Wetlands Ecol Manage (2018) 26:49–61
https://doi.org/10.1007/s11273-017-9553-z

ORIGINAL PAPER

A preliminary assessment of landscape features and cultural practices of sacred fresh water swamps in the central Western Ghats, India

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Received: 25 April 2016 / Accepted: 8 May 2017 / Published online: 15 May 2017

Abstract Sacred areas are the oldest form of habitat protection, and many of these areas contribute to biodiversity conservation. While sacred groves have received considerable scholarly attention, little is known about fresh water swamps in the Western Ghats, India and sacred swamps have largely been ignored. This paper provides a first overview testing the conjecture that sacred swamps have physical features that distinguish them from non-sacred swamps. We assessed 110 fresh water swamps in the district of Uttara Kannada, Central Western Ghats, India, through extensive field surveys. Out of them 11 swamps are 'sacred' according to local testimony. Swamps are found in wet evergreen and evergreen forest types, but sacred swamps occur only in the wet evergreen forests. Sacred swamps differ significantly from non-sacred swamps with respect to size and shape, distance to the nearest road, human settlement, and commercial orchard, and population density within a radius of 500 m. This shows that preferentially swamps close to settlements, orchards and roads have been declared as sacred, probably to regulate the continuing provision of relevant ecosystem services. While we find a variety of deities associated with these sacred swamps, the practices associated with sacred swamp status and management are essentially the same across belief groups. However, the conservation practice is at risk due to migration dynamics.

Keywords Ecosystem services · Sacred swamps · Traditional ecological knowledge · Tropical forests · Western Ghats

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Introduction

Many traditional communities follow some kind of spiritual faith, and faith can have an enormous impact on the way people think and behave, including how they relate to the natural world. Many traditional cultures celebrate ecological interactions between humans and nature with rituals such as sacrifice and puja, for example as an enactment of gratitude for

nature's abundance (Lee 2003). In addition, communities are the repositories of vast accumulations of traditional knowledge: a cumulative body of wisdom, practice and belief derived from historical experience and transmitted through generations in the form of social attitudes, principles, values and behavioural conventions (Berkes 2012; Ellen et al. 2000; Nakashima 1990). This knowledge, expressed in part via religious practices, can make the use of natural resources more sustainable. Therefore, the disappearance of such practices, especially age-old traditional skills in sustainably managing very complex ecosystems (WCED 1987), can be a tremendous loss to modern environmental management and to wider society.

Links between faith and the conservation of land and water have existed throughout the world for millennia. The concept of sacred trees and sacred forests can be found in most religious belief systems (Dudley et al. 2005). Already the hunting territories of the Australian aboriginals, for example, were marked by sacred locations delineated by landmarks such as trees, lakes, rocks and rivers (Chandran and Gadgil 1998). It may be taboo to enter, hunt or cut trees in these sacred areas, and in these faith-based restrictions, we find probably the oldest form of habitat protection on the planet, forming an extensive and largely unrecognized network of sanctuaries around the world. Many of these areas contribute substantially to biodiversity conservation (Berkes 2012; Dudley et al. 2005).

Various indigenous communities dedicate patches of forests to deities or ancestral spirits, designating them as *sacred groves*. Sacred groves are usually tracks of highly diverse forest, they are an expression of a deep relationship with nature or with the divine and can achieve preservation in a (near-) natural state via taboos and sanctions (Hughes and Chandran 1998). Indigenous perceptions of this relationship include the belief that the deities residing in the sacred groves protect villagers from calamities (Khan et al. 2008). From an ecosystem service perspective, sacred groves harbour biodiversity and are often the last refuge of endemic species (Bhagwat and Rutte 2006; Wild and McLeod 2008). They are often associated with ponds, streams or springs, which help meet the water requirements of local communities. Their vegetation cover helps to recharge aquifers by slowing down surface runoff, improving soil stability and preventing soil erosion (Descroix et al. 2001; Le Maitre et al. 1999). Sacred groves have been reported from many parts of Asia, Africa, Australia and America (Gadgil and Vartak 1976; Hughes and Chandran 1998; Hussain 1998).

In India, 13,270 sacred groves have been documented to date, but their actual number may be 10 times higher (Gokhale et al. 2001). Importantly, these sacred ecosystems are often integrated in local livelihood systems, used for small-scale resource extraction and considered important for agricultural production or solely for the spiritual and cultural wellbeing of the community (Bhagwat and Rutte 2006). They can also be significant on a large scale: while the smaller groves in the Western Ghats region are strictly protected and not subject to tree felling or biomass extraction, the larger groves function as entire resource forests and offer livelihood, sustenance and provisioning services to local communities (Malhotra et al. 2001).

A special type of sacred grove in the central Western Ghats are the *sacred swamps*: freshwater swamps dedicated to worship one deity or several deities—such as the tiger god Huli devru, or Chowdi, the goddess of water—through long term commitment and the establishment of traditional laws and practices. In the local language, Kannada, the sacred swamp is called *Devara Kaadu*, which translates into English as *forest of the god*. There is little documented information on sacred swamps, and even less exploratory research. This paper provides the first systematic overview of sacred swamps in the Western Ghats and tests the hypothesis that sacred swamps have physical or ecological features that non-sacred swamps do not have and that could justify their designation as sacred. In addition, we explore the question, if there are conservation relevant differences in deities, worship and rituals associated with sacred swamps. In this way, this paper seeks to prepare the ground for future research on more complex, interpretative social aspects of sacred swamps as well as social-ecological conservation dynamics.

Study area

The Western Ghats is a mountain range running parallel to the west coast of India. It constitutes one of the eighteen global hottest hotspots of the world, both with respect to the number of endemic biota as well as to the scale and speed of current habitat loss (Myers

et al. 2000). The hill range supports—together with Sri Lanka—approximately 4780 vascular plant and 1073 vertebrate species, of which 2180 (0.7% of the world's plant species) and 355 species (1.3% of the global vertebrate species) are endemic, respectively. At the same time, the region has lost most of its primary vegetation and only 6.8% of its original vegetation remains (Bawa et al. 2007).

The coastal Uttara Kannada district (13.85°N–15.7166°N, 74.166°E–75.2833°E) is one of the most densely vegetated districts within the Western Ghats and endowed with rich natural resources. Approximately 81% of its 10,250 km^2 is covered by forest, and about 12% used for agriculture. The district is surrounded by a range of hills that rise steeply from the coastal strip to an average height of 500 m, with some hills touching the 800 m mark. Precipitation is largely confined to the monsoon months of June to September and ranges from 3500 mm annually at the coast to 4500–5000 mm on the crest line, declining to 1000 mm on the eastern plateau (District Statistics Bureau 2011). Uttara Kannada was selected for this study because of its relatively high occurrences of freshwater swamps and sacred swamps and their significance to a wider community. In other districts of the Western Ghats only a few sacred swamps are found, and these are mostly owned by individual families; in the Uttara Kannada district the sacred swamps are under the ownership of the state forest department and managed by the local residents.

The tropical freshwater swamp forests of Uttara Kannada are marshy habitats where water oozes out in perennial streams at constant level throughout the year (Gupta et al. 2006). The swamps supply water to rivers, and are often found in areas with little relief in the crest line forests of the district. Their poorly drained mineral soils are covered by dense evergreen forests, which restrict the flow of the water. The swamps hold several endemic species of the Myristicaceae family, as well as species of the Celastraceae, Dipterocarpaceae, Anacardiaceae, Moraceae and Clusiaceae families (Chandran et al. 1999). Major tropical evergreen species found in swamps of Uttara Kannada are *Gymnacranthera canarica*, *Myristica farua* var. *magnifica*, *Mastixia arborea*, *Pinanga dicksonii*, *Hopea ponga*, *Dipterocarpus indicus*, *Pandanus unipapillatus* and *Lophopetalum wightianum* (Bhat and Kaveriappa 2009).

Although the number of plant species in the swamps is low compared to well-watered (but not waterlogged) land, the occurring species are often endemic and contribute significantly to the regional biodiversity of the Western Ghats (Chandran et al. 1999; Chandran and Mesta 2001; Roby and Nair 2006). The ecosystems of these swamps are connected by water-courses, and play a critical role in flood control and securing base flow.

Today, the freshwater swamp habitats of the Western Ghats are reduced in area and highly fragmented as a result of anthropogenic degradation. These swamp ecosystems have been degraded by a variety of factors, including diversion of water for agricultural and non-agricultural purposes; overexploitation of forest resources, especially Non Timber Forest Products (NTFPs) and medicinal plants; land use change, especially conversion to agricultural land; and general deforestation. These activities have fragmented the swamp ecosystems, and caused soil erosion, a loss of diversity, invasion of exotic species, and the decreasing vitality of trees (Varghese and Kumar 1997). Because of their high degree of endemism and continuing degradation, the primeval swamp ecosystems of the Western Ghats are now considered critically endangered and have been globally prioritised for conservation (Molur et al. 2011).

Materials and methods

Fieldwork was conducted for the identification of the freshwater swamps of Uttara Kannada district between August 2013 and March 2015. For swamp identification frontline staff of the forest department and local people were consulted. Existing lists mentioned in the literature were also used for inventory. Freshwater swamps were defined as wetlands with a permanent flow of water and at least two species of the Myristicaceae family, such as *G. canarica*, *M. arborea* or *Myristica fatua*.

The sacred swamps were identified according to local testimony of special laws, regulations and taboos pertaining to these swamps. No written documents of boundaries (such as state maps) of sacred swamps exist. Rather, the local community orally passes on the knowledge of the boundaries of the swamp from one generation to the next. Hence, the boundaries of the sacred swamp were recorded by walking along them

with a representative from the local belief group. For each site, a Garmin 60 Csx handheld GPS (global positioning system) was used to record the topographic location, size, shape and average altitude of the swamp, as well as the distance from the centre of the depression to the nearest mud and tar road, commercial spice garden/orchard, settlement or commercial centre. Size and shape were recorded for the boundaries of the wetland depression; these are also generally used by local communities to delineate the swamps. Next to the wet and low-lying core area, a small zone surrounding the core area is considered as buffer zone of the sacred swamp forests. The shape of each swamp was expressed as the quotient of the perimeter (m) and the square-root of the area (m^2). Canopy cover was measured at intervals of five meters along transects with a Cajanus tube (Sarvas 1953). Forests were identified as evergreen, semi-evergreen, or wet evergreen, using the classification of Champion and Seth (1968). Population density within a radius of 500 m from the centre of the swamps was determined via field surveys with local residents. All spatial data were processed with the GIS (geographic information system) program MapInfo 6.0. Sacred and non-sacred swamps were compared for each variable using the Mann–Whitney-test (Wilcox test) with the statistical program 'R' version 3.3.1 (R Core Team 2016).

Fifteen meetings were organised with in total around 150 participants from various stakeholders like the front line forest department staff and local people (especially members from Village Forest Committees, formed under the Joint Forest Management programme of the Ministry of Environment & Forests, as well as belief groups and their temple committees) to collect data on practices, actions, restrictions and traditional management in both the sacred and non-sacred swamps and to gather information on the deities, ancestral spirits, faiths and rituals associated with each swamp site.

Results

One hundred and ten freshwater swamps were identified in the district of Uttara Kannada. The number of swamps listed prior to this work was only 51, and hence 59 swamps have been newly identified during the research period. Eleven of these swamps are sacred according to local testimony. The sacred swamps are located in a region of the district where there is also a high concentration of non-sacred swamps (Fig. 1). Freshwater swamps appeared to occur in six forest ranges (Kyadgi, Siddapur, Janmane, Hulekal, Gersoppa and Ramanguli) in Uttara Kannada, whereas sacred swamps occur only in the Kyadgi and Janmane forest ranges (Table 1). The forest ranges are administrative units of state forest departments.

Sacred and non-sacred swamps differ significantly with respect to size, canopy cover, and distance to roads, human settlement, or commercial orchard, and population density around the swamps (Fig. 2). They also differ significantly with respect to the shape proxy, although no regularities in shape were observed and shapes varied from rough scalene triangular, convex pentagonal to trapezoid, without systematic pattern. No significant differences were found with respect to altitude.

Each sacred swamp is associated with a presiding deity; most commonly Chowdi, Jatka Beerlu, Huli Devaru (tiger god) and Bhoota (Table 2). Ten out of eleven are pre-Vedic local Hindu gods. While there is a variety of deities, we found sacred swamps to converge with respect to the laws of entry as well as restrictions and prohibitions within the sacred swamp (Table 2).

Although the younger local population increasingly migrates to the cities in search of employment, the population in the entire sacred swamps region has increased three to four times compared to 30 years ago, especially due to immigration of people from the coastal region. We have as yet no indications that this immigration has changed the conservation status of the 'sacred swamps' indicating that the traditional management rules still persist in spite of changing population.

Discussion

In the statistical analysis, 11 sacred swamps have been compared with 99 non-sacred ones. Indeed, comparison would have been strongest with 55 sacred and 55 non-sacred swamps, but since the number of available sacred swamps was limited to 11, the strongest sample-design was to maximise the number of replicates in the control group. This is allowed because the Mann–Whitney–Wilcoxon-test is not sensitive to unequal sample sizes (see e.g. http://stats.stackexchange.com/

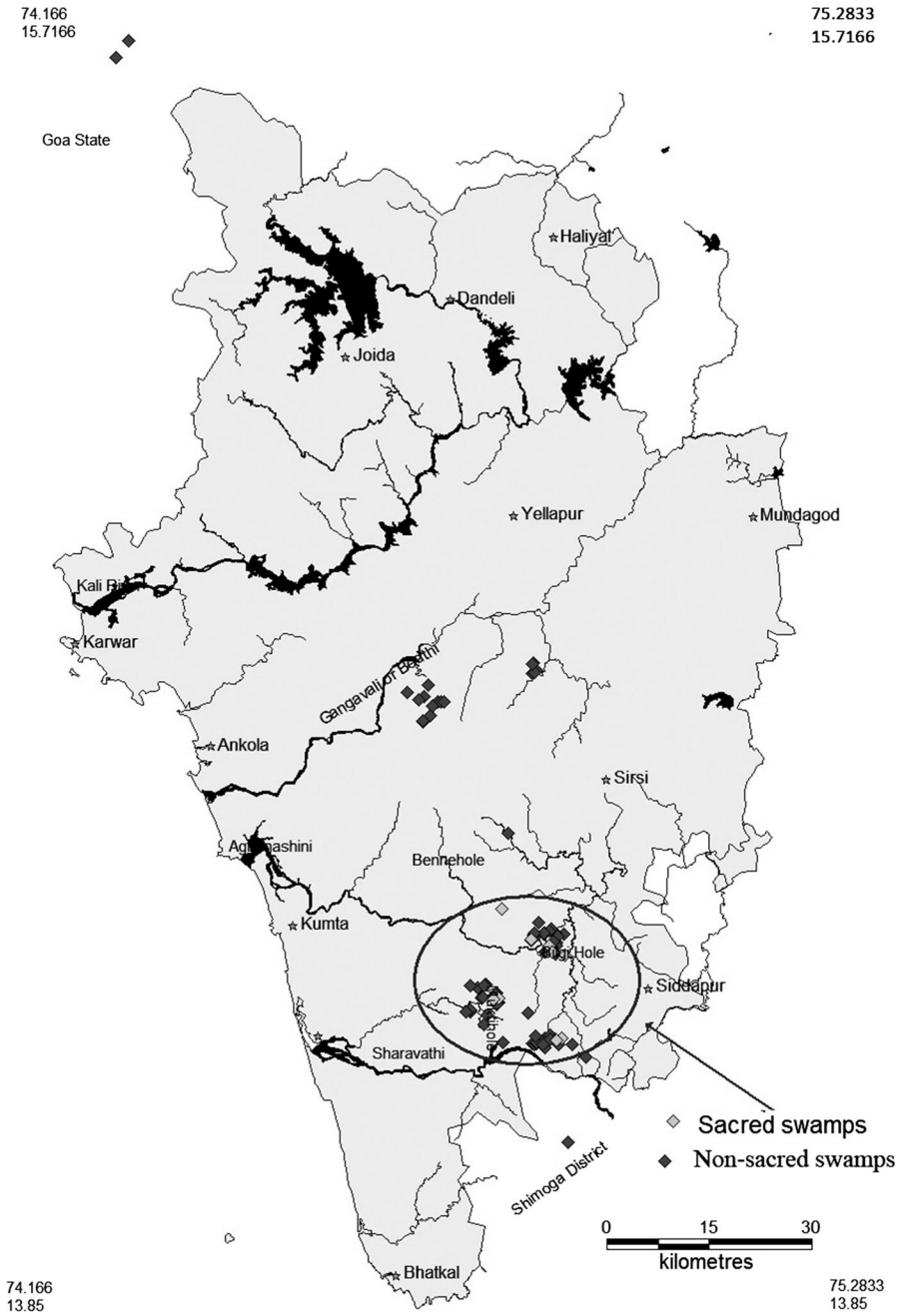

Fig. 1 Locations of sacred and non-sacred swamps in Uttara Kannada district

questions/40342/mann–whitney-u-test-with-unequal-sample-sizes). A test for each parameter with only 11 random sampled non-sacred swamps, and run 9 times showed the same significances.

The results show that sacred swamps in Uttara Kannada district have distinct physical, ecological and social features: (a) physically, sacred swamps are significantly smaller, shorter in length and more compact than non-sacred swamps, (b) ecologically, the percentage canopy cover for sacred is significantly higher than for non-sacred swamps, (c) socially: their distance from tar roads, mud roads, commercial orchards and human settlements is significantly smaller than that of non-sacred swamps. The sacred swamps also have a higher surrounding population density than non-sacred swamps. The fact that the size

Table 1 Name, location, area and altitude of sacred swamps in the Uttara Kannada district

Name	Location		Area (ha)	Altitude (m a.s.l.)
Birlakaanu Kudgund	14.293N	74.758E	0.73	577
Bogrimakki	14.387N	74.770E	0.90	536
Chaare	14.408N	74.736E	0.18	521
Chowdammana Kanu Nettikai	14.417N	74.753E	0.24	518
Jaddikodlu Kudegodu	14.392N	74.754E	1.03	471
Kere Moole	14.275N	74.771E	0.41	569
Kudegodu Devikanu	14.389N	74.757E	0.81	482
Korse (Chapparmane)	14.326N	74.688E	0.89	514
Mavingadde	14.392N	74.695E	0.48	501
Nilkund	14.449N	74.704E	0.27	482
Venkatesh Teertha	14.547N	74.705E	0.40	455

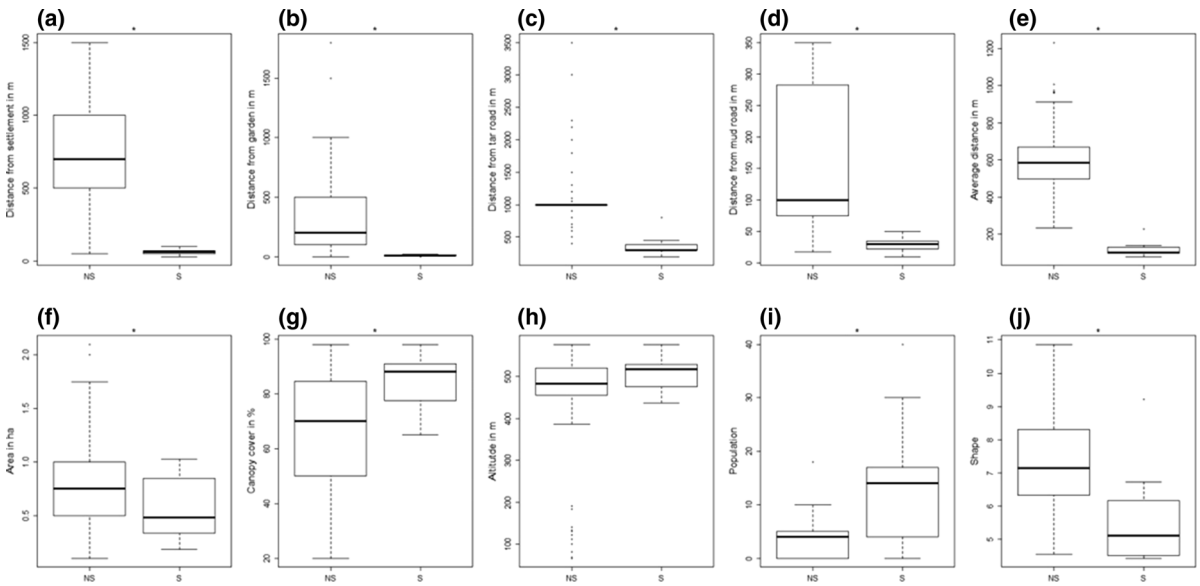

Fig. 2 Comparison of 11 sacred (S) with 99 non-sacred swamps (NS). **a** Distance to the nearest settlement. **b** Distance to the nearest commercial garden. **c** Distance to the nearest tar road. **d** Distance to the nearest mud road. **e** Shortest distance to all types of roads. **f** Area of the swamp. **g** Canopy cover. **h** Average altitude. **i** Population density—number of people living within a distance of 500 m to the swamp. **j** *Shapes* as expressed as quotient of the perimeter and square root of area. The plot shows the median (*bold line*), the *upper* and *lower quartiles* (including 50% of the data and creating the *box* inter quartile range = IQR), the whiskers marking the added 1.5*IQR (inter quartile range) at the *upper* and *lower end* of the *box*. *Outliers* (o) are values outside these ranges. An *asterisk* marks significant difference according to the Mann–Whitney-test ($p \leq 0.05$)

of sacred swamps is significantly smaller than that of non-sacred swamps may indicate that the former are under higher pressure due to human land uses. Their smaller distance to roads, settlements and commercial spice gardens also indicates a higher human pressure. Our results thus suggest that swamps close to settlements preferentially receive a *s*acred status. We interpret this as recognition by the traditional communities of the ecosystem services they provide. Closer to human settlements and in more densely populated areas, swamps and their services need stronger protection and regulation so as to prevent the fragmentation into tiny pockets (Chandran and Mesta 2001; Chandran 1997).

This interpretation is also supported by the geographical distribution of sacred swamps. Freshwater

Table 2 Associated deity (minor deity in italics) and rituals/traditional festivals connected to the worship of the individual sacred swamps

Name	Deity	Rituals/worship	Traditional laws
Birlakaanu Kudgund	Beerlu	Diwali[a], Makar Sankranti[b], Aridra[c]	Common traditional laws found in all the sacred swamps are as below
Bogrimakki	Jatka	Diwali	(1) Entry to core area only during annual worship/ritual
Chaare	Hulidevru	Diwali	(2) Prohibition of tree, branch and twig cutting in the core area
Chowdammana Kanu Nettikai	Chowdi	Annual worship[f]	(3) Prohibition of hunting, gathering and fishing
Jaddikodlu Kudegodu	Bhoota	Annual fair, Diwali	(4) Prohibition of spitting, urinating and any kind of activity that pollutes the water body
Kere Moole	Chowdi	Makar Sankranti, Diwali, Naga Panchami[d]	(5) Harvesting allowed only in the buffer zone, and only by the belief group
Kudegodu Devikanu	Devi or Amma	Diwali, Aridra	
Korse (Chapparmane)	Beerlu	Diwali, Devara Habba[e]	
Mavingadde	Jatka, *Bhoota*	Diwali, annual worship	
Nilkund	Chowdi, *Jatka*	Annual worship	
Venkatesh Teertha	Venkatesh	Diwali	

[a] Diwali- Deepavali or festival of lights is an ancient Hindu festival celebrated annually in October

[b] Makar Sankranti marks the transition of the Sun into the zodiac sign of Makara rashi (Capricorn)

[c] Aridra is the annual worship/fair during onset of the monsoon

[d] Naga panchami is the day on which cobra is worshipped

[e] Devara Habba is a special festival celebrated in the name of god

[f] Annual worship is a religious prayer where the belief group offer coconut, flowers and other offerings to presiding deities

swamps occur in six forest ranges of Uttara Kannada district (Kyadgi, Janmane, Siddapur, Hulekal, Gersoppa and Ramanguli), of which the first three ranges are situated in the wet evergreen forest region, and the others in the regions of semi-evergreen and moist deciduous forests (Ramesh and Pascal 1997). Sacred swamps are found only in the wet evergreen forest ranges of Kyadgi and Janmane but are absent in the Siddapur wet evergreen forest range. This confirms our interpretation as the swamp area in Siddapur range is very thinly populated: only two families (10 people) reside in an area of 652 hectares, of which 646 ha (nearly 99%) is still forest land. However, we could not find an explanation for the absence of sacred swamps in semi-evergreen and moist deciduous forest ranges.

Could these significant differences between sacred and non-scared swamps be the result of the protection, in the sense that all other swamps that were once present close to human settlements have been destroyed, if they did not have a status as sacred? Oral communication with local people revealed that there were previously higher numbers of non-sacred swamps, but that an estimated 75% of them have been destroyed and others have been degraded. Currently sacred swamps are the only swamps remaining within a distance of 100 m of human population. Astonishingly, our research suggests that to date not one sacred swamp has been lost due to change in land use, confirming that belief groups are paramount in conservation and management (Bhagwat and Rutte 2006). The sacred swamps have, however, partly suffered degradation, e.g. by destruction of their extremities, resulting in a significantly smaller shape proxy value compared to non-sacred swamps (Fig. 2), and by alterations in their catchment area and buffer zones. Buffer zones degrade mainly as a result of water diversion and increased intrusion of non-belief groups.

Does the nature of the deity make a difference for this result? Our results show that with respect to the deities associated with the sacred swamps, some deities are specific to the site and its characteristics. Chowdi (mentioned in three out of 11 cases) is referred to by local people as the goddess of water,

associated with a water body like a small pond and depicted with a small stone placed beneath a tree near a pond. Bhoota (*demon of the forest*, mentioned twice) is associated with patches of dense tropical forest. The interviews with local people revealed that hunter-gatherer people used to give offers to Bhoota before going into the deep forest to hunt animals. Hulidevru (tiger or panther god, mentioned once) is found in a district, where in earlier times—according to the locals—the tiger population was much larger and the killing of cattle and pet animals by tiger, panther, leopard and other wild cats was quite common. Early settlers, like the Khare Vokkaliga community, still worship the tiger and panther today. By contrast, other deities refer to the protected or sacred character of the swamp without direct association with specific swamp characteristics. Jatka (mentioned in three cases) is the deity for guarding a territory. Jatka is normally found in farms owned by individual families. Beerlu (mentioned twice) is found near the border of villages and is thought to be the guardian for the village as a whole. In the case of Devi or Vanadevate (mother god or goddess of the forest, both mentioned once), the reference appears to be health. Heaps of terracotta pots are found near the deity. According to the local people, these are from offerings during severe outbursts of contagious diseases like smallpox, chickenpox and malaria. While we thus find a variety of deities, with both swamp specific and more general character, we also found the laws and belief systems applying to the core area of swamp forests to be similar. In all the cases, the depression part of the swamps is considered sacred by local people. The buffer zone, the surrounding forests of the swamp is regulated in a similar manner across the groups as our results show. There appears to be a shared preservation tradition in the region. While different groups express the preservation practice differently (i.e. with different deities) they apply analogous practices of ecosystem and livelihood preservation.

The result remains the same if we consider the belief groups living around the sacred swamps according to different castes in the Hindu system. These include Haslers, Havyaka Brahmins, Khare Vokkaligas and Naiks. In spite of this variety of belief groups and castes, we found that the traditional restrictions regulating interaction with the sacred swamps strongly converge in practice (Table 2).

This convergence in sacred swamps preservation practice (i.e. a partially shared belief system about the swamps and shared protection rules for livelihood preservation) provides a simple explanation why all swamps considered as sacred are (relatively) successful protected: the protection of the sacred follows a roughly similar approach. This interpretation suggests that the preservation of ecosystem functioning dominates the role of deities (and whatever specific rituals they might require). Indeed, we could not find a case where a deity specific regulation would intervene negatively with the preservation of the swamps.

Possibly, these shared practices in dealing with sacred swamps help explain, why so far the net immigration to the area appears not to change the conservation status of the swamp: in spite of the variety of deities, a shared practice can be recognized across the swamps by newcomers. Still, the further dynamics of the interaction of newcomers and local population, which as we noted sees many younger people leaving, warrants further attention in the future.

Conclusions

Do sacred swamps have distinct features that indicate the sacred to play a distinct role in conservation practice? Our research suggests an affirmative answer. Approximately 10% of the fresh water swamps in Uttara Kannada district are sacred. Sacred and non-sacred swamps differ significantly with respect to their distance from major human artefacts (roads, settlements and orchards), size and shape. Sacred swamps located close to settlements are under pressure yet intact, whereas all non-sacred swamps at a similar distance have been converted to other forms of land use. Swamps close to settlements, orchards and roads have been preferentially declared as sacred, whereas more distant swamps have not been accorded this status. The significant difference between sacred and non-sacred swamps thus reveals the importance of sacred swamps as a conservation management approach. Cultural practices like restricting the entry to swamps, not allowing cutting of trees, branches and twigs, prohibiting hunting, gathering and fishing inside the swamps forests and maintaining cleanliness of water bodies have put an invisible social fence in the sacred swamps and thus have conservation impacts. Our research also suggests that these

practices are not dependent on specific deities, but rather are shared across a variety of deities and belief groups.

Yet, it is an approach that is under pressure. Our research revealed that local communities of the sacred swamps are changing: younger generations move away, and higher numbers of new people migrate towards these areas. Traditional practices associated with sacred swamps are still adhered to, but it will be difficult to pass them on in the light of the migration dynamic.

Declaring the sacred status to other swamps has the potential to conserve them. However, sacred status as a conservation practice depends on believers who follow the faith and endorse the practice. Thus it cannot be implemented top-down by government. The identification of the features of sacred swamps is a first step in the investigation of the relation between the cultural conservation practice and ecosystem functioning and values. Based on such understanding, government can better understand, if and how the cultural practice should be supported; newcomers to the area can better appreciate the value of the practice even if they are non-believers; and possibly belief groups are strengthened to assert and adapt their conservation practices.

Acknowledgements We thank local villagers, officers and front line staff of Karnataka Forest Department for their help towards the identification of freshwater swamps. Thanks to the Critical Ecosystem Partnership Fund (CEPF) for providing the grants to Snehakunja Trust, which partially supported the field surveys. We thank Balu for mapping and help during the fieldwork and Grace Boyle and three anonymous reviewers for their constructive comments.

Funding No specific funding has been obtained to carry out the research. However, grants from critical ecosystem partnership fund to Snehakunja trust, (Grant No. 55915) which partially supported the field surveys. Similarly, travel to Greifswald University from the Western Ghats, to discuss with the supervisors and fulfil the other academic procedures has been provided by Department of Peatland Studies and Palaeoecology & Departments of Environmental Ethics, Institute of Botany and Landscape Ecology, Ernst-Moritz-Arndt University, Greifswald, Germany.

Appendix

See Tables 3 and 4.

Table 3 Differences in variables in sacred and non-sacred swamps

Variable	Median (sacred)	Median (non-sacred)	*P* value	Test-statistic of Mann–Whitney–Wilcoxon-test (W)
Distance to nearest settlement (m)	60	700	<0.001	1081
Distance to nearest district garden (m)	10	200	<0.001	1029
Distance to nearest tar road (m)	300	1000	<0.001	1078
Distance to nearest mud road (m)	30	100	<0.001	1071
Distance to nearest road (m)	100	584	<0.001	1089
Altitude (m a.s.l.)	518	300	0.180	410
Size (ha)	0.48	0.75	0.025	766
Canopy cover (%)	88	70	0.009	283
Population	14	4	0.005	269
Shapes			0.001	888

Table 4 List of non-sacred swamps, area and forest types

Name of the fresh water swamp	Approx area (Ha)	Forest type
Adralli	0.5	Semi evergreen
Alavalli	0.5	Semi evergreen
Arehakllujaddi-kankumbrigudda	0.5	Semi evergreen
Attigerei Jaddi	0.1	Evergreen

Table 4 continued

Name of the fresh water swamp	Approx area (Ha)	Forest type
Bagginapalu Jaddi	1.5	Evergreen
Bale Haklu	0.2	Evergreen
Bilkandur 1	1	Evergreen
Bilkandur 2	0.5	Evergreen
Darbejaddi	1.75	Evergreen
Dasur-Muktihole	1	Evergreen
Devanuru (kodimoole halla)	0.5	Evergreen
Devimane	1	Evergreen
Dhoolalli 1	0.7	Evergreen
Dhoolalli 2	1	Evergreen
Doddakattu 1	1	Evergreen
Doddakattu 2	0.97	Evergreen
Doddakattu 3	1	Evergreen
Eitalimane	1	Evergreen
Gadikallu	0.5	Evergreen
Gamyanhonda	0.5	Evergreen
Gulehonda	0.5	Evergreen
Haadarvalli	0.4	Evergreen
Haadrimane	1	Evergreen
Haalballi Kodlu 1	2	Evergreen
Haalballi Kodlu 2	1	Evergreen
Haldota	0.5	Evergreen
Harale kodlu	0.5	Evergreen
Hasuvalli Kodlu 1	2	Evergreen
Hasuvalli Kodlu 2	1.4	Evergreen
Hasuvalli Kodlu 3	1	Evergreen
Hasviguli-Kudegodu	0.5	Evergreen
Havinbilu	0.7	Evergreen
Hebbar Gudde	0.8	Evergreen
Honnekumbu	0.24	Evergreen
Hukli-Torme	2	Evergreen
Hulidevara Kodlu	0.7	Evergreen
Joginakodlu	0.5	Wet evergreen
Kadllimane	0.5	Wet evergreen
Kanmane	1	Wet evergreen
Kanmane Kodlu 1	1	Wet evergreen
Kanmane Kodlu 2	1	Wet evergreen
Kathlekan 1	0.5	Wet evergreen
Kathlekan 10	2	Wet evergreen
Kathlekan 2	0.7	Wet evergreen
Kathlekan 3	2.1	Wet evergreen
Kathlekan 4	0.5	Wet evergreen
Kathlekan 5	1	Wet evergreen
Kathlekan 6	2	Wet evergreen

Table 4 continued

Name of the fresh water swamp	Approx area (Ha)	Forest type
Kathlekan 7	0.8	Evergreen
Kathlekan 8	0.75	Wet evergreen
Kathlekan 9	0.7	Wet evergreen
Kattepalu Jambehalla	1.5	Wet evergreen
Kenjigemane Kodlu	1	Wet evergreen
Kerekuli	0.6	Wet evergreen
Kesarakki-kankumbrigudda	0.5	Evergreen
Kharse kanu	2	Evergreen
Korbe	0.5	Evergreen
Kudre Jaddi	0.75	Wet evergreen
Kulikattu	0.6	Evergreen
Kyadagikodlu	0.5	Evergreen
Mavingudda	1	Evergreen
Malemane	0.7	Evergreen
Maratikumbri	0.5	Wet evergreen
Maruthimanekodlu	0.5	Wet evergreen
Masthiguli	0.75	Evergreen
Mavinmaradkodlu	0.5	Evergreen
Metlakal Hole-Kudegodu	0.5	Wet evergreen
Mukhatolya Kodlu	1.25	Wet evergreen
MundgeTaggu	1	Wet evergreen
Nadugehonda	0.5	Wet evergreen
Nagara Baale Kodlu	0.5	Wet evergreen
Nandisaalu	0.9	Wet evergreen
Nayatemaradkodlu	0.7	Evergreen
Neermanekodlu 1	1.25	Wet evergreen
Neermanekodlu 2	1.5	Wet evergreen
Neermanekodlu 3	1.75	Wet evergreen
Neermanekodlu 4	1.5	Wet evergreen
Nettikai	1.03	Evergreen
Nutgal Aghanashini	1	Evergreen
Nutgal	0.5	Evergreen
Ranjalkodlu	0.5	Evergreen
Sampane	1	Wet evergreen
Sharemane	0.5	Wet evergreen
Shashikodlu 1	1.5	Wet evergreen
Shashikodlu 2	0.75	Wet evergreen
Shashikodlu 3	0.41	Wet evergreen
Shingumane	0.89	Evergreen
Sodlaguppekodlu	0.7	Moist deciduous
Sodlekodlu	0.81	Wet evergreen
Somankuli 1	1	Wet evergreen
Somankuli Benadamane kaanu	0.41	Wet evergreen
Thotadmulekodlu	0.7	Evergreen

Table 4 continued

Name of the fresh water swamp	Approx area (Ha)	Forest type
Tippan Kodlu	0.5	Evergreen
Torme Kodlu 1	1	Wet evergreen
Torme Kodlu 2	0.7	Wet evergreen
Tormekodlu 3	0.8	Wet evergreen
Vaate Palu Jaddi	0.5	Evergreen
Vatekodlu-Naginmane	0.75	Evergreen
Vojgar	0.5	Evergreen

References

Bawa KS, Das A, Krishnaswamy J, Karanth U, Sambakumar N (2007) Ecosystem profile: Western Ghats & Sri Lanka biodiversity hotspot-Western Ghats region. Critical Ecosystem Partnership Fund

Berkes F (2012) Sacred ecology, 3rd edn. Routledge, New York

Bhagwat SA, Rutte C (2006) Sacred groves: potential for biodiversity management. Front Ecol Environ 4:519–524

Bhat PR, Kaveriappa KM (2009) Ecological studies on myristica swamp forests of uttara Kannada Karnataka, India. Trop Ecol 50(2):329

Champion HG, Seth SK (1968) A revised survey of the forest types of India. Govt. of India Press, Delhi

Chandran MDS (1997) On the ecological history of the Western Ghats. Curr Sci 73:146–155

Chandran MDS, Gadgil M (1998) Sacred groves and sacred trees of Uttara Kannada. Lifestyle and ecology, Indira Gandhi National Centre for the Arts. Print world, Pvt. Ltd, New Delhi

Chandran MDS, Mesta DK (2001) On the conservation of the Myristica swamps of the Western Ghats. Forest genetic resources: status, threats, and conservation strategies. Oxford and India Book House, New Delhi

Chandran MDS, Mesta DK, Naik MB (1999) Myristica swamps of Uttara Kannada district. My For 35(3):217–222

Descroix L, Viramontes D, Vauclin M, Gonzalez Barrios JL, Esteves M (2001) Influence of soil surface features and vegetation on runoff and erosion in the Western Sierra Madre (Durango, North West Mexico). Catena 43:115–135

District statistics bureau (2011) Uttara Kannada district. District statistics bureau, Karnataka

Dudley N, Higgins-Zogib L and Mansourian S (2005) Beyond belief: linking faiths and protected areas to support biodiversity conservation, a research report by WWF, equilibrium and the alliance of religions and conservation, Gland

Ellen R, Parkes P, Bicker A (2000) Indigenous environmental knowledge and its transformations: critical anthropological perspectives. Harwood Academic Publishers, Amsterdam

Gadgil M, Vartak VD (1976) The sacred groves of Western Ghats in India. Econ Bot 30(2):152–160

Gokhale Y, Malhotra KC, Chatterjee S, Srivastava S (2001) Cultural and ecological dimensions of sacred groves in India. Indian National Science Academy, New Delhi

Gupta N, Anthwal A, Bahuguna A (2006) Biodiversity of Mothronwala swamp, Doon Valley, Uttaranchal. J Am Sci 2(3):33–40

Hughes JD, Chandran MS (1998) Sacred groves around the earth: an overview. Conserving the sacred for biodiversity management. Oxford and India Book House, New Delhi, pp 69–86

Hussain A (1998) Sacred sites in Bangladesh: country report. In: Ramakrishnan PS, Saxena KG, Chandrashekhara UM (eds) Conserving the sacred for biodiversity management. UNESCO, OXFORD and IBH publication, New Delhi, p 167

Khan ML, Ashalata D, Tripathy RS (2008) The sacred groves and their significance in conserving biodiversity an overview. Int J Ecol Environ Sci 34:277–291

Le Maitre DC, Scott DF, Colvin C (1999) A review of information on interactions between vegetation and ground water. Water SA 25:137–152

Lee C (ed) (2003) The importance of sacred natural sites for biodiversity conservation. In: Proceedings of the international workshop held in Kunming and Xishungbana biosphere reserve, Peoples Republic of China

Malhotra KC, Gokhale Y, Chatterjee S, Srivastava S (2001) Cultural and ecological dimensions of sacred groves in India. Indian National Science Academy and the Indira Gandhi Rashtriya Manav Sangrahalaya, New Delhi and Bhopal

Molur S, Smith KG, Daniel BA, Darwell WRT (compilers) (2011) The status and distribution of freshwater biodiversity in the Western Ghats, India. Cambridge, UK and IUCN, Gland Switzerland and Zoo Outreach Organisation, Coimbatore, India

Myers N, Mittermeier RA, Mittermeier CG, Da Fonseca GA, Kent J (2000) Biodiversity hotspots for conservation priorities. Nature 403(6772):853–858

Nakashima DJ (1990) Application of native knowledge in EIA: Inuit, eiders, and Hudson Bay oil. Canadian Environmental Assessment Research Council, Ottawa

Ramesh BR, Pascal JP (1997) Atlas of endemics of the Western Ghats (India): distribution of tree species in the evergreen and semi-evergreen forests. Institut de Pondichery Publications du department d'Ecologie, Pondichery

Roby TJ, Nair PV (2006) Myristica swamps—an endangered ecosystem in the Western Ghats. In: The proceedings of the XVIII Kerala science congress. pp 386–388

Sarvas R (1953) Measurement of the crown closure of the stand. Commun Inst For Fenn 41(6):13

Varghese V, Kumar BM (1997) Ecological observations in the fresh water swamp forests of southern Kerala, India. J Trop For Sci 9:299–314

WCED (1987) Our common future. Oxford University Press, Oxford

Wild R, McLeod C (eds) (2008) Sacred natural sites: guidelines for protected area managers. IUCN, Gland