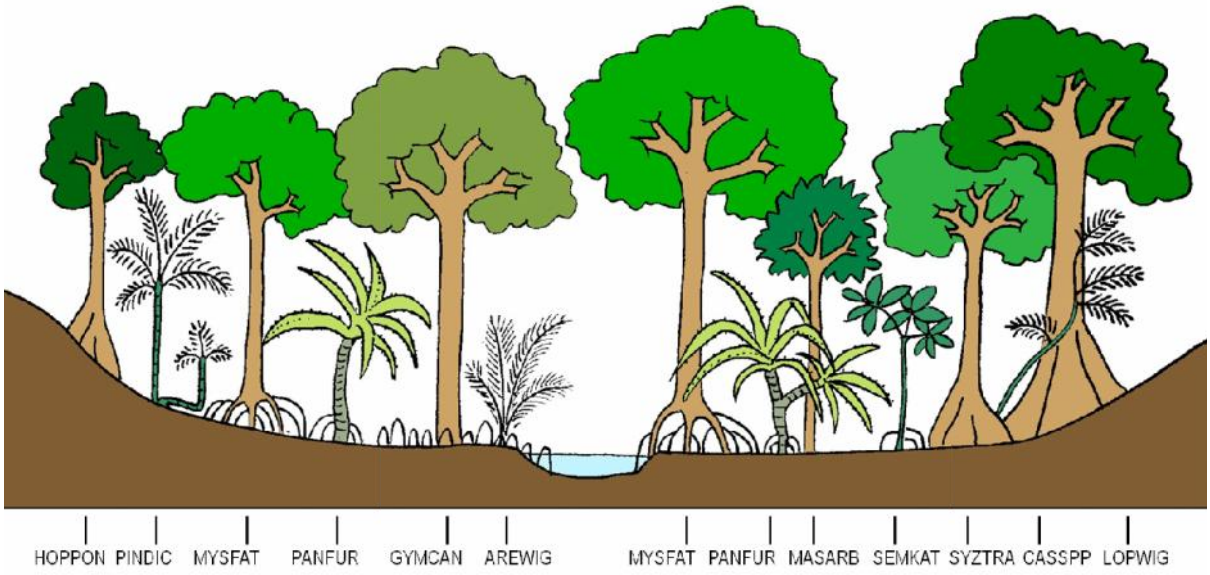

Figure 2.Generalized pattern of spatial distribution of plant species in relation to the swamps of Uttara Kannada (drawing by Caroline G)

Species listed from left: *Hopea ponga, Pinanga dicksonii, Myristica fatua var. magnifica, Pandanus, Gymnacranthera canarica, Arenga wightii, Mastixia arborea, Semecarpus kathalekanensis, Syzigium travencoricum* and *Lophopetalum wightianum*.

e) About 10,900 saplings were used for planting as part of restoration. These plants were chosen and planted in adhering to the generalized pattern of species distribution in the original swamps fragments to be linked through micro corridors. Survival rates were assessed for all the eight micro-corridors and were found to be about 60%. Of this the obligatory swamp species constituted 56% and the rest belonged to facultative and other associates. The remaining nursery raised plants were distributed among the locals for domestication, according to their choice, to reduce pressure on the forests and for cash income. *Garcinia gummi-gutta, Myristica malabarica, Cinnamomum malabatrum, Cinnamoujm zeylanicum, Artocarpus lakoocha, Artocarpus heterophyllus* and wild variety of *Garcinia indica* are few such species.

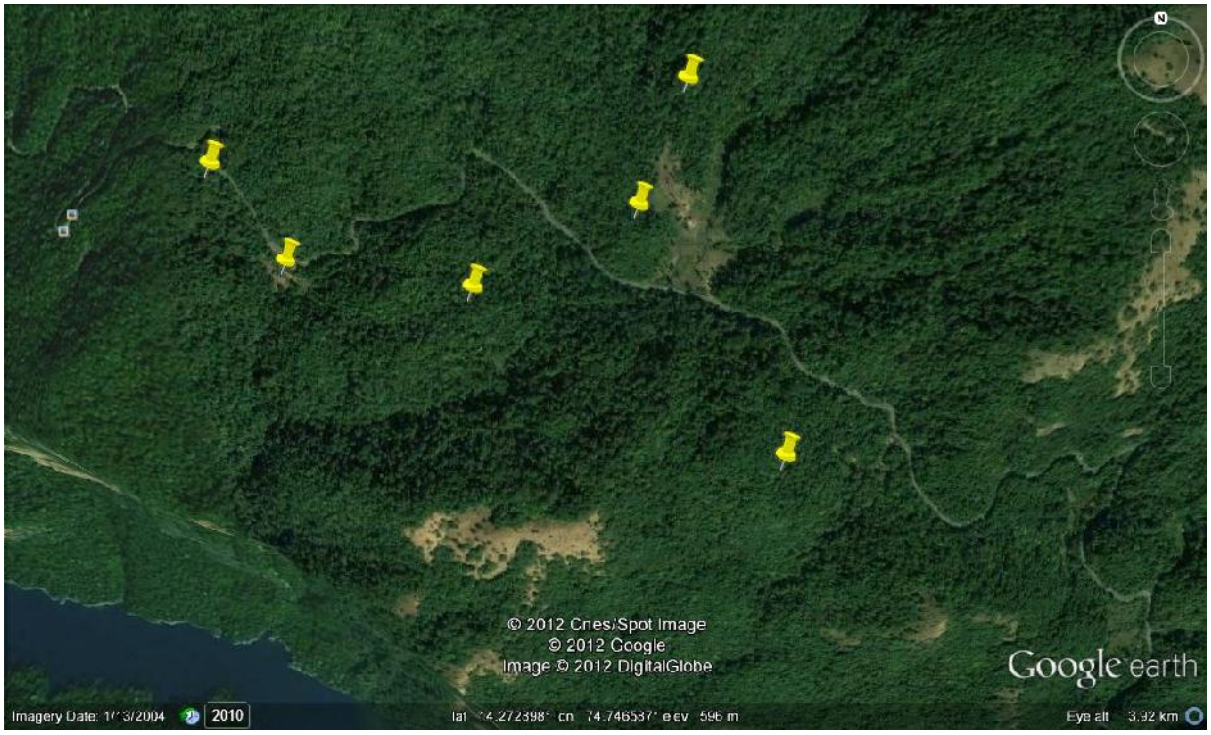

Figure 4.Restored micro-corridors linking swamps in the Kathalekan, Uttara Kannada

Table 1: Survival percentage of different swamp and associated species planted in the micro-corridors

S.no.	Species name	Survival percentage
1	*Syzygium tavancoricum*	75
2	*Mastixia arborea*	66
3	*Gymnacranthera canarica*	40
4	*Calophyllum apetalum*	80
5	*Holigarna arnotiana*	56
6	*Myristica fatua var. Magnifica*	52
7	*Semecarpus kathalekanensis*	76
8	*Lophopetalum wightianum*	64
9	*Garcinia gummi-gutta*	46
10	*Garcinia indica*	55
11	*Cinnamomum malabatrum*	30
12	*Canarium strictum*	40
13	*Dipterocorpus indicus*	56
14	*Pongamia pinnata*	53
15	*Vateria indica*	38
16	*Memecylon edule*	64

f) Re-wetting devices for soil and moisture conservation are installed at two places: in the degraded swamps of Hasolli and at Kathalekan. These devices (check dams and water percolation pits) helped to retaining more soil moisture for the swamp species.

g) To systematize the local people's involvement in the restoration activities swamp conservation committees were formed in two villages. These committees later received official village forest committees (VFCs) under Joint Forest Protection and Management plan (JFPM) under the patronage of the Karnataka forest department (KFD). To reduce taxing the swamp laced forests for fuel wood fuel efficient ovens and driers were installed in 45 houses, also supplemented by additional matching grants from the Forest Department. Under the project, training was imparted on value addition to Non Timber Forest Products and medicinal plants (eg. Preparation of juice concentrate from Garcinia indica,). Training was given on nursery raising and in grafting techniques. Women groups were taken in and around the swamp forests to sensitize them on the importance of conserving them. Training and awareness programs were organized to various stakeholders including the front line staff of forest department. A wide spectrum of persons, vocational groups, organizations and Government departments such as agriculturists, horticulturists, , landless labourers, artisans,

NTFP collectors, outside resource users, traditional herbal healers, *Myristica* swamp conservation committees, youth clubs, women groups, VFCs, KFD, minor irrigation/watershed department and other line departments, administration units from village *Panchayat* to *Zilla Panchayat* of the district, local watershed management committees were involved at various stages of the project activity. Fuel efficient ovens and driers and poly-house to raise the nursery have been installed as incentives to local people ensuring in the process their active participation in the conservation and restoration of fresh water swamps.. Meeting was held with the Western Ghats Task Force of the Karnataka Government, Chief Executive of Uttara Kannada administration, and executive officers of *taluk* administration and with development officers at village *panchayat* level. The district minister and forest minister were apprised of the activities. Chairman of Western Ghats Task Force Karnataka State Government visited the workshops on swamp restoration and management in the villages and he was convinced about the importance of such activity and expressed his appreciation of the CEPF funded project. He invited the project implementation team to make presentation of the swamp restoration activities at different levels of meetings, from local level front line staff of forest department to the higher hierarchy of forest officials from all over the Western Ghats region of Karnataka state. The team also met the Chief Minister of Karnataka. Highlights of this CEPF funded project activities were broadcasted in all India radio programmes throughout Karnataka. Publications of popular articles in Kannada were made in various local media.

Taking cognizance of the kind of the project activities aimed at conservation through community involvement and welfare the Government of Karnataka t provided extra grants to the local forest offices and to the Village Forest Committees towards strengthening management, awareness creation, , nurseries, planting in the swamp, demarcating the swamp forests to avoid any further violations on them, for display of boards on the importance of swamps and fixing name plates on swamp species.. Hence the CEPF swamp restoration project has now, virtually, merged with government sponsored conservation and participatory management programs. Providing additional incentives in the form of fuel efficient ovens and driers and matching grants from the government departments to the villagers close to the swamps. Such a gesture ensures substantially their long term involvement in restoration of swamps and in management of the restored swamps. The local language and the local accent was used in explaining the things and further the swamps were christened in the local language as *Rampatre Jaddi* meaning Myristica swamp, as no such name existed for these ancient swampy forest patches. Traditional belief systems related to conservation and

management like the association of swamps with sacred groves are getting revitalized in order to reconnect the people and nature as part of the ecological restoration process. Ecosystem services of swamps as direct sources of perennial water flow, controlling of pollutants and soil erosion, crucial habitat for pollinators, fish, amphibians, green manure and productivity was clearly explained to the local people.

4. Notable findings

Aghanashini river catchment has the higher number of swamps in the district followed by Mukti hole. Number of obligatory swamp species and their relative abundance was higher in the Muktihole catchment. Regeneration study reveals that species of all age class are not evenly distributed. Compared to other catchments, much anthropogenic pressure was observed in Bedti and Aghanashini catchments.

By installing check dams across water trenches in the degraded area we could succeed to retain the moisture in swamp area. Apart from this, irrigation could be done in the preliminary period after planting in the micro corridors.

Germination study of swamp species reveals that *Myristica fatua var. magnifica* and *Gymnacranthera canarica* produce fruits in rainy season, thus it makes them difficult to keep the fruits unaffected by the fungal contamination and from getting rotten. Disturbance in their natural habitat due to anthropogenic activities also affected the natural germination process. *Arenga wightii*, despite a variety of physico-chemical treatments failed to germinate. For *Gymnacranthera canarica* the seed germination rose up to 83 % by sealing the seeds in polybags for about 10 days. The study needs to continue, nevertheless, done to standardize the nursery techniques for these fragile species, never much thought of by silviculturists in the past.

Stakeholders participation, and of the communities as a whole, was on the higher side. The local volunteering, contributing towards much of success, was spontaneous. This positive mindset needs to be nurtured for the sustainability of such kind of non-commercial conservation project. Swamp species are not alien to them, and they were knowledgeable about traditional tangible benefits from swamps. -What is not known to them is their non-materialistic, but global significance, their ancientness and fragility and irreplacebility. Classification of swamps based on different ecological characteristics itself reveals that most of the swamps are under serious threat as it reported by Chandran (1997) and Vasudeva et al (2003).

5. Conclusion

Swamps connote a unique assemblage of landscape, habitat, plant-animal species interaction and usage pattern. Swamps are 'one and the only' kind of habitats found in select localities of the Western Ghats and this fact lends an element of social pride. Though the swamps provide tremendous ecosystem services people are thinking more of materialistic benefit like converting it to other land uses. Hence there is an urgent need to create such awareness in larger scale. In the community workshop and awareness meetings that were held in more than 25 places, participation of local people was quite overwhelming. This clearly indicates that there is a large scope, need and potential for conservation education activities of appropriate nature to enhance their understanding of swamps and guided conservation action. Different participatory methods used in the ecological restoration has speeded the recovery of degraded tropical fresh water swamps from local and wide spread anthropogenic changes. Involving major stakeholders and public support sought at various stages of the restoration helped to achieve the goal of having long term commitment of public thus bringing sustainability to entire restoration and management activities. More than the materialistic benefits one would derive from the swamps; the need is to emphasize the implicit significance, unique elements and traditional knowledge associated with swamps in order to drive down their credence. Eco-system services provided by the swamps especially the hydrological values (ground water recharge, water purification, holding of sediments) need to be highlighted.

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