WETLANDS OF THE NILGIRIS

Wetlands are a widely neglected ecosystem. Often regarded as wastelands, wetlands continue to be among the world's most threatened regions. Most of them have been converted for agriculture, ongoing drainage, conversion, pollution, over-exploitation, fishing, real estate development and even building parks. The concern for conserving them has been steadily rising over the years and received a big push with the signing of the Ramsar Convention in 1971.
The Ramsar Convention defines wetlands as areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt including areas of marine water, the depth of which at low tide does not exceed 6 meters[1].

There are four main kinds of wetlands which are marsh, swamp, bog and fen. The largest wetlands in the world include the swamp forests of the Amazon and the peatlands of Siberia. Wetlands are a perennial source of water that hold a considerable amount of water in them.

AIM OF THE STUDY:

Globally and in India, wetlands are facing relentless pressure. They have been steadily and rapidly disappearing across the country over the past decades. The most severe impact has been from humans and their activities that are commonly termed as anthropogenic pressure. Besides, increased threat of invasive plant species has also accelerated loss of wetland habitat. The hill wetlands in the Nilgiris are small yet dynamic and complex habitats that hold water from an underlying water table with biotic and abiotic connections all around. These are the lifelines to the survival in the hills providing the inhabitants with water.

Over the years, there has been apparent destruction of these valuable habitats, the scale of which is unprecedented in human habitats. With the knowledge of the wetland ecosystems and their ecological deterioration over time and an earlier understanding of the importance of water resources for the indigenous communities of the Nilgiris, the multi-disciplinary team at keystone aims at studying the social and ecological aspects of the wetlands with focus on parameters such as the overall structure, hydrogeology, biodiversity, and ecosystem services. With this understanding, the study also suggests valuable implementation strategies specific to the wetlands in consideration.

WORKING AREA:

Conservation and Sustainable Management of Wetlands in key areas in the Nilgiris is a prime interest area of Keystone. Wetlands of the Nilgiri region are unique, unlike wetlands in general – these are small sized hill wetlands, life giving in nature, habitat for a variety of wildlife, flora and meet the needs of the people.
These wetlands are fragmented in small random patches – with underground connectivity of water channels. There are no dramatic landscapes that lead to the wetland zones, it is sometimes found in the most unexpected places – and therefore has been taken for granted and their functions and roles significantly underestimated.
In the Nilgiris, wetlands have been perceived as wastelands associated with disease, difficulty and danger. Emphasizing the negative impacts and ignoring their importance, these habitats were considered obstacles in the path of progress and hence drained, filled, despoiled and degraded for economic gains. The wetland loss has been responsible for bringing to the verge of extinction many

[1] www.ramsar.org/sites/default/files/documents/library/info2007-01-e.pdf

species of animals and plants. Inadequate understanding of the crucial role and utility of wetlands is a matter of serious concern.

Historically, most wetland losses were due to agriculture. Today, the most common threat to Nilgiris wetlands is development because of fertile soil and location, many wetland areas are desirable for farming, business and housing developments and form localized high population zones within the Hill District.

In fact, a preliminary analysis suggests that the region has suffered an immense amount of loss in the number of wetlands due to agricultural interventions in the plain, fertile, valley areas. Lately, wetland losses are also due to other developmental activities like housing, community halls, toilets, schools as well as other business activities like eucalyptus oil distillation plants.

Destroying or degrading wetlands can lead to serious consequences, such as increased flooding, extinction of species, and decline in water quality. The rich biodiversity that we often see in wetlands, though abundant, is most vulnerable to any change in wetland ecology. Much of this biodiversity stands to be lost forever if wetland resources are not used judiciously. The immense loss and undermining of wetland status needs to be reviewed, active rethinking must happen and restorative action undertaken to preserve our wetlands.

It is imperative that we use the wetlands and water resources sustainably so that they don't pose an irreversible damage to the complex and interrelated wetland ecosystem. Some of the major threats to the wetlands in the Nilgiris include the invasion of species that are not native to the wetland, which reduce the water retention in the soil, pesticide inflow from the nearby fields, effects of pollution and over grazing by cattle. Some of these will be discussed in detail in the case studies below.

WETLAND SURVEY IN 2006:

In 2006, the team at Keystone conducted an intensive rapid survey and mapping of crucial wetland habitats, taking into account ecological aspects, socio-economic situation of stakeholders within the wetland home-range and economic activities. A baseline survey of 38 hill wetlands was conducted. The multi-disciplinary team had mapped, inventoried flora, fauna and dependence of people on wetlands. Wetlands had been classified in different categories as common property resources – in rural and urban areas and in private and protected areas. In each of these categories a threat assessment had been made and identified specific, local issues pertaining to the wetlands. Out of the 38 wetlands – 5 representative wetlands have been selected for a local management plan in consultation with stakeholders. Simultaneously, the following measures were also taken up:

- Four Posters had been prepared: Wetlands of Nilgiris & People, Wetland Birds, Wetlands Biodiversity and Nilgiris Wetlands Flora.

- A nursery of 771 wetland plants was raised and more than 50 wetland trees of different species had been planted.

- Implementation of a solid waste management project to install nine toilets for the families who were polluting a wetland source with human wastes was completed.

- A campaign to generate awareness on wetlands through a march, addressing stake holders on the values of wetlands and printing popular t-shirts with wetland themes.

- Advocacy with the local government succeeded in giving us permission to rehabilitate and revive the Happy Valley wetland in Kotagiri town.

- A movie of four minutes with survey findings had been made.
- A stake holder's workshop was organized in Ooty bringing together Government, NGOs, Indigenous People (Todas and Kotas) and Scientists from the National level to come out with a practical Nilgiris Wetland Recommendation.

SURVEY METHODOLOGY 2016-17:

In 2016-17, among the 38 identified wetlands, four wetlands of differing characteristics were studied in detail to come up with implementation strategies, specific to each wetland, that help restore the health of the wetland. The four wetlands that were studied in detail are the wetlands at **Elada, Upputhotti, Rifle Range** and **Thalaikundha**. The multi-disciplinary team at Keystone visited the wetlands and studied the various aspects of the wetlands as follows:

LAND USE:

Land use is the total of arrangements and inputs by humans on the land cover and landscape character of the area[2].2 The land use of the wetland and the entire watershed area was studied to understand the patterns of use and their likely impacts on the wetlands. The team analyzed the watershed area to understand the various land use types and later mapped them with the help of GIS and remote sensing. The difference in the land uses suggests the various causes of ecological damage in the wetland.

HYDROGEOLOGY:

Hydrogeology (hydro- meaning water and -geology meaning the study of the Earth) is the area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust (commonly in aquifers)[3]. The soil and rock characteristics were studied through the rock outcrops, rock trends and fissures in the watershed area.

WATER QUALITY TESTS:

Samples from different locations in the wetland were collected and tested for their various mineral contents such as Iron, Potassium, Phosphorous, Fluoride, Nitrate, Ammonia, Chloride and Residual Chlorine. The results suggest the quality of water for consumption, various contaminants that mix in the water and the overall mineral content of the wetland water. The water is tested using a tracer for 5 components such as pH, Electrical Conductivity, Total Dissolved Solids, Salinity and Temperature and Jal-TARA water testing kit that tests for Dissolved oxygen, Hardness, Fecal Coliform, Iron, Potassium, Phosphorous, Fluoride, Nitrate, Ammonia, Chloride and Residual Chlorine.

HABITAT AND SPECIES:

The flora and fauna of a wetland play a major role in maintaining the ecosystem of the wetlands intact. From timely visits, various flora and fauna of the wetlands were observed by the team and their role in maintaining the wetland ecosystem. Freshwater plants are often underestimated and they are regarded as unwanted, without understanding their role in freshwater ecosystems. The following are the roles played by freshwater plants in a wetland[4]:

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[2] https://en.wikipedia.org/wiki/Land_cover
[3] https://en.wikipedia.org/wiki/Hydrogeology
[4] http://www.environment.nsw.gov.au/wetlands/WetlandPlants.htm

- Provide the animals, birds and other underwater organisms with food.
- They provide habitat to smaller water organisms such as snails, insects, etc.,
- They help in soil stability, holding the soil and improving water clarity.
- They play an important role in the complex chemical cycles in water. They determine the health and usability of the water by maintaining the oxygen levels. They also have the ability to soak up pollutants in water.
- Under favourable situations, they have the ability to resist the growth of invasive exotics like lantana, poa grass, etc., that lead to drying up of the wetland.

ECOSYSTEM SERVICES:

Ecosystem services are nothing but the benefits that the ecosystem provides humankind with. There are categorized into four: Supporting services, Provisioning services, Regulating services and Cultural services. The following are a set of 10 'ecosystem services' – the benefits people obtain from ecosystems – provided by wetlands[5]. They cover;

1. Flood control
2. Groundwater replenishment
3. Shoreline stabilisation & storm protection
4. Sediment & nutrient retention and export
5. Water purification
6. Reservoirs of biodiversity
7. Wetland products
8. Cultural values
9. Recreation & tourism
10. Climate change mitigation and adaptation

[5] http://www.ramsar.org/sites/default/files/documents/library/services_00_e.pdf

CASE STUDY 1: ELADA

INTRODUCTION:

Elada wetland and dam is situated near Kathukatty village in Kotagiri Taluk, The Nilgiris district. It is located at a distance of about 10 km from Kotagiri town. According to the TWAD, the first protected water supply to the town was provided by TWAD in 1976 from the stream at Elada. A 57.2 m check dam was constructed there to provide 0.54 Million Liters per day to the town. A filtration system is installed in the outlet of the dam.

Figure 1-Location of Elada in the Nilgiris

The failure of monsoon in 2016 in the Nilgiris has meant drying up of the Elada dam in September itself. With the media highlighting the sorry state of this water resource, Keystone decided to profile the dam and its wetland and analyse the situation thoroughly.

LOCATION, PROXIMITY & SCALE:

The Elada wetland is located at a distance of 10km from Kotagiri town in a calm neighbourhood of native communities that are involved in intensive vegetable farming. The closest village, Kathukatty lies to the south west of the check dam at a distance of 700m.

A vehicular road leads to the wetland area from the Elada village and it extends further to the Kathukatty village. The recently laid road surrounds the wetland where the land is being commercialised for construction of resorts and for commercial farming. Due to the impeccable beauty and the calmness of the place, resorts have sprung up in the last decade leading to deterioration of freshwater in the surrounding wetland area. Quantifying this growth is beyond the scope of this study, although this should be monitored in future.

Figure 2: Imagery of the wetlands at Elada

The current wetland is a rectangular land measuring about 160m in length and 70m width with the check dam (56m x 87m) in the middle that holds water for drinking and irrigation for a part of Kotagiri town.

Figure 3: Agriculture being practised in the valley

EARLIER STUDY IN 2006:

In 2006, the team visited the site during the monsoon season in July. The water in the wetland was full and spread out and the reservoir was overflowing. The wetland water was clean, odourless and close to 90% was covered with vegetation. A small pool in the wetland with stagnant water and devoid of vegetation looked slightly grayish in colour. The stream joining the wetland also had clear water. The water in the reservoir was slightly turbid due to sedimentation. Frogs were seen both in the wetland as well as in the reservoir. The wetland was fenced on one side.

The plants found in the wetland were predominantly grass species (Cyperus globosus, Kyllingia, other few spp.,), the ground was covered with Centella asiatica, Oxalis corniculata, Commelina spp., Trifolium repens, Anotis, Fragaria nilgerrensis, Rotula rotundifolius, Plantago major. The submerged plants like Polygonum, Limnophila heterophila, Monochoria vaginalis were seen where water was stagnant. Wattle trees were found surrounding the wetland. Pteris was found along the edges in between the wattle trees.

Birds like Black Kite, Kingfisher, Wag tail, Pied Bush chat and Common grass yellow, chocolate pansy butterflies were sighted. Cows and goat were found grazing on the wetland.

The stream joining the wetland which could also be the main source of water for the wetland comes from a shola patch crisscrossing some fields. The team noticed that water was being pumped from the stream before entering the wetland by agriculturalists close to the wetland which could lead to reduced inflow. Moreover, though no direct discharge of effluent etc. could be seen into the stream or the wetland, a concern is the contamination of the stream water with chemicals and pesticides

used in the fields through which it passes. The pH of water was found lower that the permissible limit.
The datasheet with the status of the wetland in 2006 is given as Annexure 1.

SIGNIFICANCE:

Kathukatty, a Badaga village, sits in the catchment of the wetland and has around 30 households. The residents of the village depend on the wetland for their water, both drinking and for domestic use. There is a community well in the village from where the villagers used to fetch water. This well is still in use but the water is pumped from here to the village. The wetland was used by the residents to graze their cattle. Though the way of life of the residents do not affect the wetland directly, the recent chemical farming in the valley affects the quality of drinking water for the residents. The extraction of water through large number of open wells also affects the availability of groundwater.

On talking to the residents it was understood that the wetland at Elada is one among the larger wetland network along with the other valleys around the locality. Once agriculture took over, the wetlands were gradually encroached upon and converted into farmland with the exotic plants and trees such as eucalyptus and wattle, which are known for absorbing moisture from the soil and drying it up. Though they were introduced by the British to aid cultivation of the species that they desired, like tea, the species stayed and spread rapidly in the area.

LANDUSE AND LANDSCAPE CHARACTER:

Name	Area (acres)
Built-up	3.4
Fallow	0.1
Farming	31.9
Grassland	1.6
Rock	2.8
Rock/Grass	6.2
Tea	127.4
Tree cover	147.5
Wetland	14.0
Total	**335.1**

Table 1: Land use in the catchment and their area

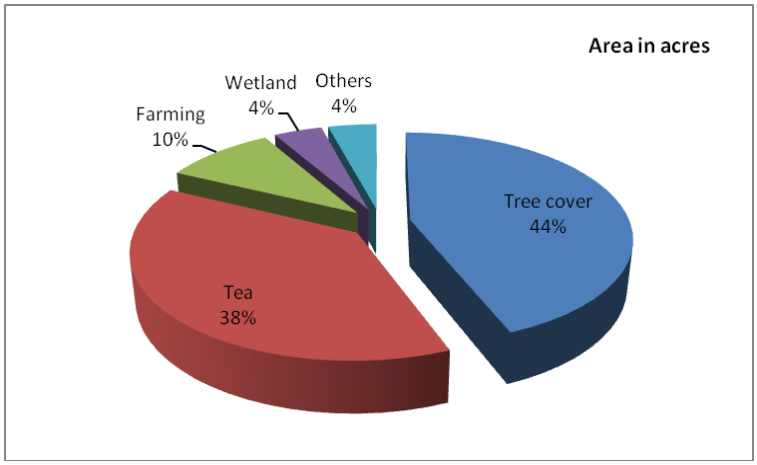

Figure 4: Proportion of the different land uses

The wetland at Elada is the source of the water to the dam. The wetland is open, small and compact situated at high altitude. The wetland though small is varied. On one end is relatively hard ground - adjacent to the agricultural land. A small stream cuts through this patch of grass leading to the pool. As the pool starts - the wetland plants are seen and the water emerges to the surface. Depth is also seen in this pool. There is a slow flow of water from the stream into this wetland. At one end of the wetland is a drainage channel which is adjacent to the field and perpendicular to the stream.

The main usage is for drinking water purpose followed by agricultural water supply. The outflow from the reservoir is the main source of water for irrigation for the nearby villagers The wetland is also a source of drinking water to the cattle which also uses the wetland area for grazing.

Figure 4: Agricultural land separated from the rest of the wetland

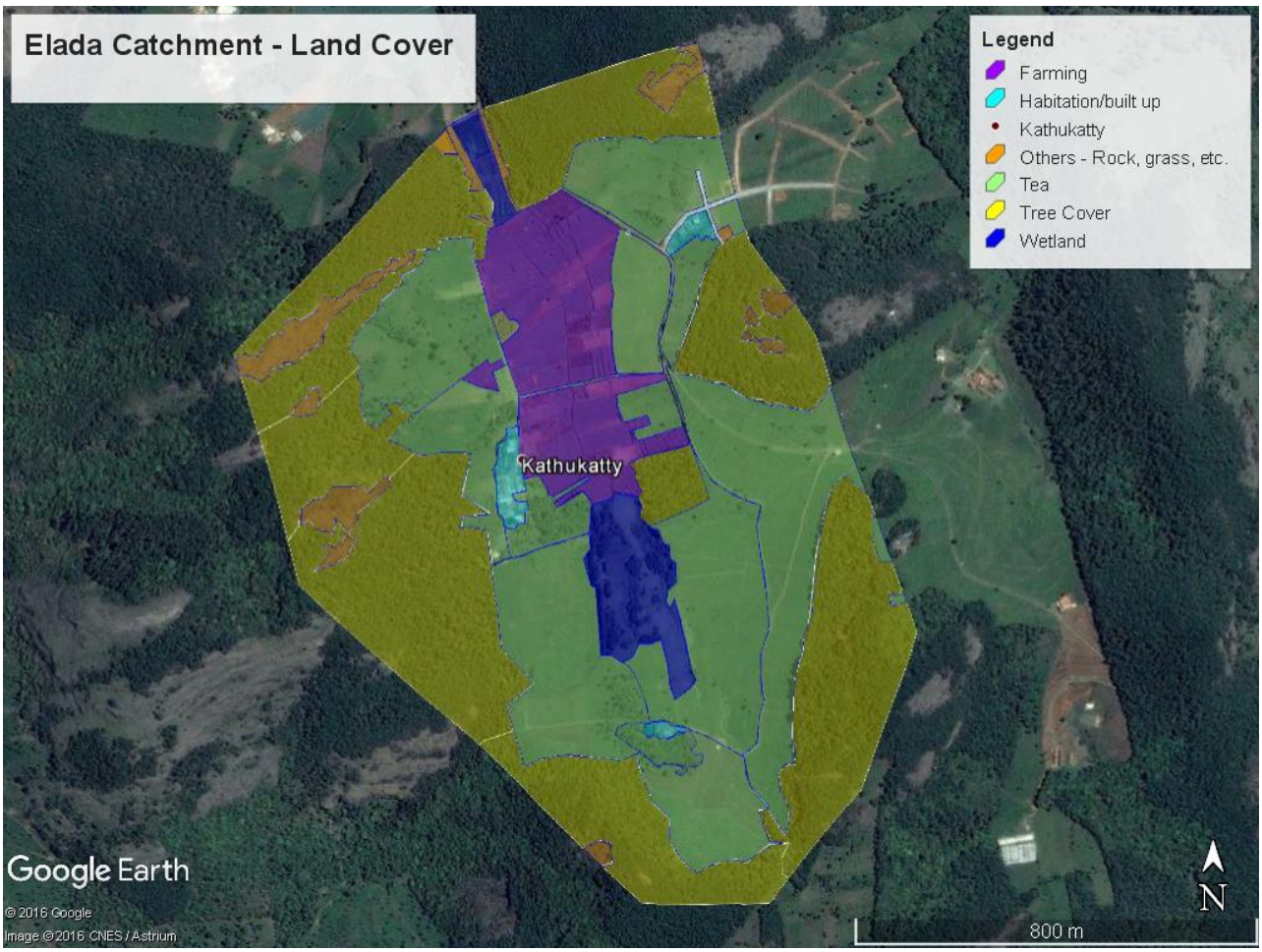

Figure 5: Land cover map overlaid on Google Earth Image

From the Land cover statistics it is evident that only 4% of the total catchment area is under wetlands. This includes another connected wetland in the upper catchment that feeds a stream to the wetland near the dam. While nearly half of the catchment is under tree cover, most of it is in fact plantation of exotic species such as Eucalyptus, Wattle etc. A discussion with residents of the Kathukatty hamlet that is located within the catchment suggests that a few decades ago much of the forest was Sholas. However over time the exotics have spread from the western part of the catchment to the North and Eastern side at the expense of Shola species.

The two wetlands have also been disconnected due to agriculture being practised in the valley. This change is also historical and comparison of imagery since 2008 has not indicated any significant increase in the farming area. The farming operations have included changing the topography of the valley portion to flatten the slopes and to reduce the stream flowing between the two wetlands to a small channel. Large amounts of pesticides and fertilisers are being used in the commercial farming being undertaken there. The used pesticide bottles thrown into the dam area indicate a variety of pesticides being used.

A private resort has been developed over the last few years just outside the catchment, although they are extracting water from an open well in this catchment. There are a large number of open wells of the farmers as well as of the Panchayat in the catchment. These have been inventoried and are being monitored periodically to understand the extraction of water and the groundwater levels.

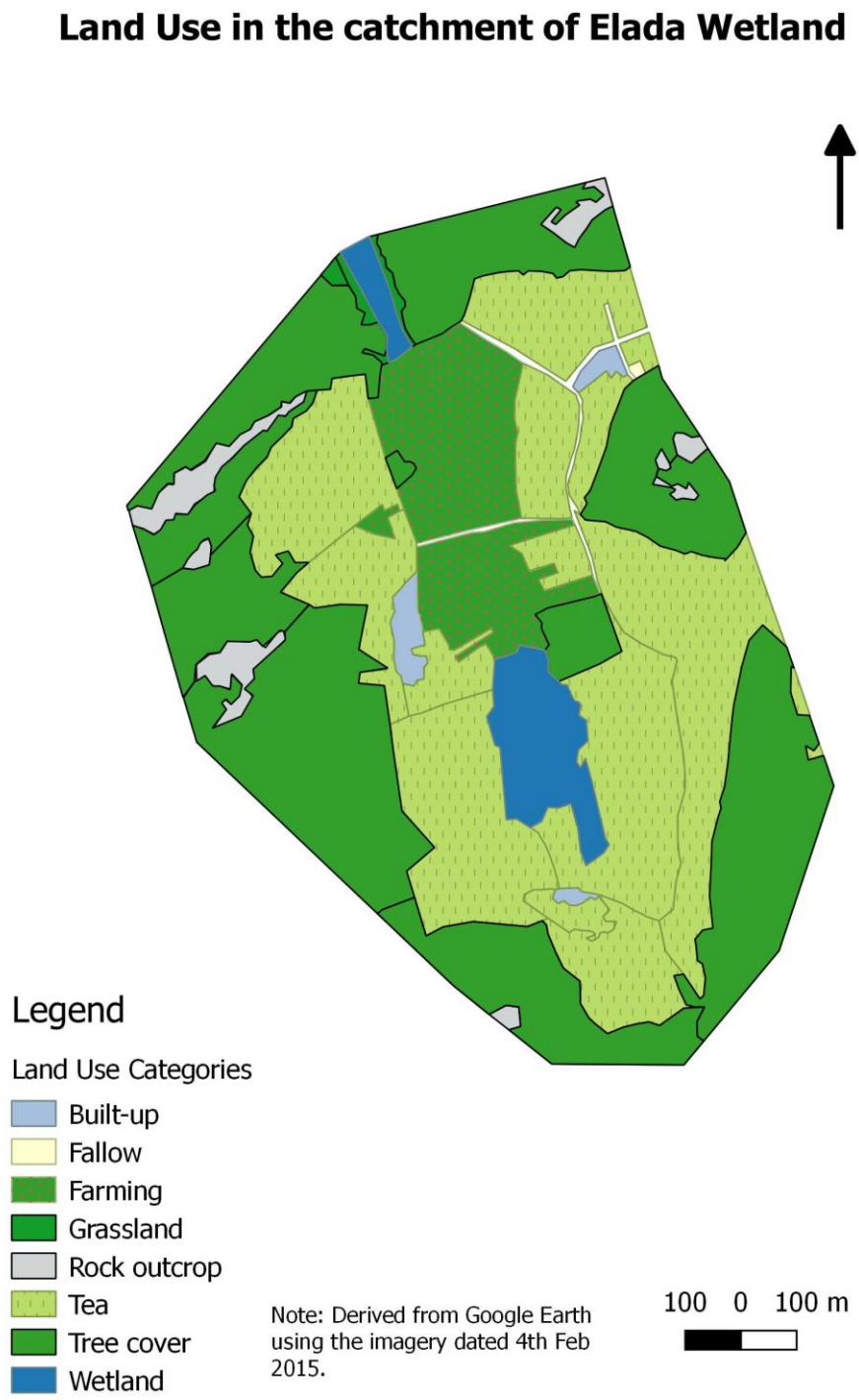

Figure 6: Land use/cover map of Elada

Figure 7: Imagery of the catchment in 2008.

Figure 8: An imagery of the same catchment in 2015.

WATER QUALITY:

A total of 28 open wells have been identified in the catchment of the dam. A sample of these numbering 13 is being monitored on a regular basis since January 2017. During July 2017, water samples from five different points were taken to test the quality of water.

Parameters	Permissible Amount	WELL 01	WELL 02	STREAM 01	STREAM 02	STREAM 03
TRACER						
pH	6.5-8.5	5.69	5.56	5.84	6.75	6.93
TDS	<500	52.9	30	17.8	39	199
EC	0-500	72.4	42.2	25.1	55.1	280
Salinity	<500	42.6	26.1	19.3	31.7	136
Temperature		23.5	23.1	23.1	24.2	25.2
LAB TESTS						
Turbidity		5.0-10.0	5.0-10.0	25	5.0-10.0	100
Iron	<0.3	<0.3	<0.3	0.3	0.3	1
Dissolved Oxygen	> 5	7.2	6	5.2	6.4	2.8
Residual Chlorine	<0.2	NIL	NIL	NIL	NIL	NIL
Chloride	<250	NIL	NIL	NIL	NIL	NIL
Nitrate	<45	<10	<10	<10	NIL	10
Phosphorous		1	1	0.5	0.1	0.1
Ammonia	<0.5	NIL	NIL	<1.0	NIL	<1.0
Flouride	<1.0	0.6	0.6	0.6	0.6	0.6

Table 2: Water quality test results of various samples

The samples were taken from two wells (private owned and community) and three points in the stream from the head wetland to the check dam.

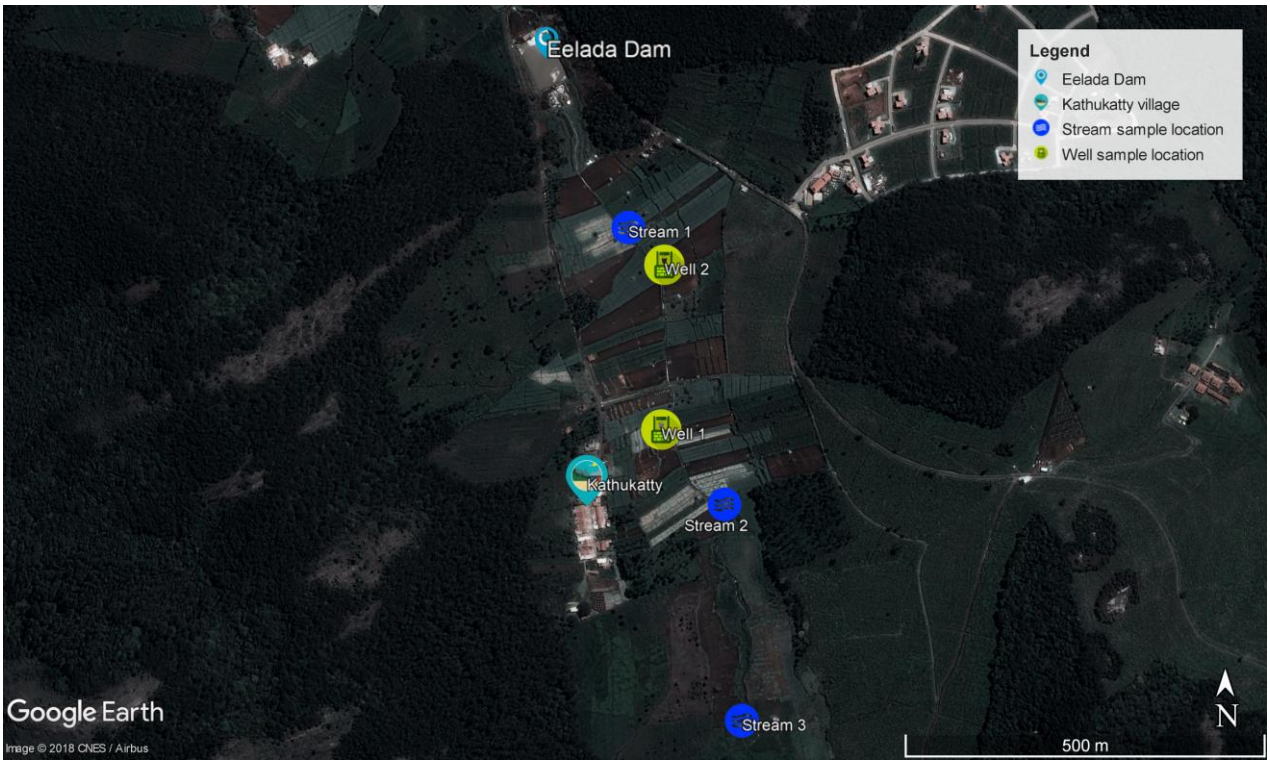

Figure 9: Water sample points in the Elada catchment

Figure 10: Stream water being used for irrigation in the adjacent fields

The water from the wells was colourless and odourless and with a turbidity ranging from 5-10. The water has a low pH level indicating that the water is acidic. This could be due to the mixing of pesticides from the intense farming around the area as pesticides have a very low pH level ranging from 3-5. The salt level of the water is also low and so is the Electrical conductivity and Total dissolved solids. The water also has very low Iron level making it suitable for consumption.

The dissolved oxygen in the sample from both the wells is above the range indicating that the water is clean and consumable and also allows for aquatic animals to survive. The level of Phosphorous is also less in the water suggesting that the water is not contaminated. The low nitrate and ammonia levels show that the there is no mix of sewage with the water.

The three samples from the stream were collected at an interval of 400m from the head wetland (which also contains a spring) towards the check dam. While the first sample showed low pH due to lack of buffer from the agriculture land to the wetland, the other two further north has acceptable pH levels. The sample at point 03 on the stream showed higher salinity than the other samples and so were the electrical conductivity and the Total dissolved solids.

Figure 11: High iron content in the water

Seen from the samples, the Iron content in the water keeps increasing as it collects more silt from the weathered materials as the stream runs downstream. The dissolved oxygen falls downstream because of the poor flow of water and stagnation at certain places. The natural flow of water is disrupted by rechanneling the stream around the farm land reducing the rate of flow in the stream. This causes the water to stagnate at certain places and makes way for moss formation. This is seen downstream towards the check dam and thus the dissolved oxygen at this point is significantly lower than the upstream.

In sample 01 and sample 03, there is presence of Ammonia which indicates what might be a mix of sewer in the water. In addition, the presence of nitrate in sample 03 shows that the water is contaminated by the presence of agricultural waste.

Overall, since the water from the sample 02 is from a place in the wetland that is not affected by intense farming and the channel maintains its natural flow with the native aquatic plants lining the stream, this water is more suitable for consumption than the other two points in the stream where the quality of water is deteriorated by intense chemical farming.

HABITAT AND SPECIES:

Students from The School, Chennai assisted in conducting a floral inventory. With the detailed floral and faunal inventory in place, it would be possible to revisit the same periodically to track changes over time. The students were put in two groups, explaining them the methodology. Plots of 1*1m were laid starting from two different directions. Group 1 laid 16 plots and group 2, 21 plots.

The plants identified from the wetlands were *Polygonum sp. Juncus effucus, Poa* sp, *Oxalis corniculata, Centella asiatica, Myriophyllum intermedium, Serpicula brevipes, Frimbristylis sp, Lindernia sp, Rotala rotundifolia, Acorus calamus, Scripus* sp., *Plantago major, and Taradaxum* sp.

Over the last decade, chemical vegetation has taken over most of the wetland area leaving only small portion of the wetland towards the north. This leaves very less room for native grasses such as *Juncus, Frimbristylis sp, Polygonum* and *Scripus.* Towards the north where a tiny patch of wetland is left untouched, there is a spring that helps maintain substantial amount of water in the wetland. Here, there are aquatics such as *Myriophyllum intermedium, Serpicula brevipes and Rotala rotundifolia* along with other endemics such as *Plantago major, Centella asiatica* and *Lindernia sp.* At the southern end of the wetland next to the checkdam, the wetland has completely dried and is taken over by Poa grass and the land is used for grazing of cows, buffalos and goats.

While most of the catchment is taken over by tea plantation, there is a significant tree cover which consists of invasives such as Eucalyptus and *Acacia meansii* that make the soil acidic and prevents growth of other native shrubs in the soil. Apart from this there is *Solanum verbascifolium,* an invasive plant lining the wetland area.

Figure 12: Exotics growing near the water source

ECOSYSTEM SERVICES

One of the important ecosystem services provided by the wetland to the inhabitants of the locality is groundwater replenishment. The wetland is the major source of water for drinking and irrigation for the residents of the communities in the watershed area. In addition to groundwater replenishment, the wetland plants also play a major role in purifying the water from from the fields and domestic use. The wetland is also a home to a valuable biodiversity that thrives in the biotic connections. The wetland also plays a role in flood control as it acts as a sponge that absorbs the excess water.

COMPARISON - SURVEY IN 2006 AND 2016

Changes were observed during the present visit when compared to the earlier visit made in 2006. A motorable road was laid in between the wetland. The poa grass has been uprooted (cut in square shape), which could be for preparing lawns. A cemented check dam has been constructed acting as a storage structure for water. Water from the check dam is being used to wash vehicles. Grazing by cows and goats was observed.

The major addition to the study in 2016 was the deriving of the catchment of the wetland near the dam and deriving its land cover map. Using the elevation data from Google Earth, we have been able to delineate the catchment area of the dam. The total area as calculated using QGIS software is 335 acres approximately. Further, using recent high resolution satellite imagery in Google Earth Pro, we have been able to derive a land cover map of the catchment area. This has enabled us to identify the actual source of the water flows into the dam, which is another wetland within the catchment.

EXISTING ACCESS AND AWARENESS

Unlike the other wetlands in consideration, the village near Elada, Kathukatty is isolated in terms of distance from the wetland. The village of 30 households depends on its drinking water and water for other domestic use from the wetland. The residents of the village now have a community well in the valley and water is being pumped to their houses from here.

Before farming could take over, the wetland and the grassland was entirely used by the community to graze their cattle. Eventually, they turned towards agriculture to earn their livelihood and further went on to leasing the land out to outsiders for cultivation, also encroachment of the wetland area. In order to maximise yield during the short period, they tend to use pesticides and fertilizer. There has been rapid encroachment of the remaining wetland for farming leaving only a smaller patch of wetland near the spring, untouched.

The water from here is being held by the checkdam and is being supplied to the rest of the town at periodic intervals. Apart from this, there are certain private players (three resorts in or near the catchment) who also source water from the wetland by pumping water from the wells.

Towards the end of this study, we found that the head wetland had been converted into chemical farming by a lessee from outside the area. The wetland was reduced to a small water hole and this could have drastic impact on the health of the wetland ecosystem in future. Being on a privately owned land, it is difficult to control such land use changes.

OPPURTUNITIES AND CONSTRAINTS

Though Elada is located in a secluded and serene area and is least urbanised when compared to the other wetlands, it is more commercialised than the others. The water here is used by various stakeholders such as the resident communities, Panchayat for supply to the town and private players to benefit their own businesses. Since there are various stakeholders involved, the conservation strategies at the wetland must also extend to the length and breadth of the issues in order to achieve a considerable return from the efforts. Beginning from deweeding the area, service provision to the nearby areas, advising organic farming, curb over extraction of water, management of funds to efficient enforcement of rules, there are multitude of areas to be covered in terms of implementation.

WAY FORWARD

Elada being an important wetland in the Nilgiris and the dam being an important source of water for Kotagiri town, there is a need to monitor it closely in the coming years. The Elada wetland is similar to numerous wetlands in the Nilgiris where the catchment is highly disturbed and there is high dependence on the water supply.
Since the extent of the wetland at Elada is large and there are a number of stakeholders involved, the conservative measures have to be done bottom up by looking into various issues and the relevant fix that would lead to a holistic solution. The intervention strategies can be looked at in the following ways addressing various issues and the stakeholders involved.

1. Creating awareness among the residents and keeping them well informed about the role of wetlands in producing drinking water and the effects of their everyday behaviour towards the wetland and encouraging them to plant native species on the catchment.
2. Creating awareness among the landowners on the long term effects of intense chemical farming and encouraging them to practice organic farming and water intensive farming in order to keep the soil healthy in the longer run.

3. Protecting the leftover wetland area by fencing it and restricting movement in the wetland area.
4. **Deweeding** of the invasive aquatic plants like water hyacinth in order to restore the health of the water.
5. Removal of exotic flora from the catchment and planting of native plants in different phases have to be carried out with the help of the Forest department.
6. **Planting of native grasses** and other shrubs in patches within the wetland in order to allow for the regeneration of the wetland over time. In addition to this, these areas should also be protected through physical barriers in order to avoid further damage.
7. In the main wetland, a **buffer on the either side of the stream** must be maintained in order to allow for the aquatic plants to thrive and further help in water retention and purification.
8. There are various wells dug in the valley by the Panchayat and the private players. More the extraction, the overall water table in the valley goes down and affects the rest of the dependents. The resident and farming communities in the catchment have to be encouraged to practice water sharing to deal with their water needs effectively.

CASE STUDY 2: RIFLE RANGE

INTRODUCTION:

Rifle range is a neighbourhood in Kotagiri that is not too far from the town area. It is a wetland that is surrounded by a number of residences and it is on the verge of being taken over by more houses in spite of the extreme dampness of the locality. Over the last twenty years the number of houses in the catchment of this wetland has been exponentially increasing due to the housing demand within the town.

Figure 1: Map showing Rifle Range's location in the district

The wetland at rifle range was home to a distillery plant established by United Breweries Ltd. nearly a century ago. The building still stands at the site, but is unoccupied and unattended due to its extreme dampness. Eucalyptus trees were introduced in this area to absorb moisture in the wetland and to make the land suitable for construction. The majority residential neighbourhood is served entirely by the wetland for its drinking and domestic use.

LOCATION, PROXIMITY & SCALE

Rifle range is at a distance of less than a kilometre from Kotagiri town centre. The wetland at Rifle range is linear and it extends from the spring in the west towards the tight residential area to the east for a distance of 275m and a width varying from 15m to 50m. The wetland is connected by a motorable road that ends where the wetland ends.

The wetland is located at one of the prime residential areas within Kotagiri and it has a varied land use around it. Apart from the dense residences on the immediate catchment, there is also a

Veterinary hospital, Fungiculture unit (edible mushrooms) and an abandoned distillery. There are six wells that were dug by the panchayat but only three of them are in use at the time of the study. The wetland at rifle range is one of the biggest among all the wetlands that are being studied in detail.

Figure 2: Context map of Rifle range

The 7 acre wetland has a stream that starts from the spring to the west that cuts across the wetland and goes downstream to Donnington through the dense neighbourhood and runs further down. The water at the head wetland is cleaner in comparison to the downstream due to the sewage being let out in the downstream. The water from rifle range is used by the immediate neighbourhood and also by the panchayat for supply to Alports area just above the wetland for an hour every alternate day.

Figure 3: Wetland at Rifle range

SIGNIFICANCE:

In order to serve the British soldiers who had encamped in the area, United Breweries Ltd started its first distillery in this area during the early 20th century. The abandoned building still stands in the ground. Since the area was marshy when they set foot, the area was planted with Eucalyptus trees that are best known for absorbing water from the ground. This was done as an attempt to make the land suitable for construction. Though the building was built by drying the land up, it wasn't quite enough to sustain. Very soon, the foundation got weaker and the building started sinking in with cracks appearing on the building. This made them abandon the building and move elsewhere. Though there is a legend saying that the wetland was once a lake, interaction with the residents helped us understand that it has always been a marshy land with a stream cutting through, only larger and with more water than what we see now.

SURVEY METHODOLOGY

The survey of the wetland at Rifle range was carried out by the team from Keystone Foundation during August 2017. The team was involved in observing and analysing various parameters such as the general profile and dimensions/extent, hydrogeology and biodiversity of the wetland to understand the overall wetland ecosystem.

LANDUSE AND LANDSCAPE CHARACTER:

The team at Keystone visited the site and analysed the landuse of its watershed area and traced the same out using Google Earth. The proportions of the various types were also calculated to get an idea of the extent of various uses in the watershed area contributing to the wetland.

Total area of catchment	108 acres
Total perimeter of the catchment	2595 m
Total area of wetland	6.99 acres
Total perimeter of the wetland	1192 m

Table 1: Area of the wetland and the catchment

Name	**Area (acres)**
Built-up	28.93
Tea	55.28
Tree cover	8.59
Wetland	6.99
Miscellaneous	8.21
Total	**108**

Table 2: Land use in the catchment and their area

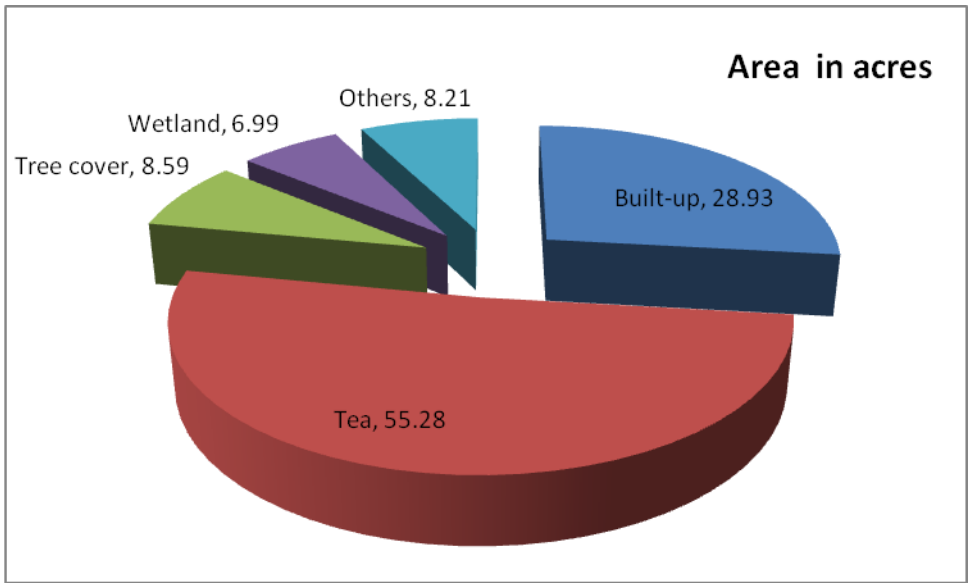

Figure 4: Proportion of the different land uses

Figure 5: Head wetland at Rifle range

Almost half of the watershed area is occupied by tea plantations (51% of the watershed) that reach down till the wetland itself in the head wetland. Since tea requires a dry landscape to grow in, most of the growth here has failed due to the swampy nature of the wetland. The tea plantations are however found till the ridge of the watershed area.

Figure 6: Land cover map of Rifle Range overlaid on Google Earth Image

Though tea occupies most of the watershed, the density of residences in this area is significantly high (27% of the watershed) as compared to the other wetlands that are studied (Elada, Upputhotti and Thalikundah). This is probably due to the close proximity of the wetland to the town centre. While a handful of the current neighbourhood started inhabiting the place around 50 years back, most of the houses were built in the last decade due to the housing demand within the town area irrespective of the dampness due to the wetland. With this came the digging of private wells due to the abundance of water in the locality. Apart from this, the residences also let their domestic waste water into the wetland through pipelines set up by the individual families themselves.

There are 6 Panchayat dug wells of which 3 are used for supplying water to the nearby areas, especially Alports, a neighbourhood just above the wetland which faces severe water scarcity. Over the years, this led to the drying up of most part of the wetland leaving only a tiny stream that runs from East to West and further down to Donnington carrying sewage. The planting of Eucalyptus trees to dry the land up for construction also plays a major role in this scenario. On talking to the older residents there, it was understood that the wetland used to hold a substantial amount of water through most seasons of the year which was high enough to reach a person's knee with a stream that was as wide as three meters.

Apart from this, there is very minimal tree cover left in the area due to dense built up in the locality. The wetland hardly covers 6% of the overall watershed due to the encroachment of houses and other buildings in the area. However, most part of the wetland is dry due to over extraction in the recent past.

GEOLOGY:

The catchment has a very gradual slope which allows for infiltration of water all along the catchment. The depression has clayey soil as a result of silt deposited over time. The entire watershed area has deep top soil with a layer of weathered charnockite, a soft, thoroughly decomposed and porous rock, often rich in clay that is more than 20' deep. Below the deep

weathered charnockite layer is the bedrock. The depth of the top soil gradually increases from the ridge of the catchment to the depression. Most of the rocks here are weathered leaving weathered soil and other weathered materials with no rock outcrops in the area.

The catchment area for Rifle range wetland had no rock exposures. The weathered layer exposures along the roadsides and other exposed areas were studied. The rock trends were not clear as there were less rock outcrops. The stream from the wetland flows in a NW – SE direction and meets the Longwood shola stream and flows into Donnigton town and downstream.

Figure 7: Exposure in Polytechnic ground showing semi weathered layer in the middle surrounded by Regolith

The ground in Shakthi malai next to the polytechnic was the starting point. The regolith or weathered layer goes more than 7 metres deep, the semi weathered rock is seen (refer picture above) in one part of the exposure. There are vertical fractures seen in the semi weathered rock. The process of spheroidal weathering was also seen in the exposure.

Figure 8: Dyke/Hard rock intrusion seen in Polytechnic ground Figure 9: Spheroidal Weathering

There are roads dividing the catchment from the wetland into two halves. The road cuttings from Ramchand towards club road shows weathered layer depth between 2 metres to 7 meters. Hard rock was not seen anywhere in the catchment. The catchment is divided into two parts by the road, the top part being the main recharge area is cut from the catchment. The important aquifer for the wetland is the weathered unconfined layer which stores and transmits water to the wetland. There are two major drainages feeding the wetland, one starting from the left flank (West) which brings water mixed with sewage from the dense habitations in Ramchand area, and the other drainage forming from the right flank (NNE) from below Windygap area in club road. The drainage from the right flank also has a depression spring close to the valley which feeds the wetland. The soil in the wetland is clayey type which helps in holding the water above ground level. The movement of ground water is much slower in the clayey sediment.

Figure 10: Potential recharge areas of Rifle Range wetland is shown in the map.

WATER QUALITY:

The water sample was taken from two points in the wetland along the stream (marked on the map above); where the stream is intersected by the bridge where a community well is used to draw water for washing clothes and at the end of the wetland. Though the quality of water at both these points is almost the same, there were few differences in terms of the iron content, hardness and coliform in water.

Figure 11: Map showing the location of water sample collection for quality test

The sample from **point 01** was at a very important junction in the wetland where the flow of water in the stream is interrupted by a crossover bridge that leads to the residences built on the catchment area. The water here was clear and odourless and has a higher pH possibly due to the mix of detergents that have high alkalinity. The salt content in this water is within the permissible level for drinking water and so are the electrical conductivity and the total dissolved solids.

Figure 12: Residents washing clothes near a panchayat well

There was presence of iron in the water that was evident from the rust orange base and an oily film on top. The iron level in this water is 1mg/l whereas the permissible level is 0.3mg/l. Apart from being an aesthetic problem, the colour does not affect the quality of the water for consumption. Due to lack of open defecation and sewage release into the stream water, there is no Coliform or ammonia present in the water.

Water quality			
	BIS standards	**Point 01 on stream**	**Point 02 on stream**
COORDINATES			
pH	6.5-8.5	7.86	6.55
TDS	<500 ppm	210	112.4
Electrical Conductivity	0 - 1500	151	79.8
Salinity	<200 mg/l	104	57.7
Temperature		26.9	25.4
Water quality tests with Jal Tara Kit			
Residual Chlorine	<0.2	NIL	NIL
Turbidity	5-10	5-10	5-10
Chloride	<250-1000 mg/l	NIL	NIL
Dissolved Oxygen	5	6	4
Flouride 1.0mg/l	<1.0	0.6	0.6
Phosphorus		0.1	0.1
Iron	0.3	1	3
Hardness	<200	120	80
Ammonia	0.5	<1	<1
Coliform	Nil	Absent	Present
Nitrate	<45	NIL	NIL

Table 3: Water quality test results

Whereas in **sample 02**, at the end of the wetland, the pH level was within the permissible limit but on the lower side indicating that the water is acidic. Similarly, the electrical conductivity, TDS and Salinity were also within the limits. Iron content in this sample is higher than sample 02 and as high as 3mg/l which gives it a strong odour and a subtle orange colour. The presence of faecal Coliform indicates that the sewer from the nearby houses could be let out here.

There is no intense farming around the area. Therefore, in both cases, there was no Chloride or Residual Chlorine. The very low level of phosphorous in the wetland limits the growth of aquatic plants in the entire wetland.

Though the quality of water is within the permissible levels for drinking at the wetland, as the stream travels further down, the water is fully contaminated as the stream collects all the domestic waste from the households and turns into a drainage duct rather than a freshwater stream.

Figure 13: Sewage being drained into the stream

HABITAT AND SPECIES

Figure 14: Dense aquatic plants lining the stream in the wetland

The wetland at Rifle range houses a number of indigenous wetland species of flora and fauna, whereas exotics are mostly found on the catchment. Amidst the dense residential development, the animals, birds and insects along with the plants help maintain the wetland ecosystem at Rifle range wetland. The terrestrial animals found along the wetland include wild boars, goats, buffalos, monkeys and Cows. The wetland is used as a grazing ground for the nearby household who own cattle as observed. Due to the practice of dumping waste in the wetland by the households, there were a number of boars that eat through the piles of waste.

The bird species include Long tailed Shrike, Pied Bushchat, Red whiskered Bulbul, Wagtail, Common Sparrow, Crow, Common Myna, Swift, and Pond heron. Bee varieties such as *Apis Dorsata* and *Apis Cerana* were also found foraging on the flowers of Lindernia. Apart from this dragonflies and ladybugs were also found.

In the wetland at Rifle range, one can see *Isachne, Scripus, Centella Asiatica, Viola, Kyllinga, Eupotarium, Tea, Cyperus, Viola, Poa grass, Hydrocotyle, Commelina, Arum, Rorippa, Brachiara plantaginea, Axonopus compressus,E.Nigra* and *L. Misorensis.* The plant profile in this area is dominant with the native aquatic plants that help retain the wetland water at a desirable quality. Due to this, the water quality tests also showed a relative increase in the quality after passing through 100 metres long dense aquatic plants.

At the depression, where the stream runs, the landscape is dominated by *Arum, Isachne, Scripus* and *Ludwigia* which are native aquatic plants that play a major role in retaining water in the stream and in improving the quality of water as it runs downstream. Apart from that the dried up patches are taken over by a mix of both native and exotic grasses. Lining the wetland towards the south is Eucalyptus that was first introduced by United Breweries Ltd in early 20th century to make the marshy land suitable for construction.

ECOSYSTEM SERVICES

The wetland at Rifle range is fully surrounded by residences that fully depend on the wetland for their drinking water and water for other domestic uses. Therefore one of the important ecosystem services provided by the wetland is groundwater replenishment and water purification. The encroachment by built structures at Rifle range is minimal leaving the wetland to play its role in water replenishment successfully. In addition to this, the wetland aquatic plants play a major role in purifying the water at the wetland and helps serve the community with better quality drinking water. The wetland also helps in flood control during monsoons.

EXISTING ACCESS AND AWARENESS AMONG STAKEHOLDERS

Residents of the neighbourhood are the only stakeholders that can have a direct, yet far reaching effect in terms of conserving the wetland. While the older residents are aware of the wetland characteristics as they have been coexisting with the wetland for generations, the newer residents are unaware of the situation as it doesn't affect their livelihood directly. The town panchayat (local government body), the secondary stakeholder, is under pressure to supply the town with water, supplying from water surplus areas to water deficit areas within the town, leaving the wetland in disarray. There is competing pressure on the wetland from all the stakeholders, by constant digging of wells, encroachment of the wetland for parking and ad hoc measures to control flooding and drought which leads to the ecological degradation of the wetland.

Figure 15: Wetland being used for parking by the nearby residents

Figure 15: Wetland being used for parking by the nearby residents

OPPURTUNITIES AND CONSTRAINTS

The opportunities and constraints in conserving the wetland at Rifle range lies mainly with its residents. Educating the neighbourhood on the importance of the wetland will improve the sense of belonging among the residents to create a positive effect. Pressure on the wetland due to housing, parking and lack of household and community services are a few areas where the wetland can be improved.

WAY FORWARD

The analysis of the wetland at Rifle range suggests that the wetland is in a stage where minimal interventions can be carried out to conserve the wetland. Once well maintained, this would develop the health of the wetland. The following are the few recommendations towards wetland conservation at rifle range:

1. Mobilising the important stakeholders such as the residents of the wetland and its catchment, landowners and the Panchayat.
2. Creating awareness among the residents and keeping them well informed about the role of wetlands in producing drinking water and the effects of their everyday behaviour towards the wetland.

3. Efficient waste management system to be developed towards waste collection from low lying areas that avoids waste accumulation in the wetland.
4. This in turn also reduces the human wildlife conflict as there are plenty of wild boars in the area that feed into the waste.
5. Regulating the number of bore wells in the area to effectively extract water to supply to other areas in the town.
6. Deweeding the wetland and removing of exotic plants and trees is necessary to allow the native wetland species to grow.
7. With the help of the Forest department and the local stakeholders, native species have to be planted in the catchment where exotics have taken over.
8. Since the wetland is already rich in native aquatics, it is essential to protect them through fencing and also create new patches of native plants and allow them to spread across the wetland.
9. In the wetland, a **buffer on the either side of the stream** must be maintained in order to allow for the aquatic plants to thrive and further help in water retention and purification.
10. In order for these measures to sustain over a period of time, the wetland has to be fenced in certain critical areas and areas of intervention. Movement through the wetland should also be restricted and regulated to avoid damage due to human intervention.
11. Downstream, the condition of the stream has to be improved by desilting, trapping sewage outlets from the household and improving the edge conditions of the stream.

With the implementation of these strategies and efficient monitoring of the over the period of time, the health of the wetland ecosystem can be restored.

CASE STUDY 3: UPPUTHOTTI

INTRODUCTION

Upputhotti wetland is situated near Yedapalli village in Coonoor Taluk, The Nilgiris district. It is located at a distance of about 5.4 km from Coonoor town. Apart from Ralliah dam and Bandhumai dam, Upputhotti (via Gymkhana stream, which is a downstream of Upputhotti) is one of the main sources of drinking water to Coonoor town.

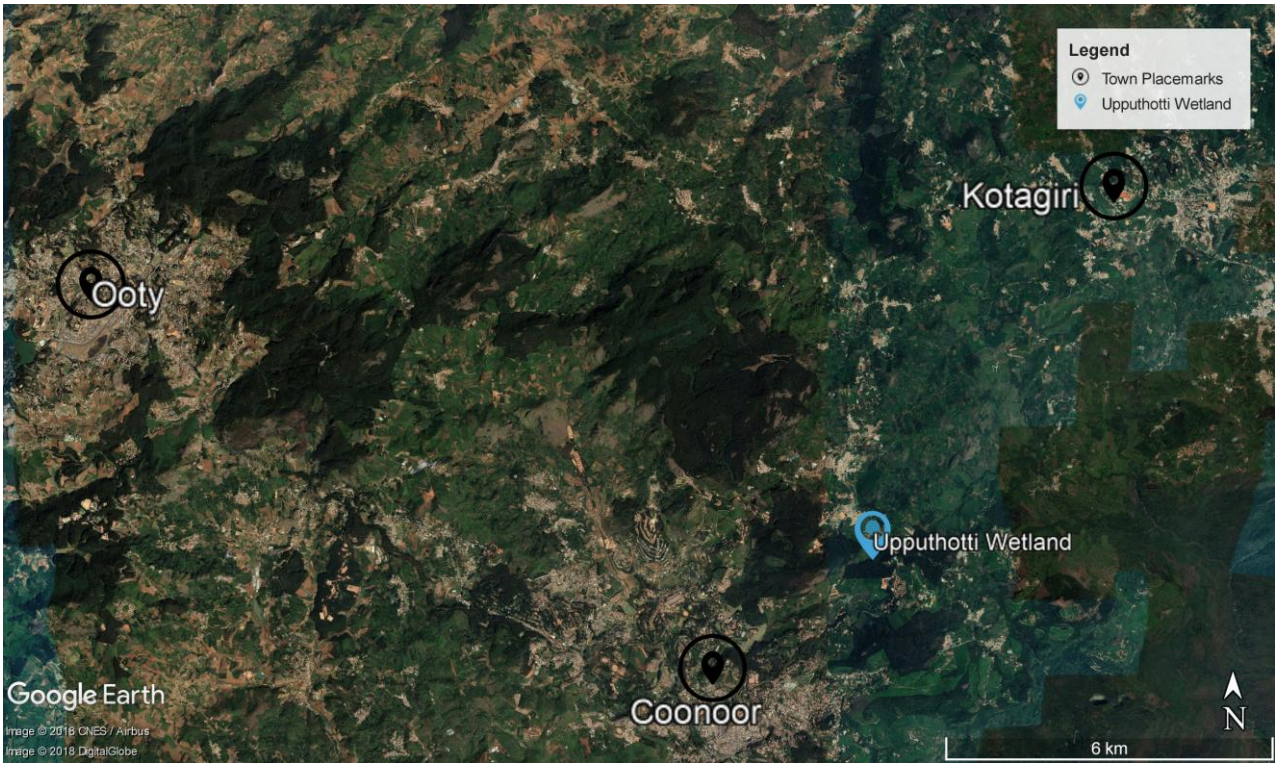

Figure 1: Map showing Upputhotti wetlands location in the district

Coonoor town has been facing an acute water scarcity in the recent past due to the drying up of its major sources due to monsoon failure and mismanagement of the natural sources by the municipality and the citizens[6]. Keystone Foundation therefore analyses the existing conditions of the head wetland at Upputhotti, that in turn serves the Gymkhana stream (both being sources of water to Coonoor town) and comes up with relevant implementation strategy to overcome the overall water scarcity issue.

LOCATION, PROXIMITY & SCALE

Upputhotti wetland is situated at a distance of 5.4 kms from Coonoor town adjacent to the road connecting Coonoor with Kotagiri. The wetland falls in close proximity to Yedapalli village which lies on the ridge of the catchment area. The wetland at Upputhotti is differentiated into two;

- **Head wetland** of area 0.25 acres and perimeter 166m and
- **Main wetland** of area 5.66 acres and perimeter 904m.

The two wetlands are separated by the Coonoor-Kotagiri main road.

[6] http://www.downtoearth.org.in/news/coonoor-hill-city-without-water-for-past-one-month-41239

Figure 2: Head wetland at Upputhotti

The head wetland is of area 0.25 acres and has a rectangular profile. This part of the wetland is at two levels separated by a path that leads to 3 houses in the catchment. Along its catchment, the wetland here is surrounded by tea plantations. We surmise that a spring may have existed given the presence of a temple north of the wetland. It is a common practice among the locals to conserve the springs by building a temple marking its significance as one of the life supporters. The water runs off from this wetland, passes through the tea plantations and reaches the main wetland.


Figure 3: Upputhotti Wetland

The main wetland is a triangular piece of land of area 2.12 acres with its broader end in the north and tapers towards the south. The wetland is home to a number of indigenous plant varieties that help maintain the wetland ecosystem along with a number of birds, animals, bees and other insects. The wetland is relatively untouched except for a couple of municipality dug wells. The catchment area is taken over by the exotic and invasive varieties of plants till the brim of the depression in addition to a substantial amount of tea cultivation on the slope from the head wetland. Apart from this, there are a couple of industrial buildings (processing unit and warehouse) on the catchment.

Figure 4: Panchayat well at Upputhotti from which 6500 litres of water is drawn everyday

Every day, 32,500 (5x6500 litres) litres of water is taken from one of the wells) in the wetland by the Coonoor Municipality to serve certain resorts, schools and hospitals in the locality. Apart from this the municipality also draws a few thousand litres of water from the collection tank that is built south of the wetland.

SIGNIFICANCE:

The name Upputhotti in Tamil literally means salt tank (uppu - salt & thotty - tank). The wetland got its name from a popular ritual among the badagas who live in the nearby villages, where the villagers bring their buffaloes to the wetland and make small water holes and add salt to the holes and feed their buffaloes and pray to their ancestors. Due to the deterioration of the wetland, the custom has been moved to other grasslands adjacent to the village.

Environmentally, the wetland plays a vital role in determining the health of the water downstream in terms of its quality and quantity. Apart from this, it also maintains the water levels in the wells and tanks in the vicinity which serve the nearby villages.

SURVEY METHODOLOGY:

The survey of the wetland at Upputhotti is carried out by the team from Keystone Foundation during July-August 2017. The team was involved in observing and analysing various parameters such as the general profile and dimensions/extent, hydrogeology and biodiversity of the wetland to understand the overall wetland ecosystem.

LANDUSE AND LANDSCAPE CHARACTER:

Total area of catchment	71.2 acres
Total perimeter of the catchment	2250m
Total area of wetland	2.37 acres (0.25+2.12)
Total perimeter of the wetland	682m (166+516)

Table 1: Area of the wetland and the catchment

Name	**Area (acres)**
Built-up	6.43
Tea	45.8
Tree cover	12.35
Wetland	3.44
Total	**7.56**

Table 2: Land use in the catchment and their area

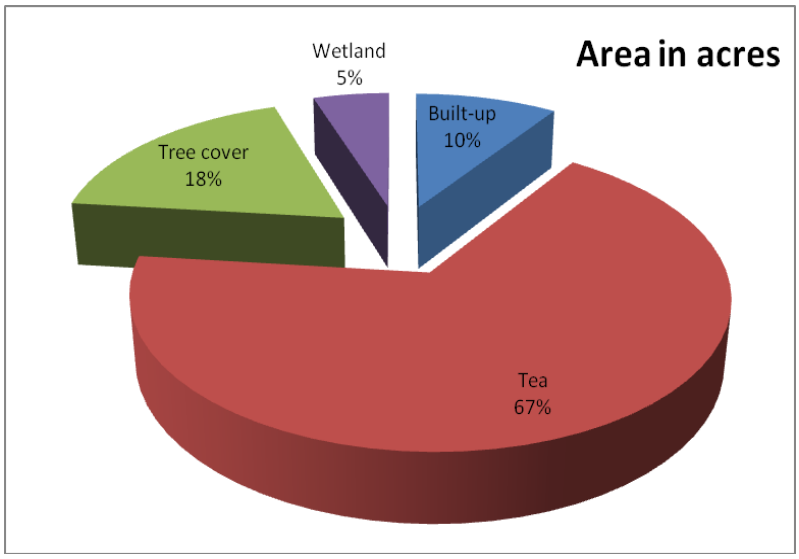

Figure 5: Proportion of the different land uses

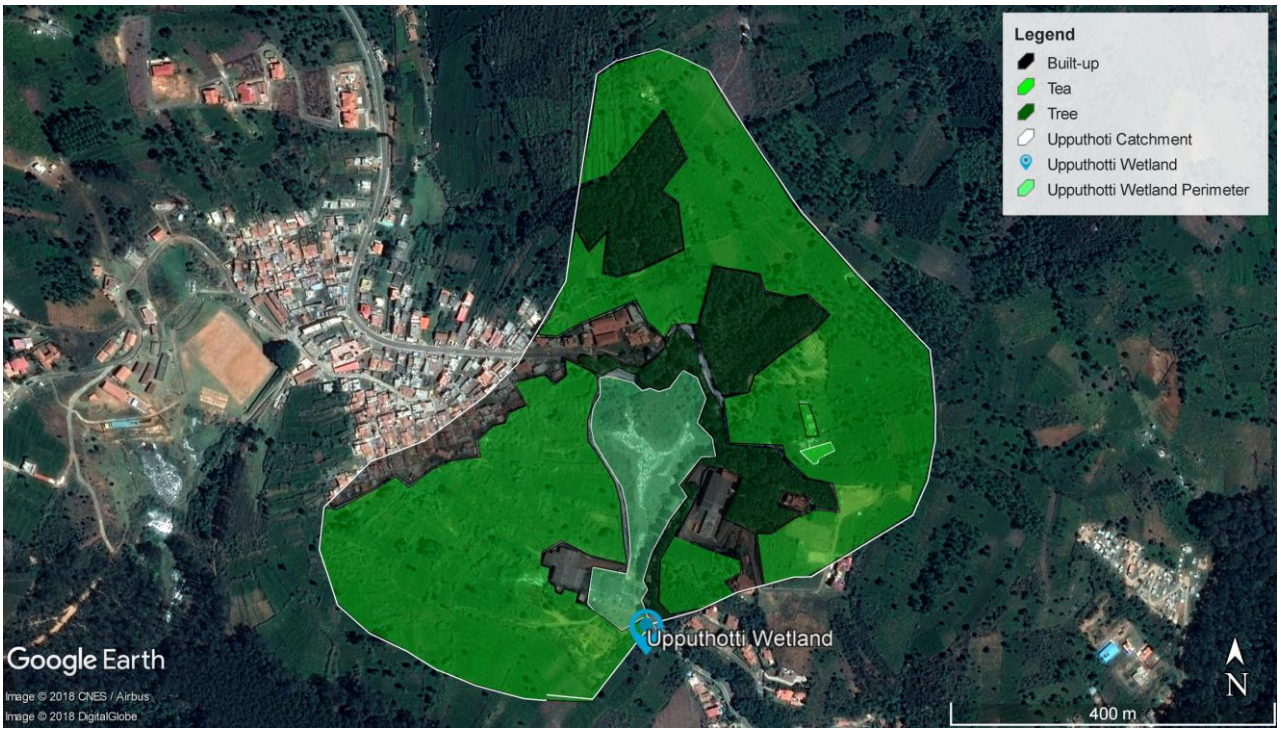

Figure 6: Land cover map overlaid on Google Earth Image

As observed all along the hills, tea plantation takes over a vast majority of the catchment area. The plantations on the east and west of the wetland along the ridges of the catchment area constitute 67% of the overall catchment area. This isn't a threat in particular as they don't use excess water like the exotics, allowing the wetland to hold substantial amount of water. About 18% of the catchment is occupied by tree cover that includes mostly exotic varieties such as Eucalyptus, Wattle, etc. These species are especially a threat to the wetland as they take over the wetland on occasions where it dries due to monsoon failure. Wattle in particular colonises nearby areas aggressively.

Figure 7: An imagery of the catchment in 2003.

Figure 8: An imagery of the catchment in 2017.

To the north of the wetland, a part of Yedapalli village sits on the catchment area. In addition to the north of the wetland, there are a couple of industrial buildings to the east and south of the wetland which together constitute 10% of the overall catchment area. The houses in the villages depend on the wetland for its water and over extraction in these villages would again affect the health of the wetland.

The wetland along with the grassland around consists of just 5% of the overall catchment area which could be a much larger area before the exotics took over. In comparison to other wetlands in the Nilgiris, the wetland at Upputhotti is relatively smaller constituting an area of 3.44 acres. Considering the size and the pace of urbanisation and expansion in the nearby villages and Coonoor town, the wetland in particular is in a vulnerable state. On unfortunate occasions of monsoon failure, over extraction of water by government and private sources, etc. is common. When a part of the wetland dries up for a period of time, there is high chance of exotics taking over the wetlands and preventing the wetland from retaining water in it. This in turn would kill the overall wetland ecosystem over time.

Though the satellite imagery from 2003 and 2017 do not show a drastic change in landuse, it is hard to miss that the area is rapidly urbanising and the built up area is increasing in the catchment and its surrounding.

GEOLOGY:

There are three drains in the catchment from the northern side that funnel water into the wetland, two of which are marked through depression in the terrain and the other is the drain from the head wetland. The wetland is composed of clayey soil formed due to accumulation of silt from the catchment area. The catchment is lined with relatively shallow top soil (1’9” – 2’), below which there is a presence of weathered charnockite, a soft, thoroughly decomposed and porous rock, often rich in clay. Poorly weathered charnockite grit aquifers also are capable of producing groundwater. The weathered charnockite here also have horizontal fissures, commonly caused by stress

exceeding rock strength. The bedrocks are found at 2.5m below the weathered layer with horizontal fissures.

Figure 9: Rock outcrop seen near the head wetland

In addition to this, there is also a presence of Charnockite, a metamorphic rock which is formed due to high pressure and temperature with a NE-SW strike of foliation. This indicates the Archean continental landmass of the peninsula.

HYDROLOGY:

Water quality		
Coliform		Taken
pH	6.5-8.5	7.66
TDS	<500 ppm	53.1
Electrical Conductivity	0 - 1500	75.3
Salinity	<200 mg/l	39.4
Water quality Lab test		
Sample No.		01
Parameter	**Acceptable limit as per BIS**	**Actual level in the sample**
Location		11.37666 N, 76.81444 E
Residual Chlorine	<0.2	NIL
Turbidity	5-10	5-10
Chloride	<250-1000 mg/l	NIL
Flouride 1.0mg/l	<1.0	0.6

Phosphorus		1
Iron	0.3	0.3
Hardness	<200	NIL
Ammonia	0.5	**1**
Coliform	Nil	Present
Nitrate	<45	NIL

Table 3: Water quality results for the water from the stream

The water sample was taken from the southern tapering end of the wetland where the stream continues to run further south. The water was tested for the presence of a number of minerals and the results are analysed against the permissible levels provided by BIS.
The results showed a neutral pH level of 7.66 indicating that the water is neither acidic nor alkaline. The water shows very low salt levels and therefore the electrical conductivity and it is suitable for consumption. The total dissolved solids too are well below the permissible levels.

The water and the surrounding area has a high Iron content which is evident through the oily film on water and the subtle rusty orange colour of the water. The iron level in this water is 0.3mg/l. Apart from the colour being perceived as an aesthetic problem, the water is good for consumption. In spite of the colour, the water is clear with a low turbidity level ranging from 5-10 units.

There is no intense farming around the area and there is no presence of sewage from the nearby villages that mixes with the wetland water. Therefore there is no Chloride or Residual Chlorine. The presence of phosphorous in the wetland water supports the growth of aquatic plants. The phosphorus could be from runoff from the tea fields.

Considering all the mineral levels of the water, it is considered harmless and fit for drinking. But further downstream the same stream is used for washing clothes and the households let their sewage out onto the stream, contaminating it. The extracted water from these wells is taken to the water treatment plant at Gray's hill before releasing for consumption.

HABITAT AND SPECIES:

The wetland at Upputhotti is home to a number of indigenous wetland species of flora and fauna. The animals, birds and insects along with the plants help maintain the wetland ecosystem at Upputhotti. The terrestrial animals found along the wetland include Barking deer, Porcupine and Cows. The wetland is used as a common grazing ground for the nearby villages which is seen from grazed blades of the grasses. When overgrazed, they have the ability to reduce the grass's ability to help in percolation.

Figure 10: 1m x 1m plots done for the plant inventory at Upputhotti

The bird varieties include Red Vented Bulbul, Red Whiskered Bulbul, Pied Buschat, Longtail Shrike, Jungle fowl, Crow and Spotted dove. Bee varieties such as *Apis Dosata* and *Apis Cerana* were also found foraging on the flowers of the spiny plant. Apart from this insects and bugs such as dragonflies, ladybugs and blue green bugs were found.

In the wetland at Upputhotti, one can see *Centella asiatica , Scirpus, Eriocaulon, Hydrocotyle, Prismatocarpus, Rotala, L. Coccinea, Isachne, Viola, Lyndernia,Limnphila,mysorensis, Linum, Utricularia, Commelina* and *Kyllinga.* The plant profile in this area is dominant with the native aquatic plants that help retain the wetland water at a desirable quality.

The marshy part of the wetland had a diverse species of wetland of herbs,grasses and sedges such as ,Hydrocotyle sibthorpioides,Viola distans,Lindernia sp. ,*Eriocaulon collinum, Ischaemum ciliare , Isachne globosa,Juncus prismatocarpus, Kyllinga melanopserma . Pennisetum clandestinum* dominated the margins of the wetlands . In slightly higher elevations adjacent to the stream where the land is dry Gamochaeta, *Anotis sp.,* Taradaxum sp. , Cirsium wallichii were observed. The marshy was surrounded by exotic invasive species such as *Lantana camara, Ageratina adenophora* inter dispersed with few native tree species like *Syzygium,Glochidion* etc.completely taken over the edges of the wetland where the land is dry. In addition to this, the entire catchment area is also covered with exotic varieties of plants and trees such as Eucalyptus, Wattle, Pine trees etc.,

These plants are vastly invasive exotics that take over the wetland area as the wetland dries due to various reasons. These species use up a lot of water leaving very little for the native plants and the aquatic organisms to survive. In addition to this, the entire catchment area is also covered with exotic varieties of plants and trees such as Eucalyptus, Wattle, Cypress, etc.,

Figure 12: Native grass Eriocaulon found in Upputhotti

ECOSYSTEM SERVICES:

The wetland at Upputhotti provided the communities with cultural values associated with the salt festival that took place at the wetland earlier. The wetland plays a major role in providing the neighbourhood with clean water and helps sustain the wetland ecosystem by providing home to the various flora, fauna and microbes. In addition to this, the wetland also plays a vital role in flood control. Due to its location and being the lowest point in the wetland network, the wetland also has nutrient retention properties and allows it to flow downstream.

EXISTING ACCESS AND AWARENESS AMONG STAKEHOLDERS:

Though the wetland had been of religious significance in the past, the nearby communities have turned their backs on the wetland. The ignorance thus makes way for the exploitation of the land for dumping and other activities. While there are no accounts of direct letting out of sewage into the wetland, there has been continuous dumping of waste in the wetland near the village. Water from the wells has also been taken out by private players to serve their hotels, resorts and schools.

The downstream from the wetland runs till Coonoor town passing Providence College for Women whose students from the Eco Club and faculties, on discussion with the team from Keystone agreed to play an integral part in conserving the wetland at Upputhotti which is less than a kilometre from the college campus. The activities that they were interested in doing towards the conservation of the wetland were de-weeding of exotics, planting Shola species of plants and trees (the characteristic forest type of Nilgiri hills that help in water retention) and policing by keeping a watch of any undesirable activities in the wetland and its vicinity. This measure will also help in creating awareness among the community and mobilizing them towards wetland conservation

Figure 13: Waste being dumped on the catchment adjacent to the main road

OPPURTUNITIES AND CONSTRAINTS:

The opportunities and constraints of the wetland lie in its size. While the interventions on the wetland for its conservation will have a far reaching effect, the vulnerability of drying is higher in case of monsoon failures over time. Going forward, Well 01, which is on the wetland, will be monitored regularly to observe any changes in the water quality and levels during various seasons.

WAY FORWARD:

There are numerous factors affecting the health of wetlands – water extraction, land use change, grazing, rainfall, climate change, invasive species, waste dumping, chemical and biological pollution etc. Being an important source of water to Coonoor town, there is an urgent need in conserving the wetland at Upputhotti. Since the size of the wetland is small in comparison to other wetlands in Nilgiris and due to the limited threats that deteriorate the wetland and the quality of water, the wetland health can be made better by very minimal interventions. The following are a few recommendations:

- Creating awareness among the residents and keeping them well informed about the role of wetlands in producing drinking water and the effects of their everyday behaviour towards the wetland.
- Since the wetland is at a vulnerable location next to the highway that connects Coonoor with Kotagiri, it is necessary to protect the wetland. The already laid fence has to be repaired in order to protect the wetland from human intervention and other disturbances.

- One of the main concerns in the wetland is the invasion of the exotics all over the catchment. Therefore it is necessary to involve the forest department in the removal of the exotics and planting native plants along the catchment in order to increase water retention in the soil.
- The digging of bore wells and the water extraction from the wells have to be regulated in order to preserve the water in the long run.
- A part of the wetland is used by the nearby village for dumping of solid waste. Therefore an effective solid waste management system has to be developed for the area clubbed with frequent monitoring.
- Involvement of stakeholders such as the local residents, local NGO-Yuva Parivartan and Providence College for Women in playing an essential part of the conservation of wetland at Upputhotti.
- Since the size of the wetland is small in comparison with the other wetlands in consideration, the effective implementation of these strategies, even over a small period of time may show a significant development in the quantity and quality of water in the wetland.

THALAIKUNDHA

INTRODUCTION:

Thalaikundha is a small settlement north of Ooty which at its first glance appears alluring to the eye but little do we know that the place is home to an ecological degradation that could affect the water health of the entire locality due to the dangerous practices followed of late. The village is at a distance of 6.8kms from Ooty town centre and falls under the Hullathy panchayat. The wetland is at the mouth of the Sandynulla reservoir that stores water for irrigation around the area.

Figure 1: Map showing the location of Thalaikundha in the map of Nilgiris

Though the water here is not used for drinking, the wetland has a major role to play in the entire network of wetlands that maintain the ecosystem and provide the town with healthy drinking water. The entire network of wetlands extends to about 2.5kms north to south and 1.5 km east to west before the link is broken by any human made disturbances such as a settlement, farm land or road. Of the entire network, we look into the wetland at the mouth of the reservoir in detail, due to the scope of intervention and the magnitude of result through the intervention.

LOCATION, PROXIMITY & SCALE:

The wetland is at a distance of 7.3km, a 15min drive from Ooty town through the grasslands and eucalyptus cover of the Hindustan Photo Film Manufacturing Company (HPF) towards Mysore. The wetland is accessible by road and the road cuts through the various inlets to the wetland but at the same time allowing them to flow through culverts. While the entire wetland measures about 78 acres, the wetland that is looked into in detail is about 31 acres including the stream, the wetland and the grassland that is taken over by exotics.

The wetland is linear extending for a distance of 1.16km from SW to NE and the width ranges between 50m to 155m. At the south western tip the wetland connects to the Sandynulla reservoir. In

the past, during the monsoon, the water levels in the reservoir have risen leaving the entire wetland with water (Google imagery attached below).

Figure 2: Satellite imagery of Thalaikundha in 2017

Figure 2: Satellite imagery of Thalaikundha in 2017

In comparison with the other wetlands covered in the study, the size of Thalaikundha is the largest and is of prime importance. There are various species of native flora and fauna that maintain the ecosystem in the wetland.

Figure 3 -

Figure 4: Colonies developed along the wetland

The wetland is surrounded by a number of communities that have made settlements in the locality by mid-20th century when Hindustan Photo Film Manufacturing Company (HPF) was set up in

1960. The catchment along the ridge towards the south of the wetland is occupied by the units of HPF along with a few staff quarters.

Most colonies here are as old as 50 years and some of them have built their houses on the valley itself. The colony on the wetland to the east of the main wetland, called Indiranagar was of 15 households, depending on a common well for water (drinking and domestic use). The residents complain about the quality of water in the well due to the clogging of the water in the wetland. This was due to the culvert under the road which is filled with so much garbage and silt that it stops excess water from running off. The residents have petitioned to the Hullathi punchayat for clearing of the culvert but in vain. The wetland acts as an open defecation site for the neighbourhood as the profile of the wetland with bushes and running water allows it.

Very close to the wetland towards its north, there is a Mund (a toda settlement) called Muthanad Mund which houses about 7-10 families and large grassland where their Temple sits. The settlement is surrounded by acres of farmland (chemical farming) along the catchment.

SURVEY METHODOLOGY:

The survey of the wetland at Thalaikundha was carried out by the team from Keystone Foundation. The team was involved in observing and analysing various parameters such as the general profile and measurements, hydrogeology, land use and biodiversity of the wetland to understand the overall wetland ecosystem.

LANDUSE AND LANDSCAPE CHARACTER:

Total area of catchment	396.23 acres
Total perimeter of the catchment	5484 m
Total area of wetland	43.05 acres (31.3+7.13+4.62)
Total perimeter of the wetland	5432m (3000+717+1715)

Table 1: Area of the wetland and the catchment

Name	Area (acres)
Built-up	20
Farmland	34
Tree cover	273
Wetland	43
Grassland	26
Total	396

Table 2: Land use in the catchment

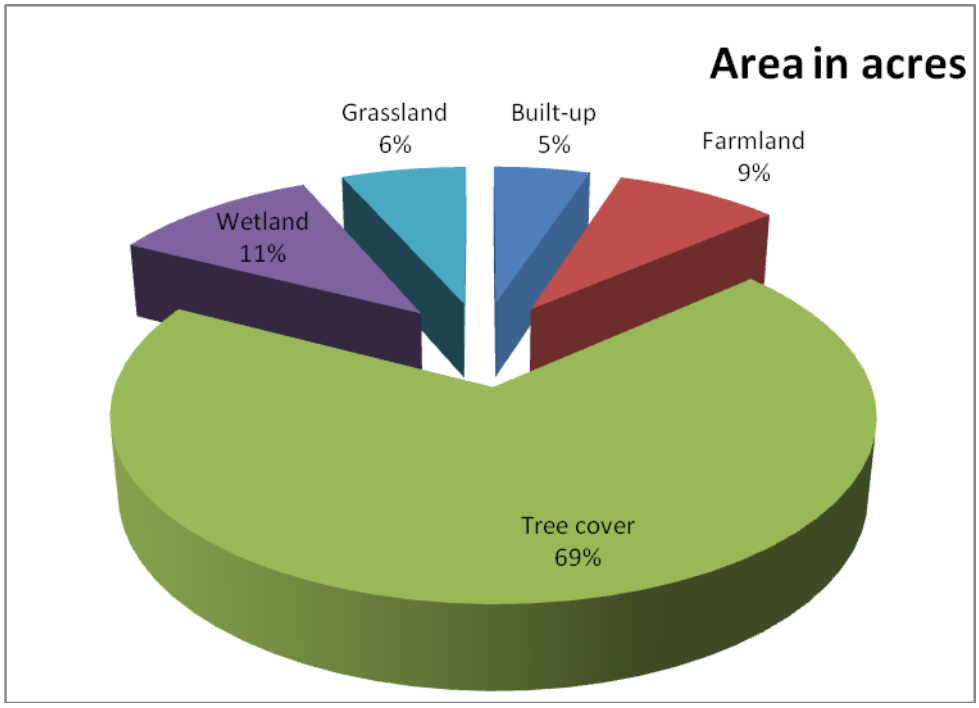

Figure 5: Proportion of the different land uses

The overall catchment area of the wetland at this area is about 396.23 acres including a variety of land uses such as built residential and commercial areas, tree cover, grasslands, and farmland. One striking difference between the other wetlands in consideration and this wetland is the absence of tea cultivation which is very characteristic of Nilgiris.

The largest area in the catchment is occupied by tree cover (69% of the catchment area). The species found here are mostly exotics such as Cypruss, eucalyptus, acacia etc, with remnants of native species such as Mahonia, Melaleuca and Rhododendron. Over the period of 10 years (evident from the satellite imagery) the tree cover has spread over to a great extent. There could be two reasons for this spread; the exotics such as acacia are better capable of spreading and deliberate plantation by the forest department to increase the tree cover in the area.

The wetland itself being a large area occupies about 11% of the watershed area and it is edged by the tree cover. Though considerably a small area, farmland where carrots, potatoes, beetroots etc. are cultivated takes up about 9% of the watershed area at the crucial spots. While few of them are on the catchment slopes, the rest are on the wetland area itself which dried up over time.

The rest of the watershed is covered with grasslands and residential and commercial built up areas. Though the built up area is small in the catchment, the built environment ecologically degrades the wetland the most when compared to the rest. The solid waste and waste water from the shops and houses in the locality are directly let into the wetland due to ignorance to the role of the wetland in providing them with water for their daily needs.

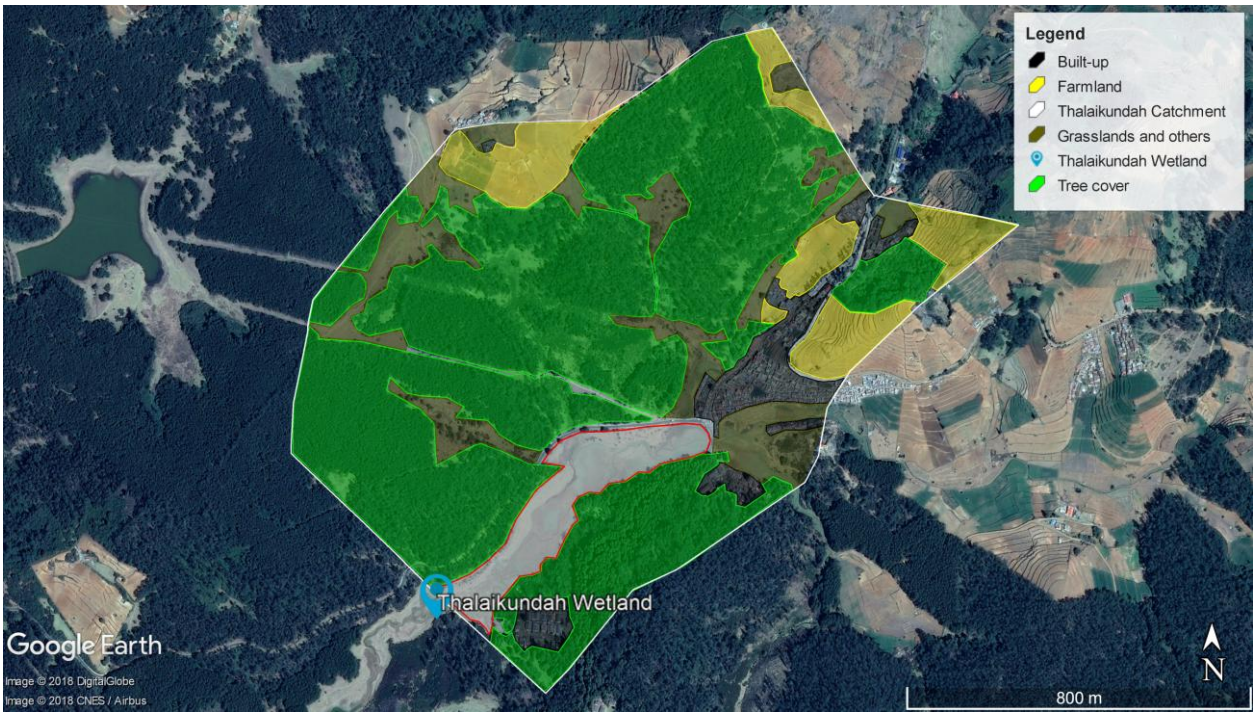

Figure 6: Land cover map overlaid on Google Earth Image

Figure7: Wetland at Thalaikundha with exotics around

Figure 8: An imagery of the same catchment in 2003

Figure 9: An imagery of the same catchment in 2016

GEOLOGY:

There are six drains in the catchment from the northern side that funnel water into the wetland, two of which are marked through depression in the terrain and the other is the drain from the head wetland. The wetland is composed of clayey soil formed due to accumulation of silt from the catchment area. The catchment is lined with relatively shallow top soil (1'10" – 2'), below which there is Regolith, an unconsolidated weathered rock layer made of heterogeneous materials like soil,

dust and broken rock. While this condition was in the head wetland, the rest of the catchment had a layer of Charnockite below the topsoil, which is formed due to high pressure and temperature.

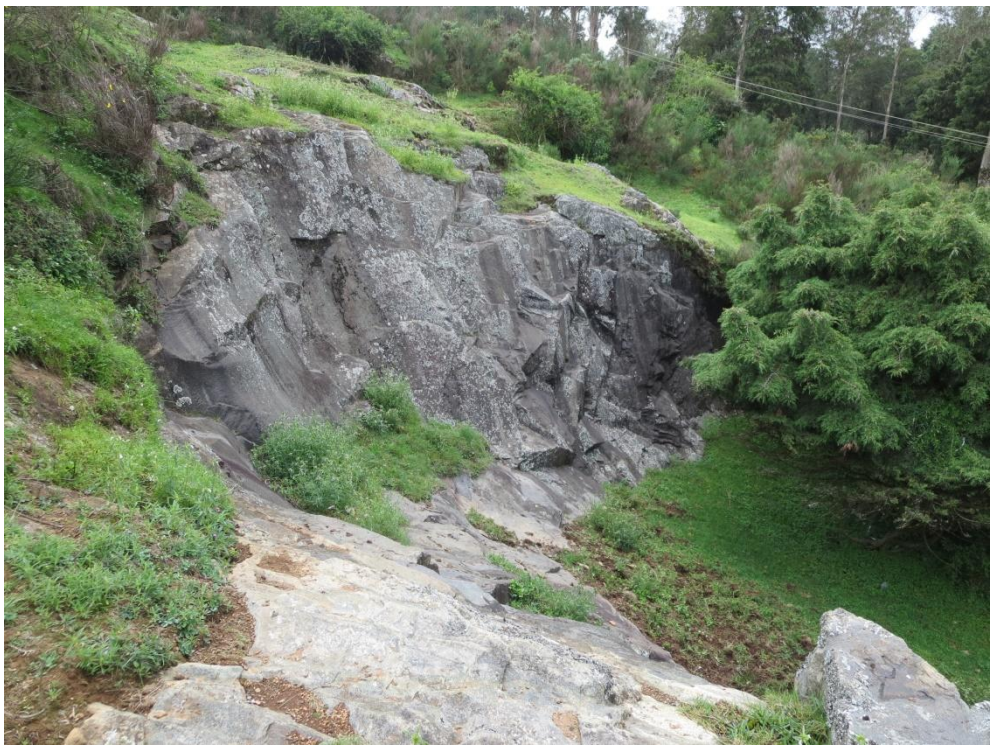

Figure 10: Rock outcrops in the catchment

Apart from this, various rock fractures were observed indicating the direction of movement of water at four different points. The rock at this point was made of Quartzite with granite veins.

HYDROLOGY:

The water sample was collected from two sources; the stream in the main wetland before it reached the Sandynulla reservoir after collecting water from different sources (both natural and domestic outlets) and a community well from the Indiranagar Colony. The water was tested for the presence of a number of minerals and the results are analysed against the permissible levels provided by BIS.

THE WATER FROM THE STREAM:

Water quality		
Coliform		Taken
pH	6.5-8.5	7.34
TDS	500 – 2000 ppm	251
Electrical Conductivity	0 - 1500	354
Salinity	<200 mg/l	171
Temperature		24.8° C
sample taken for lab test		Y
Water quality Lab test		
Sample No.		01
Location		
Wetland Name		Thalaikundha

pH/6.5-8.5	6.5-8.5	7.34
Colour/Odour	Agreeable	Yellow, unclear, bad odour
Temp C* >25*		24.8° C
Residual Chlorine	<0.2	NIL
Turbidity	5-10	100-200
Chloride	<250-1000 mg/l	171.12
Flouride 1.0mg/l	<1.0	1.5
Phosphorus		0.1
Iron	<0.3 mg/l	3
Hardness	<200	252
Ammonia	0.5	2
Coliform		Yes
Nitrate	<45	NIL

Table 3: Water quality test results for the stream water

There was substantial amount of running water in the stream and that was mostly due to the collection of domestic run off from the nearby colonies mixed with black and grey water and agricultural runoff from the nearby fields mixed with harmful pesticides and other chemicals. The water from this point was yellowish, unclear with a bad odour with a high turbidity of 100-200 and with a pH of 7.34 which is a permissible amount. This pH level of this water along with an average temperature of 24° C allows for aquatics to thrive, e.g. Eicchornia, Myriophyllum,etc.
The salt level in the water is within the permissible level but on the higher side. Similarly, the electrical conductivity and the total dissolved solids are also within the permissible level.

The water has a very high content of Iron of 3mg/l which makes the water unsuitable for domestic consumption. Though there is no presence of residual chlorine, the presence of chloride in the water indicates the mixing of sewage into the water. This is also further reinforced by the practice of open defecation in the area which will increase the chloride level in the water. The presence of phosphorous, which 2mg/l could be contributed by the nearby farms of indicates that the wetland is not too far from fully getting contaminated. As the wetland is used for open defecation, there is a presence of Ammonia. The naturally occurring fluoride level in the ground water is also high (1.5mg/L). This can be deflouridised simply by coagulating the water with alum. Overall, the water is hard with 252 mg/L due to its high mineral content and is thus not suitable for drinking.

THE WATER FROM THE PUBLIC WELL:

Water quality		
Coliform		Taken
pH	6.5-8.5	7
TDS	<500 ppm	720
Electrical Conductivity	0 - 1500	510
Salinity	<200 mg/l	349
Temperature		24.6° C
Sample taken for lab test		Y
Water quality Lab test		
Sample No.		02
Location		Public well at Indira nagar
Wetland Name		Thalaikundha
pH/6.5-8.5	6.5-8.5	7

Colour/Odour	Agreeable	Clear with no bad odour
Temp C* >25*		24.6° C
Residual Chlorine	<0.2	NIL
Turbidity	5-10	5-10
Chloride	<250-1000 mg/l	141.76
Flouride 1.0mg/l	<1.0	0.6
Phosphorus		0.5
Iron	<0.3 mg/l	<0.3
Hardness	<200	200
Ammonia	0.5	NIL
Coliform		Yes
Nitrate	<45	NIL

Table 3: Water quality test results for the well water

Near the head wetland, there is Indira Nagar, a colony of 15 houses that is built on the brim of the wetland and they share a community well for drinking water and other domestic use. The water level in the well is at the level of the wetland itself but highly infested by moss. The culvert that carries excess water from one side of the road to another under the bridge is fully blocked due to waste and silt deposit. This causes the wetland water to clog during monsoons as there is no escape. This poses a huge threat to the hygiene in the neighbourhood. As told by the residents, there have been cases of dengue in the colony due to the stagnation of water in the area.

Figure 11: The community well used by the residents of Indira Nagar

The water was clear with no bad odour and a permissible pH level of 7 which is ideal for drinking water. The total dissolved solids in this water are 720ppm whereas the permissible level is below

500ppm. This, along with the high Sodium Chloride level causes the water to be salty. The electrical conductivity therefore is within the permissible limit but higher than the stream water due to high salinity. This could also be due to the high salinity of water as it contributes to some of the ions. High TDS content shows the interaction of water with salts in the aquifer leading to corrosion, and may cause gastro intestinal irritation.

The iron content of the water is well below the permissible limit.Though there is no presence of residual chlorine, the presence of chloride in the water indicates the mixing of sewage into the water which is evident from the soak pits that are built very close to the drinking water well.

Overall, the water is border line hard with 200 mg/L due to its low mineral content and it is still acceptable for drinking. The water quality test results clearly show that the well water is at its verge of getting contaminated and it is important to take the necessary measures to save the water from fully getting contaminated. It is necessary to monitor the water quality seasonally to track variations.

In spite of the large amount of water that is collected in this wetland, the quality of water is not good enough for consumption and is used for irrigation in the nearby areas. Domestic activities being one of the main contributors to the degradation of wetland health, the water quality can be improved to be used for consumption in the near future with some simple yet effective measures such as as creating awareness among communities, service provision, solid waste management, deweeding of exotic and desilting allowing for the movement of water downstream.

HABITAT AND SPECIES:

The wetland Thalaikundha hosts a number of species flora and fauna, both endemic and exotic. There are several birds in the wetland and catchment area such as Crows, Pied Buschat, Red Whiskered Bulbul, Pond heron, Scaly breasted munia, Common Myna, Jungle fowl, Spotted dove, Streak-throated Woodpecker, Long tailed shrike, White browed wagtail, Sparrow, Shikra, Jungle babbler and Swift. Bee varieties such as *Apis Dosata* and *Apis Cerana* were also found foraging on the certain flowers. Apart from this insects and bugs such as dragonflies, ladybugs and blue green bugs were found.

There are different varieties of plants such as grasses, aquatics, shrubs, and trees. The grass species include *Pennisetum, Cyperus Acorus, Rumex, Juncus, Luzula, Kyllinga, Plantago, Mariscus grass* and *Paspalum vaginatum* that are native to the wetland and help in water retention in the wetland. The exotic grasses include Poa and crow's-feet grass that are found in the relatively dry areas. The grasses in the wetland are grazed by cows, goats and horses leaving half cut grass blades that deter percolation of water into the soil.

There were a lot of aquatic plants in the wetland one of which is the invasive, *Eichhornia crassipes (water hyacinth)*. Most part of the standing water in the wetland is covered by the Hyacinth which outside its native region, the Amazon basin, is considered a threat to the freshwater ecosystem. By covering the surface of the water, its cuts off sunlight for the water, obstructs water flow and thereby starves water of oxygen. Since the presence of oxygen is necessary for water to purify itself, the quality of water in the locality is highly compromised. Apart from this, there are also other aquatics such as *Myriophyllum aquaticum, Alternanthera*, and mosses that are considered invasive too, clogging waterways.

Figure 12: Water Hyacinth, an invasive has taken over the surface of the water

Figure 13: Invasive species such as Cuprusses, Eucalytus and Wattle have taken over the wetland

Though there are native grasses such as patches of Juncus and other plants to benefit the water, they are outnumbered by the exotics. On the wetland there were also a few mushrooms that were grown.

The catchment is covered with a dense tree cover that includes invasives species such as Eucalyptus, Wattle and Cupresses with remnants of certain shola trees like Mahonia, Melaleuca and Rhododendron that indicate the presence of a Shola forest in the area before the exotics took over.

ECOSYSTEM SERVICES:

Along the head wetland, the wetland is surrounded by communities who have been settled there for more than half a century. The wetland plays a vital role in flood control. Due to the recent blocking of the culverts due to silt and garbage, there is serious flooding in this area during monsoons. The wetland also plays a major role in groundwater replenishment and water purification as the health of the wetland directly affects the health of the drinking water for the communities around. Though there are no cultural values attached to the wetland, the wetland has the ability to act as an effective recreation area for the nearby communities and for outsiders. As the wetland is at the mouth of the Sandynulla reservoir, the wetland also plays an important role in nutrient retention and allows it to flow downstream.

EXISTING ACCESS AND AWARENESS:

On talking to the people in the neighbourhood of Thalaikundha, it was quite evident that they are quite unaware of the wetland system in their locality and its significance in providing drinking water to the area. The health of the wetland directly affects the health of the locality as they fully depend on the well water for drinking. While the residents petition to desilt the culverts to drain excess water from their neighbourhood, little do they know that giving up on encroaching the wetland area for farming, dumping of water, letting out of sewage and open defecation in the wetland and stream are as important as desilting to get a holistic result from the measures.

OPPURTUNITIES AND CONSTRAINTS:

Though the size of the wetland and the catchment is huge, the extent of urbanisation in the catchment is negligible when compared to the grasslands and tree cover. The degradation due to human intervention in this area is still reducible by simple implementation strategies and effective enforcement of rules. Mobilising residents and creating awareness is a first step. The constraint in the implementation of conservation strategies is the size of the watershed area which has various parameters that affects the health of the water from the upstream.

Due to the extent of area, location of the wetland at the mouth of the reservoir and the natural landscape, there is scope of developing the area into a tourist destination with restricted movement.

WAY FORWARD:

The wetland at Thalaikundha and its catchment is a landscape that is part of a large and complicated wetland system. The water from the reservoir is now used by the nearby communities for irrigation and by the villages downstream for drinking. Once conserved and maintained over a period of time, the water from the wetland can be made suitable for drinking at the source itself. The conservation strategies are as follows:

1. **Solid waste management** has to be effectively carried out in the neighbourhood which protects the wetland from turning into a dumping area.
2. **Sewerage provision** for the neighbourhood in order to avoid the sewage outlet into the wetland.
3. **Avoiding open defecation** in the neighbourhood by ensuring public toilets for the community with the help of the Panchayat.
4. **Desilting** of the culverts in order to allow for the free flow of water from one part of the wetland to the other. This will avoid stagnation of water in different areas in the wetland which cause mosquito infestation.
5. **Deweeding** of the invasive aquatic plants like water hyacinth in order to restore the health of the water.

6. Removal of exotic flora from the catchment and planting of native plants in different phases have to be carried out with the help of the Forest department.
7. **Planting of native grasses** and other shrubs in patches within the wetland in order to allow for the regeneration of the wetland over time. In addition to this, these areas should also be protected through physical barriers in order to avoid further damage.
8. In the main wetland, a **buffer on the either side of the stream** must be maintained in order to allow for the aquatic plants to thrive and further help in water retention and purification.
9. As discussed above, the location and the landscape of the wetland allows for it to be developed into a **tourist destination** which speaks about wetlands and the integral role of wetlands in providing water to the masses.

   These interventions, when carried out in phases, in cooperation with all the stakeholders and with regular monitoring, will improve the quality of water in the wetland over time in order to be used for consumption. In addition to this, these interventions may also increase the quantity of water in the wetland and the reservoir over time.

Annexure 1: Datasheet from 2006 survey