CEPF SMALL GRANT FINAL PROJECT COMPLETION REPORT

Organization Legal Name:	Keystone Foundation
Project Title:	Hill Wetlands in the Nilgiri Biosphere Reserve - A People's Conservation Initiative.
Date of Report:	15th Dec 2012
Report Author and Contact Information	Archana Sivaramakrishnan

CEPF Region: Western Ghats (Mysore-Nilgiri Corridor)

Strategic Direction: 1 - Enable action by diverse communities and partnerships to ensure conservation of key biodiversity areas and enhance connectivity in the corridors.

Grant Amount: $ 19,702.20

Project Dates: April 2011 to August 2012

Implementation Partners for this Project (please explain the level of involvement for each partner):

Type here:

- Dr S .Narendra Prasad, Open source geospatial Foundation- India chapter – Demarcation of boundaries of wetlands and mapping
- Dr S Muralidharan, Principal Scientist, Division of Ecotoxicology, Salim Ali Centre for Ornithology & Natural History, Coimbatore – Pesticide Residue Study of Wetlands.
- Arun Kanagavel, Research Associate, Conservation Research Group, Kerala and Wildlife Information, Liasion and Development, Coimbatore – Biodiversity Surveys especially of mammal, bird, reptile, amphibian, fish and odonate diversity

Conservation Impacts

Please explain/describe how your project has contributed to the implementation of the CEPF ecosystem profile.

In the context of Strategic Direction 1 of enabling action by diverse communities and partnerships to ensure conservation of key biodiversity areas and enhancement of connectivity in the corridors, this project has facilitated action by community groups, including geographical communities and school children, by scientific institutions such as SACON (www.sacon.in)and the Open Source Geospatial Foundation (www.osgeo.in). Biodiversity conservation groups such as the Conservation Research Group (https://sites.google.com/site/webcrgkerala/) have also contributed in a convergence of the effort to support conservation of wetlands in mountain ecosystems and highlight the threats to the continued health of these systems.

The project has also helped community groups dialogue with the Forest Department of the Government of Tamil Nadu and with the Central Soil and Water Conservation and

Research and Training Institute (www.cswcrtiweb.org) on the issues around wetlands and strategies to be adopted for their conservation.

The biodiversity assessments carried out under the aegis of the project have identified over 128 floral species, including 19 endemic species (Appendix 1). The faunal surveys revealed 19 species of which 8 fall within the threatened category of the IUCN Red List (Appendix 2).

Please summarize the overall results/impact of your project against the expected results detailed in the approved proposal.

Biodiversity surveys of the three sites have been completed and the results registered (Appendix 1). One community has offered to engage in a community education and awareness programme on wetland diversity. Management mechanisms for the wetland in one location have been evolved. GIS based mapping for the wetland sites has been completed (http://indiabiodiversity.org/map?layers=ibp:lyr_368_nilgiri_wetland&title=Landuse%20around%20Nilgiri%20wetlands). On the advocacy front, discussion with the CSWCRTI and HADP are ongoing on the importance of mainstreaming wetland conservation in district development plans.

Please provide the following information where relevant:

Hectares Protected: The project has facilitated mechanisms for securing tenure of about 7 Ha of wetland area.

Species Conserved: The description of the amphibian and avian diversity at the project sites has generated significant interest within the scientific community, that would help in future prioritized conservation of these taxa. A proposal has been forwarded for the inclusion of Tarnad Mand as an Important Bird Area. (Appendix 3)

Describe the success or challenges of the project toward achieving its short-term and long-term impact objectives.

In the short term, the project has been successful in engaging with local communities, schools and the forest department in discussions on the need for conservation of the wetlands. The calculation of the direct economic flows from the wetlands (Appendix 4) has also caught the attention of the local communities and leant an impetus for conservation (Appendix 5).

Towards the long term objectives of the project, the discussion on the need to map accurately the number and extent of wetlands has strengthened collaborations with the HADP and the CSWCRTI. The toxicity study conducted with SACON (Appendix 6) is also a preliminary one and lays the foundation for more detailed studies in this regard.

Were there any unexpected impacts (positive or negative)?

None.

Lessons Learned

Describe any lessons learned during the design and implementation of the project, as well as any related to organizational development and capacity building. Consider lessons that would inform projects designed or implemented by your organization or others, as well as lessons that might be considered by the global conservation community.

Among the important lessons that we take away from this project are:

- The need to work in an embedded manner as much as possible. By this we mean, that engaging with the primary community in a manner that design, implementation and monitoring of the project are all done with the community.
- The importance of drawing on expertise from diverse stakeholders such as SACON in the area of assessment of toxic residues in wetland habitats , Open Source Geospatial in the area of mapping of wetlands and CRG, in the area of survey of small mammals, amphibians and reptiles..

Project Design Process: (aspects of the project design that contributed to its success/shortcomings)

Nil

Project Implementation: (aspects of the project execution that contributed to its success/shortcomings)

Nil

Other lessons learned relevant to conservation community:

(Please type some friendly advice for future conservation on hill wetlands please)

ADDITIONAL FUNDING

Provide details of any additional donors who supported this project and any funding secured for the project as a result of the CEPF grant or success of the project.

Donor	Type of Funding*	Amount	Notes
HADP	Cash	Rs 10000	Towards Biodiversity surveys
Conservation Research Group, Kerala	Partner	Rs 15000	Towards Biodiversity surveys and report writing

****Additional funding should be reported using the following categories:***

A *Project co-financing (Other donors contribute to the direct costs of this CEPF project)*

B *Grantee and Partner leveraging (Other donors contribute to your organization or a partner organization as a direct result of successes with this CEPF project.)*

C *Regional/Portfolio leveraging (Other donors make large investments in a region because of CEPF investment or successes related to this project.)*

Sustainability/Replicability

Summarize the success or challenge in achieving planned sustainability or replicability of project components or results.

The success of the project in achieving sustainability has been in the area of community involvement in the project. In one of the project locations, the nature of the project site proved to be private property de facto and therefore public involvement could not be elicited. This has proved to be challenge.

Summarize any unplanned sustainability or replicability achieved.

Among the unplanned aspects has been the fact that the project has been able to facilitate applications for secure tenure on one of the wetland sites. This was requested for by the community in the face of a threat of encroachment by an adjoining community. Application for community forest resource have been facilitated under the Scheduled Tribes and Other Traditional Forest Dwellers'(Recognition of Forest Rights) Act, 2006 for Tarnad Mand.

Safeguard Policy Assessment

Provide a summary of the implementation of any required action toward the environmental and social safeguard policies within the project.

The project intervention used multi-pronged strategy of strengthening awareness, clarifying tenure and facilitating systems for management of the common property resource. Systems for responsible access of the wetland were evolved through group discussions and in the *gram sabha.* This process drew on traditional knowledge from the community and in active consultation with all groups who use the resource.

Performance Tracking Report Addendum

CEPF Global Targets

(April 2011 to August 2012)

Provide a numerical amount and brief description of the results achieved by your grant.
Please respond to only those questions that are relevant to your project.

Project Results	Is this question relevant?	If yes, provide your numerical response for results achieved during the annual period.	Provide your numerical response for project from inception of CEPF support to date.	Describe the principal results achieved from April 2011 to August 2012. (Attach annexes if necessary)
1. Did your project strengthen management of a protected area guided by a sustainable management plan? Please indicate number of hectares improved.	No			Please also include name of the protected area(s). If more than one, please include the number of hectares strengthened for each one.
2. How many hectares of new and/or expanded protected areas did your project help establish through a legal declaration or community agreement?	No			Please also include name of the protected area. If more than one, please include the number of hectares strengthened for each one.
3. Did your project strengthen biodiversity conservation and/or natural resources management inside a key biodiversity area identified in the CEPF ecosystem profile? If so, please indicate how many hectares.	Yes	About 7 Ha.		Wetland area in Tarnad Mand
4. Did your project effectively introduce or strengthen biodiversity conservation in management practices outside protected areas? If so, please indicate how many hectares.	Yes	About 7 Ha.		Wetland area in Tarnad Mand applied for under Community Forest Resource under the FRA
5. If your project promotes the sustainable use of natural resources, how many local communities accrued tangible socioeconomic benefits? Please complete Table 1below.	Yes			

If you answered yes to question 5, please complete the following table.

Table 1. Socioeconomic Benefits to Target Communities

Please complete this table if your project provided concrete socioeconomic benefits to local communities. List the name of each community in column one. In the subsequent columns under Community Characteristics and Nature of Socioeconomic Benefit, place an X in all relevant boxes. In the bottom row, provide the totals of the Xs for each column.

Name of Community	Community Characteristics								Nature of Socioeconomic Benefit												
									Increased Income due to:												
	Small landowners	Subsistence economy	Indigenous/ ethnic peoples	Pastoralists/nomadic peoples	Recent migrants	Urban communities	Communities falling below the poverty rate	Other	Adoption of sustainable natural resources management practices	Ecotourism revenues	Park management activities	Payment for environmental services	Increased food security due to the adoption of sustainable fishing, hunting, or agricultural practices	More secure access to water resources	Improved tenure in land or other natural resource due to titling, reduction of colonization, etc.	Reduced risk of natural disasters (fires, landslides, flooding, etc)	More secure sources of energy	Increased access to public services, such as education, health, or credit	Improved use of traditional knowledge for environmental management	More participatory decision-making due to strengthened civil society and governance.	Other
Tarnad Mand, Todas – particularly Vulnerable Tribal Group	X		X	X			X							X	X				X	X	
Total	**1**		**1**	**1**			**1**							**1**	**1**				**1**	**1**	

If you marked "Other", please provide detail on the nature of the Community Characteristic and Socioeconomic Benefit:

Additional Comments/Recommendations

None

Information Sharing and CEPF Policy

CEPF is committed to transparent operations and to helping civil society groups share experiences, lessons learned, and results. Final project completion reports are made available on our Web site, www.cepf.net, and publicized in our newsletter and other communications.

Please include your full contact details below:

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List of Appendices:

1) Appendix 1 : Biodiversity survey report/publication
2) Appendix 2 : Faunal Survey Report
3) Appendix 3 : Proposal for IBA in Tarnad Mand
4) Appendix 4 - Report of livelihood linkages and economic value of wetland
5) Appendix 5 - Conservation Action Plan and Report of Activities undertaken by HWCG
6) Appendix 6 - SACON-Pesticide study
7) Appendix 7 - Maps of the 3 swamps
8) Appendix 8 - Conservation Education Module (Wetlands school session plans)
9) Appendix 9 - Preliminary Resource Use & Problem Analyses Report
10) Appendix 10 - Report (including media coverage) of Wetland's Day celebrations

Credit : Keystone Foundation

Biodiversity Assessment Report

Methodology

Physical Parameters

The ph reading and flow of water was recorded for the three wetlands sites. Ph was measured using a digital ph meter. The flow of water was measured by using one L bottle and a stop watch. The time taken to fill up the one L bottle was measured as the flow of water. The frequency of the measure of these parameters will be done seasonally.

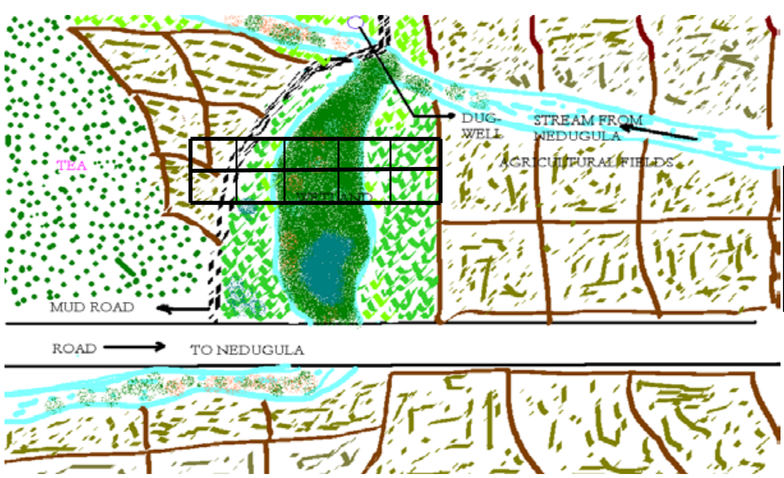
Biological parameters

Biodiversity inventory was done for the three wetlands site Nedugula, Tarnadmund, and Bison swamp.

The method adopted for vegetation survey in the wetlands areas was of vegetation sampling method (Peet et al. 1998). This is a flexible, multipurpose sampling method which can be used to sample such diverse communities as grass- and forb-dominated savannahs, dense shrub thickets, forest, and sparsely vegetated rock outcrops etc.

1. The method employs a set of 10 modules in a 20m x 50m layout.
2. Within the site to be surveyed, these 20 x 50m grids are located such that the long axis of the plot is oriented to get heterogeneity within the plot.
3. Once the plot is laid out, all species within the plot are identified, an aggregate wood stem count is made, and cover is estimated at the 0.1 hectare scale.
4. The vegetation survey will be done seasonally. The boundaries of the plot are marked with a peg.

Nedugula: diagrammatic representation of the site



	50m			10
				20m

Nedugula:

Only one plot (50*20) was laid as the wetlands area was of a small size. The wetland is surrounded by agricultural area and tea plantation. The wetlands area includes a stream which is 22m wide. A check dam is built recently. Activities like washing of clothes and carrots takes place. The water storage part of the check dam is seen with *Naja* sp. Kingfisher was feeding on the small fishes (Unidentified) that were present in the check dam. About 30 plant species were recorded. The stream was covered and dominated with *Polygonum barbatum, Myriophyllum intermedium* (Endemic) and *Rorippa nasturtium-aquaticum.* The drier part of the wetlands is cover with *Poa annua* grass and *Cnicus walllichi.* 14 species of birds, 1species of amphibian and reptile, 4 species of odonates and 2 species of butterfly were recorded.

Tarnadmund:

The plots were laid along the margins of the wetlands and also in the centre of the wetlands. Five plots (50*20) were laid in the wetlands. The wetland is surrounded by shola grassland ecosystem. The slope at the tail end of the wetlands is seen with cultivation of carrot and beans. Water for this agriculture fields is pumped from a dug well near the tail end of the wetland. 65 plant species were recorded from the plots. The wetland is dominated by *Juncus* sp and *Poa* sp. 17 species of birds, 4 species of butterfly, 2 species of mammals and odonates, 3 species of amphibian, 1 species reptile and was observed.

Bison swamp:

The plots were laid in and around the wetlands. Ten plots (50m*20m) were laid. The wetland is surrounded by Shola and wattle plantation. About 70 species of plants were recored. The swamp is dominated with *Chrysopogon* grass along with *Eriocaulon* and *Impatiens sp.* Snakes were observed.

Results and Discussion

Tarnadmund

The grassland surrounding the wetlands is grazed by semi-wild buffaloes owned by the indigenous Toda community. This grassland is dominated by *Eulalia phaenothrix*, *Ischaemum indicum* and introduced grass kikuyu, *Pennisetum clandestinum* which run wild. *Cerpis acaulis*, *Gentiana pedicellata* are found in the grassland.

Swampy vegetation. A total of 75 species belonging to 52 genera and 30 families were recorded. The families with the largest number of species were Asteraceae, Cyperaceae and Poaceae. Tree specie, i.e. *Rhododendron arboreum* was recorded from on the edges of the swamps. Endemicity was relatively high, 9 endemic species were recorded. Among the 13 Poaceae species, 2 were endemic to the Nilgiris and 1 Western Ghats - Sri Lanka hotspot. One species each of Eriocaulonaceae , Rosaceae Rubiaceae , Berberidaceae and Ericaceae were endemic to Western

Credit : Keystone Foundation

Ghats. 1 species each of Haloragiaceae and Poaceae were endemic to Nilgiris The dominant species were *Juncus glaucus*, *Pycreus sanguinolentus* and *Ischane globosa*.

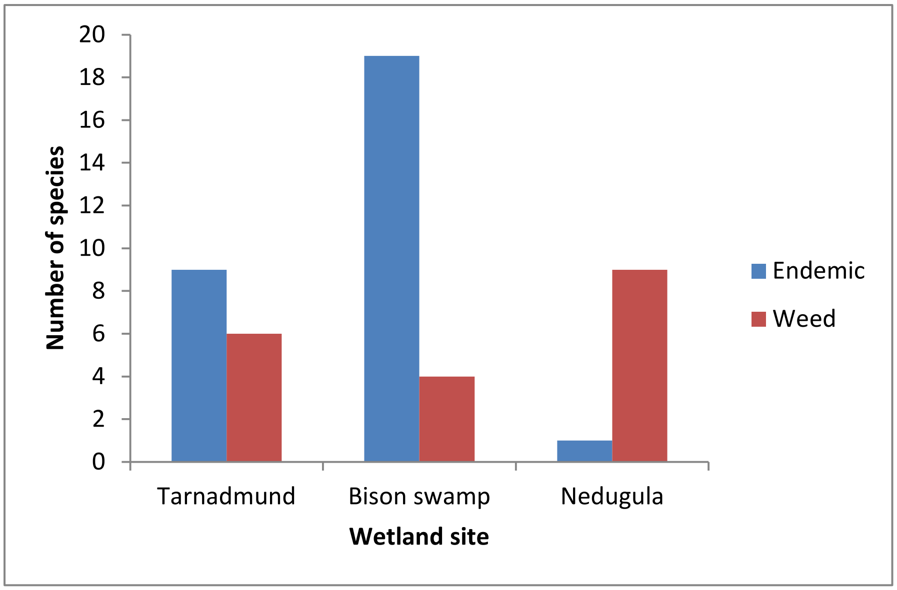
Bison swamp

A total of 66 belonging to 59 genera and 33 families were recorded. The families with the largest number of species were Poaceae, Cyperaceae and Asteraceae. Three tree species, i.e. *Rhododendron arboreum, Gaultheria fragrantissima* and *Ilex wightiana* were recorded on the edges of the swamps. Endemicity was high, 19 endemic species were recorded. Only one species of Asteraceae, Rubiaceae, Commelinaceae, Haloragiaceae, Ericaceae and among the 12 Poaceae species, 7 were endemic to the Western Ghats - Sri Lanka hotspot.2 species of Eriocaulonaceae, 1 Rananculaceae and Orchidaceae were endemic to Western ghats. 1 species of Rosaceae and 2species of Poaceae was endemic to Nilgiris. The dominant species were *Eriocaulon brownianum*, *Juncus glaucus* and *Chrysopogan zeylanicus.*

Nedugula

A total of 41 species belonging to 37 genera and 22 families were recorded. The families with the largest number of species were Asteraceae, Solanaceae and Cyperaceae. Only one endemic species, *Myriophyllum oliganthum* was recorded. The numbers of both native and invasive species were highest in the grazed swamps. The dominant species were *Rorippa nasturtium-aquaticum*, *Eclipta prostrata* and cultivated crops like Carrots.

	Tarnadmund	Bison swamp	Nedugula
Endemic	9	19	1
Weed	6	4	9



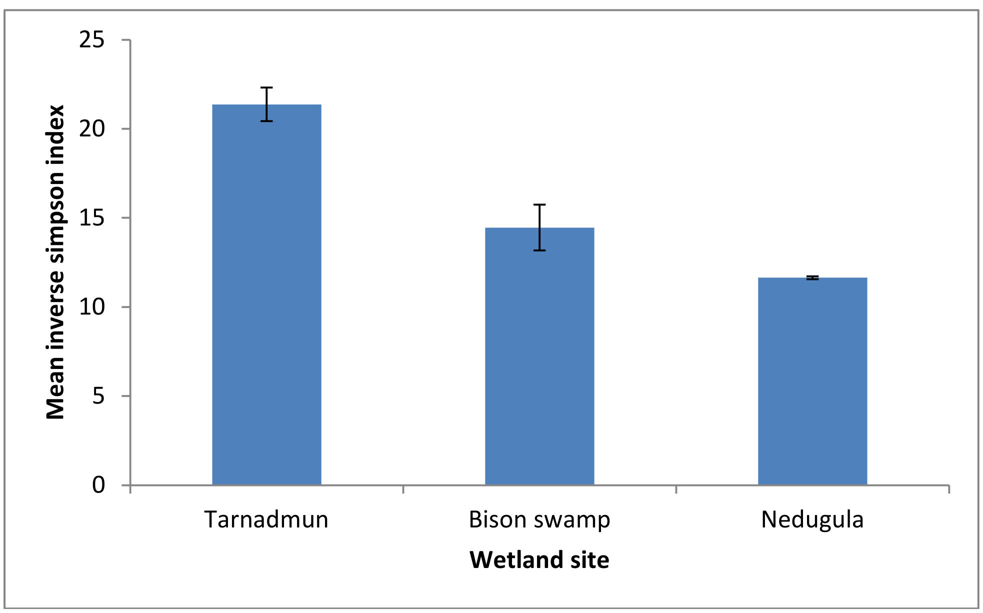
Credit : Keystone Foundation

DIVERSITY OF WETLAND PLANTS

A total of 128 plant species, belonging to 56 families were recorded from the three wetlands. The three wetlands differ in floristic composition. At Tarnadmund, 75 species were recorded in the wet season and 61 in the dry season. At bisonswamp, 70 species were recorded in the wet season and 17 species in the dry season. At Nedugula , 41 species were recorded in the wet season and in the13 dry season.

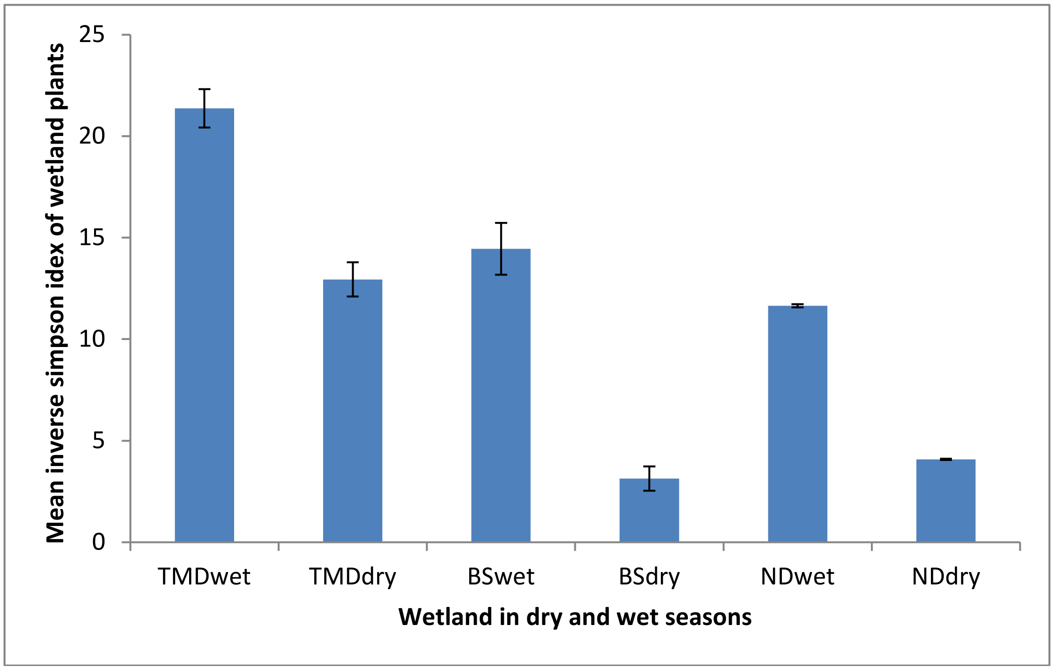
The diversity in wet season tended to be richer than the dry season. The order of plant diversity inthe wet season was Tarnadmund > Bisonswamp > Nedugula and in the dry season Tarnadmund > Bisonswamp > Nedugula . Occurrence of fire during the dry season has been observed in Bisonswamp and Nedugula sites. The most speciose families were Asteraceae, Poaceae, Cyperaceae with 16, 13, 11 species respectively. followed by Apiaceae, Solanaceae,Polygonaceae and Rosaceae(4 each). Commelinaceae, Eriocaulonaceae and Fabaceae were represented by 3 species each. Two species from Balsaminaceae, Caryophyllaceae, Droseraceae, Ericaceae, Geraniaceae, Haloragiaceae, Hydrocharitaceae, Lamiaceae, Rananculaceae, Rubiaceae, Scrophulariaceae and Verbenaceae. Only one species was recorded for Acanthaceae, Amaranthaceae, Aquifoliaceae, Areaceae, , Berberidaceae, Boraginaceae, Brassicaceae Campanulaceae, Ceasalpinaceae, Chenopodiaceae, Elaeagnaceae, Euphorbiaceae, Fumariaceae, Gentianaceae, Lentibulariaceae, Linaceae, Lythraceae, Melastomaceae, Mimosaceae, Oleaceae, Myrtaceae, Passifloraceae, Phytolaccaceae, Orchidaceae, Piperaceae, Plantaginaceae, Pontederiaceae, Proteaceae, Rhamnaceae, Saxifragaceae, Smilaceae, Theaceae, Violaceae and Xyridaceae.

We compared the mean inverse simpson diversity index for diversity of wetland plants across the three wetlands. Tarnad mund showed the highest diversity followed by Bison swamp and Nedugula (Fig 1).



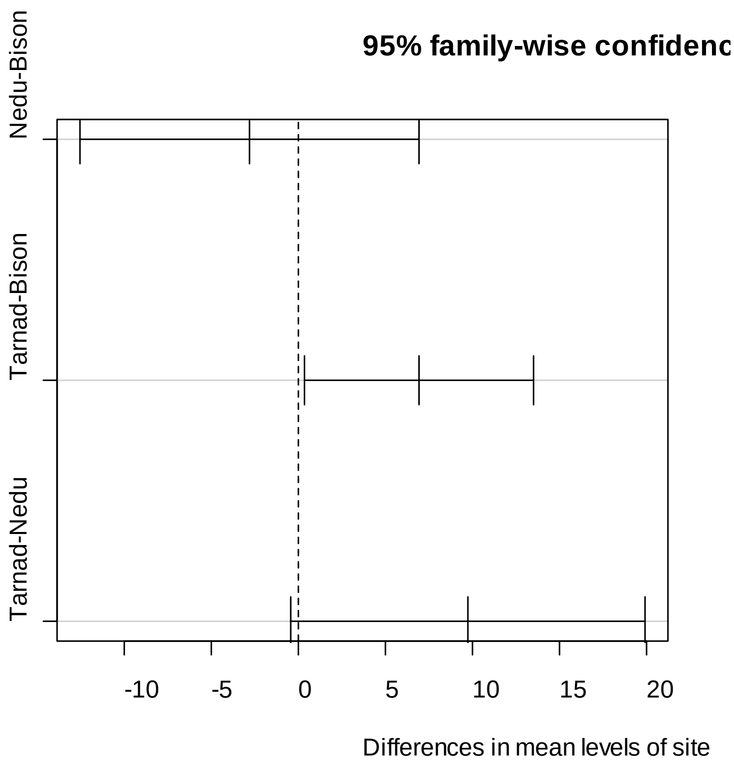
Credit : Keystone Foundation

Data from the dry season were collated and analysis in R2.8.1 (library: vegan) revealed Bison swamp to have the lowest diversity and Bison swamp held the highest diversity of wetland plants (Fig 2).



The Tukey HSD test for multiple comparison of means revealed a significant difference in the means between Tarnad and Nedugula (p=0.0617503) and between Tarnad and Bison swamp (p=0.0385770) (p=0.9158).

Credit : Keystone Foundation



DISTURBANCE INDICATORS

We pooled in data on each wetland's vegetation and disturbance parameters and tested for significance the diversity index as a function of (i) native as against plantation as surrounding matrix, and (ii) use of wetland water for vegetable cultivation.

A multiple regression with these parameters as explanatory variable suggested that the use of wetland water for iirrigation and the matrix of eucalyptus and acacia plantation had negative impacts on the diversity index of a wetland, plantations having a highly significant effect (p=0.00728) and irrigation, a slightly significant effect (p=0.032).

Credit: Keystone Foundation

Faunal surveys at high elevation wetlands in the Nilgiri Biosphere Reserve

Methodology

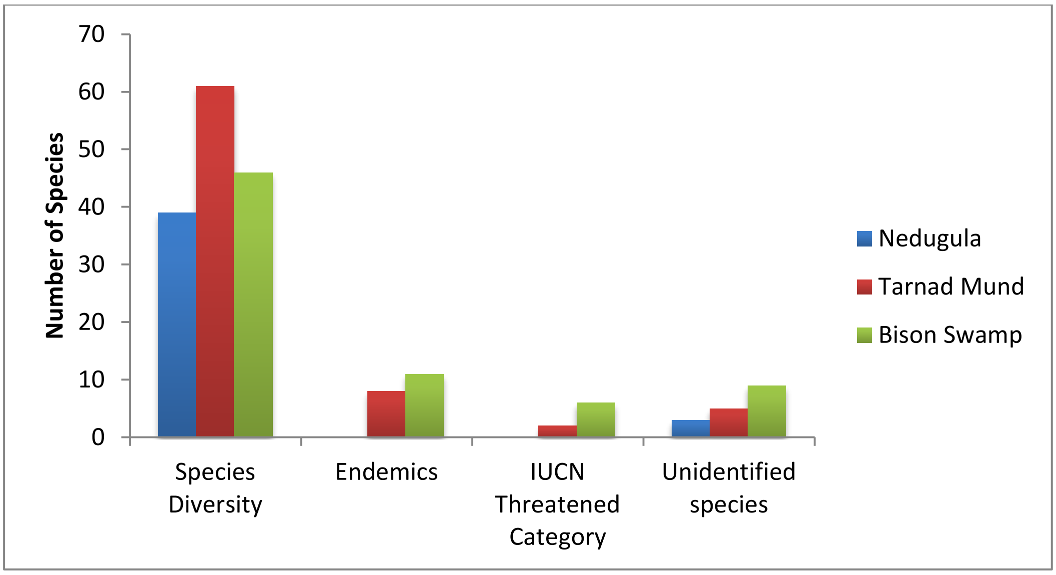
Mammal, bird, reptile, amphibian, fish and odonate diversity was explored at the three wetland sites (Nedugula, Tarnad Mund and Bison Swamp) in August (2011), October (2011), February (2012) and April (2012) using visual encounter surveys. Fish diversity was assessed at multiple points, the number of survey points determined by the length and number of streams. Indirect sightings of mammals through scat/dung or hair were also recorded. Camera traps were setup at Tarand Mund and Bison Swamp from February 2012 to better understand the mammalian diversity at these sites. Traps were not set at Nedugula due to security reasons from the adjacent human habitation. Only those bird species seen perched or active within the wetland complex were considered a part of the wetland diversity and not those flying away overhead. Species encountered were then identified using field guides (Ali 2002; Daniels 2005; Prater 2005; Subramanian 2005; Whitaker & Captain 2008). Camera trap surveys could be initiated at the sites to increase the detection of mammalian species.

Results and Discussion

The three sites differed in species diversity (Fig 1, see attached Excel sheets). At Nedugula, 28 species of birds, two reptiles, two amphibians, a fish and six odonates were encountered. Three species could only be identified upto the genus level. Of those adequately identified, none were endemic or threatened as per the IUCN Red list. At Tarnad Mund, four species of mammals, 42 birds, one reptile, four amphibians, one fish and nine odonates were encountered. Five species could only be identified upto the genus level. Of those adequately identified, eight species were endemic and two featured in the threatened category of the IUCN Red List. At Bison Camp two species of mammals, 10 birds, two reptiles, eight amphibians and two odonates were encountered. Five species could only be identified upto the genus level and three only upto the family level. Of those adequately identified 11 species were endemic and six featured in the threatened category of the IUCN Red List.

If sites are to be prioritised for conservation as per endemicity and threat status of species they would be in following sequence - Bison Swamp < Tarnad Mund < Nedugula. However if landscape-level threats are to be considered Tarnad Mund and Nedugula would need increased attention due to the intensity of grazing and resource utilisation in place.

Figure 1. Species diversity, endemicity and threat status at the three wetland sites



Credit: Keystone Foundation

References

Ali, S. (2002). *The Book of Indian Birds.* Oxford University Press, Delhi.

Daniels, R.J.R (2005). Amphibians of Peninsular India, University Press, Hyderabad.

Prater, S.H. (2005). *The Book of Indian Animals.* Oxford University Press, Delhi.

Subramanian, K.A. (2005) Dragonflies and Damselflies of Peninsular India-A Field Guide. Centre for Ecological Sciences, Indian Institute of Science and Indian Academy of Sciences, Bangalore.

Whitaker, R. & A. Captain (2008). Snakes of India – The Field Guide. Draco Books, Chennai.

Credit: Keystone Foundation

Report of livelihood linkages and economic value of wetland : Nedugula and Tarnad Mand

Introduction

Hill Wetlands of varying sizes are found all across the Nilgiris district. Not only do they support a large and varied biodiversity, they are also of importance to the human settlements in the vicinity. While it is commonly understood that the large tracts of vegetable farming and some tea in the proximity are supported by the wetland, there has been no quantification of the actual economic value of the wetland to the human habitations in the vicinity.

Methodology

A sequence of data collection methods were adopted to ascertain the economic value of the wetlands concerned to the proximate human habitations. In the first step, group discussions were held with the members of the habitations in each case and an outline map of the land use around the wetland was drawn. The resource map so generated is depicted below for both the wetland areas of Tarnad Mand and Nedugula.

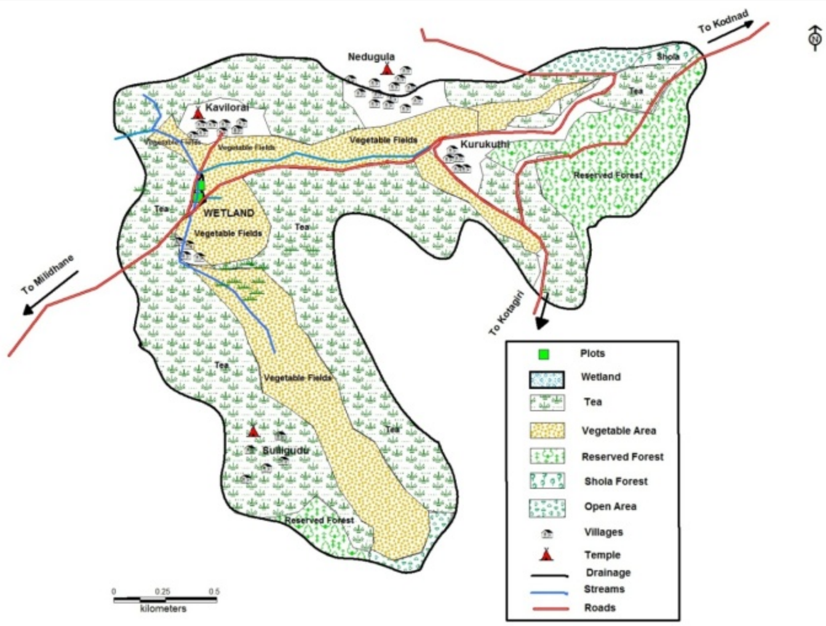


Figure 1: Land use around Wetland in Nedugula

Credit: Keystone Foundation

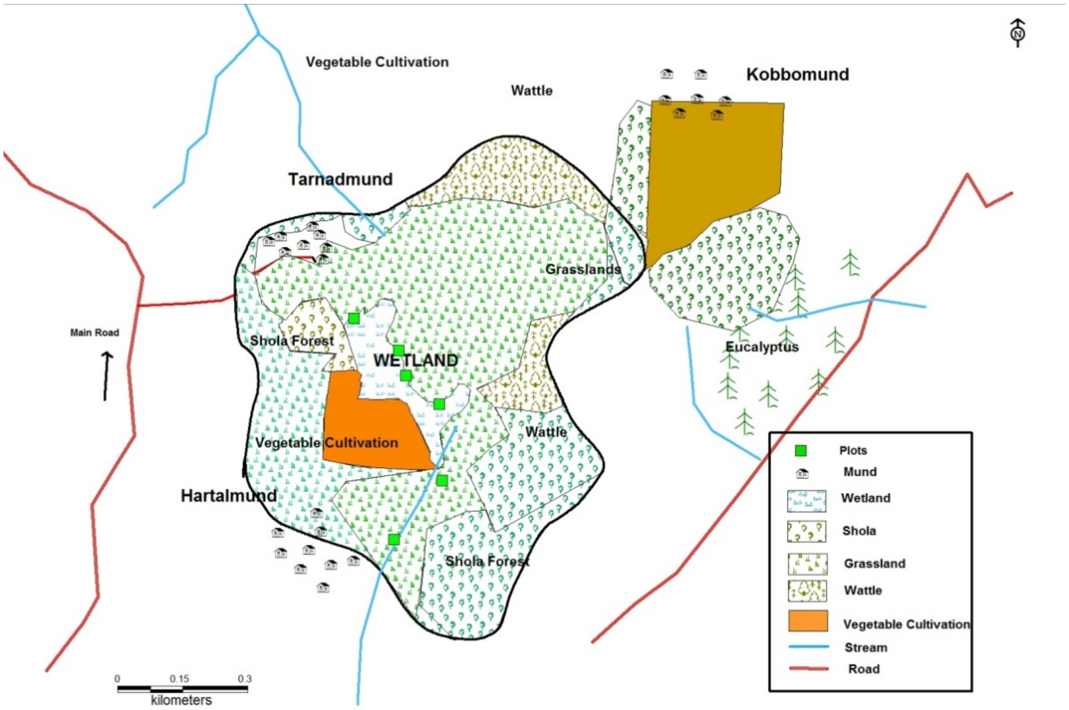


Figure 2 : Landuse around Wetland in Tarnad Mand

Subsequently, a perimeter of the wetland was measured using a GPS instrument. The wetland perimeter was understood to include the drainage area of the wetland as well as the catchment of the drainage area. Members of the Hill Wetland Conservation Group(HWCG) assisted project members in both the locations. The broad areas of varying land use within the wetland perimeters were also demarcated. The data on the land use that emerged from the delineation is represented below.

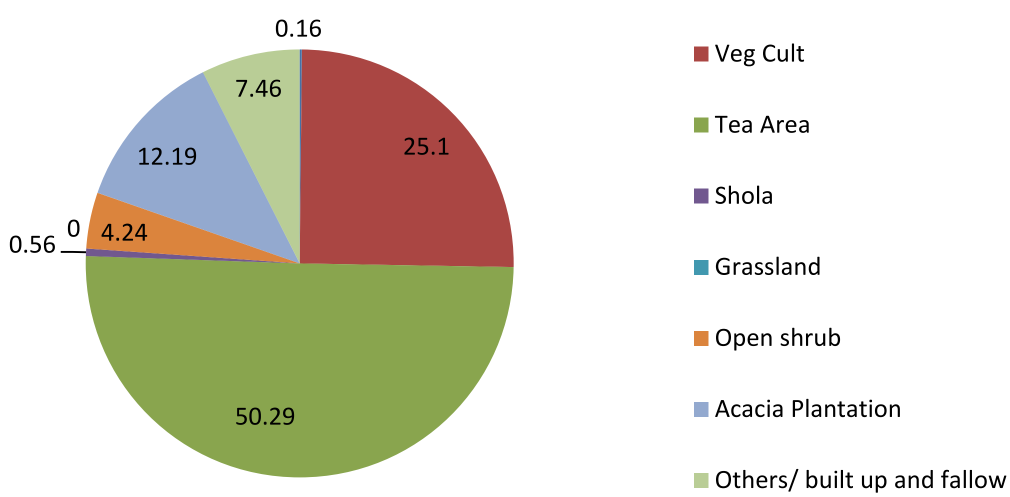


Figure 3: Relative Proportion of varying landuse around wetland in Nedugula

Credit: Keystone Foundation

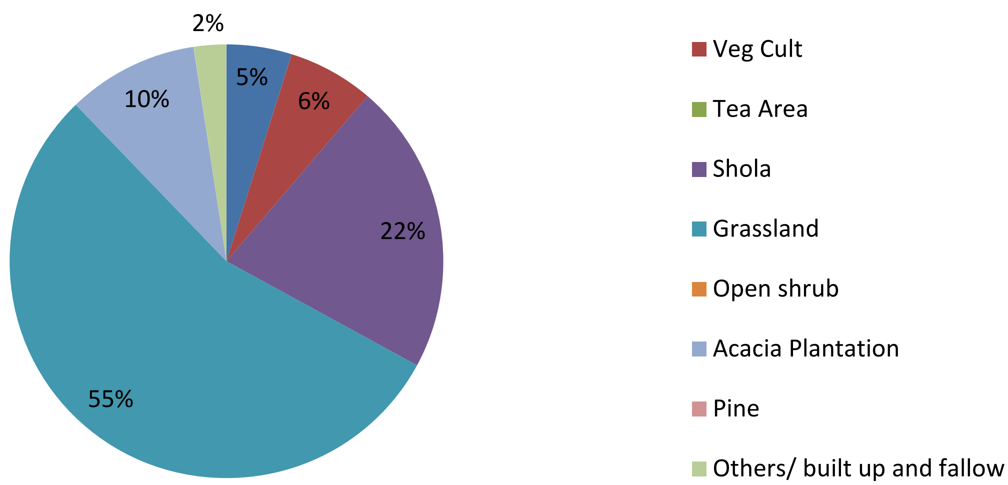


Figure 4 : Proportion of varying landuse around wetalnd in Tarnad Mand

Village level discussions revealed that the direct influence of the wetland on economic activity in the villages should be determined by the extent to which vegetable cultivation was practiced. Cattle rearing was identified as a second key area. The dependence of agriculture on the wetland in Nedugula is far more than in Tarnad Mand where a smaller percentage of the wetland area is under vegetable cultivation.

A survey questionnaire was drafted for sharing with the HWCG, which then selected a member from within the village to administer the questionnaire to each household. The findings of the survey are discussed below.

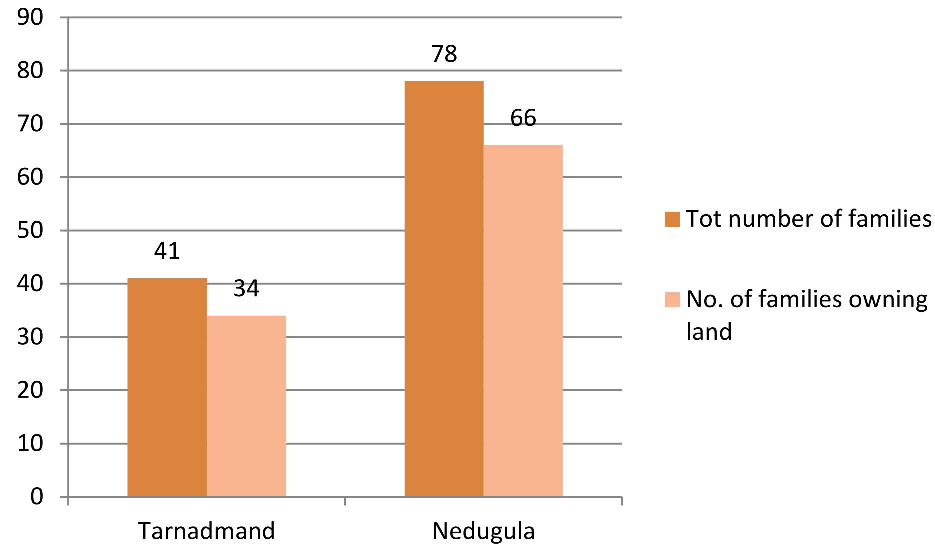
Table 1: Number of families and Population

Village	No of Families	Total Population
Nedugula	78	331
Tarnadmand	41	170

A total of 119 families were surveyed across the 2 villages. Tarnad Mand comprises the four habitations of Tarnad Mand, ArtalMand, KobbuMand and Pudu Mand. The total population in the 5 habitations is 501.

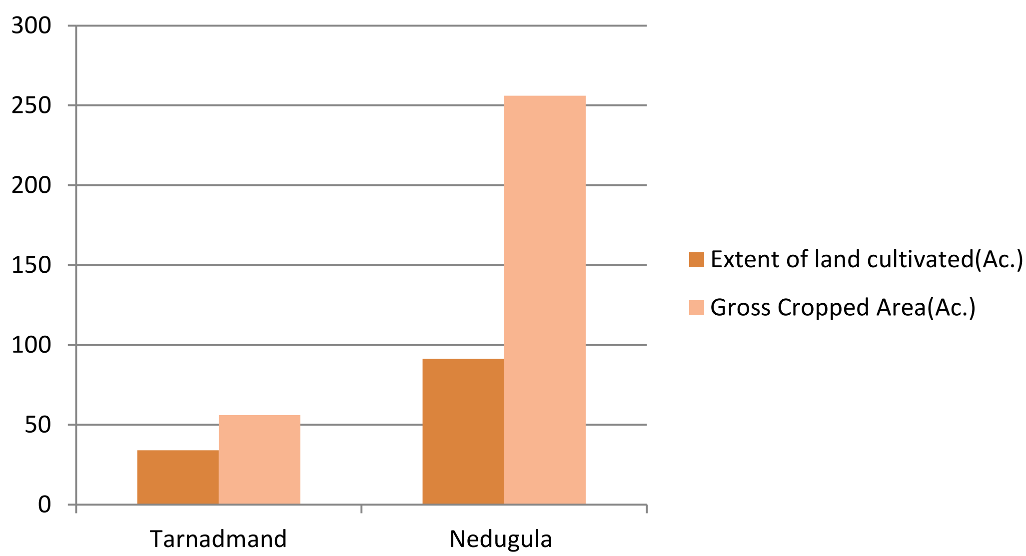
Credit: Keystone Foundation

Table 2 : Number of families owning land in wetland area



In Nedugula, about 84% of families in the village own land in the wetland area and the corresponding figure for Tarnad Mand in 83%.. The land area under vegetable cultivation in both villages is vastly different, Nedugula cultivating almost 91 acres while the area in Tarnad Mand is only about 34 Ac.

Table 3: Extent and intensity of cultivation in wetland area



Credit: Keystone Foundation

The main crops grown in both villages include beans, cabbage, beetroot, carrot and potatoes. The total yield of all vegetables was estimated from the survey response and the market value of each vegetable was taken at an average of the price range across the year. The results arrived at are shown in the table below.

Table 4: Quantum of Vegetable Production and estimated market value

Habitation	Total vol of produce(tonnes)	Value of Produce(approx in '000Rs.)
Tarnadmand	49	493
Nedugula	941	9270

The wetland in TarnadMand has traditionally been an integral part of the grazing grounds of the Toda buffalo. Community elders recall upto 500 head of cattle in the area once. The survey shows only about 49 buffaloes.

Table 5 : Number of Livestock in Wetland Area

Habitation	Cow	Buffalo
Tarnad Mand	5	49
Nedugula	7	0

The survey attempted to understand if there was any income from the sale of milk from the cattle. The cow's milk was largely reported to be for household consumption with some non sale distribution to neighbors. Buffaloes in Tarnad Mand are kept more for ritual purposes than their milk yields. Their milk is consumed within the household and any income from sale of milk seems to be small.

Tenurial aspects of Wetland use

Tenure over the wetland area has emerged as n important dimension of wetland use from the various small group discussions that were held to interpret the survey findings. In Nedugula, where the wetland is located in private land, there seems to be very little community

Credit: Keystone Foundation

jurisdiction over the land use. In Tarnad Mand, the wetland cuts across the Toda Patta land which is a revenue assignment to the Toad community. However, this current status of this land is unclear. The forest department claims ‘ownership’ over it as does the community. Under the circumstances that the community has been using the said extent of land for grazing, they are eligible to claim tenure over it under the provisions of the Scheduled Tribes and Other Traditional Forest Dwellers’ (Recognition of Forest Rights) Act, 2006. Pudu Mand, one of the habitations of Tarnad Mand has initiated the process of filing community claims over about 7 Ha. Of land. There are competing claims to this land from the neighbouring village of Sholur Kokkal as well. While there is a strong cultural motivation for the protection of the wetland amongst the Todas, due to its connection to the sacred buffalo and its pasture, we recognize that the lack of capital to invest in vegetable cultivation has also been an important factor in the fact that only a small portion of the wetland area is appropriated for vegetable cultivation currently.

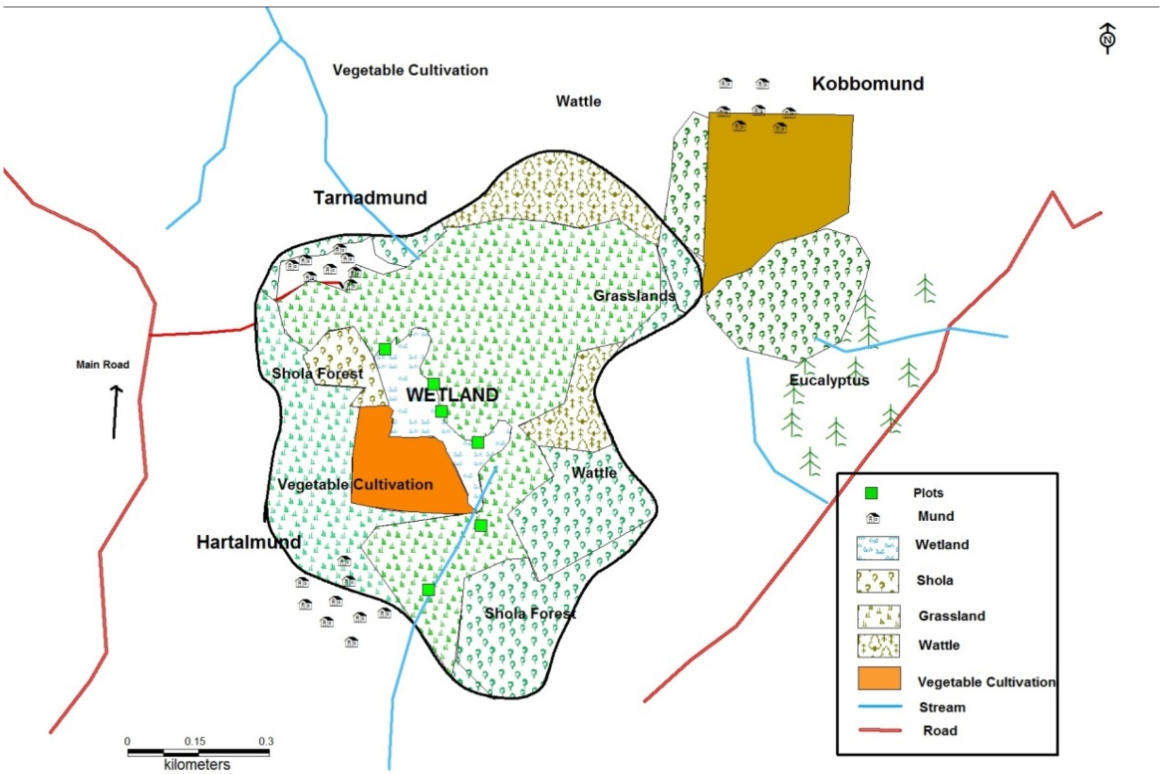
Credit: Keystone Foundation

Conservation Action Plan and Report of Activities undertaken by Hill Wetland Conservation Group in Tarnad Mand

Status and Issues for Conservation

The wetland in Tarnad Mand is located amidst a shola-grassland complex. Lying to the west of Udhagamandalam, the landscape on either side of the Ooty-gudalur Road is dotted with many Toda mands or settlements. Tarnad Mand is one of the few mands to have a vibrant wetland still remaining. TarnadMand itself is composed of 4 habitations viz. Tarnad Mand, Hartal Mand, Pudu Mand and Kobbu Mand.

A schematic representation of the wetland and its adjoining areas is depicted below:



In the upper reaches of the catchment of the wetland, there are shola forests surrounded by plantations of wattle. Village elders estimate that the shola-grassland complex spread to over 200 acres and has since been invaded upon by the wattle plantation. The Elders opine that when a fire occurs inside a shola destroying the forest, correspondingly the wetland also dries up. They blame the artificially planted Eucalyptus and Acacia trees by the forest department for the drying up of numerous wetlands in the region, as they maintain that Eucalyptus trees tend to drain out water from the surroundings.

The wetland originates from a spring and is spread over a large plain area, wherein it is joined periodically by other inflows from the nearby Shola. The total drainage area of the wetland .

Credit: Keystone Foundation

Travelling for about 500 m it becomes a water rich wetland. Near the lower end of its course, the water is diverted for agriculture by members of Pudu Mand.

As part of the project activities, the following activities were undertaken in association with the Hill Wetland Conservation Group in Tarnad Mand.

1. Biodiversity assessment transects
2. Sample collection to ascertain pesticide residues
3. Socioeconomic survey

Biodiversity Assessment

Plots were laid along the margins of the wetlands and also in the centre of the wetlands. Five plots (50*20) were laid in the wetlands. The wetland is dominated by *Juncus* sp and *Poa* sp. 17 species of birds, 4 species of butterfly, 2 species of mammals and odonates, 3 species of amphibian, 1 species reptile and was observed. A proposal for inclusion of the site as an Important Bird area has been forwarded.

The grassland surrounding the wetlands is grazed by semi-wild buffaloes owned by the indigenous Toda community. This grassland is dominated by Eulalia phaenothrix, Ischaemum indicum and introduced grass kikuyu, Pennisetum clandestinum which run wild. Cerpis acaulis, Gentiana pedicellata are found in the grassland.

Swampy vegetation. A total of 75 species belonging to 52 genera and 30 families were recorded. The families with the largest number of species were Asteraceae, Cyperaceae and Poaceae. Tree specie, i.e. Rhododendron arboreum was recorded from on the edges of the swamps. Endemicity was relatively high, 9 endemic species were recorded. Among the 13 Poaceae species, 2 were endemic to the Nilgiris and 1 Western Ghats - Sri Lanka hotspot. One species each of Eriocaulonaceae , Rosaceae Rubiaceae , Berberidaceae and Ericaceae were endemic to Western Ghats. 1 species each of Haloragiaceae and Poaceae were endemic to Nilgiris The dominant species were Juncus glaucus, Pycreus sanguinolentus and Ischane globosa.

Credit: Keystone Foundation

Pesticide Residue Assessment

Given the large scale use of inorganic pesticides and fertilizers for vegetable cultivation, researchers from SACON were invited to monitor the residue levels of organochlorine, organophosphate and synthetic pyrethroid pesticide residue levels in sediments and fish. 6 sediment samples and 1 sample of fish(*Danio* sp) were collected.

Danio sp. fingerlings collected from Tarnadmund had low levels of organochlorines (2.25-2.76ng/g). *Danio* sp. fingerlings were not found to be contaminated with either organophosphate or synthetic pyrethroids. The levels were only below detectable limits. The Study concludes that even if the fishes were expected to have higher pesticide concentrations than the sediment samples, many factors might have been responsible for the present condition. Size and age of the fish, route of entry and concentration available for intake are very important factors for bioaccumulation.

Socioeconomic Survey

The socioeconomic survey of use of wetland by the surrounding community shows the dependence of vegetable cultivation to the extent of about 34 ac. On the wetland. Almost 85% of all the households benefit from this agriculture and through the cattle rearing (about 50 head of cattle. There is a large scale use of inorganic pesticides and fertilizers that might be contaminating the water of the wetland.

Credit: Keystone Foundation

Conservation Action Plan

Based on the results of the assessments of the wetland system, the HWCG in Tarnad Mand decided on a two pronged course of action in the short term.

- Submission of Claim under Forest Rights Act : The first course of action was to submit a community forest resource claim under the Scheduled Tribes and Other Traditional Forest Dwellers'(Recognition of Forest Rights) Act, 2006. This claim is to the extent of about 7 Ha of wetland area has been submitted on behalf of Pudu Mand to secure the existing land use around the wetland. This action was in response to the threat of conversion of part of the wetland catchment to vegetable cultivation by the neighboring village of Sholur Kokkal. Similar claims are being planned on behalf of the other habitations of Tarnad Mand.

- School Session: The HWCG has also started hosting the children from the Glenmorgan government school on outdoor sessions to observe the wetland habitat. This activity started during the project is expected to continue. The children are encouraged to observe wetland flora, birds and animal movements.

- Village Elder leads Village Children : In addition to the above school sessions, the HWCG has nominated Sri Kondilli, a village elder to accompany village children on a transect of the wetland area and catchment to share traditional knowledge about the habitat, the uses of various grasses a nd trees and the need to conserve the habitat.

- Research on Toxicity : Given that the study on pesticide residues has returned inconclusive results on the extent of residue found in fish and soil samples, the HWCG has welcomed further research on the same while accepting the need to be vigilant about the excessive use of inorganic inputs.

Credit: Keystone Foundation

- Need for cooperation with neighbouring villages on wetland conservation : The village realizes the need for dialogue with the neighbouring village especially, Sholur to arrive at a join strategy for conservation.

PESTICIDE CONTAMINATION IN SELECT WETLANDS OF NILGIRIS DISTRICT WITH SPECIAL REFERENCE TO SEDIMENTS AND FISH

Report Submitted toKeystone Foundation, Kotagiri, Nilgiris District

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SACON

Sálim Ali Centre for Ornithology and Natural History

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Credit : Report by Dr S. Muralidharan , Salim Ali Centre for Ornithology and Natural History for Keystone Foundation

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Executive Summary

Intensive use of synthetic pesticides in agriculture and public health has resulted in serious environmental hazards. The freshwater bodies adjoining agriculture fields are continuously being contaminated by toxic chemical pesticides. Many organic pesticides and trace elements are hydrophobic; that is, in aquatic environment they tend to be associated with sediment and biological tissues rather than dissolved in water. Hence, studying sediments and fishes are the effective tools to assess the occurrence of these contaminants in the environment.

Pesticides and their transformation products (TPs) are mainly hydrophobic, persistent and bioaccumulable that are strongly bound to sediment/ soil. Of the various aquatic organisms, fishes are proven as excellent indicators of agrochemical contamination, because they can acquire organic pollutants from food, suspended particles or directly from water. Fish can be found virtually everywhere in the aquatic environment and they play a major ecological role in the aquatic food webs because of their function as a carrier of energy from lower to higher trophic levels.

In the present study, 19 sediments samples from three wetlands in Nilgiris district, namely Tarnadmund, Nedugula and Bison Swamp and fingerlings from Tarnadmund were collected and analyzed for organochlorines, organophosphates and synthetic pyrethroids.

Data are discussed to understand the status in the residue levels in the context of usage pattern and policy. Maximum concentration of γ HCH (14.19 ng/g) was recorded in sediment collected from agricultural field in Nedugula. Levels were very less in Bison Swamp (BDL to 0.45 ng/g). Σ *DDT ranged from BDL to 75.01; BDL to 48.49 and BDL to 1.71 ng/g in Tarnadmund, Nedugula and Bison Swamp sediments respectively. Among cyclodiene pesticides (α endosulfan, heptachlor epoxide, chlordane and mirex) analysed, trace level of* Σ *heptachlor was detected only in hilly terrain of Tarnadmund (0.37 ng/g), where agricultural activities have been intense, while residues of α endosulfan, chlordane and mirex were not detected in any of the sediments and fingerlings. Phorate (13.25 ng/g) was the maximum in the pond sediments of Nedugula wetland, followed by Malathion (9.82 ng/g) in the same site. High concentrations of Phorate and Malathion residues in sediment samples of Nedugula reflect their current use on cabbage, carrot and tea. Residues of ethion was the maximum in sediments collected from the upper (2.90 ng/g) and downstream (2.61 ng/g) areas of Nedugula, while it was BDL in Bison Swamp.*

Among the individual synthetic pyrethroids, Σ *fenvalerate was found to be higher (20.95 ng/g) than other pesticides. Deltamethrin was not detected in any of the sediments samples analysed. Fingerlings of Danio sp could be collected only from a pond near Tarnadmund. It had β HCH (0.61 ng/g) among the HCH isomers tested. The metabolites of DDT, namely o,p DDT and p,p' DDD were detected in the range of 1.26 to 1.50 and 1.0 to 1.26 ng/g, respectively. All other OCs, OPs and SPs tested were BDL in Danio sp. It is necessary to mention that the quantum of pesticide residues detected may not reflect the threat because, the toxicity differs among pesticides. Apart from accumulation in animal tissues through food*

chains, locally high rainfall and laterite soil in the district facilitate speedy leaching of toxic chemicals leading to contamination of water bodies not only in the hills but also in the plains.

It looks impossible to dispense with the use of pesticides and other chemicals to meet the growing food requirement by the ever growing human population. Hence, there is a need to promote safe and efficient use of pesticides for sustainable agricultural production in the district although the best will be to dispense with the use of chemicals and adopt organic farming and promote effective and sound Integrated Pest Management programmes.

1. GENERAL INTRODUCTION

Adequate information is available in India to say that our wetlands are contaminated either by pesticides or industrial effluents or by both. It may be noted that the consumption of pesticide in India has crossed more than 40,000 metric tons (MT) from a mere 5,000 MT of 1960s (http://www.indiastat.com retrieved on January 2011). These pesticides find their way to the wetlands either through runoff or seepage and inflict deleterious effects on the entire wetland system. Worst still is that these contaminants even make their way to the nearby drinking water sources also. Estimates show that three million people around the world suffer from pesticide poisoning every year, of which 2,00,000 die, mostly in countries such as India (Sahgal, 2003 and Vijayan *et al.,* 2004).

The intensive use of synthetic pesticides in agricultural fields and public health operation systems has resulted in serious environmental hazards (Singh *et al.,* 2004 & 2006). The freshwater bodies adjoining agriculture fields are continuously being contaminated by the toxic chemical pesticides (Bouregeois *et al.,* 1993, Nayak *et al.,* 1995 and Kalavathy *et al.,* 2001) and pose potential direct threats to freshwater organisms, particularly sensitive animals, such as fish and prawns (Saravanan *et al.,* 2003, Selvarani and Rajamanickam, 2003 and Park *et al.,* 2004).

Pesticide residues may be comprised of many substances, including specified derivatives such as degradation products, metabolites and impurities that are considered to be of toxicological importance. Several studies showed that pesticides could cause health problem such as birth defects, nerve damage and cancer (John *et al.,* 2001, Bedi *et al.,* 2005 and Aulakh *et al.,* 2006). Pesticides can be divided into many classes, of which the Organochlorines (OCs) were the first group to be invented. OC pesticides are non-polar, lipophilic, toxic and highly persistent compounds. These synthetic chemical pesticides reach the aquatic environment via soil percolation, air drift or surface runoff, leaching, disposal of empty containers, etc. Further, these OCs end up in groundwater and their transformation products may remain for years (Mudiam *et al.,* 2011). As a result, they can be biomagnified through food chains and produce harmful effects at every level (Muralidharan *et al.,* 2009).

The organophosphate (OP) groups of pesticides are being most commonly used across the world. They have replaced OCs, having the advantage of being readily biodegradable and less persistence in the environment. Their degradation process is faster than other agrochemicals (Sattar, 1990). These pesticides are potent cholinesterase (ChE) inhibitors. They can bind covalently with the serine residue in the active site of acetyl cholinesterase (AchE), thus preventing its natural function in the catabolism of neurotransmitters.

Pyrethroids are derived from natural pyrethrins with some modifications to enhance their environmental stability or alter their insecticidal activity. Since they guarantee as an effective agent against a broad range of pests, and stable under field conditions, they are used as insecticides in agriculture worldwide (Shan *et al.,* 1999 and Mak *et al.,* 2005). Many products such as Raid brand pesticides that are commonly found in retail stores for home use contain pyrethroids such as Permethrin and Deltamethrin, to eliminate household pests such as ants and spiders (De Pasquale, 2010). Pyrethroids are expected to be present in environment due to their predominant usage for the control of pests. Several studies have indicated that pyrethroids are highly toxic to a number of non-target organisms such as honeybees, freshwater fishes and aquatic arthropods even at very low concentrations (Smith and Straton 1986; Oudou *et al.,* 2004).

Pesticides and their transformation products (TPs) are mainly hydrophobic, persistent and bioaccumulable that are strongly bound to sediment/ soil. Pesticides that exhibit such behaviour include the organochlorines such as DDT, endosulfan, endrin, heptachlor, lindane and their TPs. Most of them are now banned for agriculture but their residues are still present (Vijayan *et al.* 2008, Muralidharan *et al.* 2010). Several metabolic pathways have been suggested, involving transformation through hydrolysis, methylation, and ring cleavage that produce several toxic phenolic compounds. The pesticides and their TPs are retained by soils to different degrees, depending on the interactions between soil and pesticide properties. The most influential soil characteristic is the organic matter. The higher the organic content, the greater the adsorption of pesticides and TPs. The capacity of the soil to hold positively charged ions in an exchangeable form is important with paraquat and other pesticides that are positively charged. Soil pH is also of some importance (Andreu and Pico, 2004).

Fish is a valuable bioindicator because its detoxification enzymes (e.g. mono-oxygenases) have lower activity than in mammals and thus allows a higher toxicant bioaccumulation. Moreover, fishes can acquire pollutants from food, suspended particles or directly from water (Jayakumar and Muralidharan, 2011). Fish can be found virtually everywhere in the aquatic environment and they play a major ecological role in the aquatic food webs because of their function as a carrier of energy from lower to higher trophic levels (Muralidharan *et al.,* 2008, Jayanthi and

Muralidharan, 2009, Muralidharan *et al.,* 2009 and Muralidharan, 2010). Despite their limitations, such as relatively high mobility, fish are generally considered to be the most feasible organisms for pollution monitoring, especially pesticides in wetlands/ agro-ecosystems (Dhananjayan and Muralidharan, 2010). Hence, studying residue levels in fishes is the most effective tool to assess the contamination load in an aquatic environment.

The current study was carried out with the following objective;

To document the status of pesticide contamination (organochlorines, organophosphates and synthetic pyrethroids residue levels) in sediments and fish collected from Tarnadmund, Nedugula and Bison Swamp wetlands of Nilgiris district.

2. BACKGROUND INFORMATION

The importance and usefulness of wetlands was first brought to the notice of the world through a Convention on Wetlands held at the Iranian city of Ramsar, in the year 1971. The Convention was an inter-governmental treaty that provided the framework for national action and international co-operation for the conservation and wise use of wetlands and their resources. As of 9th March 2007 there are 154 Contracting Parties to the Convention, with 1650 wetland sites, totalling 149.6 million hectares, designated for inclusion in the Ramsar list of Wetlands of International Importance.

The worldwide consumption of pesticide is about 2 million MTs per year, of which 24 % is consumed in USA alone, 45 % in Europe and 25 % in rest of the world. In this context, the average usage of pesticides in India is about 0.6 kg/ha. Among various types of pesticides used in India, 40 % belong to OCs (Abhilash and Singh, 2009). The annual (2008-'09) consumption of chemical pesticides for agriculture in the country has been estimated at 43,860 metric tons (MT).

Consumption of pesticides in India varies with the cropping pattern, intensity of pests and disease and agro-ecological regions. Pesticide use is particularly high in regions with good irrigation and also in those areas where commercial crops are grown (i.e. cashew plantations in northern Kerala and Karnataka). The major use of pesticides in India is for cotton crops (50 - 55 %), followed by paddy and wheat (>40 %) (Shetty, 2004). Chemicals belonging to groups such as organophosphates, carbamates and synthetic pyrethroids are indiscriminately used to control crop pests unaware of their impacts on the ecosystem.

An extensive study done on inland wetlands of India by SACON indicates the threats and conservation issues of the wetlands across the country. They pointed out two overwhelming issues of immediate concerns: huge loss of wetlands in the country and, contamination of the remaining ones. There has been a loss of about 38% of wetlands across the country, since the last 10 years. And, in some districts the loss is up to 88%. A very conservative figure worked out from the existing data shows that there is a substantial loss in the number of wetlands, about 2,76,940 to 2,92,327 during the last 10 years. One of the major reasons for such drastic decline is the failure to consider wetland as a productive unit of land. Instead, it has been considered as wasteland. Land use statistics of none of the states shows a separate category of wetland.

Therefore, apparently there is no legal apparatus for protecting the wetlands. Lack of awareness of wetland values could be one of the major reasons for not recognizing wetland as a separate entity and for not giving the importance it deserves (Vijayan *et al.,* 2004). It has been reported that wetland is the most productive ecosystem and that in terms of economic and ecosystem service values it outweighs forest ecosystems almost seven times. Compounding to the loss of wetlands is that almost all the wetlands studied from 14 states in the country are polluted. In many cases, the fishes are not fit for human consumption, because of the high levels of heavy metals or pesticides. It is a cause for great concern that not even one of the several hundred fishes studied from 115 wetlands was free from pesticides/ heavy metal (Vijayan *et al.,* 2004).

Rao *et al.,* (1994) reported residues of DDT, HCH and Carbofuran associated with high organic contents in the waters of Ooty Lake. Rajukkannu *et al.,* (1989) reported residues of a few nematicides in potato. Regupathy and Kuttalam in (1990) recorded organochlorine contamination in human milk in Nilgiri district. Vijayan and Muralidharan in 1999 conducted a study on pesticide contamination in sediment, water, fishes and bird samples collected from major water bodies of Nilgiri district.

The present study was undertaken to monitor the residue levels of organochlorine, organophosphate and synthetic pyrethroid pesticide residue levels in sediments and fish collected from Tarnadmund, Nedugula and Bison Swamp wetlands of Nilgiris district.

3. MATERIALS AND METHODS

3.1. Study sites

Wetlands, namely Tarnadmund, Nedugula and Bison Swamp were selected for the present study.

Figure 1 : Viiew of TarnadMand Wetland

Figure 2: View of Nedugula wetland

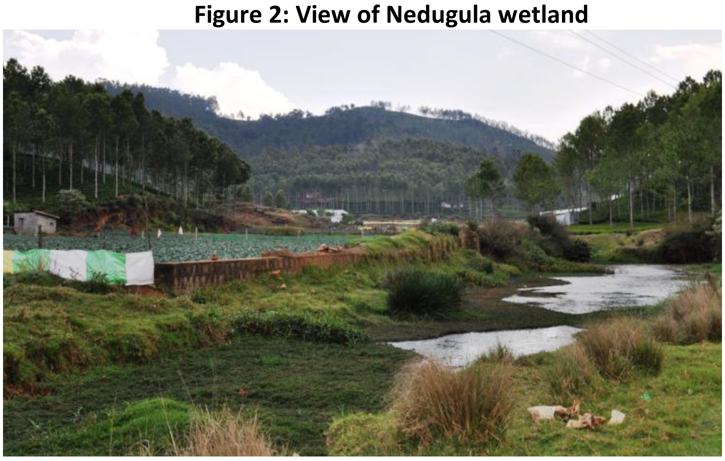
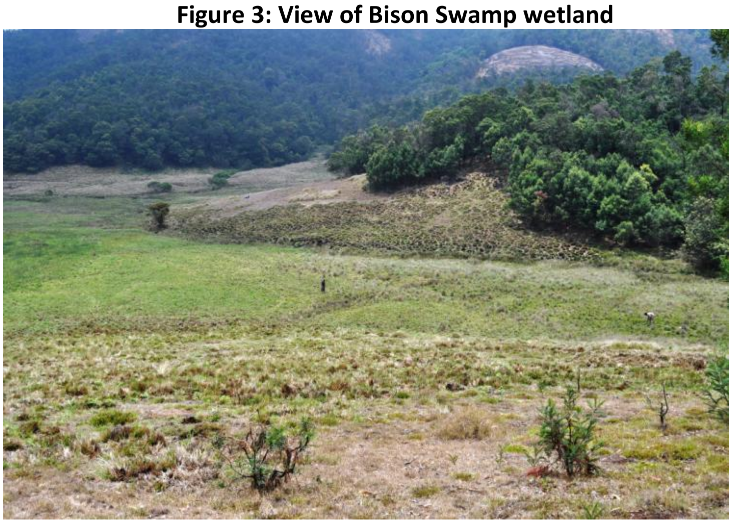


Figure 3: View of Bison Swamp wetland



3.2. Sample collection

Nineteen sediment samples were collected from three wetlands, namely Tarnadmund, Nedugula and Bison Swamp of Nilgiris district. Due to low water availability fish samples were not available in Nedugula and Bison Swamp to quantify pesticide residues. Only one species of fingerlings (*Danio* sp) could be collected in Tarnadmund and pooled together to make a sample in triplicate. All the samples were labelled and packed in clean polythene bags, transported on ice to the laboratory at Sálim Ali Centre for Ornithology and Natural History, Coimbatore. Fish samples were cleaned off dirt in tap water and whole fingerling was minced into smaller pieces and sub samples were taken from the homogenate. About 10 g of the homogenate was weighed using a top loading electronic balance (Mettler AE420) and transferred to clean specimen vials and stored in freezer at -20°C until further analysis.

Figure 4 : Sediment sample collection

3.2.1. Sample processing

3.2.1. i. Sediment

Samples were processed adopting standard operating protocol (Codex Alimentarius WHO/FAO, 2003). Samples were air dried and ground with pestle and mortar, and sieved through 0.5 mm sieve prior to further processing (Je *et al.,* 2003). About ten g of dry sediment samples were mixed with anhydrous sodium sulphate (Qualigens fine chemicals, Mumbai) and then transferred into a 250 ml pre-washed conical flask, about 150 ml Dichloromethane (Merck Specialties, Mumbai) was added and the samples were sonicated in Ultrasonic water bath for 60 min at 30°C. After sonication they were allowed to stand in 30°C water bath overnight. The samples were again sonicated for 60 minutes at 30°C, and then filtered through prewashed glass wool placed on the Pasteur pipette (Hoof and Hsieh 1996). The extracts were condensed using rotary evaporator (Buchi) to a specific aliquot on a florisil (60-120µ mesh size SD Fine chemicals, Mumbai) and silica gel (60-100µ mesh size, Qualigens fine chemicals, Mumbai) packed glass column for clean up. The eluate was condensed in a vacuum evaporator and stored in deep freezer at -20˚C until final analysis was carried out.

3.2.1. ii. Fingerlings

QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) multiresidue extraction method was followed with suitable solvents and reagents for extracting pesticide residues. Ten grams of tissue was taken and ground with mortar and pestle to get a homogenous mixture. Then the homogenate was transferred into a 50 ml centrifuge tube (Oakridge, Tarsons) and 20 ml of Acetonitrile (Merck Specialties, Mumbai) was added to it and shaken vigorously for a minute. To the centrifuge tube, 4 g of anhydrous Magnesium sulphate ($MgSO_4$ - Himedia, Bangalore), 1g of Sodium chloride (NaCl - (Merck Specialties, Mumbai) salts were added and centrifuged at 10,000 rpm for 10 mins. Then the organic layer of the samples (4 ml) was transferred into a 15 ml centrifuge tube which contained 100 mg of PSA and 600 mg of $MgSO_4$ and again centrifuged at 5,000 rpm for 5 mins. From the above extract, 2 ml was transferred into test tube to evaporate to dryness and reconstituted with 1 ml of HPLC grade n-

Hexane and stored in deep freezer at -20˚C until final qualitative analysis was carried out.

Figure 5. Extraction of pesticide residues - in progress

3.3. Chemical Analysis

Quantitative analysis of OC, OP, and SPs were made with Agilent Model 7890A Series Gas Chromatograph equipped with 7000 GC-Quadruple and HP-5 fused silica capillary column (15m x 0.25mm I.D x 0.25μm film thickness) coated with 5% phenyl methyl siloxane with Helium (IOLAR) as carrier gas (1.2 ml/min) and chromatographic operating conditions were as follow: detector 325^0C; injector: 325^0C; oven temperature was programmed as 70^0C-1min; 8^0C/min-280^0C-9.2 min. All the samples were analyzed for organochlorine pesticides, namely alpha-Hexachlorocyclohexane (α-HCH), beta-Hexachlorocyclohexane (β-HCH), delta Hexachlorocyclohexane (δ-HCH), gamma-Hexachlorocyclohexane or lindane (γ-HCH), o,p-Dichlorodiphenyltrichloroethane (DDT), o,p-Dichlorodiphenyldichloroethylene (DDE), p,p-Dichlorodiphenyldichloroethylene (DDE),o,p-Dichlorodiphenyldichloroethane (DDD), p,p-Dichlorodiphenyldichloroethane (DDD), α-Endosulfan, heptachlor, Heptachlor Epoxide (HE), Chlordane and Mirex, organophosphate pesticides, namely Phorate, Malathion, Phenthoate, Primiphos ethyl and Ethion and Synthetic Pyrethroids, namely Permethrin I, Permethrin II, Cypermethrin I, Cypermethrin II, Cypermethrin III, Cypermethrin IV, Deltamethrin I, Deltamethrin II, Fenvalerate I and Fenvalerate II. An equivalent mixture manufactured by Sigma-Aldrich chemicals (Accustandard - United States) was used as standard. Concentrations of individual compounds were quantified from the peak area of the sample to that of the corresponding external standard. Recoveries of the compounds from fortified samples (50 μg/kg) ranged from 91 to 102% and the results were not corrected for per cent recovery and expressed in wet weight basis. Analysis were run in batches of 10 samples plus four quality controls (QCs), namely reagent blank, matrix blank, QC check sample and random sample in duplicate. The minimum detection limit for each pesticide was given in table 1. The limits of detection (LOD) for the method were in the range of 0.25-0.75; 0.29-0.62 and 0.09-0.40 ng/g for the organochlorine, organophosphate and pyrethroid compounds respectively. All concentrations are expressed on dry weight basis for sediments and wet weight basis for fingerling.

Table 1: Detection limit of pesticides analyzed in the present study

S.No	Name of the pesticide/ group	Detection limit (ng/g)
	Organochlorines (OCs)	
1.	α HCH	0.27
2.	β HCH	0.43
3.	γ HCH	0.33
4.	δ HCH	0.32
5.	*o,p* DDT	0.75
6.	*o,p* DDE	0.32
7.	*p,p* DDE	0.33
8.	*o,p* DDD	0.30
9.	*p,p* DDD	0.58
10.	α Endosulfan	0.38
11.	Heptachlor	0.25
12.	Heptachlor Epoxide	0.49
13.	Chlordane	0.33
14.	Mirex	0.25
	Organophosphates (OPs)	
15.	Phorate	0.33
16.	Malathion	0.36
17.	Phenthoate	0.44
18.	Primiphos ethyl	0.62
19.	Ethion	0.29
	Synthetic Pyrethroids (SPs)	
20.	Permethrin I	0.21
21.	Permethrin II	0.31
22.	Cypermethrin I	0.30
23.	Cypermethrin II	0.40
24.	Cypermethrin III	0.34
25.	Cypermethrin IV	0.34
26.	Deltamethrin I	0.09
27.	Deltamethrin II	0.31
28.	Fenvalerate I	0.38
29.	Fenvalerate II	0.27

4. RESULTS AND DISCUSSION

4.1. Total pesticide residues in sediments of select wetlands in Nilgiris district

Nineteen sediments samples from three wetlands of Nilgiris district, namely Tarnadmund (TAR), Nedugula (ND) and Bison Swamp (BSW) and *Danio* sp. fingerlings from Tarnadmund were collected and the data have been analysed to check the overall load of pesticides in the study sites with reference to group, namely organochlorines, organophosphates and synthetic pyrethroids. Further, within the groups, levels of individual pesticides and their isomer and metabolites have been compiled to understand the problem with reference to their usage.

Total OCP residue load was found to be the maximum (157.20 ng/g) in midstream sediments of Nedugula, followed by downstream in Tarnadmund (135.57 ng/g), while it was below detection limit (BDL) in midland and highland areas of Bison Swamp. Total organophosphate residues were found to be higher in pond sediments in Nedugula (23.54 ng/g) followed by near stream in Tarnadmund (8.63 ng/g). Total synthetic pyrethroids were found to be higher in sediments collected from midstream in Nedugula (62.79 ng/g) followed by downstream in Tarnadmund (39.62 ng/g), while the levels were found to be the lowest in Bison Swamp (1.13 ng/g). The mean variations in the total organochlorines, organophosphates and synthetic pyrethroids residue levels in sediments are presented in Fig. 3-5.

4.1.1. Residues of organochlorine pesticides in sediments in Tarnadmund, Nedugula and Bison Swamp wetlands of Nilgiris district.

Many organic pesticides and trace elements are hydrophobic; that is, in aquatic environments they tend to be associated with sediment particles and biological tissues rather than dissolved in water. For this reason, sampling sediment and fish is an effective way to assess the occurrence of these contaminants in the aquatic environment.

a). HCH and its isomers

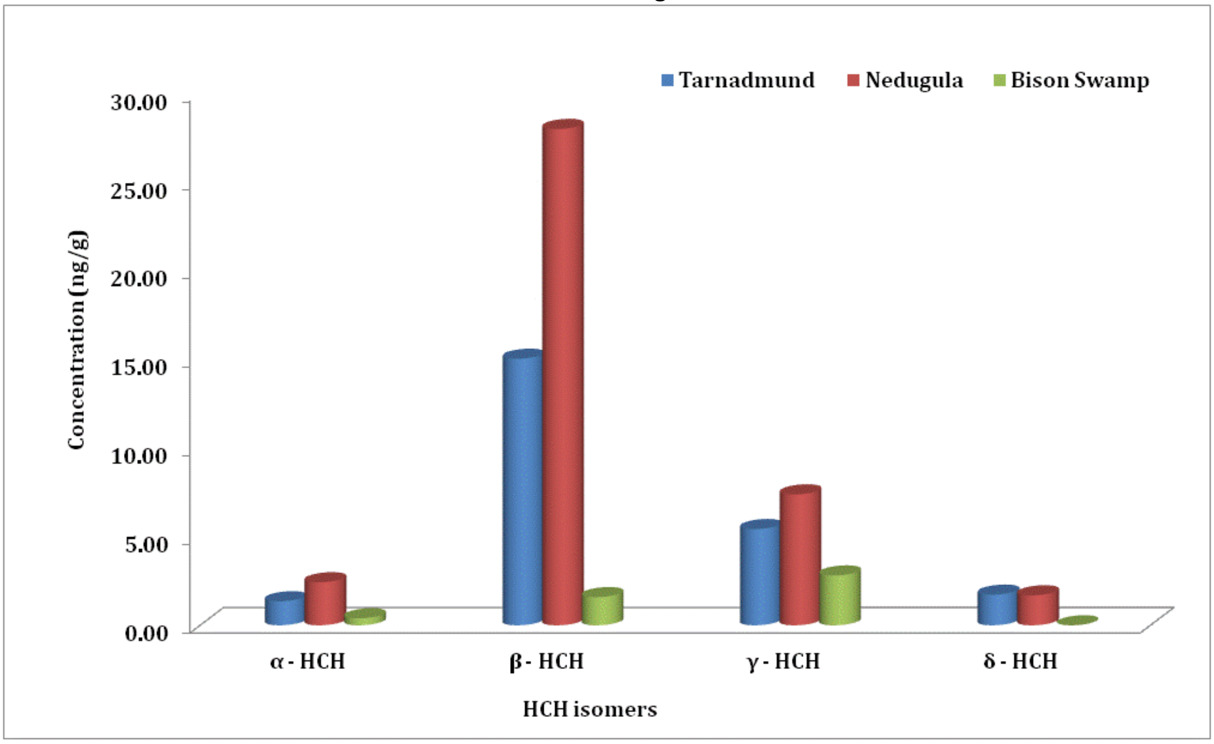
Four isomers of HCH, namely alpha (α), beta (β), gamma (γ) and delta (δ) were detected in the sediments collected from the study sites in Nilgiris district. Variations in the HCH isomer residue levels in sediments are presented in Fig. 1. Alpha HCH was recorded the maximum in sediments collected from the pond (4.06 ng/g) and midstream area of Nedugula (4.03 ng/g), while it was minimum in Bison Swamp (BDL - 0.45 ng/g). Predominance of α HCH in environmental samples reflects the recent use of technical mixtures of HCH (Doong *et al.,* 2002). Maximum concentration of γ HCH (14.19 ng/g) was recorded in sediment collected from agricultural field in Nedugula, followed by midstream (13.39 ng/g) and pond sediments (12.60 ng/g) of the same area. Levels were very less in Bison Swamp (BDL to 0.45 ng/g). The levels of γ HCH was higher (10.98 ng/g) in downstream sediments of Tarnadmund as well. δ HCH levels were the maximum in downstream area of Tarnadmund (2.65 ng/g). In Nedugula, δ HCH was detected in the pond (2.14 ng/g) and midstream area (2.10 ng/g) whereas levels were below detection limit (BDL) in Bison Swamp. β HCH (89.15 ng/g) was the maximum in the midstream sediments in Nedugula wetland. Residues of total HCH (Σ HCH) in sediments ranged between BDL and 108.71 ng/g.

Levels of α HCH in the sediments of Nedugula (BDL - 4.06 ng/g) and Tarnadmund (BDL -3.09 ng/g) are higher than the levels reported by Vijayan and Muralidharan, (1999) in Pykara, while levels in Bison Swamp are lower. Further, levels of Σ HCH in 70 % of the samples are higher than the levels reported by Vijayan and Muralidharan, (1999) from sediments of various reservoirs, namely Avalanche, Uppar Bhavani, Emerald, Kamaraj Sagar, Pykara and Maravakandy, Ooty lake and rivers such as Coonoor and Moyar in Nilgiris district. Σ HCH levels are lower than the levels recorded in the coastal sediments of Chennai, Cochin and Visakapattinam (Senthilkumar *et al.,* 2001) and the river sediments of Gomati, Lucknow, India (Malik *et al.,* 2009).

Technical HCH is a broad spectrum organochlorine insecticide that was available for decades and used throughout the world for agricultural and non-agricultural purposes because of its effectiveness and low cost (Li *et al*. 1998; Raina *et al.,* 2008; Carvalho *et al*. 2009b). It has more than five isomeric forms (α, β, γ, δ and ε etc), which are all toxic, recalcitrant and exhibits both acute and chronic toxicity, particularly β isomer, acts as an environmental estrogen (Walker *et al*. 1999). Its use continued unabated until HCH was also banned in 1997 in India, but restricted use was allowed for lindane (99% γ HCH). It is still used illegally for control of mosquitoes and other insect pests (Raina *et al.,* 2008 and Lal *et al.,* 2010).

The presence of β isomer, the most persistent isomer (Phillips *et al*. 2005), can be attributed to the degradation of α HCH. Wu *et al*. (1997) demonstrated that the transformation of α HCH occurs under both toxic and anoxic conditions, while β HCH increased resistance to microbial degradation and lower volatility (Babu Rajendran *et al*. 2005; Phillips *et al*. 2005). Considering that the half-life of lindane is 30-300 days in water and 2 years in soils (INE, 2004), its detection in this study suggests its continuing use for either agricultural or public health purpose. In addition, β HCH and lindane isomers exceeding the sediment quality guidelines (SQG), the threshold effect level (TEL), the probable effect level (PEL) (Buchman 2008) and the maximum permissible concentration (MPC) (Crommentuijn *et al.* 2000) in sediments collected from streams of Tarnadmund and downstream, agricultural field and pond areas of Nedugula indicate possibility of adverse effects to organisms. It is known that lindane causes endocrine disorders (CEC, 2003). Although technical HCH is restricted in many countries, such as Canada, the USA, European Union and Mexico, lindane is still used to treat seeds and control ectoparasites in cattle. Lindane is also used to a lesser degree as a pharmaceutical to treat lice and scabies in developing countries (Li 1999; INE 2004).

Figure 6 : Mean concentration of HCH isomers in sediments collected from select wetlands in Nilgiri district.



b). DDT and its metabolites

Three isomers of DDT (*o,p* DDT, *o,p* DDE and *o,p* DDD) and 2 metabolites (*p,p'* DDE and *p,p'* DDD) were detected in the sediments collected from the study sites in Nilgiris district. Variations in residue levels of DDT isomers and metabolites in sediments are presented in Fig. 2.

Residues of o,*p* DDT were detected in 70 % of the samples. Residues of *p,p'* DDD was the maximum (36.11 ng/g) in the downstream sediments of Tarnadmund, followed by of o,*p* DDT (33.27 ng/g) in the same site. The levels of o,*p* DDD, o,*p* DDE and *p,p'* DDE were in the ranges of BDL to 3.91; BDL to 0.92; BDL to 0.94 ng/g respectively in Tarnadmund samples. Levels of these chemicals were < 0.5 ng/g in other sites. This indicates the past usage of this pesticide in this region. Σ DDT ranged from BDL to 75.01; BDL to 48.49 and BDL to 1.71 ng/g in Tarnadmund, Nedugula and Bison Swamp sediments respectively.

Wong *et al.* (2010) detected the highest concentration of DDT in urban soils of an endemic malarial region, Maxico (360 ng/g), while the concentrations found in agricultural soils of the same region (mean of Σ DDT = 10 ± 21 ng/g) were lower than the present study. However, levels of Σ DDT in >50 % of the samples are higher than the levels reported by Vijayan and Muralidharan, (1999) from various reservoirs, namely Avalanche, Uppar Bhavani, Emerald, Kamaraj Sagar, Pykara and Maravakandy, Ooty Lake and rivers such as Coonoor and Moyar in Nilgiris district. Σ DDT levels are lower than the levels recorded in the coastal sediments, Chennai, Cochin and Visakapattinam (Senthilkumar *et al.,* 2001) and in river sediments of Gomati, Lucknow, India (Malik *et al.,* 2009).

The Σ DDT concentration obtained in this study is higher than the concentration reported by Babu Rajendran *et al.,* (2005) in sediments (0.04 to 4.79 ng/g) collected from the Bay of Bengal, India; Pandit *et al.,* (2006) in coastal marine sediments (5.68 ng/g) of Mumbai and lower than the sediments (BDL to 480 ng/g) collected from select locations along the Mumbai trans-harbour line, Mumbai (Vijayan *et al.,* 2008).

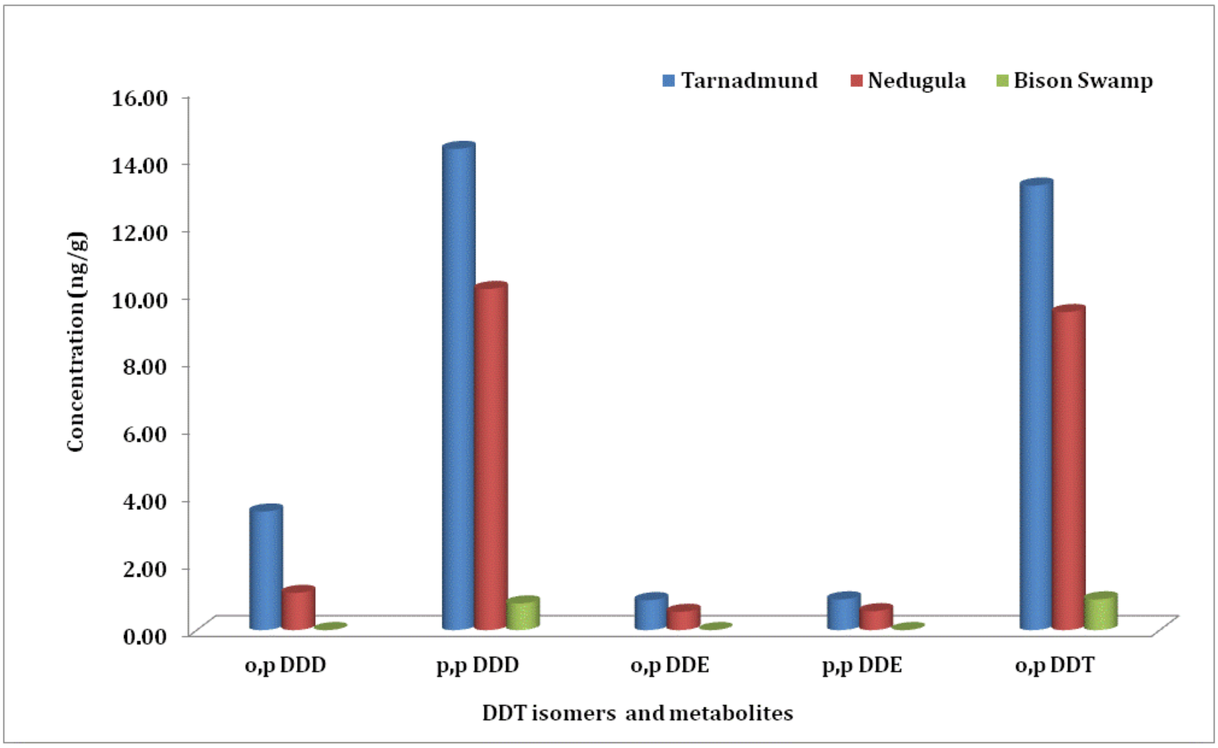
The DDE/ DDT ratio in sediments measured in the Tarnadmund and Nedugula indicates slower degradation rates in these wetlands. The high incidence of DDE has ecological implications because this metabolite is more persistent and toxic than DDT. Furthermore, DDE is known to alter metabolic functions in organisms by acting as an antiandrogen, binding to androgen receptors and inhibiting transcriptional activation, which causes reproductive abnormalities (WHO 2004). The concentrations of *p,p'* DDE (BDL - 0.94 ng/g) did not exceed the sediment quality guidelines (SQG), threshold effect level (TEL), probable effect level (PEL) (Buchman 2008) and maximum permissible concentration (MPC) (Crommentuijn *et al.* 2000).

However, as per the Canadian sediment quality guidelines on PEL, the concentrations of total DDT exceeded the 6.75 ppb level in 27 % of the samples.

Technical DDT is typically composed of 77.1% *p,p'* DDT, 14.9% *o,p* DDT, 4% *p,p'* DDE, and some other trace impurities; thus, the ratio of parent compounds to metabolites has been used to infer the age of contaminant residues in sediments (Zhu *et al.* 2005). In many parts of India, DDT has also largely lost its effectiveness (Sharma, 1999).

In India, the use of DDT in agriculture was banned in 1989 with a mandate to use a maximum of 10,000 tons of DDT per annum for the control of malaria and Kala-azar and this policy is strictly adhered to till date (Dash *et al.,* 2007). DDT can accumulate and biomagnify in organisms (Walker 2001) due to its lipophilicity (K_{ow} = 5.7 - 6.36) and persistence ($T_{1/2}$ = 10 - 15 years). Their long persistence is the reason that residues of DDT and its metabolites can still be detected in the environment. DDE is the primary metabolite found in the environment and is more persistent than DDT. The degree of persistence of DDE varies considerably, as persistence depends on soil type and temperature. The estimated half-life of DDE in tropical and temperate soils is 10 and 30 years, respectively (Hwang *et al.* 2006), while the half-life of DDT varies from 6 weeks to 1.5 years in tropical soils and from 10.5 to 35 years in temperate soils (Fogh *et al.* 2001). The concentrations of p,p'-DDE observed in this study are lower than to those found by Carvalho *et al.* (2002) in the Pabellon Lagoon, Maxico (0.3 - 26 ng/g).

Figure 7: Mean concentration of DDT isomers and metabolites levels in sediments collected from select wetlands in Nilgiri district.

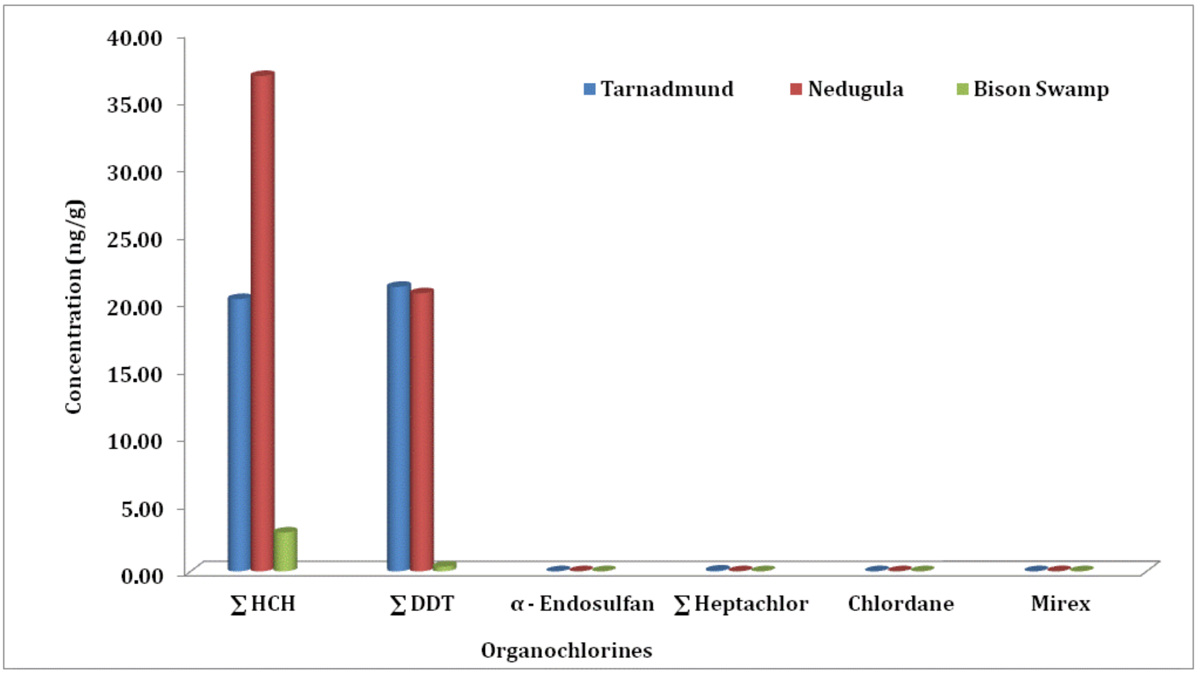


c). Cyclodiene insecticides

Four cyclodiene pesticides (α endosulfan, heptachlor epoxide, chlordane and mirex) have been included in the present study. Of all the samples analysed, trace level of Σ heptachlor was detected only in hilly terrain of Tarnadmund (0.37 ng/g), where agricultural activities have been intense, while residues of α endosulfan, chlordane and mirex were not detected in any of the sediments from the other sites. Further, Σ heptachlor levels are lower than the levels reported by Vijayan and Muralidharan, (1999) from various reservoirs, namely Avalanche, Uppar Bhavani, Emerald, Kamaraj Sagar, Pykara and Maravakandy, Ooty lake and rivers such as Coonoor and Moyar in Nilgiris district and coastal sediments of Chennai, Cochin and Visakapattinam (Senthilkumar *et al.,* 2001) and Gomati river, Lucknow India (Malik *et al.,* 2009). The Supreme Court vide its order dated May 13, 2011 had banned the manufacture, sale, use and export of endosulfan in India. The court had later allowed exports of the stocks but the ban on its use, manufacture and sale within India continued. In April this year the pesticide manufacturers once again appealed to the apex court that they be allowed to manufacture endosulfan from the stock of raw material, Hexachlorocyclopentadiene (HCCP), available with them and use it within the country. The court ordered the centre to revert with a disposal plan of the banned pesticide. The centre has recommended that no further exports of HCCP be allowed in the country. However, the endosulfan manufactures should be allowed to manufacture endosulfan, with the available stock of HCCP, and sell it within India except Kerala and Karnataka (http://www.cseindia.org; Retrieved on 15th October 2012).

The levels of total OCs in the present study are lower than the levels reported by Kumarasamy *et al.,* (2012) in sediments of Tamiraparani river basin, Tamil Nadu during summer. Further, the levels of the OC pesticides and metabolites recorded in the present study are lower than the levels recorded in the sediments of Mahala reservoir, Jaipur (Misra, 1989; Misra & Bakre 1994); Unnao district, Uttar Pradesh, northern Indo-Gangetic region (Singh *et al.,* 2007) and sediments of paddy agroecosystem in Padayetti village, Kerala (Muralidharan & Ganesan 2011).

Figure 8 Levels of organochlorine pesticide residues in sediments collected from select wetlands in Nilgiri district.



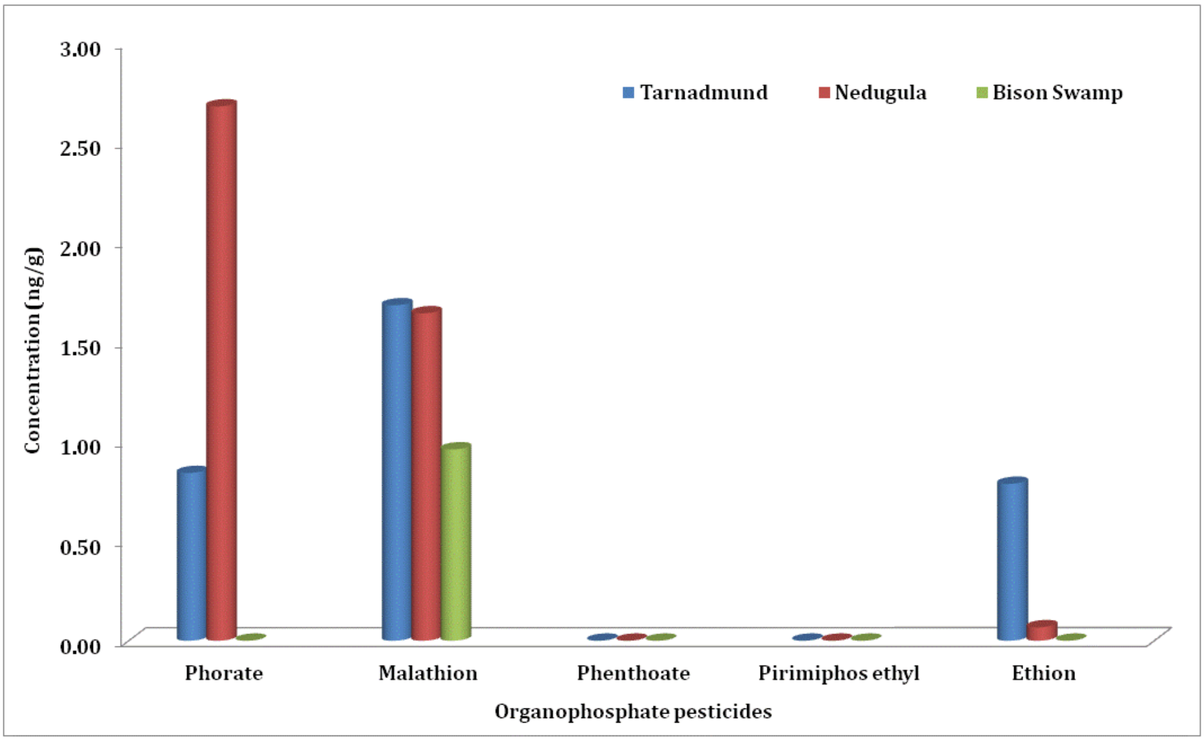
4.1.2. Residues of organophosphate pesticides in sediments in Tarnadmund, Nedugula and Bison Swamp wetlands of Nilgiris district.

Among the three wetlands, residues of total OP in sediments were found to be the maximum in Nedugula (mean 4.39 ng/g; n=7), followed by Tarnadmund (mean 3.31 ng/g; n=7) and minimum in Bison Swamp (mean 0.96 ng/g; n=5). The levels were in the ranges of BDL to 8.63 ng/g; BDL to 23.54 ng/g and BDL to 2.91 ng/g in Tarnadmund, Nedugula and Bison Swamp respectively.

Among the individual OP pesticides analysed in sediments, Phorate and Malathion were detected in 18 and 55% of samples respectively. While Ethion was detected only in 13% of samples, Phenthoate and Primiphos ethyl were not detected in any of the samples analysed. Phorate (13.25 ng/g) was the maximum in the pond sediments of Nedugula wetland, followed by Malathion (9.82 ng/g) in the same site. High concentrations of Phorate and Malathion residues in sediments samples of Nedugula reflect the current use on cabbage, carrot and tea. Residues of ethion was the maximum in sediments collected from the upper (2.90 ng/g) and downstream (2.61 ng/g) areas of Nedugula, while it was BDL in Bison Swamp. The residues of phorate ranged from BDL to 3.51 and BDL to 13.25 ng/g in Tarnadmund and Nedugula sediments respectively. While in Bison Swamp it was BDL.

Sediments collected from Bison Swamp did not have any residues of OP. Variations in organophosphate pesticides were given in Fig. 4. Total OP residues measured in the present study (BDL to 23.54 ng/g) were lower than the levels (0.03 to 1294 ng/g) reported by Parra *et al.* (2012) in sediment samples collected from Culiacan Valley, Mexico.

Figure 9 : Levels of organophosphate pesticides in sediments collected from select wetlands in Nilgiri district.



4.1.3. Residues of synthetic pyrethroids in sediments in Tarnadmund, Nedugula and Bison Swamp wetlands in Nilgiris district.

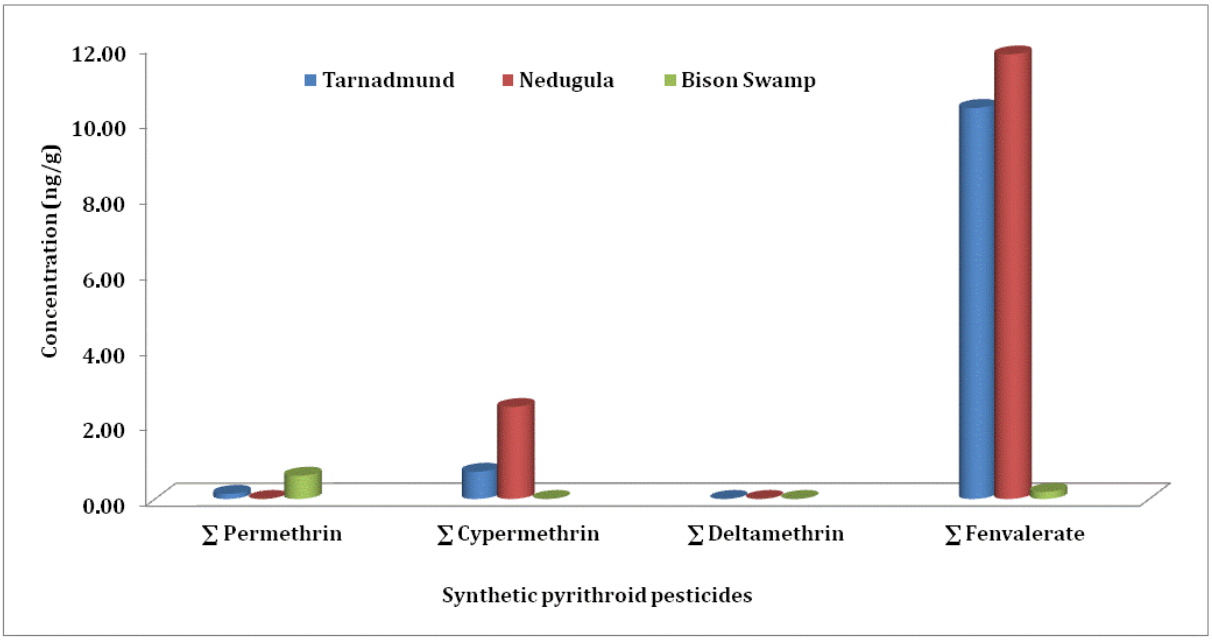
Levels of synthetic pyrethroids in sediments in the study sites differed (Fig. 5). Total synthetic pyrethroids were found to be higher in sediments collected from midstream in Nedugula (62.79ng/g) followed by sediment collected from downstream in Tarnadmund (39.62ng/g).

Among the individual synthetic pyrethroids, Σ Fenvalerate was found to be higher (48.10 ng/g) than other pesticides. Deltamethrin was not detected in any of the sediments samples analysed. Sediment samples collected from Bison Swamp recorded minimal concentration of the synthetic pyrethroids, trace amount of Σ Permethrin (mean 0.61 ng/g) and Σ Fenvalerate (mean 0.8 ng/g) were recorded in sediment collected from streams of Bison Swamp; whereas levels of other SPs were BDL.

Residues of Σ Fenvalerate (48.10 ng/g) and Σ Cypermethrin (10.90 ng/g) were the maximum in sediments collected from middle stream area of Nedugula while it was the lowest in Bison Swamp (BDL - 0.30 ng/g).

Some of these compounds could pose potential threats to the aquatic ecosystems. The present study clearly describes the levels of contaminants in Tarnadmund, Nedugula and Bison Swamp wetlands in Nilgiri district. Hence, it is necessary to continuously monitor the environmental contaminants levels to understand the transport, environmental fate and effects.

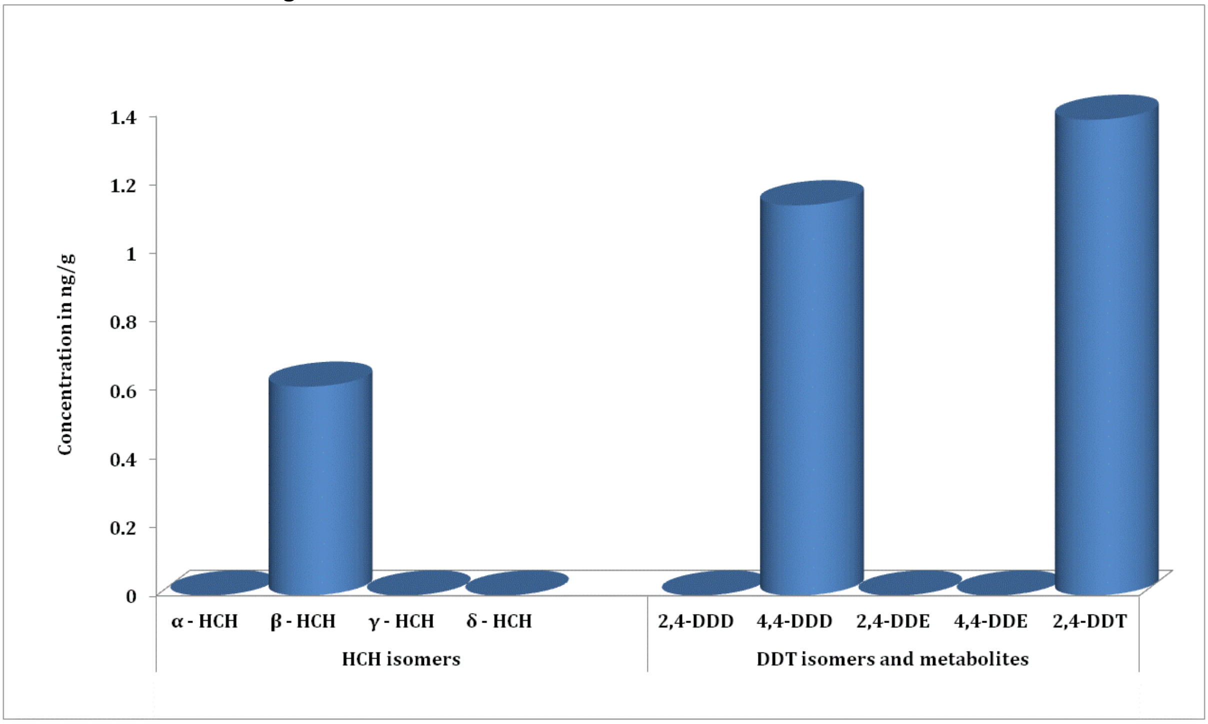
Figure 10 : Levels of synthetic pyrethroid pesticides in sediments collected from select wetlands in Nilgiri district.



4.1.4. Residues of organochlorine, organophosphate and synthetic pyrethroid pesticides in *Danio* sp. fingerlings collected from Tarnadmund wetland in Nilgiris district.

As referred in the methodology, fingerlings of *Danio* sp could be collected only from a pond near Tarnadmund. Levels of HCH and DDT isomers and metabolites levels in fingerlings are presented in Fig. 6. Among the HCH tested only β HCH (0.61 ng/g) was detected in the fingerlings. The metabolites of DDT, namely *o,p* DDT and *p,p* DDD were detected in the range of 1.26 to 1.50 and 1.0 to 1.26 ng/g, respectively. All other OCPs (α endosulfan, chlordane and mirex) tested were BDL.

Figure 11 : Mean concentration of HCH and DDT isomers and metabolites in Danio sp fingerlings collected from Tarnadmund, Nilgiri district.



Levels of Σ DDT are lower than the levels reported by Vijayan and Muralidharan, (1999) in around 1050 fishes comprising six species of fishes studied from various reservoirs (BDL to 65.52 ng/g), namely Avalanche, Uppar Bhavani, Emerald, Kamaraj Sagar, Pykara and Maravakandy, Ooty lake and rivers such as Coonoor and Moyar in Nilgiris district. Vijayan and Muralidharan, (1999) recorded δ-HCH (77.68 ng/g), α-Endosulphan (16.24 ng/g) and *p,p'*-DDD (5.25 ng/g) in the fishes collected from Kamaraj Sagar reservoir, Ooty. In the present study concentration of δ-HCH and α-Endosulphan was found to be below detection limit. However *p,p'*-DDD was recorded in the range of 1.00 to 1.26 ng/g. The residues of DDT recorded in the present study are 5-fold lower than the levels (BDL- 12.3 ng/g) recorded in nine freshwater fishes of different inland wetlands in Karnataka by Dhananjayan Muralidharan (2010).

Residues of OCs in fishes have often been used as indicators of contamination of aquatic environments (Muralidharan *et al.,* 2009). Fishes are most effective indicators of environmental contaminants present in the water as they have greater potential to bioaccumulate and biomagnify particularly the persistent OCs (Muralidharan and Dhananjayan 2010).

Although organochlorine pesticides are found to be higher in sediment samples collected from Tarnadmund than the other places, *Danio* sp. fingerlings collected from Tarnadmund had low levels of organochlorines (2.25-2.76ng/g). *Danio* sp. fingerlings were not found to be contaminated with either organophosphate or synthetic pyrethroids. The levels were only below detectable limits. Even if the fishes were expected to have higher pesticide concentrations than the sediment samples, many factors might have been responsible for the present condition. Size and age of the fish, route of entry and concentration available for intake are very important factors for bioaccumulation. Incidentally we could collect only fingerlings which obviously did not stay in the water for the long to pickup contaminants.

Although many of the OC group of pesticides have been banned, still we find unsafe level of residues in the environment. Further, many short-lived pesticides belonging to OP and SPs are being used quite extensively in the name of replacements. But the impact created by these ephemeral substances on the aquatic ecosystems and particularly fishes are not assessed. These fishes are also considered to be conveyers of chemical carcinogens to the human population.

As the OC pesticides have adverse effects not only on the fishes and other aquatic ecosystems, but also on the public health, their regular monitoring is strongly advised. Although we have phased out many OCs due to their ill effects, still there are many being used for agricultural crop pests and public health purposes. Further, whatever we used till recently are expected to be in the environment for many years.

Figure 12 : OP and SP pesticides being intensively applied for potato, carrot and cabbage

Figure 13 : Agricultural runoff pollutes the wetlands

5. SUMMARY AND CONCLUSION

- Wetlands in Nilgiris, as in rest of India are deteriorating due to severe anthropogenic pressure, changes in land use/ land cover, developmental activities and improper use of agrochemicals.

- Nineteen sediments samples from three wetlands in Nilgiris district, namely Tarnadmund, Nedugula and Bison Swamp and fingerlings from Tarnadmund were collected and analyzed for organochlorines, organophosphates and synthetic pyrethroids. Data are discussed to understand the trend in the residue levels in the context of usage pattern and policy.

- Among the sediments collected from three wetlands, the Σ OCP residues were the maximum in Nedugula (mean 57.43 ng/g; n=7), followed by Tarnadmund (mean 41.39 ng/g; n=7) and minimum in Bison Swamp (mean 3.22 ng/g; n=5).

- Residues of Σ HCH in sediments ranged between BDL and 108.71 ng/g. Among the HCH isomers, β HCH (89.15 ng/g) was the maximum in midstream sediments of Nedugula; whereas concentration of γ HCH (14.19 ng/g) was found to be high in sediment collected from agricultural fields in Nedugula, followed by middle stream (13.39 ng/g) and pond sediments (12.60 ng/g) in the same area. The levels were comparatively less in Bison Swamp.

- β-HCH and lindane exceeded the sediment quality guidelines (SQG), threshold effect level (TEL), the probable effect level (PEL) (Buchman 2008), and the maximum permissible concentration (MPC) (Crommentuijn *et al.* 2000) in sediments collected from stream area of Tarnadmund and downstream, agricultural field and pond areas of Nedugula indicating possibility of adverse effects to organisms. It is known that lindane causes endocrine disorders (CEC, 2003).

- Residues of *p,p'* DDD (36.11 ng/g) and o,*p'* DDT (33.27 ng/g) were the maximum in the downstream sediments of Tarnadmund. Σ DDT residues in Bison Swamp sediments were BDL.

- In the year 2009, 3314 tonnes of DDT was produced in India for the control of malaria and visceral leishmaniasis (Stockholm Convention on POPs November 12, 2010). DDT can accumulate and biomagnify in organisms (Walker 2001) due to its lipophilicity (K_{ow} = 5.7 - 6.36) and persistence ($T_{1/2}$ = 10 -15 years). Their long persistence is the reason that residues of DDT and its metabolites are still detected in the environment.

- DDE/ DDT levels measured in sediments samples of Tarnadmund and Nedugula indicate DDT usage and slower degradation rates in these wetlands. The high incidence of DDE has ecological implications because this metabolite is more persistent and toxic than DDT. Furthermore, DDE is known to alter metabolic functions in organisms by acting as an antiandrogen, binding to androgen receptors and inhibiting transcriptional activation, which causes reproductive abnormalities (WHO 2004).

- Concentrations of p,p' DDE (BDL - 0.94 ng/g) did not exceed sediment quality guidelines (SQG), including the threshold effect level (TEL), the probable effect level (PEL) (Buchman 2008), and the maximum permissible concentration (MPC) (Crommentuijn *et al.* 2000).

- Of all the samples analysed, trace level of Σ heptachlor was detected only in hilly terrain of Tarnadmund (0.37 ng/g), where agricultural activities have been intense. Interestingly residues of α endosulfan, chlordane and mirex were not detected in any of the sediment or fingerling samples.

- Concentrations of Σ HCH, Σ DDT residues in 70 % of the samples included in the present study are higher than the levels reported by Vijayan and Muralidharan (1999) from various reservoirs, namely Avalanche, Uppar Bhavani, Emerald, Kamaraj Sagar, Pykara and Maravakandy, Ooty lake and rivers such as Coonoor and Moyar in Nilgiris district.

- Although maximum concentration of OCPs was recorded in sediment samples collected from Tarnadmund, the fingerlings from the same area detected only trace levels (2.25 - 2.76ng/g). This may be because the fingerlings did not stay longer in the habitat to concentrate the contaminants present in the sediment.

- Total organophosphate residues was found to be higher in sediment samples collected from Nedugula (23.54 ng/g) followed by small stream in Tarnadmund (8.63 ng/g).

- Maximum residue levels of Phorate (13.25 ng/g) and Malathion (9.82 ng/g) were recorded in the sediments of Nedugula wetlands.

- Out of 19 sediments samples analysed for OP residues, Phorate and Malathion were detected in 18 and 55 % respectively; whereas Ethion was detected only in

13 % of samples. Phenthoate and Primiphos ethyl were not detected in any of the samples analysed.

- Trace amounts of Σ Permethrin (mean 0.61 ng/g) and Σ Fenvalerate (mean 0.8 ng/g) were recorded in sediment collected from the streams of Bison Swamp; while levels of other SPs were BDL.

- Total synthetic pyrethroids were found to be higher in sediments collected from middle stream in Nedugula (62.79 ng/g) followed by downstream in Tarnadmund (39.62 ng/g). Σ Fenvalerate (48.10 ng/g) and Σ Cypermethrin (10.90 ng/g) were high in sediments collected from midstream of Nedugula, while the levels were found to be the lowest in Bison Swamp (BDL-0.30 ng/g).

- Although sediment samples from Bison Swamp showed lowest concentration of organochlorines and organophosphates, synthetic pyrethroids were in considerable levels.

- The present study clearly indicates the levels of contaminants in Tarnadmund, Nedugula and Bison Swamp wetlands in Nilgiri district. It is necessary to continuously monitor the pesticide residue levels to understand their transport, environmental fate and effects.

- Due to lack of water, fingerlings could be collected only in Tarnadmund. Total organochlorine content in fingerlings ranged from 2.25 to 2.76 ng/g. Concentrations of organophosphate and synthetic pyrethroids were found only at below detectable levels.

- The Stockholm Convention (2010) cites 12 persistent organic substances (POPs) or *dirty dozens* that are considered to be extremely harmful because of their persistence in the environment, potential for bioaccumulation in tissues through the food chain and human and wildlife toxicity (Wei *et al.* 2007). Out of the 12 POPs, only one pesticide (Σ DDT) was detected in this study. In 2009, the Convention included 9 additional POPs, including α-HCH, β-HCH, and γ-HCH or lindane (Stockholm Convention 2009), which are detected in this study.

- It is necessary to mention that the quantum of pesticide residues detected may not reflect the threat because, the toxicity differs among pesticides. Apart from accumulation in animal tissues through food chains, high rainfall and laterite soil in the district facilitate speedy leaching of toxic chemicals leading to contamination of water bodies not only in the hills but also in the plains.

- Sediment provide habitat for many aquatic organisms but is also a major repository for many persistent chemicals that are introduced into surface waters. Concentrations of contaminants are often several orders of magnitude higher in sediment than overlying water. Thus the long-term release of low concentrations of chemicals into water can result in elevated concentrations in sediments. Contaminated sediments may be directly toxic to aquatic life or can be a source of contaminants for bioaccumulation in the food chain.

- Even if these pesticides are present in very trace quantities in sediments, they are hazardous because fishes are known to concentrate them to 100s of folds. Unfortunately, these chemicals are not always selective and many have adverse effects on non-target organisms.

- It looks impossible to dispense with the use of pesticides and other chemicals to meet the growing food requirement by the ever growing human population. Hence, there is a need to promote safe and efficient use of pesticides for sustainable agricultural production in the district although the best will be to dispense with the use of chemicals and adopt organic farming and promote effective and sound Integrated Pest Management programmes.

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Credit: Keystone Foundation

Maps of the three Wetlands

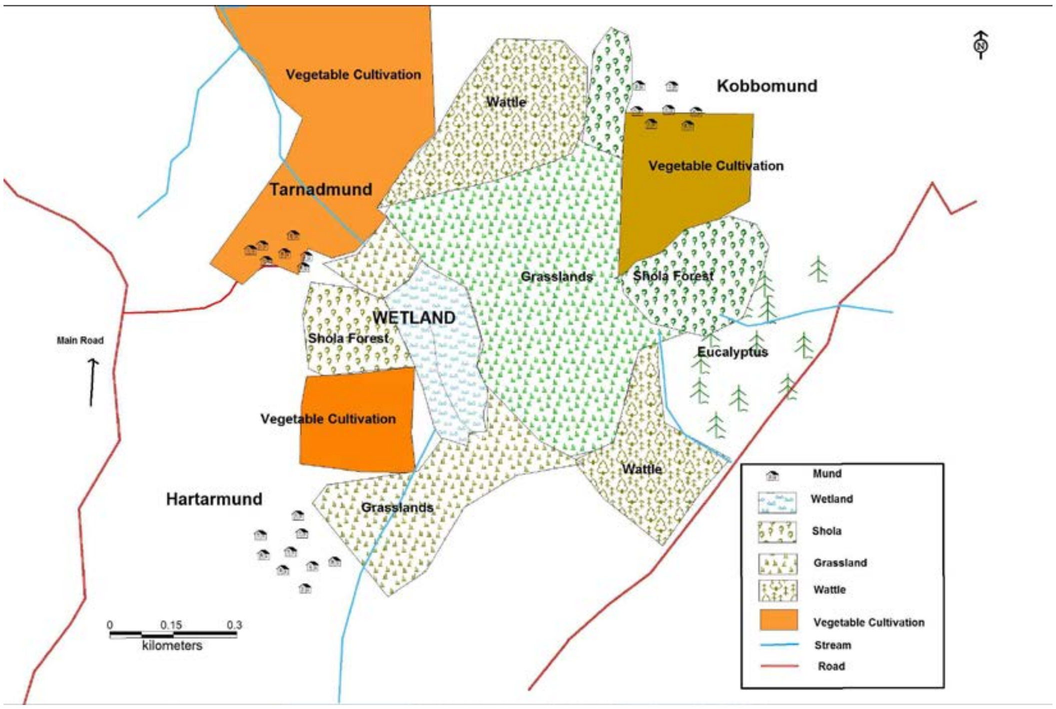


Figure 1: Tarnad Mand

Credit: Keystone Foundation

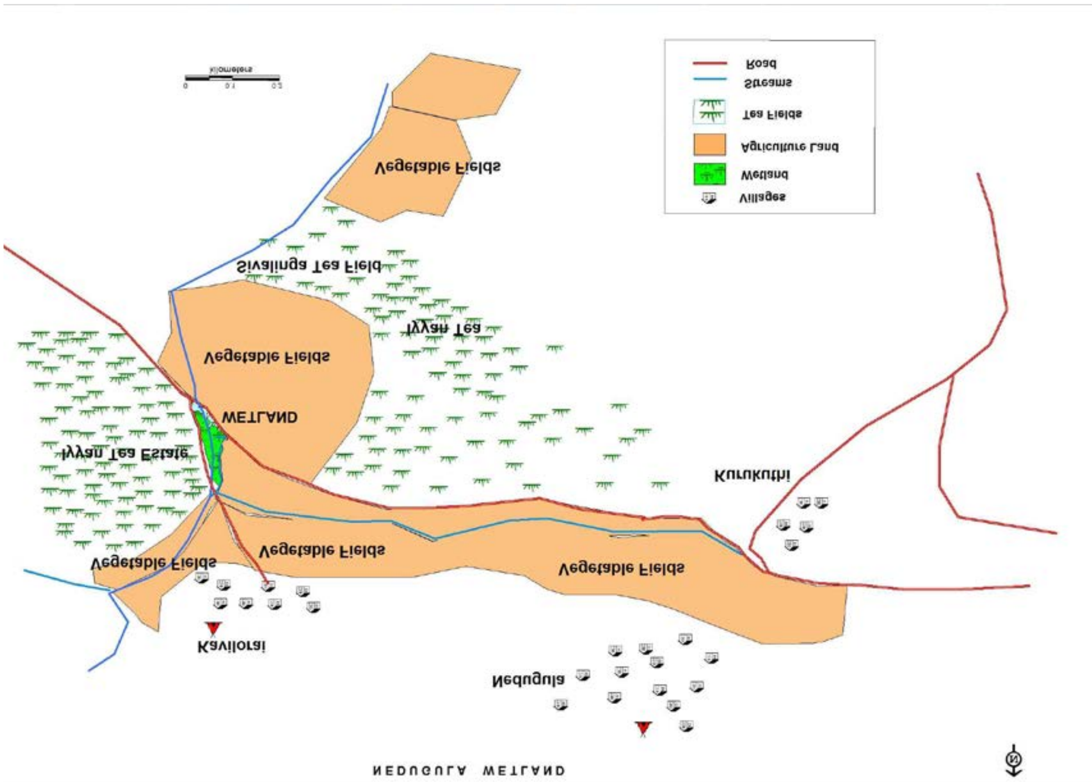


Figure 2 : Nedugula

Credit: Keystone Foundation

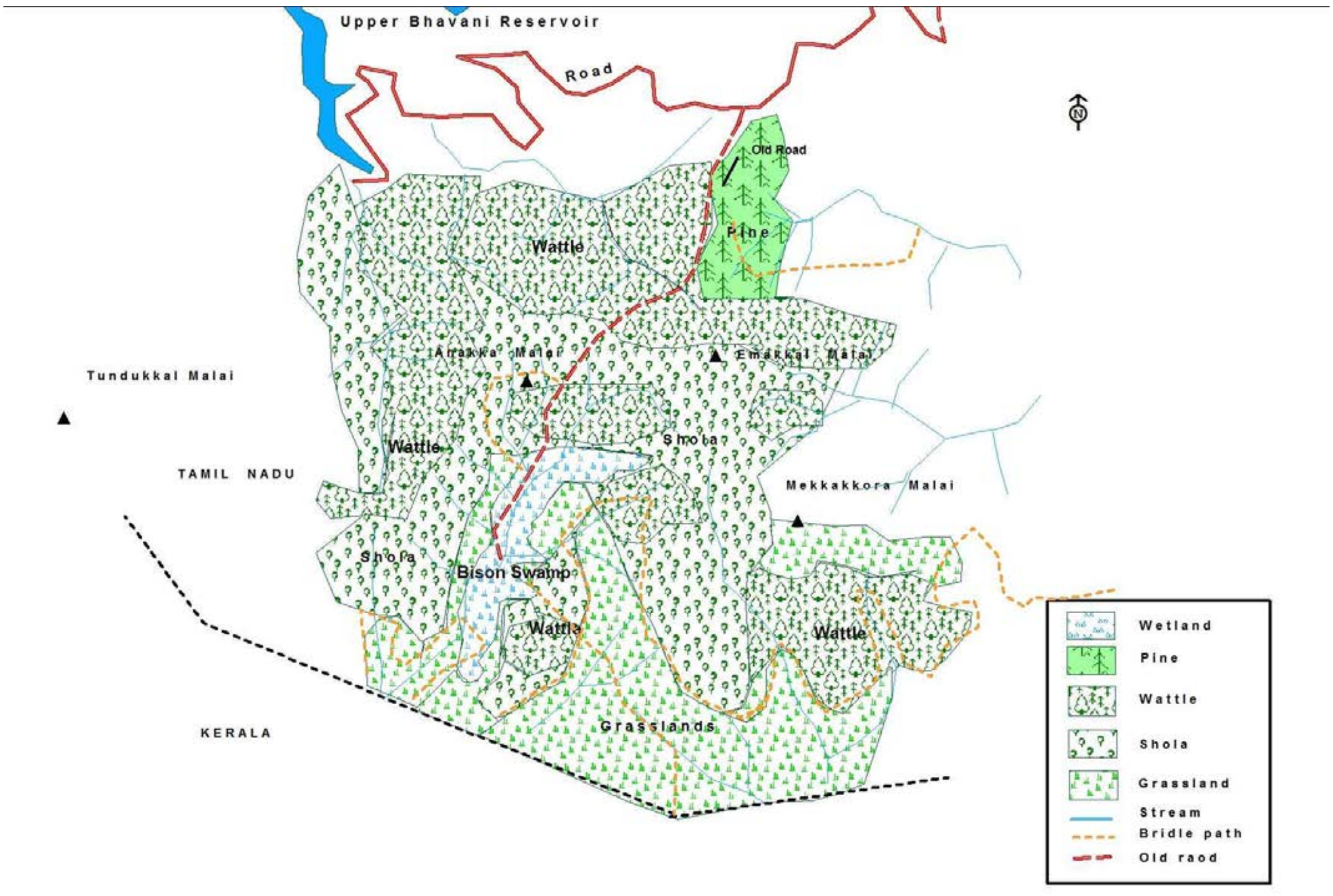


Figure 3 : Bison Swamp

Credit: Keystone Foundation

CONSERVATION EDUCATION: WETLANDS MODULE

The need for a concerted effort at conservation education cannot be overstated in the context of the NBR. A variety of factors including growing human populations, policies of land use change, changing climatic factors and increasing human wildlife conflicts have lead to a fragmentation of habitats and inadequate protection to islands of biodiversity. Wetlands are a typical example of this. Providing vital ecosystem services to the entire region and downstream, these resources have been ignored by policy and rampantly abused. These are also important habitats for a range of bio diverse life forms.

While we understand that indigenous knowledge inherently carries a respect and conservation ethic of all natural resources including wetlands, the onslaught of rapid changes has weakened the mechanisms of practice and transfer of indigenous knowledge. Changing livelihood patterns have been among the chief factors. There is a need to engage with local communities on how to revive elements from indigenous knowledge and communicate them to the younger generation. We envisage that an equally important aspect of conservation education is to facilitate fora of discussion among community members on the changing status of natural resources around them, their own relationship to these and how they can be conserved.

The wetland school sessions are part of the effort to address children on various dimensions of wetlands. The school session themselves are part of a larger conservation education effort targeted at all community members. Given below is an outline of wetlands session plans. It is envisaged that these sessions will be conducted in seven schools, all adjoining the three project wetlands. These sessions have been divided into three sets to address the learning needs of children at various levels of schooling.

These wetlands sessions are envisaged both inside the classroom as well as project activities. Thus, children will be encouraged to 'adopt' certain portions of wetlands near their houses and study dimensions through observation. Further, village elders will be enlisted to conduct some sessions/accompany children to the wetlands, to enable sharing of traditional knowledge.

The school outreach segment of the project is expected to involve children from the habitations dependant on the project wetlands and enlist their support in the overall management plan that will be evolved.

Credit: Keystone Foundation

Sl No	Title	Duration	Components	Activities
1	Introduction to Wetlands	2 hour	What is a wetland Uses of wetlands	Listing of wetlands known to children Drawing HW : Choose a wetland and list how many animals and plants live in the wetlands
2	Living and non living thing in the wetlands	1 hour	Description of observation	Sharing of last month's wetland observation notes bird checklist
3	Habitat and wetland types	2 hour	Field visit with village elders	Discussion on differences in different types of wetlands
4	Zonation and life cycle	½ day	Identify zones	Adopt a wetland
5	Adaptations	½ day	Field visit	
6	Food web and chain	½ day	Description	Adopt a portion of food web
7	Relationships in the wetlands	½ day	Field visit Explaining mutualism etc.	Based on the observation of food web-discussion on the relationship between each level of the food chain
8	Wetland's threats impacts	½ day	Field visit	Questionnaire
9	Cultural dimensions of wetlands	½ day	Field visit with village elders	Interaction with villagers, indigenous information collection
10	Wetland Protection	2 hour		

Credit: Keystone Foundation

LIST OF SCHOOLS

Selection of schools is priority based. Modules will be done in the schools that are in the vicinity of the project site (Nedugula, Korakunda, Glenmorgan).The list of schools near the vicinity of the wetland was made as below.

Nedugula

1. Govt. Higher Secondary School.
2. Hillfort Matric School, Kericombai, Nedugula, Kotagiri.
3. Govt. Higher Secondary School, Milithane

Tarnadmund:

4. Govt. Elementary School, Glenmorgan Estate. 1-5std
5. Govt. School, Camp. 1-8std

Korakunda

6. Govt Elementary school 1-Vstd

Thaishola

7. Govt Elementary school 1-Vstd

Three target groups of children have been identified and the modules allocated accordingly

Class	Module
I-V	'1-3
VI-VIII	'4-6
IX-XII	'7-10

SCHEDULE

Minimum of three module/ month will be done.

One module/month in each of the selected three schools will be done.

The modules will be started during the month of August and finish by May.

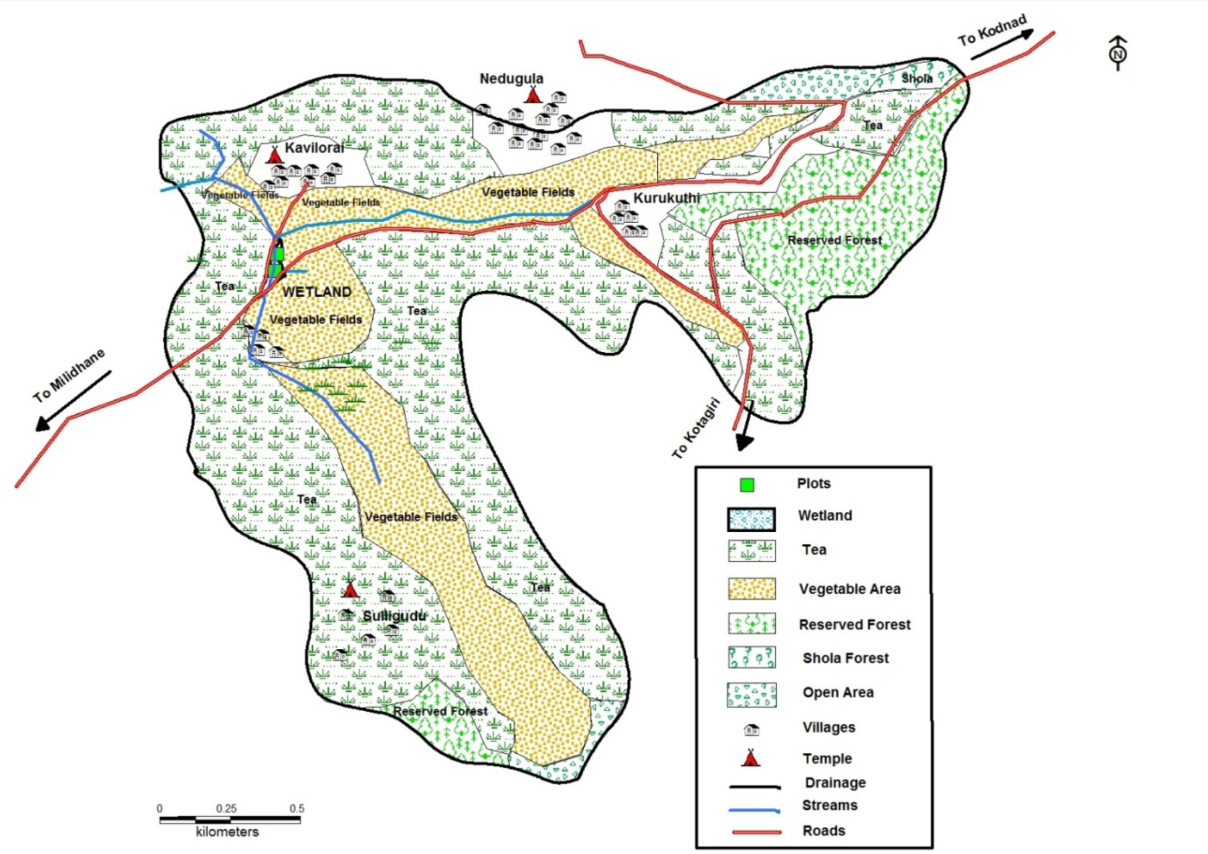
Credit: Keystone Foundation

Preliminary Resource Use & Problem Analyses Report

A preliminary analysis of the use of the three wetlands under the project was done using participatory methodology including small group discussions, transect and resource mapping. A listing of problems was also done simultaneously to feed into the problem analyses for the project.

Nedugula

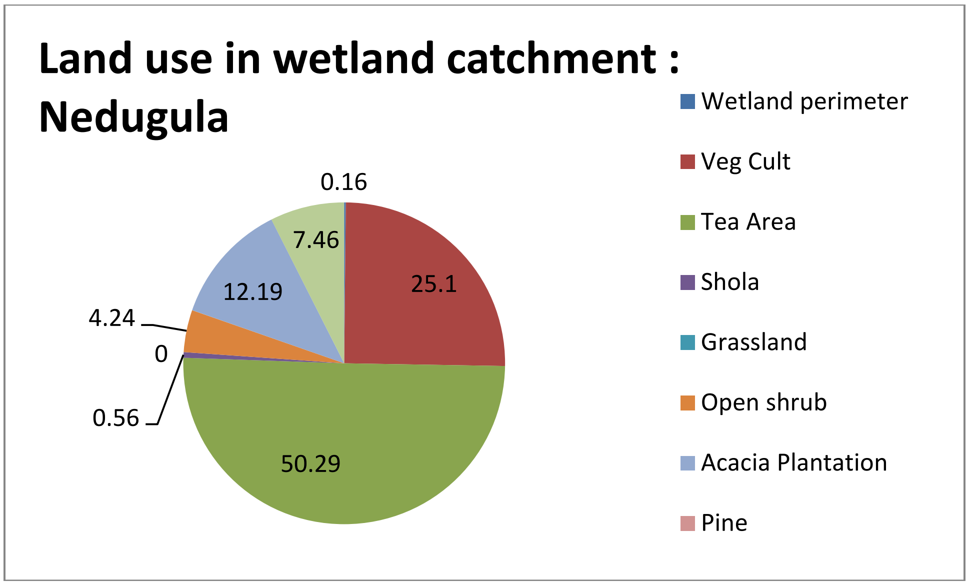
A schematic representation of the wetland was derived from the resource mapping and is given below.



The wetland is popularly referred to as the *Hada*. The ownership of the land on which the wetland is situated has been a matter of dispute for a while. A joint meeting of farmers from the habitations of Kavalorai, Kurkuthi and Nedugula reveals that the wetland is spread over the lands of two owners. One part is leased and the other right half is used by Bellajja family from Nedugula. The surrounding land belongs to Kavilorai, Kurukuthi and Nedugula farmers. The tea plantations near the wetland are that of the Iyyan group and Sivalingan from Kottanalli village.

The wetland remains the same time immemorial except for the recent check dams which came up recently. The village in general does not seem happy about the construction of the check dams but seem to accept the fact the President of the Panchayat had commissioned them in good faith. The whole stream has been de silted and widened about 5 months ago(in Dec 2011); earlier the stream was very narrow and used to flood the fields when there was heavy rains. The community notices that after the check dam was built the stagnant water is being polluted though there is sub surface flow.

The water from the checkdam is used for agricultural purposes. Although there is no pumping of water directly from the wetland, there are 36 pumpsets that source water from the region around the wetland. The water from the wetland is used for the washing of vegetables before they are taken to the market. There has been a proposal submitted by the village to the Panchayat to install a carrot washing machine that could be used by all farmers. The water is not used for drinking water except for the handful of goats that are grazed near the roadside by people from the nearby Sri Lankan colony.

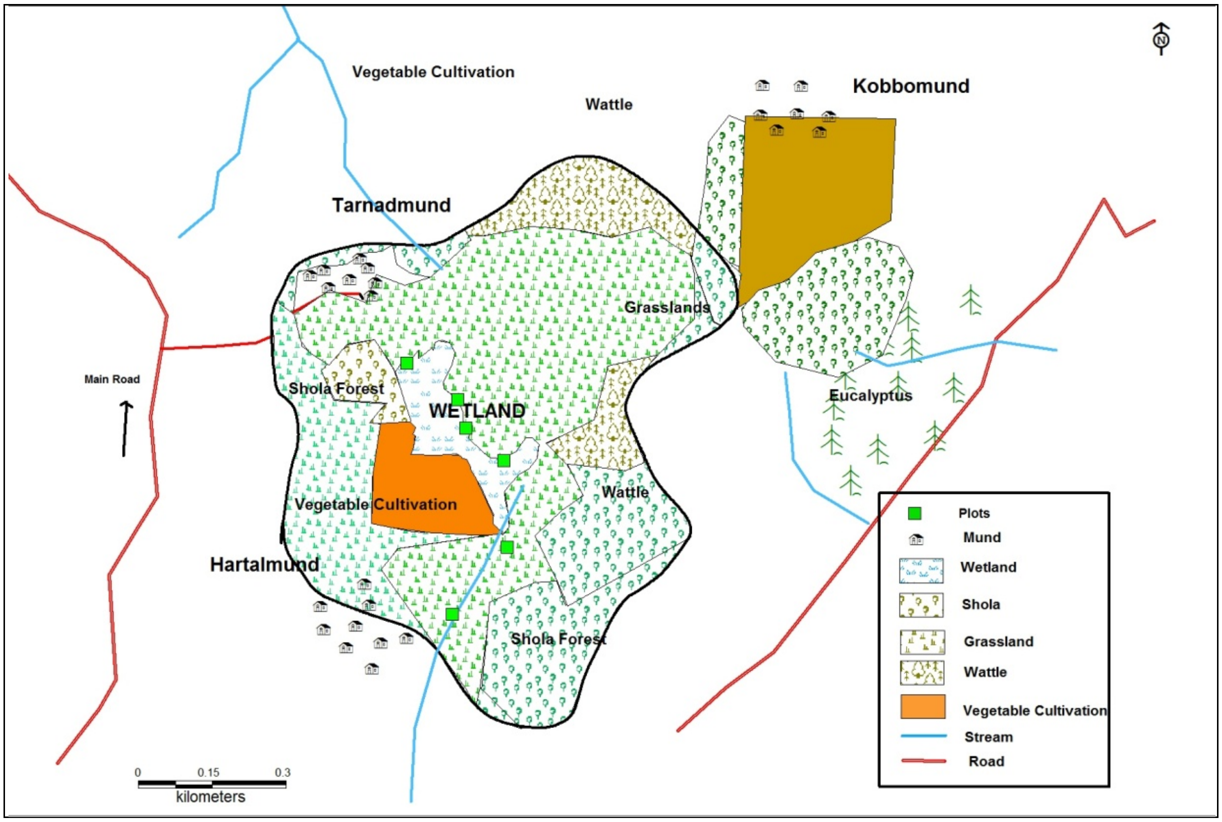


The agriculture near the wetland is predominantly vegetables that are grown using chemical fertilizers and pesticides. A discussion on the possibility of organic farming reveals that the farmers are quite aware of the benefits of organic agriculture both to the health of the soil as well as of the consumer. The Horticulture department had initiated a pilot project in 2005 -06 to do organic farming in this village. Under the aegis of this project, a society was created and 30 members with 30 acres of cultivable land came forward to convert to organic agriculture. Each farmer was given inputs free of cost and there was some training on their use. However the project did not sustain due to lack of follow up visits by the Department. There seems to be a need for a concerted project to assist willing farmers in the conversion to organic agriculture.

Credit: Keystone Foundation

Tarnad Mand

A schematic representation of the wetland was derived from the resource mapping and is given below.

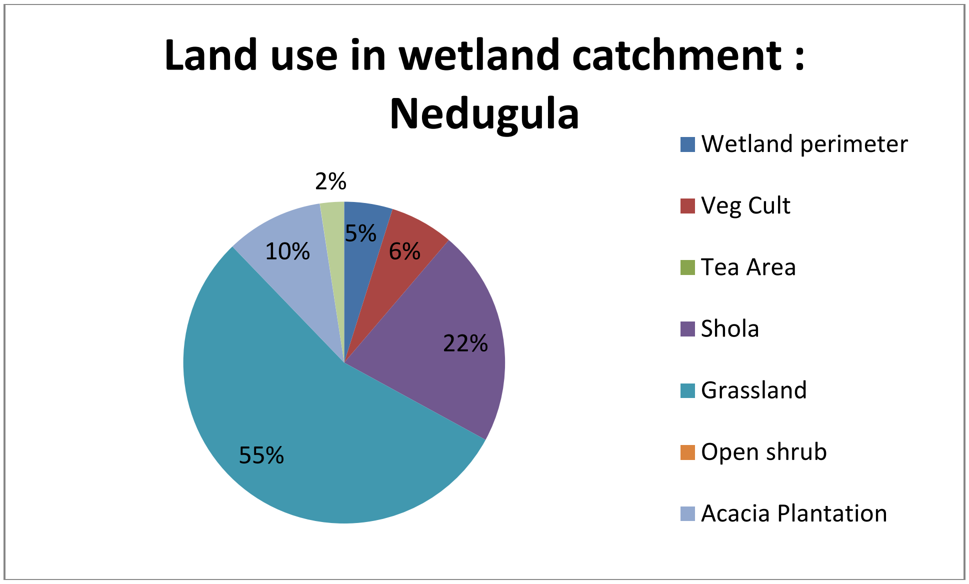


The wetland commonly referred to as 'ther' lies between the three Toda habitations of Tarnad Mand, Arthal Mand and Kobbu Mand. The three are collectively referred to a Tarnad Mand. Famers from Arthal and Kobbu Mand practice vegetable cultivation on the slopes immediately adjoining the wetland while Tarnad Mand farmers cultivate tea on the uplands and do not use the water from the wetland for agriculture.

The wetland itself lies on Toda Patta land, a revenue assignment to the Todas as per a colonial Government Order 1893. Around this are reserve forests with wattle and eucalyptus plantations. The wetland is used for grazing by the Toda buffalo and there are 4 pumps that are used to lift water for irrigation from the wetland. The land around the wetland is itself covered by grasslands and shola forests except for the patch that is under vegetable cultivation.

The elders from the village recall that the depth of the swamp was more and used to come up to his knees when they were after their buffaloes, but now they have dried up to almost half the size of the earlier area. This, they attribute to fewer rainy days and that the sholas in the catchment have been planted with eucalyptus. There is a understanding that the eucalyptus plantations have reduced sub surface flow that used to feed into the wetland. The expanse of agriculture has also increased.

Credit: Keystone Foundation



The other major change has been the spread of wattle over the grasslands. The community attributes the shrinking of the wetland to this also. The only perceived advantage of the wattle plantation is that it provides for ready fuel wood. They only collect dry twigs from sholas, since they depend on sholas for medicinal, temple use and also for collection of non timber forest produce like honey.

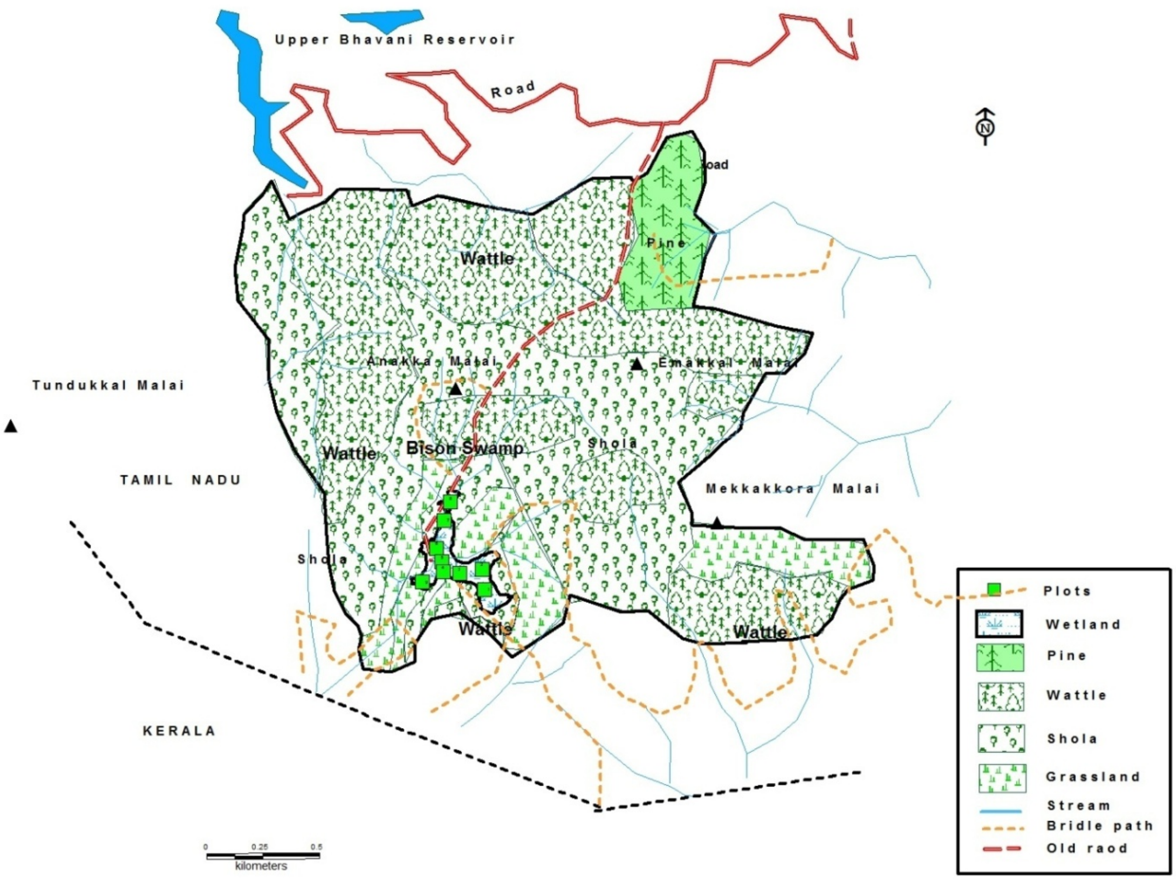
The community is unable to appreciate the threat of the wetland shrinking due to the spread of agriculture. This may be because currently only 6% of the area around the wetland is under agriculture. The community opines that there are also cultural reasons why the wetland cannot be appropriated for other use.

Credit: Keystone Foundation

CC BY

Bison Swamp

A schematic representation of the wetland was derived from the resource mapping and is given below.

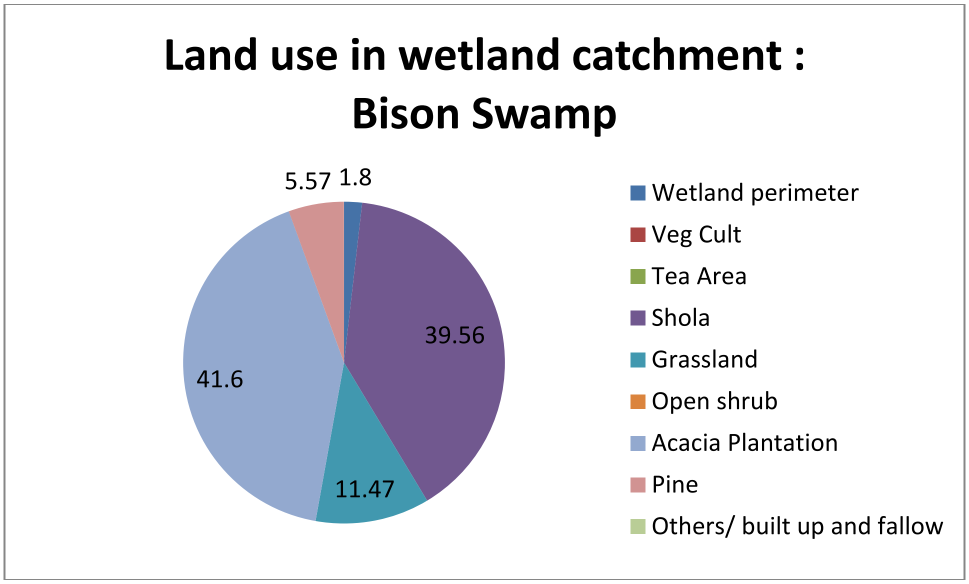


Bison Swamp wetland lies within a patch of Reserve Forest in the Nilgiris South Territorial Division. As such entry within the area is restricted and can be accessed nly by permission by the District Forest Officer. The catchment is predominantly a grassland –shola complex followed by wattle plantations. There are two major streams that feed into the wetland.

The wetland itself is largely a wildlife habitat. There is some evidence of use by the Todas for harvesting grass for thatch and ritual purposes but discussions with the neighbouring Toda settlement of Onai Mand reveal that this use is on the decline.

There is evidence of fire outbreak and litter that suggests that the area is also accessed by tourists.

Credit: Keystone Foundation



Credit: Keystone Foundation

Conserve Wetlands to Improve Quality of Life

World Wetlands Day was celebrated in Happy Valley Kotagiri with a meeting and a rally of school children to raise awareness regarding the need to conserve wetlands. The President of the Town Panchayat, Shri Vapu along with local ward members Mr Kannan and Mr Sarvanan attended the meeting. Shri G Shashidaran, AEE TWAD Board and Mr Manikandan, Guard, Kotagiri Forest Range also graced the occassion. Children from the CSI Higher Secondary School, Kotagiri and Hillfort Public School, Nedugula participated.

Speaking on the occassion, Shri Samraj of Keystone Foundation gave an overview of the importance of wetlands in hill districts like the Nilgiris. He said that wetlands functioned as water filters to yield clean water downstream. He recalled several rituals related to wetlands in local indigenous tradtions and called on the children and the local government to take measures to stop the pollution of wetlands with garbage and construction material.

Credit: Keystone Foundation

Mr Vapu in his address recalled the degraded state of the Happy Valley Wetland six years ago and expressed his happiness at the regeneration of a small forest at the head of hte wetland. He noted the increase in water flow from the wetland due to the afforestation efforts and said that the water from the wetland served 3 wards in the Panchayat. He urged the children to plant at least a tree each to improve the quality of the environment and their own lives. He asked the children to lead the drive against use of plastics in their own homes.

Happy Valley is the site of a wetland conservation initiative by Keystone Foundation in collaboration with the Town Panchayat. A small plot at the head of the wetland has been identified and over 600 saplings have been planted here. This has resulted in a once degraded patch turning into a small forest restoring the habitat of many wildlife including barking deer, gaur, bears and many kinds of birds. 20 new saplings were planted in empty patches to mark the occassion. The meeting was organized under the aegis of a Critical Ecosystem Partnership Fund – ATREE small grants project, that aims to increase people's participation in the conservation of hill wetlands.