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Draft Report

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Economic Valuation of Ecosystem Services A Case Study of Ousteri Wetland, Puducherry

THE ECONOMICS OF ECOSYSTEMS
AND BIODIVERSITY-INDIA INITIATIVE

WETLANDS



Ministry of Environment, Forest
and Climate Change
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THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY-INDIA INITIATIVE

Indo-German Biodiversity Programme

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- The Economics of Ecosystems and Biodiversity - India Initiative (TII)
- India Business and Biodiversity Initiative (IBBI)
- Conservation and Sustainable Management of Existing and Potential Coastal and Marine Protected Areas
- Himachal Pradesh Forest Ecosystem Services Project
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Economic Valuation of Ecosystem Services: A Case Study of Ousteri Wetland, Puducherry

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THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY-INDIA INITIATIVE

The Economics of Ecosystems and Biodiversity – India Initiative (TII) aims at making the values of biodiversity and linked ecosystem services explicit for consideration and mainstreaming into developmental planning. TII targets action at the policy making levels, the business decision level and awareness of citizens. TII has prioritized its focus on three ecosystems - forests, inland wetlands, and coastal and marine ecosystems - to ensure that tangible outcomes can be integrated into policy and planning for these ecosystems based on recommendations emerging from TII.

In addition to the existing knowledge, TII envisions establishing new policy-relevant evidences for ecosystems values and their relation to human well-being through field-based primary case studies in each of the three ecosystems. In response to an open call for proposals for conducting field-based case studies in the context of relevant policy or management challenges for conservation and the sustainable use of biodiversity and ecosystem services, over 200 proposals were received. A Scientific and Technical Advisory Group (STAG), comprising eminent ecologists and economists, appraised the proposals and recommended 14 case studies for commissioning under TII.

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KEY MESSAGES

Ousteri lake can irrigate 3,800 acres of land and plays a crucial role in recharging groundwater aquifers. It is a bird sanctuary, and has rich flora and fauna. It has suffered pressure from land-use changes in the catchment area, encroachment, siltation, pollution from industry and agriculture, overfishing, poaching, and groundwater exploitation. How much access to ecosystem services needs to be restricted for the sake of conservation?

FINDINGS

- In 2015, the recreational benefits enjoyed by visitors is estimated to be **₹5.72 million (US\$ 95,333)**.
- Agricultural benefits amount to **₹11.5 million (US\$ 191,667)** per year.
- The estimated value of groundwater used for irrigation is **₹269,652 (US\$ 4,494)** per year.
- The economic value of biodiversity conservation is estimated to be **₹2.44 million (US\$ 40,667)** per year.
- Since 2004, **2,800 acres** of land around the lake have been converted for commercial, non-agricultural purposes, causing water to stagnate permanently. While this enhanced groundwater recharge and recreational benefits, it has also caused eutrophication.
- Untreated wastewater from **250** industrial units upstream ends up in the wetland.
- The total economic value of ecosystem services with management is **₹19.67 million (US\$ 327,834)** per year and the net present value of the benefits is **₹82.89 million (US\$ 1.4m)**.



RECOMMENDATIONS

- Enhance awareness and cooperation among stakeholders and explore incentive-based institutional arrangements for managing the wetland.
- Evaluate the cost of minimising effluents.
- Ensure cooperation among industries and government in order to treat effluents.
- Regulate access to ecosystem benefits such as fishing, collection of medicinal plants and bathing.
- Since tourists are willing to pay for improved facilities, increase the entrance fee to cover management costs.
- Monitor solid waste dumping and groundwater exploitation by commercial establishments.
- Ensure farmers adopt practices that minimise non-point source pollution from agriculture.
- Share revenue from ecotourism and water supply with local government bodies.



Photo: Ritesh Sharma

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EXECUTIVE SUMMARY

Economic Valuation of Ecosystem Services: A Case Study of Ousteri Wetland, Puducherry

Out of the total geographical area of the world, 'wetlands' occupy an area of more than 1,280 million hectares. A significant number of people are dependent either directly or indirectly on wetlands for their survival. Rapid degradation of wetlands across the world brings a non-linear impact on economic welfare, i.e. a small reduction in the wetland ecosystem causes a more than proportionate reduction in the economic welfare of the people dependent on such ecosystems. It is not only the current generation, but also future generations that will be deprived of enormous benefits if the wetlands continue to deteriorate at the current rate. Apart from wetland degradation, the potential problem of global climate change is also expected to exacerbate the negative impact on economic welfare of poorer people. Indeed, protecting the wetlands could contribute significantly to minimising the negative impact on economic welfare caused by global environmental problems in the coming years. However, improving and protecting the wetlands in a complex world results in economic trade-off, arising from using scarce economic resources towards minimising negative externalities for wetland conservation.

Ousteri wetland is situated near the village Oussudu, partly in Puducherry and partly in Tamil Nadu. Much of the Ousteri bank in the Tamil Nadu side consists of rural settlements, while the Puducherry side of the lake is predominantly urban and suburban. Ousteri is the largest water body of the Puducherry region, with a water-spread area of 700 hectares. It can store up to 540 million ft³ of water, capable of irrigating close to 3,800 hectares of land. What distinguishes Ousteri most is its ability to attract a very rich and diverse population of migratory birds, making it one of the ecologically important wetlands of Asia. Ousteri has been popular with perches as well as waders among the birds, thereby attracting a larger number of avian species. The water body plays a crucial role in recharging the groundwater aquifers. It also harbours rich flora

and fauna. It is an important wintering ground for migratory birds, ranked among the most important wetlands of Asia.

In the recent past, Ousteri wetland and its watershed have been subject to enormous pressure from land use change, encroachment, siltation, pollution from industry and agriculture and groundwater exploitation. Recently, the Puducherry and Tamil Nadu governments have declared this wetland a bird sanctuary and as a result, the villagers have been restricted from accessing many of the ecosystem benefits that they enjoyed in the past. So, there is an economic trade-off between different ecosystems. Although there are management plans for protecting the Ousteri wetland, the economic value of the ecosystem services gained or lost due to protection measures has not yet been estimated and incorporated in the management objectives. With this aim in mind, the present study was conducted to measure the economic value of the changes in ecosystem services of Ousteri wetland in the context of the proposed management objectives. The economic valuation exercise was carried out with the help of an integrated economic, geological, hydrological and ecological modelling framework.

The study adopts an inter-disciplinary methodology. The wetland as a primary resource is treated as a 'natural capital' and the ecosystem services and benefits are considered as flow of income that contributes to the welfare of the society. The natural capital as such is undergoing changes in terms of ecological and hydrological features. Therefore, the present study has captured the ecological, geological and hydrological dynamisms of the natural capital and then moves on to estimate the economic value of ecosystem services arising from such a dynamic nature of the natural capital. We conducted focus group discussions, informal as well as structured interviews with many stakeholders and identified the benefits that users could currently utilise and the benefits that they have foregone due to conservation efforts. The net gains

under the conservation regime have been estimated in monetary values for three important benefits, namely recreational benefits, benefits from groundwater irrigation and benefits of biodiversity protection.

We estimated the economic value of the above benefits by using both revealed and stated preference methods. We used the travel cost method, production function approach and contingent valuation method to estimate such values. In the case of recreational value, the total number of visitors to the site was estimated by using a complete enumeration among the visitors during 10 different days from September, 2014 to April, 2015. The average number of visitors per day was estimated to be 257. Based on this value, the total number of visitors is predicted to be 93,805 in 2014-15. A detailed survey was conducted among all visitors on two days (a normal day and on a holiday) in order to estimate the travel cost and their maximum willingness to pay (WTP) for improved tourism facilities. The expenditure (including cost of travel and all other expenses on the site) incurred by an average visitor is estimated to be ₹49.00 per visit. In addition, their WTP for improvements in tourism facilities is equivalent to ₹12.00 (expressed as entrance fee). So, the total value of the recreational benefits per person per visit is estimated to be ₹61.00 (i.e. ₹49 as actual cost incurred + ₹12.00 as additional WTP value). Based on this value, the total value of recreational benefits enjoyed by all the visitors is estimated to be ₹5722105.00 at 2014 prices.

In the case of estimating the monetary value of groundwater irrigation, we selected 20 farmers using the purposive sampling method. Out of 20 sample farmers, 13 farmers own land in the western part of Ousteri and cultivate paddy; these farmers are called 'treatment group' farmers. The remaining 7 farmers (called 'control group' farmers) cultivate land in other villages, far away from Ousteri. Both farmers utilise groundwater for cultivation purposes. Selecting 20 farmers in two villages that are located far apart provides a 'with' and 'without' scenario, so that we could estimate the marginal difference in the agricultural benefits of groundwater recharged by the wetland. Based on the information elicited from the farmers, we found that compared to the farmers in the control group, the treatment group farmers cultivating land in the wetland-bed are benefited marginally by ₹5,862.64 (as farm income), due to the availability of additional groundwater. The revenue records obtained from Tamil Nadu and Puducherry governments suggest that in total, around 1961.03 acres (or 793.52 ha) of ayacut area in 10 villages under the wetland command,

is being cultivated with groundwater. So, the total marginal benefit from groundwater in agriculture in all seven villages is estimated to be ₹11496813.01 per annum (at 2014 prices). The availability of additional groundwater, equivalent to one hour of pumping, is found to increase the net farm income by ₹28.75.

In the case of use values from biodiversity protection, we utilised the contingent valuation method. Our sample households (200 households) constitute 3.2% of all 6,230 households in the seven villages selected. The results suggest that an average household is willing to pay a maximum of ₹392.8 (or ₹393) per year (at 2014 prices) for protecting the wetland. The total economic value of the direct ecosystem benefits to be enjoyed by the households in all seven villages is estimated to be ₹2447144.00 per annum (at 2014 prices). The net present value (NPV) of the gross benefits for the 5-year time period (at a 6% discount rate) comes to ₹5903376.43.

The total economic value of all three benefits, namely, recreational, irrigation and biodiversity protection, is equivalent to ₹1,96,66,062.00 per year. The net present value of the gross benefits is equivalent to ₹8,28,80,098.21 ($r = 6$, $N = 5$) or approximately, ₹83.00 million.

The results show that the economic value of even a very limited number of ecosystem benefits, i.e. recreational benefits, groundwater irrigation and biodiversity protection, currently originating from Ousteri, can be significant. The conservation measures initiated by the governments and the existing negative externalities such as industrial pollution, encroachment and siltation reduced the number and size of ecosystem benefits utilised by different stakeholders. Most of the people living around the wetland were willing to pay for its conservation, with the expectation that they could maximise their expected benefits by using ecosystem benefits from the wetland as complementary goods/services. Although the traditional users of the region have been denied access to the ecosystem benefits due to conservation measures, involving the local people in managing the wetland and allowing them to share some of the benefits would create a win-win situation for the users and governments. Cooperation between the people and the governments can minimise the transaction costs (such as monitoring costs) of wetland management. Such a cooperative institutional mechanism comes in the form of 'payment for ecosystem services' (PES), which embeds incentives for the stakeholders to protect the wetland in an efficient, equitable and sustainable basis in the coming years.

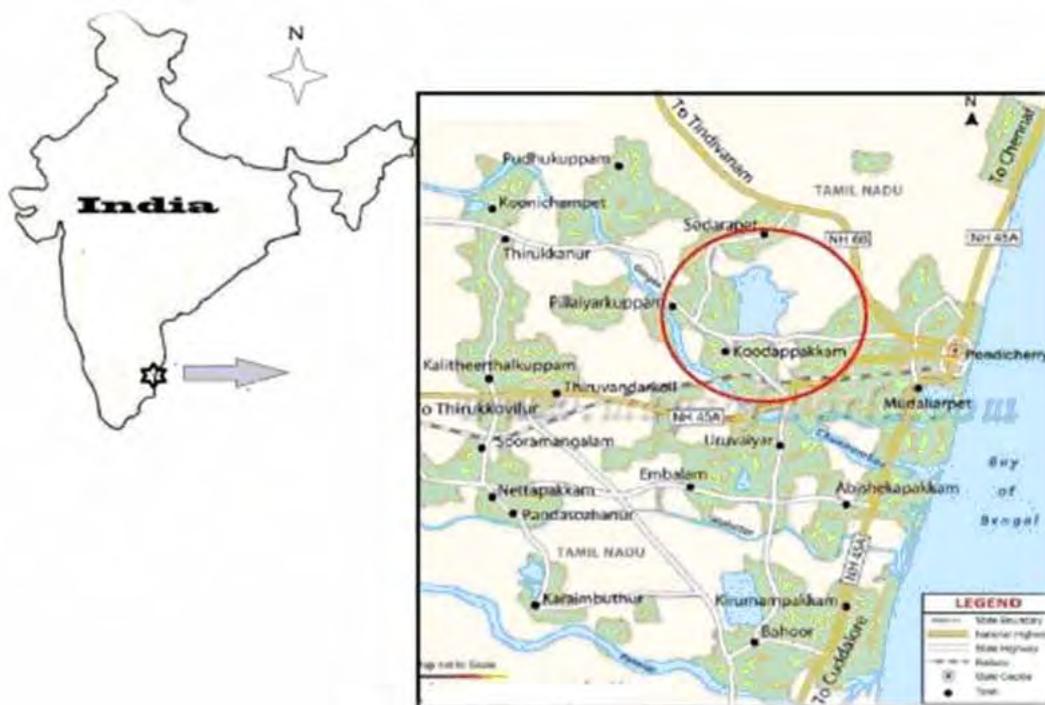
1. Introduction

Ousteri (also called, Oussudu) wetland is situated near the village Usudu, which is located 8 km west of Puducherry City, at 11° 56' 51" N, 79° 44' 13" E. The wetland occupies 800 ha of land, out of which the water-spread area constitutes 700 ha (or, 87.5%). It is an inter-state wetland, of which 390 ha lies in Puducherry and 410 ha in Tamil Nadu. It has been identified as a wetland of national importance under the National Wetland Conservation Programme, and has also been declared to be one of the 93 important wetlands in Asia by the Asian Wetland Bureau¹. The International Union for Conservation of Nature (IUCN) has identified this wetland as a heritage site and the Bombay Natural History Society (BNHS) named it as an Important Bird Area (IBA) (SACON, 2011). While much of the Ousteri bank in its Tamil Nadu side consists of rural settlements, the Puducherry side of the wetland is characterised predominantly by urban or suburban features (Figure 1 and 2). Ousteri is the largest fresh-water wetland in the Tamil Nadu and Puducherry region and it can store up to 540 million ft³ of water in a given time period; it has the potential

to irrigate close to 5000 acres of land with both surface and groundwater irrigation (Chari and Abbasi, 2007). Ousteri, as a 'natural capital', plays a crucial role in generating various ecosystem services, which include harbouring rich biodiversity, recharging groundwater aquifers, stabilising micro-climate, etc. It attracts a very rich and diverse population of migratory birds, making it one of the most important bird sanctuaries in South India. For example, the wetland acts as a home for 66 species of birds belonging to 47 families. In the case of flora, there are 480 plant species, out of which 20 species are found to be endangered; in the case of fauna, there are 20,000 birds belonging to 166 species, as well as 63 butterfly species, 10 amphibian and 29 reptilian species, 25 fish species, and 14 mammal species. Since it has been popular with perches, and waders among the birds, it attracts a large number of avian species (see SACON, 2011).

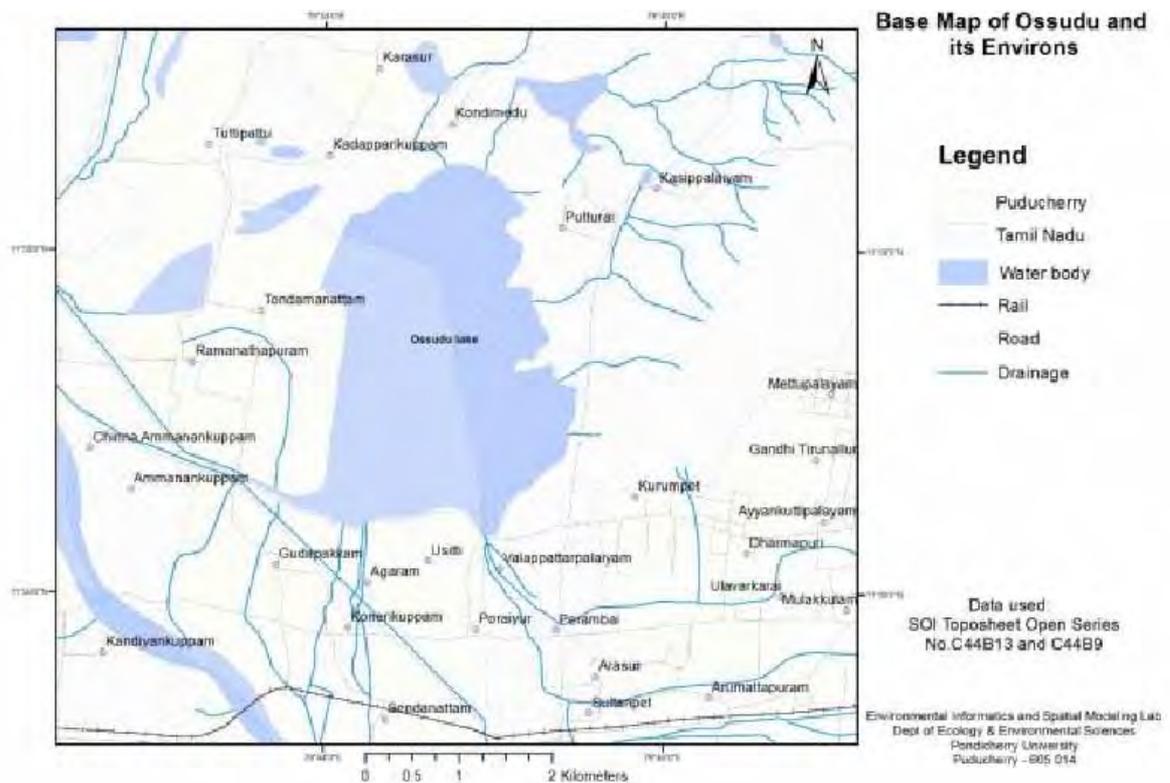
The wetland and its watershed have been subjected to tremendous pressure due to negative externalities caused by land use changes, industrialization and urbanization taking place in its neighbourhood. For example, the water spread area of the wetland declined by 26% from 1956 to 1998 (SACON, 2011), due to

Figure 1: Location map of the Ousteri



¹ *The Hindu*, August 31, 2014.

Figure 2: Base Map of the Ousteri



reasons such as siltation and encroachment. Though the ecological aspects of the changes in the landscape and its impact on the wetland ecosystems had already been studied by researchers, e.g. Chari and Abbasi, 2007, and SACON, 2012, no attempt has so far been initiated to systematically assess the economic impact of changes in the wetland and the resulting changes in its ecosystem services.

2. Brief Literature Review

There are a number of studies on the economic valuation of ecosystem services of wetlands around the world, e.g. Acharya, 2000; Barbier, 2013; Barbier *et al.* 1997; Brander *et al.* 2006; De Groot *et al.* 2006; Sagoff, 2011. In this section, we make an attempt to briefly review a limited number of studies. At the conceptual level, a paper by Brendan *et al.* (2008) discusses how integration of economic concepts and ecosystem services can provide planners and decision makers with a full spectrum of information for making conservation more effective. Since policy decisions are based mainly on benefit-cost analysis, this paper demonstrates how economic values of

ecosystem services can strengthen ecosystem service research, which in turn guides the decisions related to conservation. The paper discusses the distinction between services and benefits, understanding the importance of marginal ecosystem changes, formalizing the idea of a 'safe minimum standard' for ecosystem service provision, and the method with which one can capture the public benefits of ecosystem services. It provides the results from a survey of the literature and a questionnaire of research regarding how ecosystem service research can be integrated into the policy process. The economic concepts presented serve as a practical guide for ecosystem service research to become more immediately relevant to policy. Another paper, by de la Hare *et al.* (2011), deals with the ecosystem services of inland wetlands in Spain from the perspective of the EU Water Framework Directive Implementation. In Spain, inland wetlands are numerous and have been classified in a broad range of categories. The typology recognises up to 27 different types of inland lake in Spain. The paper reviews current knowledge about the evaluation of the ecosystem services provided by inland wetlands, and presents a discussion about two

cases that have been subject to economic evaluation. The results obtained highlight the fact that a significant amount of work is required to identify and characterize specific ecosystem services provided by wetlands in Mediterranean conditions, which in turn will do a great deal to highlight the importance of their conservation.

The Ramsar Bureau, along with others, has brought out a report entitled, 'Economic valuation of wetlands: A guide for policy makers and planners', which was authored by Barbier *et al.* (1997). The report aims at providing specific guidelines to policy makers and planners on valuing the various ecosystem services of the wetlands. During the middle of the 1990s, a number of economic valuation studies on wetland ecosystem services have been undertaken around the world, and environmental economists have strengthened the methodologies and methods for valuing innumerable non-market values of the environment, such as aesthetic benefits and option values. Barbier *et al.* (1997) synthesised this literature to show how to conduct economic valuation studies and how the values generated would be useful for wetland management worldwide.

The valuation guidelines provide an appraisal framework for measuring the 'net economic benefits' of putting the wetland under different uses. Stage one of the framework deals with determining the overall objective or problem and choosing an appropriate assessment approach from three broad categories, namely: impact analysis, partial valuation and total valuation. Stage two involves defining the scope and limits of the analysis and the information required for the chosen assessment approach. Stage three necessitates determining the evaluation techniques and data collection methods required for the economic appraisal including any analysis of distributional impacts. Relevant guidelines from this report have been adopted in conducting the economic valuation exercise under the present study.

When the wetland undergoes certain changes, the quantity and quality of the ecosystem services will also undergo subsequent change. How to practically estimate the economic impact of such changes? Acharya

(2000) estimated the economic value of hydrological services provided by the Hadejia-Jama'are wetlands in Nigeria. The author used production function approach to estimate the marginal value of groundwater in the wetlands and its impact on agriculture and households. The change in the water availability due to reduction in water in the wetland was found to negatively affect agricultural output and household welfare. A survey among the randomly selected vegetable growers and households revealed that 1 metre reduction in water availability leads to a loss of agricultural income equivalent to US\$ 4360.00. In the case of households, reduced water availability, which increases water collection time and the cost of water in private market, resulted in a loss of welfare equivalent to US\$ 13029.00 per day. So, reduction in water would lead to imposed social costs, and the magnitude of the impact is non-linear across different economic entities.

A recent wetland valuation study by Zhu Lin *et al.* (2011) estimated the economic value of ecosystem services in the Yeyahu Wetland Nature Reserve, Beijing, China. These ecosystem services included water quality improvement, biodiversity maintenance, erosion control, recreational opportunity, raw material supply and existence value. Both market-based and stated preference methods were used to calculate the value of eight wetland ecosystem services. In 2007 prices, the total economic value of wetland in the Yeyahu Wetland Nature Reserve was about 3.9×10^8 Yuan (RMB). The results showed that significant values came from conservation of biodiversity and recreational opportunity. The main reasons were: firstly, Yeyahu Wetland Nature Reserve was the habitat for migrant birds, and the government had made more efforts to protect precious birds, and secondly, households enjoyed recreational benefits from the natural and artificial wetlands that are located outside the cities, and these households are also willing to pay for improving and maintaining the quality of the wetlands for potential recreational benefits. The decline of vegetation cover made the economic value of erosion control the lowest. The shrinking of water resources and the deterioration

Prior research has shown that a 1 metre reduction in water availability can lead to equivalent agricultural income loss of US\$ 4360.00. Reduced water availability can result in welfare loss equivalent to US\$ 13029.00 per day

of water quality caused the economic value of water supply to decrease. The valuation results could help decision-makers understand the present status of the Yeyahu Wetland Nature Reserve and provide a scientific basis for strategic decision.

Is it possible to generate economic values of wetland ecosystems from the existing studies rather than initiating fresh valuation studies? A meta-analysis by Brander *et al.* (2006) examined subsets of the available wetland valuation literature focusing on temperate wetlands, a limited set of wetland functions, and a limited set of valuation techniques. The researchers utilised inputs from over 190 wetland valuation studies, providing 215 value observations. It is a more comprehensive meta-analysis of the valuation literature that includes: tropical wetlands, e.g. mangroves; estimates from diverse valuation methodologies; and a broader range of wetland functions, e.g. biodiversity value. The studies included in the meta-analysis utilised both revealed and stated preference methods to elicit the economic values. With a focus on more comprehensive geographical coverage, the meta-analysis found that socioeconomic variables, such as income and population density, that are often omitted from such analyses do play an important role in explaining wetland value. The study also assessed the prospects for using this analysis for out-of-sample value transfer, and found average transfer errors of 74%, with just under one-fifth of the transfers showing errors of 10% or less. This implies that economic values of individual wetlands are influenced by site-specific factors and therefore, transferring a value from one wetland to another is not desirable. One of the key results from the meta-regression analysis is the importance of the GDP per capita and population density variables in explaining variation in the wetland value. Both variables were shown to have a positive relationship with wetland value. The results suggested that the freshwater marshes were valued less than other wetland types and there was no clear relationship between wetland size and the value. Of the various wetland functions that were identified, water quality improvement was found to be valued the highest. Ghermandi *et al.* (2010) extended the Brander *et al.* (2006) model of meta-analysis to predict the wetland values using 385 observations from 167 primary valuation studies pertaining to 181 natural and man-made wetlands. The results suggest that: a) man-made and marine wetlands fetched higher values than other types of wetlands; b) urban wetlands generated more values than rural wetlands, such as flood control and storm buffering; c) wetland values

were positively related to GDP per capita; and f) the presence of alternative wetlands led to reductions in the value of a particular wetland.

In the Indian context, there are few studies which focus on the monetary valuation of non-market benefits of wetlands. Some of those that do exist are: Chattopadhyay, 2001; Das *et al.* 2000; Mukherjee and Kumar, 2012; Ramachandra and Rajinikanth, 2011; Verma, 2001. It has been empirically demonstrated that the food requirements of the significant number of poor households in rural areas in less developed countries are met mostly via the wetlands at the local level. For example, the overall direct economic contribution of the Chilika Lake in Odisha, India, is estimated to be ₹2000 million per annum (Kumar, 2010). Its welfare implications are enormous. Similarly, clean drinking water is essential for improving human capital, and wetlands contribute directly to the enhancement of human capital by way of supplying good quality drinking water to the households. Since wetlands supply purified drinking water, the society could save enormous amounts of opportunity cost, which is the cost that the households would have to incur on alternative water supply in the absence of wetlands. Supplying clean drinking water turns out to be the 'social benefit' of wetlands. Similarly, a significant number of local people are dependent on wetlands for irrigation, fodder, reeds, etc. For example, Mukherjee and Kumar (2012) estimated the economic value of the environmental benefits of Kalobaur wetland in West Bengal by using a household survey among 55 farm households. The benefits covered in the survey were: irrigation water for paddy and jute cultivation, jute retting, fisheries, fodder, grazing, and collection of leaf vegetables. Out of all benefits, those from jute retting, fodder collection and grazing accounted for a significant amount of the total benefits enjoyed by the households. A study by Verma (2011) aimed at valuing the benefits and resources of the Bhoj wetland in Madhya Pradesh for appropriate allocation of wetland use, to help planners and policy makers, and to develop a socially acceptable, environmentally sound and economically feasible strategy for wetland management. Based on an ecosystem modelling developed for the Bhoj wetland, the economic valuation exercise utilised direct valuation method, cost of illness approach (defensive or preventive costs), hedonic pricing method and contingent valuation method. The economic values estimated included supplying drinking water to the city, the value of benefits accruing to various people whose livelihoods depended upon the wetland, the value of preventive measures that people

Ousteri has been considered as a vital water body in Puducherry region since ancient times. Of late, there are profound man-made and natural conflicts and trade-offs revolving around the management of Ousteri wetland

used to avoid water borne diseases and the people's willingness to pay to enjoy better recreational facilities, including the effect of the presence of the Upper Lake on the value of property prices. Based on the resulting economic values, the author has come out with a set of recommendations to manage the Bhoj wetland on a sustainable basis. The above studies categorically demonstrate that the economic values of wetland ecosystems do play an important role in policy decisions regarding protection of wetlands for enhancing inter-temporal economic welfare. In the absence of such values, the importance of wetlands in influencing economic welfare is largely ignored in policy decisions; as a result, the wetlands deteriorate. Moreover, current thinking about economic valuation among the planners and policymakers, which is rare, takes place only after the wetlands have undergone tremendous pressure and deterioration. Economic valuation results can play a major role in undertaking precautionary measures in conserving the wetlands. Economic valuation exercises would also help the policymakers to develop necessary data inventory on many aspects, such as the hydrology and ecology of the wetlands, which is largely missing at present. With all these things in mind, the present study aims at estimating the monetary value of the changes in the ecosystem services due to changes in the geological, hydrological and ecological components of the wetland.

3. The Issue

Historically, it is evident that Ousteri has been considered as a vital water body in Puducherry region and received official patronage right from ancient times. Of late, there are profound conflicts and trade-offs revolving around the management of Ousteri wetland. The conflicts are both natural as well as man-made, and they can be classified into three different categories:

a) Prior to 2006, a major portion of water in Ousteri was utilised mainly for irrigation purposes. Around 3855 acres of agricultural land in the command area benefitted from surface irrigation from

the wetland. Discussions among the villagers in the command area revealed that paddy, a water-intensive crop, was the dominant crop cultivated during two seasons, *kariff* and *rabi*, in a year. Apart from crop production, extra-market benefits from agricultural operations in the command area due to availability of additional irrigation water also supported other allied activities, such as animal husbandry. However, rapid urbanisation accompanied by commercial, residential and industrial expansion in the outskirts of Puducherry city consumed a significant amount of agricultural land in the command area. The booming real estate market around Puducherry, especially in the middle of 2000s, increased the opportunity cost of cultivable land significantly, and as a result, the market forces gradually paved way for diversion of the cultivable lands towards non-agricultural purposes.

According to ecologists, when a significant amount of water in the wetland was used for irrigation purposes, the wetland possessed two types of ecosystems, namely: water-based ecosystem for around 8 months (i.e. June–January), and dry-land ecosystem for the remaining four months (i.e. February–May), in any given year. The water-based ecosystem harboured fish, birds, and other water-dependent flora and fauna, while the dry-land ecosystem supported shrubs, grass and certain reptiles; the two types of ecosystems were complementary to each other, since each type contributed to the ecological wellbeing of the other one. For example, sedimentation that occurred during water-based ecosystem enriched the fertility of the soil, which promoted diversity and growth of shrubs and grass during ensuing dry season. Similarly, dry-land ecosystem enriched the soil quality inside the wetland (due to decaying of grass, manure from the grazing livestock, etc.), mitigated the effects of certain pollutants and destroyed invasive plants; as a result, the wet-land ecosystem that followed became healthy. Discussions among the villagers in the neighbourhood of the wetland revealed that existence of two types of ecosystems in sequence generated a significant amount of economic benefits to the

individuals and households living in villages around the wetland. For example, when the water was drained for irrigation purposes the village panchayats auctioned fish in the wetland and earned a substantial amount of income, from INR. 50,000 to INR. 60000 per annum, which was spent on various local public goods in the villages, such as a community hall. Similarly, during dry season, farmers could extract benefits such as top soil and algae from the wetland and use them to improve the soil fertility and to increase the agricultural production and productivity; by doing this, they could also minimise the social costs by way of reducing the use of chemical fertilisers. During dry season, livestock from the surrounding villages benefited from open-grazing inside the wetland; it helped the livestock owners to either increase the milk output or reduce the dependence on fodder purchased from the market, or both. When the cultivable land in the command area was gradually converted for non-agricultural purposes, the quantity of water drained for irrigation purposes declined drastically; as a result, the wetland started holding water throughout the year making the water-based ecosystem perennial while the dry-land ecosystem disappeared, along with the benefits derived from it, such as fish and fodder. So, land use changes caused a trade-off across different types of ecosystem benefits.

b) Policy measures initiated by the governments to conserve the wetland are found to have produced conflicts among different stakeholders and a trade-off among different ecosystem benefits. Puducherry Government declared the Ousteri wetland a bird sanctuary in 2008. Subsequently, Tamil Nadu Government reciprocated the declaration in 2014. What factors influenced both the governments to collectively act, though independently, are not known to us. However, protection of the wetland enhanced availability of certain already-existing ecosystem benefits, generated certain additional benefits and shirked certain other benefits that were traditionally utilised by the neighbouring villagers. For example, protecting the wetland and maintaining minimum water level throughout the year attracted birds that stayed permanently in the wetland; previously, the wetland attracted only those birds that migrated seasonally. Similarly, water availability in the wetland paved the way for generating additional benefits, such as recreation. Though conservation measures produced extra-marginal benefits, such measures diminished certain other benefits, causing welfare loss to the users. For example, the Puducherry Government fenced the entire stretch of wetland,

4 kilometres, starting from Ousteri village till Pathukannu, which restricted the entry of humans and livestock inside the wetland. As a result, the villagers who were utilising direct benefits – such as subsistence fishing, bathing, washing clothes, collecting lotus for commercial purpose, etc. – were deprived of access. Thus, the conservation efforts by the governments led to social costs, due to reduced availability of direct benefits previously enjoyed by the villagers.

c) Though collective action independently carried out by the two governments brought about certain desirable changes in the quality of the wetland and its ecosystems, non-cooperation among the two governments in addressing certain negative externalities, especially industrial pollution, leads to deterioration of the wetland. In other words, if the governments had adopted a cooperative approach in addressing negative externalities the resulting outcomes would have been socially and intertemporally beneficial to the society. For example, industrial activities in the Sedarapet area, located in the upstream region of the wetland, cause pollution that adversely affects the quality of water in the wetland. Around 250 industrial units operating in this area are identified as ‘red category’ industrial units by the pollution control board. Indeed, if the pollution from Sedarapet Industrial Estate is properly controlled, it will minimise the social costs imposed by the polluting activities. Similarly, if the concerned authorities regulate water extraction by industrial and commercial activities in the neighbourhood and restrict illegal dumping of solid and liquid wastes inside the wetland, it would significantly minimise the costs borne by the society. The profound negative externalities continue to affect the quality of the ecosystem services, despite the conservation measures. More cooperation among the governments to contain the prevailing negative externalities would significantly improve the quality of the wetland, thereby enhancing ecosystem benefits further. The problem is that such cooperation has not yet emerged, and therefore the trade-off between ecosystem services – especially between the disposal service and other forms of services – continues to prevail.

One of the major management problems to be addressed in the context of Ousteri wetland is to strengthen the existing institutions and bring in new institutions so that the existing conflicts and trade-offs are minimised and the wetland is managed efficiently on a sustainable basis. A more cooperative environment has to be created, in which all major stakeholders participate in managing the wetland and reaping

the ecosystem benefits so that a win-win outcome is produced for all stakeholders. The present study makes an attempt to generate useful information which can be used to strengthen institutions for sustainable management of the wetland.

4. Objective Of The Study

A major objective of the present study is to estimate the economic value of ecosystems arising from increments and decrements in important ecosystem services due to changes in the Ousteri wetland. More precisely, the proposed study aims at estimating the economic value of the marginal benefits and costs of wetland management regimes over a period of time. A specific objective would be to assist the decision-making bodies to implement appropriate incentive-based conservation measures for sustainable management of the wetland, apart from other institutional approaches.

5. Methodology

The study adopts an inter-disciplinary methodology. The wetland as a primary resource is treated as a 'natural capital', while the ecosystem services and benefits are considered as flow of income that contributes to the welfare of the society. The natural capital as such is undergoing changes in terms of its ecological and hydrological features; therefore, the present study aims at capturing the ecological and hydrological dynamisms of the natural capital and then moves on to estimate the economic value of ecosystem services arising from the dynamic nature of the natural capital. In the present study, we adopted the 'total economic value' (TEV) framework, whereby $TEV = \text{direct use values} + \text{indirect use values} + \text{option value}$. Economic values are to be estimated in monetary terms. In this study, we focused only on three components of the TEV: direct benefits, indirect benefits, and option value. A detailed research is needed to investigate if the wetland generates a significant amount of existence value as well.

The standard 'marginal approach' is adopted, in which the marginal impact on the selected ecosystem services of improvements in the quality of wetland is being measured in terms of monetary values. Both the revealed preference (RP) and the stated preference (SP) methods have been used to place monetary values on the ecosystem services. In the case of fodder, fuel-wood, fish, etc., the opportunity cost approach was utilised; wherever possible, we assessed the monetary values by using the direct market prices of the above benefits. We

employed production function approach to measure the marginal value of irrigation water currently being utilised by the farmers in the neighbourhood of the wetland. In the case of recreational benefits, the 'travel cost method' was employed to estimate the preferences of the tourists towards recreational benefits. In order to arrive at the total economic value of biodiversity protection, a 'contingent valuation method' (CVM) became the natural choice. More details about the implementation of the economic valuation techniques are available in the respective sections below. The study also utilised both secondary and primary data extensively in estimating the ecological, hydrological and economic aspects of the wetland and its ecosystems.

6. Ecological Status of Ousteri

Ousteri is an ecologically important wetland that harbours many different types of flora and provides a suitable habitat for various types of fauna. Ousteri, due to its extreme hydrological fluctuations across the annual cycle, gives rise to a unique pattern of flora and fauna. The northeast monsoons leave the wetland flooded during the winter months.

Ousteri and its environs provide a wide variety of habitats for many floral species, in which 190 species are listed as 'least concern', 23 species are 'near threatened', and 24 species are 'vulnerable', according to the IUCN Red List (Table 2 and Figure 3a). About 14 floral species come under 'endemic' categories. With regard to fauna, 202 are listed as 'least concern', 13 species are listed as 'near threatened', two species are 'vulnerable', three species are 'endangered', and one is in the 'critically endangered' category (Figure 3b). Moreover, 5 fauna species are in 'endemic' categories. On the whole, a considerable number of Red List species is found in the wetland environs. This, in fact, reveals the ecological significance of the wetland and its environs. A detailed list of flora and fauna and its ecological status is given in Tables 3–13.

6.1. Floristic Status of Ousteri

Traditionally, Ousteri had been primarily used as a tank for irrigation purposes. Though the command area had declined drastically in recent years, one can still find vast stretches of agricultural land surrounding it. The natural vegetation, altered much by human agencies, consists of over 220 species, belonging to 63 families. The vegetation study conducted by SACON (2011) recorded 472 plant species in total, out of which herbs represent 40%, followed by trees, which represent 21%

Table 1: Floristic Status of Ousteri

Life forms	Family	Genera	Species
Tree	38	77	100
Shrubs	31	47	63
Herbs	50	125	191
Climbers	11	31	39
Stragglers	11	18	20
Grass	1	34	59

Source: Based on primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

(see Table 1). Other forms of life supported by the wetland are represented by less than 100 species.

6.2. Faunal Status of Ousteri

Ousteri harbours not only rich floristic diversity but also a vast faunal diversity. Previous studies – such as Alexander and Sivasankar 2013; Chari and Abbasi (2003); Murugesan et al. (2013); Padmavathy et al. (2010); and SACON (2011) – have listed the faunal diversity of the wetland at different intervals. There are 166 bird species, 63 butterfly species, 9 frog species, 3 turtle species, 10 lizard species, 15 snake species, 24 fish species, and 14 mammals found around the wetland (see Tables 2–7). Fish are an integral component of the Ousteri biome. The fish stock is dominated by small and coarse fish, such as *P. atherinoides* and *M.*

Figure 3a: IUCN Red listed flora of Ousteri. (Number of species is indicated on top of each bar)

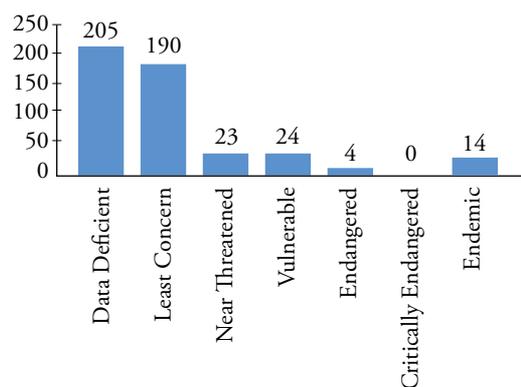


Figure 3b: IUCN Red listed fauna of Ousteri. (Number of species is indicated on top of each bar)

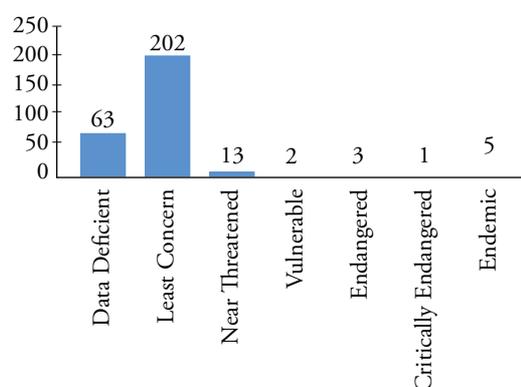


Table 2: Ecological Significance of the Species Present in and around the Ousteri.

IUCN Categories	Tree	Shrub	Herb	Grass	Climbers	Stragglers	Butterflies	Avifauna	Ichthyofauna	Herpetofauna	Mammals
Data Deficient	27	25	61	48	26	18	46	--	11	5	1
Least Concern	40	22	105	11	10	2	12	153	10	16	11
Near Threatened	3	14	3	--	3	--	--	10	2	1	--
Vulnerable	14	--	6	--	--	--	--	--	1	--	1
Threatened	1	--	3	--	--	--	--	--	--	--	--
Endangered	1	1	2	--	--	--	--	2	--	--	1
Critically Endangered	--	--	--	--	--	--	--	1	--	--	--
Endemic	2	--	12	--	--	--	5	--	--	--	--
Invasive	12	1	6	--	--	--	-	--	--	--	--

Table 3: List of Tree species recorded in and around Ousteri

Sl. No.	Scientific Name	Family	IUCN Status
1	<i>Acacia auriculiformis</i>	Mimosaceae	LC
2	<i>Acacia chundra</i>	Mimosaceae	LC
3	<i>Acacia leucophloea</i>	Mimosaceae	LC
4	<i>Acacia mangium</i>	Mimosaceae	INVASIVE
5	<i>Acacia nilotica</i>	Mimosaceae	INVASIVE
6	<i>Adenanthera pavoniana</i>	Mimosaceae	DD
7	<i>Aegle marmelos</i>	Rutaceae	LC
8	<i>Albizia amara</i>	Caesalpiniaceae	DD
9	<i>Albizia lebbek</i>	Caesalpiniaceae	LC
10	<i>Allophyllus serratus</i>	Sapindaceae	DD
11	<i>Artabotrys odoratissimus</i>	Annonaceae	DD
12	<i>Atalantia monophylla</i>	Rutaceae	DD
13	<i>Atalantia racemosa</i>	Rutaceae	VULNERABLE
14	<i>Azadirachta indica</i>	Meliaceae	LC
15	<i>Bambusa arundinacea</i>	Poaceae	DD
16	<i>Barringtonia acutangula</i>	Lecythidaceae	DD
17	<i>Bauhinia racemosa</i>	Caesalpiniaceae	DD
18	<i>Bombax ceiba</i>	Bombacaceae	INVASIVE
19	<i>Borassus flabellifer</i>	Arecaceae	ENDANGERED
20	<i>Buchanania axillaris</i>	Anacardiaceae	DD
21	<i>Butea monosperma</i>	Fabaceae	LC
22	<i>Calophyllum inophyllum</i>	Clusiaceae	DD
23	<i>Capparis aphylla</i>	Capparidaceae	DD
24	<i>Capparis grandis</i>	Capparidaceae	ENDEMIC
25	<i>Cassia siamea</i>	Caesalpiniaceae	LC
26	<i>Cassine glauca</i>	Celastraceae	ENDEMIC
27	<i>Ceiba pentandra</i>	Bombacaceae	LC
28	<i>Chloroxylon swietenia</i>	Rutaceae	LC
29	<i>Cocos nucifera</i>	Arecaceae	LC
30	<i>Commiphora berryi</i>	Burseraceae	DD
31	<i>Cordia obliqua</i>	Boraginaceae	NT
32	<i>Cordia sebastiana</i>	Boraginaceae	NT
33	<i>Corypha umbraculifera</i>	Arecaceae	LC
34	<i>Crateva adansonii</i>	Capparidaceae	LC
35	<i>Crateva magna</i>	Capparidaceae	LC
36	<i>Dalbergia paniculata</i>	Fabaceae	LC
37	<i>Delonix elata</i>	Caesalpiniaceae	LC
38	<i>Delonix regia</i>	Caesalpiniaceae	LC

Contd...

Sl. No.	Scientific Name	Family	IUCN Status
39	<i>Diospyros montana</i>	Ebenaceae	LC
40	<i>Drypetes roxburghii</i>	Euphorbiaceae	LC
41	<i>Drypetes sepiaria</i>	Euphorbiaceae	DD
42	<i>Ficus benghalensis</i>	Moraceae	LC
43	<i>Ficus hispida</i>	Moraceae	LC
44	<i>Ficus racemosa</i>	Moraceae	LC
45	<i>Ficus religiosa</i>	Moraceae	LC
46	<i>Flacourtia indica</i>	Flacourtiaceae	INVASIVE
47	<i>Gmelina arborea</i>	Verbenaceae	VULNERABLE
48	<i>Ixora arborea</i>	Rubiaceae	VULNERABLE
49	<i>Khaya senegalensis</i>	Meliaceae	THREATENED
50	<i>Lannaea coromandelica</i>	Burseraceae	DD
51	<i>Lepisanthes tetraphylla</i>	Sapindaceae	VULNERABLE
52	<i>Madhuca longifolia</i>	Sapotaceae	VULNERABLE
53	<i>Mallotus philippensis</i>	Euphorbiaceae	INVASIVE
54	<i>Mangifera indica</i>	Anacardiaceae	DD
55	<i>Melia azaderach</i>	Meliaceae	INVASIVE
56	<i>Millingtonia hortensis</i>	Bignoniaceae	LC
57	<i>Mimusops elengi</i>	Sapotaceae	VULNERABLE
58	<i>Mitragyna parvifolia</i>	Rubiaceae	DD
59	<i>Morinda tinctoria</i>	Rubiaceae	DD
60	<i>Muntingia calabura</i>	Tiliaceae	DD
61	<i>Pandanus odoratissimus</i>	Pandanaceae	LC
62	<i>Peltophorum pterocarpum</i>	Caesalpiniaceae	LC
63	<i>Phoenix sylvestris</i>	Arecaceae	LC
64	<i>Phyllanthus emblica</i>	Euphorbiaceae	DD
65	<i>Pithecellobium dulce</i>	Caesalpiniaceae	LC
66	<i>Polyalthia longifolia</i>	Annonaceae	DD
67	<i>Polyalthia suberosa</i>	Annonaceae	NT
68	<i>Pongamia pinnata</i>	Fabaceae	LC
69	<i>Prosopis juliflora</i>	Mimosaceae	INVASIVE
70	<i>Randia brandisii</i>	Rubiaceae	DD
71	<i>Randia dumetorum</i>	Rubiaceae	DD
72	<i>Ricinus communis</i>	Euphorbiaceae	LC
73	<i>Salvadora persica</i>	Salvadoraceae	VULNERABLE
74	<i>Samanea saman</i>	Caesalpiniaceae	INVASIVE
75	<i>Santalum album</i>	Santalaceae	VULNERABLE
76	<i>Sapindus emarginata</i>	Sapindaceae	VULNERABLE

Contd...

Sl. No.	Scientific Name	Family	IUCN Status
77	<i>Semecarpus anacardium</i>	Anacardiaceae	DD
78	<i>Solanum trilobatum</i>	Solanaceae	VULNERABLE
79	<i>Spathodea campanulata</i>	Bignoniaceae	INVASIVE
80	<i>Sterculia foetida</i>	Sterculiaceae	VULNERABLE
81	<i>Streblus asper</i>	Moraceae	LC
82	<i>Strychnos nux-vomica</i>	Loganiaceae	LC
83	<i>Swietenia macrophylla</i>	Meliaceae	LC
84	<i>Syzygium cumini</i>	Myrtaceae	INVASIVE
85	<i>Tamarindus indica</i>	Caesalpinaceae	LC
86	<i>Tecoma stans</i>	Bignoniaceae	INVASIVE
87	<i>Tectona grandis</i>	Verbenaceae	VULNERABLE
88	<i>Terminalia arjuna</i>	Combretaceae	LC
89	<i>Terminalia bellirica</i>	Combretaceae	LC
90	<i>Terminalia catappa</i>	Combretaceae	LC
91	<i>Thespesia populnea</i>	Malvaceae	LC
92	<i>Thevetia peruviana</i>	Apocynaceae	DD
93	<i>Vitex altissima</i>	Verbenaceae	DD
94	<i>Vitex leucoxydon</i>	Verbenaceae	DD
95	<i>Vitex negundo</i>	Verbenaceae	VULNERABLE
96	<i>Vitex trifolia</i>	Verbenaceae	VULNERABLE
97	<i>Wrightia tinctoria</i>	Apocynaceae	LC
98	<i>Ziziphus mauritiana</i>	Rhamnaceae	INVASIVE
99	<i>Ziziphus trinervia</i>	Rhamnaceae	LC
100	<i>Ziziphus xylopyrus</i>	Rhamnaceae	DD

The list of flora and fauna species given in the above table are based on the primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

cavasius, owing to the highly eutrophic conditions and low levels of dissolved oxygen. The presence of both low *inorganic* phosphorous and high *organic* phosphorous in the water source is indicative of highly eutrophic nature of the wetland. Abundance of nutrients and favourable pH has promoted dense growth of aquatic macrophytes and phytoplankton. As a result, penetration of light on the bottom of the wetland has been prevented, leading to low dissolved oxygen levels in the wetland. Such lowered oxygen levels would have created conditions that are stressful to certain fish, resulting in their low species richness. Currently, the water body is dominated by small fish species; this may be attributed to the presence of dense mats of suspended and submerged macrophytes that provide protection for the small fish, reducing their predation. In addition, the excessive turbidity

in the water is also known to decrease the efficiency of predators that rely on visual cues to capture their prey.

7. Hydrological Status Of Ousteri

Apart from run-off from precipitation in the catchment area, the water body receives water from Suthukeni dam through Suthukeni channel. The surplus water from the Veedur dam, located in the Villupuram District of Tamil Nadu, is the main source of water to the Suthukenni dam. Based on the details available from the Public Works Department (PWD), the area of free catchment and intercepted catchment of the wetland in total works out to be 15.54 km² and the total circumference is 7.3 km. The total capacity of the wetland is 540 million ft³. and the full tank level is 14.2 m (Table 14).

Table 4: List of Herb Species Recorded in and around Ousteri

Sl. No.	Scientific Name	Family	IUCN Status
1	<i>Acalypha indica</i>	Euphorbiaceae	LC
2	<i>Acanthospermum hispidum</i>	Asteraceae	DD
3	<i>Achyranthes aspera</i>	Amaranthaceae	THREATENED
4	<i>Achyranthes bidentata</i>	Amaranthaceae	ENDEMIC
5	<i>Aerva lanata</i>	Amaranthaceae	DD
6	<i>Aerva persica</i>	Amaranthaceae	LC
7	<i>Aeschynomene aspera</i>	Fabaceae	LC
8	<i>Ageratum conyzoides</i>	Asteraceae	LC
9	<i>Aloe vera</i>	Aloeaceae	LC
10	<i>Alternanthera paronychioides</i>	Amaranthaceae	LC
11	<i>Alternanthera pungens</i>	Amaranthaceae	LC
12	<i>Alternanthera sessilis</i>	Amaranthaceae	LC
13	<i>Alternanthera tenella</i>	Amaranthaceae	LC
14	<i>Alysicarpus monilifer</i>	Fabaceae	ENDEMIC
15	<i>Alysicarpus rugosus</i>	Fabaceae	INVASIVE
16	<i>Alysicarpus vaginalis</i>	Fabaceae	LC
17	<i>Amaranthus spinosus</i>	Amaranthaceae	DD
18	<i>Ammania baccifera</i>	Lythraceae	LC
19	<i>Andrographis alata</i>	Acanthaceae	DD
20	<i>Anisomeles indica</i>	Lamiaceae	DD
21	<i>Aponogeton natans</i>	Aponogetanaceae	LC
22	<i>Asclepias curassavica</i>	Asclepiadaceae	LC
23	<i>Asystasia dalzieliana</i>	Acanthaceae	INVASIVE
24	<i>Asystasia gangetica</i>	Acanthaceae	INVASIVE
25	<i>Bacopa monnieri</i>	Scrophulariaceae	LC
26	<i>Barleria buxifolia</i>	Acanthaceae	THREATENED
27	<i>Bergia ammanioides</i>	Elatinaceae	LC
28	<i>Biophytum sensitivum</i>	Oxalidaceae	ENDEMIC
29	<i>Blepharis molluginifolia</i>	Acanthaceae	DD
30	<i>Blepharis tetrphylla</i>	Acanthaceae	LC
31	<i>Boerhavia diffusa</i>	Nyctaginaceae	DD
32	<i>Boerhavia erecta</i>	Nyctaginaceae	VULNERABLE
33	<i>Borreria hispida</i>	Rubiaceae	ENDEMIC
34	<i>Borreria ocymoides</i>	Rubiaceae	DD
35	<i>Borreria pusilla</i>	Rubiaceae	DD
36	<i>Bothriochloa pertusa</i>	poaceae	DD
37	<i>Bulbostylis barbata</i>	Cyperaceae	VULNERABLE
38	<i>Caldesia parnasifolia</i>	Alismataceae	LC
39	<i>Cassia obtusa</i>	Caesalpinaceae	LC

Contd...

Sl. No.	Scientific Name	Family	IUCN Status
40	<i>Cassia occidentalis</i>	Caesalpinaceae	LC
41	<i>Celosia polygonoides</i>	Amaranthaceae	ENDEMIC
42	<i>Centella asiatica</i>	Apiaceae	LC
43	<i>Ceratophyllum demersum</i>	Ceratophyllaceae	LC
44	<i>Ceratopteris thalictroides</i>	Ceratopteridaceae	LC
45	<i>Cleome aspera</i>	Capparidaceae	DD
46	<i>Cleome monophylla</i>	Capparidaceae	ENDEMIC
47	<i>Cleome viscosa</i>	Capparidaceae	LC
48	<i>Clitoria ternatea</i>	Fabaceae	DD
49	<i>Coldenia procumbens</i>	Boraginaceae	LC
50	<i>Commelina benghalensis</i>	Commelinaceae	LC
51	<i>Commelina benghalensis</i>	Commelinaceae	LC
52	<i>Commelina clavata</i>	Commelinaceae	LC
53	<i>Commelina longifolia</i>	Commelinaceae	LC
54	<i>Corchorus aestuans</i>	Tiliaceae	DD
55	<i>Corchorus capsularis</i>	Tiliaceae	DD
56	<i>Corchorus olitorius</i>	Tiliaceae	DD
57	<i>Corchorus tridens</i>	Tiliaceae	DD
58	<i>Crossandra infundibuliformis</i>	Acanthaceae	LC
59	<i>Crotalaria evolvuloides</i>	Fabaceae	NT
60	<i>Crotalaria juncea</i>	Fabaceae	LC
61	<i>Crotalaria mysorensis</i>	Fabaceae	NT
62	<i>Croton sparsiflorus</i>	Euphorbiaceae	LC
63	<i>Cryptocoryne retrospiralis</i>	Araceae	ENDANGERED
64	<i>Cryptocoryne spinalis</i>	Araceae	LC
65	<i>Cynotis axillaris</i>		DD
66	<i>Cynotis tuberosa</i>	Commelinaceae	LC
67	<i>Cyperus articulatus</i>	Cyperaceae	LC
68	<i>Cyperus corymbosus</i>	Cyperaceae	LC
69	<i>Cyperus difformis</i>	Cyperaceae	LC
70	<i>Cyperus digitatus</i>	Cyperaceae	LC
71	<i>Cyperus distans</i>	Cyperaceae	LC
72	<i>Cyperus exaltatus</i>	Cyperaceae	LC
73	<i>Cyperus iria</i>	Cyperaceae	LC
74	<i>Cyperus nutans</i>	Cyperaceae	LC
75	<i>Cyperus pangorei</i>	Cyperaceae	LC
76	<i>Cyperus pilosus</i>	Cyperaceae	LC
77	<i>Cyperus procerus</i>	Cyperaceae	VULNERABLE
78	<i>Cyperus rotundus</i>	Cyperaceae	LC
79	<i>Desmodium gangeticum</i>	Fabaceae	DD

Contd...

Sl. No.	Scientific Name	Family	IUCN Status
80	<i>Digera muricata</i>	Amaranthaceae	DD
81	<i>Digera muricata</i>	Amaranthaceae	DD
82	<i>Ecbolium viride</i>	Acanthaceae	DD
83	<i>Eclipta alba</i>	Asteraceae	LC
84	<i>Elastostemma sp.</i>	Urticaceae	DD
85	<i>Enicostemma littorale</i>	Gentianaceae	LC
86	<i>Euphorbia hirta</i>	Euphorbiaceae	LC
87	<i>Euphorbia microphylla</i>	Euphorbiaceae	LC
88	<i>Euphorbia rosea</i>	Euphorbiaceae	DD
89	<i>Evolvulus alsinoides</i>	Convolvulaceae	DD
90	<i>Evolvulus nummularius</i>	Convolvulaceae	DD
91	<i>Fimbristylis argentea</i>	Cyperaceae	LC
92	<i>Fimbristylis bisumbellata</i>	Cyperaceae	LC
93	<i>Fimbristylis cinnamometorum</i>	Cyperaceae	LC
94	<i>Fimbristylis complanata</i>	Cyperaceae	LC
95	<i>Fimbristylis cymosa</i>	Cyperaceae	LC
96	<i>Fimbristylis dichotoma</i>	Cyperaceae	LC
97	<i>Fimbristylis miliaceae</i>	Cyperaceae	LC
98	<i>Fimbristylis ovata</i>	Cyperaceae	LC
99	<i>Glinus lotoides</i>	Boraginaceae	LC
100	<i>Glinus oppositifolius</i>	Boraginaceae	LC
101	<i>Gloriosa superba</i>	Liliaceae	LC
102	<i>Gompherena decumbens</i>	Amaranthaceae	VULNERABLE
103	<i>Gynodropsis pentaphylla</i>	Capparidaceae	DD
104	<i>Heliotropium indicum</i>	Boraginaceae	LC
105	<i>Hibiscus micranthus</i>	Malvaceae	LC
106	<i>Hybanthus ennaespermus</i>	Violaceae	DD
107	<i>Hydrilla verticillata</i>	Hydrocharitaceae	LC
108	<i>Hyptis suaveolens</i>	Lamiaceae	INVASIVE
109	<i>Indigofera linnaei</i>	Fabaceae	LC
110	<i>Indigofera trifoliata</i>	Fabaceae	LC
111	<i>Indigofera trita</i>	Fabaceae	LC
112	<i>Indoneesiella echioides</i>	Acanthaceae	LC
113	<i>Justicia procumbens</i>	Acanthaceae	LC
114	<i>Justicia simplex</i>	Acanthaceae	LC
115	<i>Justicia tranquebariensis</i>	Acanthaceae	DD
116	<i>Kyllinga nemoralis</i>	Cyperaceae	LC
117	<i>Leanotis nepetifolia</i>	Lamiaceae	ENDEMIC
118	<i>Lemna minor</i>	Lemnaceae	LC
119	<i>Lepidagathis cristata</i>	Boraginaceae	LC

Contd...

Sl. No.	Scientific Name	Family	IUCN Status
120	<i>Limnophytum obtusifolium</i>	Alismataceae	VULNERABLE
121	<i>Lindernia antipoda</i>	Scrophulariaceae	LC
122	<i>Malvastrum coromandelianum</i>	Malvaceae	DD
123	<i>Mariscus panicus</i>	Cyperaceae	LC
124	<i>Martynia annua</i>	Pedaliaceae	INVASIVE
125	<i>Melochia corchorifolia</i>	Sterculiaceae	DD
126	<i>Merremia emarginata</i>	Convolvulaceae	LC
127	<i>Merremia tridentata</i>	Convolvulaceae	LC
128	<i>Micrococca mercurialis</i>	Euphorbiaceae	DD
129	<i>Mollugo cerviana</i>	Aizoaceae	DD
130	<i>Mollugo nudicaulis</i>	Aizoaceae	DD
131	<i>Mollugo pentaphylla</i>	Aizoaceae	DD
132	<i>Monochoria vaginalis</i>	Pontederiaceae	LC
133	<i>Najas indica</i>	Najadaceae	LC
134	<i>Najas minor</i>	Najadaceae	LC
135	<i>Nelumbo nucifera</i>	Nymphaeaceae	LC
136	<i>Nothosaerva brachiata</i>	Amaranthaceae	LC
137	<i>Nymphaea nouchalii</i>	Nymphaeaceae	LC
138	<i>Ocimum sanctum</i>	Lamiaceae	LC
139	<i>Oldenlandia biflora</i>	Rubiaceae	LC
140	<i>Oldenlandia umbellata</i>	Rubiaceae	LC
141	<i>Orthosiphon pallidus</i>	Lamiaceae	VULNERABLE
142	<i>Ottelia alismoides</i>	Hydrocharitaceae	LC
143	<i>Pancratium triflorum</i>	Amaryllidaceae	ENDEMIC
144	<i>Parthenium hysterophorus</i>	Asteraceae	INVASIVE
145	<i>Pavonia procumbens</i>	Malvaceae	DD
146	<i>Pavonia zeylanica</i>	Malvaceae	DD
147	<i>Pedaliium murex</i>	Pedaliaceae	ENDEMIC
148	<i>Pentatropis microphylla</i>	Asclepiadaceae	DD
149	<i>Phylla nodiflora</i>	Verbenaceae	LC
150	<i>Phyllanthus amarus</i>	Phyllanthaceae	DD
151	<i>Phyllanthus gardenerii</i>	Euphorbiaceae	LC
152	<i>Phyllanthus maderaspatensis</i>	Euphorbiaceae	DD
153	<i>Phyllanthus uliginosa</i>	Euphorbiaceae	LC
154	<i>Phyllanthus wightianus</i>	Euphorbiaceae	DD
155	<i>Physalis minima</i>	Solanaceae	DD
156	<i>Pistia stratiotes</i>	Araceae	LC
157	<i>Polycarpaea corymbosa</i>	Caryophyllaceae	ENDEMIC
158	<i>Polycarpon prostratum</i>	Caryophyllaceae	LC
159	<i>Polygonum glabrum</i>	Polygonaceae	DD

Contd...

Sl. No.	Scientific Name	Family	IUCN Status
160	<i>Polygonum hydropiper</i>	Polygonaceae	LC
161	<i>Potamogeton nodosus</i>	Potamogetonaceae	LC
162	<i>Pseudarthria viscida</i>	Fabaceae	NT
163	<i>Psilotrichum elliotii</i>	Amaranthaceae	LC
164	<i>Pupalia lappacea</i>	Amaranthaceae	DD
165	<i>Rhynchosia minima</i>	Fabaceae	THREATENED
166	<i>Rothia indica</i>	Fabaceae	ENDEMIC
167	<i>Ruellia patula</i>	Acanthaceae	LC
168	<i>Ruellia tuberosa</i>	Acanthaceae	LC
169	<i>Salvinia molesta</i>	Salviniaceae	DD
170	<i>Sansevieria roxburghiana</i>	Liliaceae	ENDANGERED
171	<i>Scirpus littoralis</i>	Cyperaceae	LC
172	<i>Scoparia dulcis</i>	Scrophulariaceae	DD
173	<i>Sebastiania chamaelea</i>	Euphorbiaceae	ENDEMIC
174	<i>Sesbania procumbens</i>	Fabaceae	LC
175	<i>Sida acuta</i>	Malvaceae	LC
176	<i>Sida cordata</i>	Malvaceae	LC
177	<i>Sida cordifolia</i>	Malvaceae	LC
178	<i>Sida rhomboidea</i>	Malvaceae	LC
179	<i>Solanum surrattense</i>	Solanaceae	DD
180	<i>Stachytarpheta jamaicensis</i>	Verbenaceae	DD
181	<i>Stemodia viscosa</i>	Scrophulariaceae	DD
182	<i>Striga asiatica</i>	Scrophulariaceae	DD
183	<i>Stylosanthes fruticosus</i>	Fabaceae	LC
184	<i>Synedrella nodiflora</i>	Asteraceae	DD
185	<i>Tephrosia purpurea</i>	Fabaceae	LC
186	<i>Tephrosia villosa</i>	Fabaceae	LC
187	<i>Trianthema decandra</i>	Aizoaceae	DD
188	<i>Tribulus terrestris</i>	Zygophyllaceae	DD
189	<i>Trichurus monsoniae</i>	Amaranthaceae	DD
190	<i>Triumfetta rhomboidea</i>	Tiliaceae	DD
191	<i>Triumfetta rotundifolia</i>	Tiliaceae	DD
192	<i>Vallisneria spiralis</i>	Vallisneriaceae	DD
193	<i>Vigna trilobata</i>	Fabaceae	DD
194	<i>Viscum articulatum</i>	Viscaceae	DD
195	<i>Viscum ramosissimum</i>	Viscaceae	DD
196	<i>Waltheria indica</i>	Sterculiaceae	DD
197	<i>Wedelia urticifolia</i>	Asteraceae	LC
198	<i>Zornia gibbosa</i>	Fabaceae	LC

The list of flora and fauna species given in the above table are based on the primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

Table 5: List of Shrub Species Recorded in and around Ousteri

Sl.No	Scientific Name	Family	IUCN Status
1	<i>Abutilon hirtum</i>	Malvaceae	NT
2	<i>Abutilon indicum</i>	Malvaceae	NT
3	<i>Acalypha fruticosa</i>	Euphorbiaceae	DD
4	<i>Agave americana</i>	Agavaceae	NT
5	<i>Anisomeles malabarica</i>	Lamiaceae	NT
6	<i>Arundo donax</i>		LC
7	<i>Azima tetracantha</i>	Salvadoraceae	DD
8	<i>Barleria acuminata</i>	Acanthaceae	DD
9	<i>Barleria cristata</i>	Acanthaceae	DD
10	<i>Barleria prionotis</i>	Acanthaceae	DD
11	<i>Breynia vitis-idaea</i>	Euphorbiaceae	DD
12	<i>Calotropis gigantea</i>	Asclepiadaceae	LC
13	<i>Calotropis procera</i>	Asclepiadaceae	LC
14	<i>Carissa carandas</i>	Apocynaceae	NT
15	<i>Carissa spinarum</i>	Apocynaceae	NT
16	<i>Carmona retusa</i>	Boraginaceae	DD
17	<i>Cassia tora</i>	Caesalpiniaceae	DD
18	<i>Chromolaena odorata</i>	Asteraceae	DD
19	<i>Clausena dentata</i>	Rutaceae	LC
20	<i>Colocasia esculenta</i>	Araceae	LC
21	<i>Crinum asiaticum</i>	Amaryllidaceae	NT
22	<i>Crotalaria verrucosa</i>	Fabaceae	NT
23	<i>Datura innoxia</i>	Solanaceae	LC
24	<i>Datura metel</i>	Solanaceae	LC
25	<i>Dendrophthoe falcata</i>	Loranthaceae	NT
26	<i>Dicrostachys cinerea</i>	Mimosaceae	DD
27	<i>Dodonaea viscosa</i>	Sapindaceae	DD
28	<i>Ehretia pubescens</i>	Boraginaceae	DD
29	<i>Fluggea leucopyros</i>	Euphorbiaceae	DD
30	<i>Fluggea virosa</i>	Euphorbiaceae	DD
31	<i>Glycosmis mauritiana</i>	Rutaceae	LC
32	<i>Glycosmis pentaphylla</i>	Rutaceae	LC
33	<i>Gmelina asiatica</i>	Verbenaceae	DD
34	<i>Grewia hirsuta</i>	Tiliaceae	NT
35	<i>Grewia tenax</i>	Tiliaceae	NT
36	<i>Hibiscus vitifolius</i>	Malvaceae	LC
37	<i>Indigofera tinctoria</i>	Fabaceae	NT
38	<i>Ipomoea cornea</i>	Convolvulaceae	INVASIVE

Contd...

Sl.No	Scientific Name	Family	IUCN Status
39	<i>Jatropha curcus</i>	Euphorbiaceae	LC
40	<i>Jatropha glandulifera</i>	Euphorbiaceae	LC
41	<i>Jatropha gossypifolia</i>	Euphorbiaceae	LC
42	<i>Jatropha tanjorensis</i>	Euphorbiaceae	LC
43	<i>Justicia betonica</i>	Acanthaceae	LC
44	<i>Justicia gendarussa</i>	Acanthaceae	LC
45	<i>Maba buxifolia</i>	Ebenaceae	ENDANGERED
46	<i>Maytanus emarginata</i>	Celastraceae	DD
47	<i>Memecylon edule</i>	Melastomataceae	DD
48	<i>Ochna ontusata</i>	Ochnaceae	DD
49	<i>Opuntia stricta</i>	Cactaceae	LC
50	<i>Pavetta indica</i>	Rubiaceae	DD
51	<i>Phoenix loureirii</i>	Arecaceae	DD
52	<i>Phragmites karka</i>	Poaceae	LC
53	<i>Phyllanthus polyphyllus</i>	Euphorbiaceae	DD
54	<i>Phyllanthus reticulatus</i>	Euphorbiaceae	DD
55	<i>Plumbago zeylanica</i>	Plumbaginaceae	DD
56	<i>Randia malabarica</i>	Rubiaceae	DD
57	<i>Rauwolfia tetraphylla</i>	Apocynaceae	NT
58	<i>Solanum torvum</i>	Solanaceae	LC
59	<i>Solanum trilobatum</i>	Solanaceae	LC
60	<i>Strobilanthus consanguinea</i>	Acanthaceae	NT
61	<i>Tarennia asiatica</i>	Rubiaceae	LC
62	<i>Typha angustata</i>	Poaceae	LC
63	<i>Urena lobata</i>	Malvaceae	DD

The list of flora and fauna species given in the above table are based on the primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

The water influx and discharge (in million ft³) data available for the period between 1999 and 2009 portrays the water fluctuation scenario of the water body. As Puducherry receives maximum rainfall during the northeast monsoon (October–December) every year, during which the availability of water in Ousteri also increases. The volume of water is maximum in the months of December and January and it declines gradually from February onwards. During summer (March–May) and the southwest monsoon (June–September), the water level is comparatively lower in the wetland. Periodic drying of the water body occurred during the months of June, July and August (Figure 4a) in the past. But after the restriction of outflow of water in 2004, the wetland never dried up in any part of the year.

7.1. Analysis of Rainfall

The rainfall data for 100 years reveals that the average rainfall level is generally over 1000 mm, which is a normal characteristic of the Puducherry region and that of the east coast region of India. The highest level of rainfall (2,604 mm) was recorded in 1943, while the lowest level (566 mm) was recorded in 1968 (Figure 4b). There exists an oscillating trend in rainfall level, with higher and lower points in rainfall moving with crests and troughs every 5 years. The rainfall level appears to be relatively higher in recent times since 1995, with more than 8 years having an average rainfall level higher than 1,500 mm. The years between 1940 and 1960 received dry spells, especially in 1949, 1950 and 1951. Before 1940,

Table 6: List of Grass Species Recorded in and around Ousteri

Sl.No	Scientific Name	Family	IUCN Status
1	<i>Alloteropsis cimicina</i>	Poaceae	DD
2	<i>Andropogon pumilus</i>	Poaceae	DD
3	<i>Apluda mutica</i>	Poaceae	DD
4	<i>Aristida adscensionis</i>	Poaceae	DD
5	<i>Aristida funiculata</i>	Poaceae	DD
6	<i>Aristida hystrix</i>	Poaceae	DD
7	<i>Arundo donax</i>	Poaceae	DD
8	<i>Axonophus compressus</i>	Poaceae	DD
9	<i>Bothriochloa pertusa</i>	Poaceae	DD
10	<i>Brachiaria ramosa</i>	Poaceae	LC
11	<i>Brachiaria remota</i>	Poaceae	DD
12	<i>Cenchrus ciliaris</i>	Poaceae	DD
13	<i>Caldesia parnassifolia</i>	Poaceae	LC
14	<i>Chloris barbata</i>	Poaceae	DD
15	<i>Chloris dolichostachya</i>	Poaceae	DD
16	<i>Chrysopogon aciculatus</i>	Poaceae	DD
17	<i>Chrysopogon asper</i>	Poaceae	DD
18	<i>Coelachyrum lagopoides</i>	Poaceae	DD
19	<i>Cymbopogon citratus</i>	Poaceae	DD
20	<i>Cymbopogon flexuosus</i>	Poaceae	DD
21	<i>Cymbopogon martinii</i>	Poaceae	DD
22	<i>Cynodon barberi</i>	Poaceae	DD
23	<i>Cynodon dactylon</i>	Poaceae	DD
24	<i>Dactyloctenium aegyptium</i>	Poaceae	DD
25	<i>Dactyloctenium aristatum</i>	Poaceae	DD
26	<i>Eleusine indica</i>	Poaceae	LC
27	<i>Eragrostis amabilis</i>	Poaceae	DD
28	<i>Eragrostis plumosa</i>	Poaceae	DD
29	<i>Eragrostis uniolooides</i>	Poaceae	LC
30	<i>Eragrostis viscosa</i>	Poaceae	DD
31	<i>Iseilema antheporoides</i>	Poaceae	DD
32	<i>Iseilema laxum</i>	Poaceae	DD
33	<i>Leptochloa chinensis</i>	Poaceae	DD
34	<i>Manisurus myoros</i>	Poaceae	DD
35	<i>Mnesithea laevis</i>	Poaceae	DD
36	<i>Ophiuros exaltatus</i>	Poaceae	DD
37	<i>Oplismenus compositus</i>	Poaceae	DD
38	<i>Oropetium thomaeum</i>	Poaceae	DD
39	<i>Panicum notatum</i>	Poaceae	DD
40	<i>Panicum psilopodium</i>	Poaceae	LC
41	<i>Panicum trypheron</i>	Poaceae	DD
42	<i>Paspalidium flavidum</i>	Poaceae	LC
43	<i>Paspalidium geminatum</i>	Poaceae	LC
44	<i>Paspalidium punctatum</i>	Poaceae	LC
45	<i>Paspalum longifolium</i>	Poaceae	LC
46	<i>Paspalum scrobiculatum</i>	Poaceae	LC
47	<i>Paspalum vaginatum</i>	Poaceae	LC
48	<i>Perotis indica</i>	Poaceae	DD
49	<i>Saccarum spontaneum</i>	Poaceae	DD
50	<i>Sacciolepis indica</i>	Poaceae	DD
51	<i>Sehima nervosa</i>	Poaceae	DD
52	<i>Setaria pumila</i>	Poaceae	DD
53	<i>Setaria verticillata</i>	Poaceae	DD
54	<i>Sporobolus coromandelianus</i>	Poaceae	DD
55	<i>Sporobolus indicus</i>	Poaceae	DD
56	<i>Sporobolus maderaspatanus</i>	Poaceae	DD
57	<i>Sporobolus spicatus</i>	Poaceae	DD
58	<i>Vetiveria zizanioides</i>	Poaceae	DD
59	<i>Zoysia matrella</i>	Poaceae	DD

The list of flora and fauna species given in the above table are based on the primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

Table 7: List of Climber Species Recorded in and around Ousteri

Sl.No	Scientific Name	Family	IUCN Status
1	<i>Aristolochia bracteolata</i>	Aristolochiaceae	DD
2	<i>Aristolochia indica</i>	Aristolochiaceae	DD
3	<i>Gymnema montanum</i>	Asclepiadaceae	DD
4	<i>Hemedesmus indicus</i>	Asclepiadaceae	DD
5	<i>Ichnocarpus frutescens</i>	Asclepiadaceae	DD
6	<i>Leptadania reticulata</i>	Asclepiadaceae	DD
7	<i>Oxystelma esculentum</i>	Asclepiadaceae	LC
8	<i>Pentatrophis microphylla</i>	Asclepiadaceae	DD
9	<i>Pergularia daemia</i>	Asclepiadaceae	DD
10	<i>Sarcostemma brunonianum</i>	Asclepiadaceae	DD
11	<i>Sarcostemma intermedium</i>	Asclepiadaceae	DD
12	<i>Tylophora benthamii</i>	Asclepiadaceae	DD
13	<i>Tylophora indica</i>	Asclepiadaceae	DD
14	<i>Wattakaka volubilis</i>	Asclepiadaceae	DD
15	<i>Cuscuta reflexa</i>	Convolvulaceae	DD
16	<i>Ipomoea hederifolia</i>	Convolvulaceae	DD
17	<i>Ipomoea pescarpae</i>	Convolvulaceae	DD
18	<i>Ipomoea pestigiridis</i>	Convolvulaceae	DD
19	<i>Coccinia grandis</i>	Cucurbitaceae	DD
20	<i>Cucumis</i>	Cucurbitaceae	LC
21	<i>Diplocyclos palmatus</i>	Cucurbitaceae	LC
22	<i>Kedrothis foetidissima</i>	Cucurbitaceae	LC
23	<i>Luffa aegyptiaca</i>	Cucurbitaceae	LC
24	<i>Mukia maderaspatana</i>	Cucurbitaceae	LC
25	<i>Tragia involucrata</i>	Euphorbiaceae	LC
26	<i>Tragia plukenetii</i>	Euphorbiaceae	LC
27	<i>Cassytha filiformis</i>	Lauraceae	LC
28	<i>Cissampelos pereira</i>	Menispermaceae	DD
29	<i>Cocculus hirsutus</i>	Menispermaceae	DD
30	<i>Pachygone ovata</i>	Menispermaceae	DD
31	<i>Tiliacora acuminata</i>	Menispermaceae	DD
32	<i>Tinospora cordifolia</i>	Menispermaceae	DD
33	<i>Passiflora foetida</i>	Passifloraceae	DD
34	<i>Antigonon leptopus</i>	Polygonaceae	DD
35	<i>Cardiospermum halicacabum</i>	Sapindaceae	LC
36	<i>Cayratia pedata</i>	Vitaceae	DD
37	<i>Cissus quadrangularis</i>	Vitaceae	NT
38	<i>Cissus trifolia</i>	Vitaceae	NT
39	<i>Cissus vitigena</i>	Vitaceae	NT

The list of flora and fauna species given in the above table are based on the primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

the rainfall pattern was even, with high points not more than 1,500 mm and the low points not less than 800 mm.

7.2. Water Quality Issues

Ousteri wetland recharges the aquifer of Vanur–Ramanathapuram sandstone, which is one of the major and important aquifers that supplies drinking water to the entire population in the Puducherry region (Chari and Abbasi 2007). The water quality of Ousteri was assessed by considering 23 parameters that were valued in accordance with BIS standards set for drinking purposes (see Table 15). The water samples were collected from 10 different random locations inside the wetland. Appropriate parameters

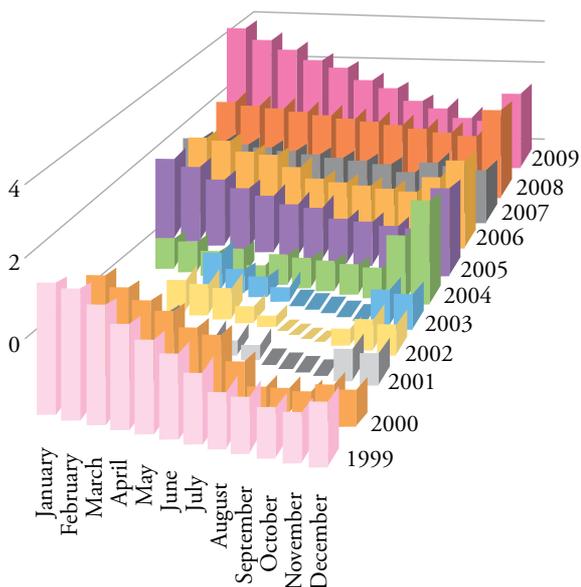
including physical, chemical, biological and presence of heavy metals, have been considered for assessment of the surface water quality. The quality was assessed for pH, EC (Electronic Conductivity), Turbidity, Hardness, Calcium, Magnesium, Chloride, Phosphate, Sulphate, Alkalinity, Iron, Copper, Manganese, Zinc, Lead, Cadmium, Chromium, TDS (Total Dissolved Solids), COD (Chemical Oxygen Demand), BOD (Biochemical Oxygen Demand), and DO (Dissolved Oxygen). As seen in the Table 15 and Figure 5, the parameters which are within the BIS range are pH, Sodium, Potassium, Phosphate, Iron, and Manganese. There are many parameters within the low range, like Electronic Conductivity (EC), Hardness, Calcium, Magnesium, Chloride, Alkalinity, Sulphate, Copper,

Table 8: List of Straggler Species Recorded in and around Ousteri

Sl.No	Scientific Name	Family	IUCN Status
1	<i>Caesalpinia bonduc</i>	Caesalpiaceae	DD
2	<i>Cadaba indica</i>	Capparidaceae	DD
3	<i>Capparis sepiaria</i>	Capparidaceae	DD
4	<i>Capparis zeylanica</i>	Capparidaceae	DD
5	<i>Maerua oblongifolia</i>	Capparidaceae	DD
6	<i>Celastrus paniculatus</i>	Celastraceae	DD
7	<i>Combretum ovalifolium</i>	Combretaceae	DD
8	<i>Abrus precatorius</i>	Fabaceae	DD
9	<i>Canavalia gladiata</i>	Fabaceae	DD
10	<i>Clitoria ternatea</i>	Fabaceae	DD
11	<i>Derris scandens</i>	Fabaceae	LC
12	<i>Glychirrhiza glabra</i>	Fabaceae	DD
13	<i>Salacia chinensis</i>	Hippocrateaceae	DD
14	<i>Loseneeriella obtusifolia</i>	Hippocrateaceae	DD
15	<i>Hugonia mystax</i>	Linaceae	DD
16	<i>Acacia caesia</i>	Mimosaceae	LC
17	<i>Acacia torta</i>	Mimosaceae	DD
18	<i>Jasminum rigidum</i>	Oleaceae	DD
19	<i>Ziziphus oenoplia</i>	Rhamnaceae	DD
20	<i>Toddalia asiatica</i>	Rutaceae	DD

The list of flora and fauna species given in the above table are based on the primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

Figure 4a: Month wise water level data in Ousteri between 1999 – 2009. Water level in Mcm³



Zinc, Cadmium, Chromium and TDS (Total Dissolved Solids). Among all the parameters, the sulphate values are found to be very low, when compared to the BIS standards. The parameters that have a high range are Turbidity, COD (Chemical Oxygen Demand), BOD (Biochemical Oxygen Demand), Dissolved Oxygen (DO), Arsenic and Lead. The COD values are relatively higher than the BIS standards.

A major concern is the high values of Arsenic and Lead, because they are heavy metals and have adverse health consequences on living organisms. The presence of heavy metals in the water is mainly due to the release of effluents from industrial units located in Sedarapet, on the southern side of Ousteri wetland. Wetlands with a calcium content greater than 25 mg/l have been considered calcium rich and when the levels of alkaline exceed 100 mg/l, it is considered alkaline eutrophic in nature. In Ousteri, due to the near eutrophic range of

Figure 4b: Annual rainfall pattern (values in mm) in Puducherry between 1900 and 2013

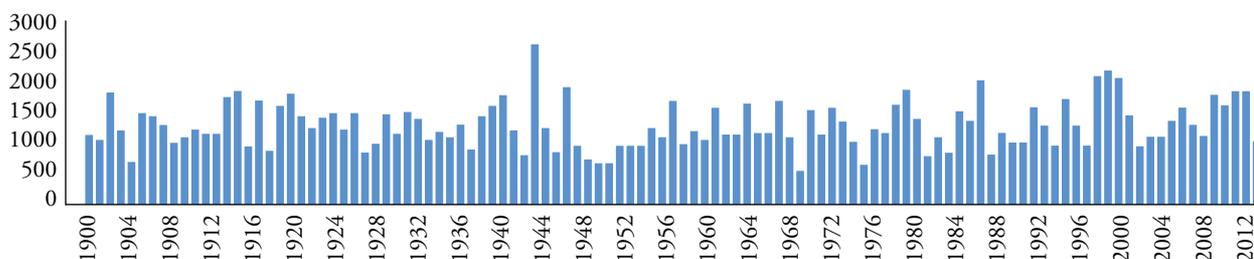
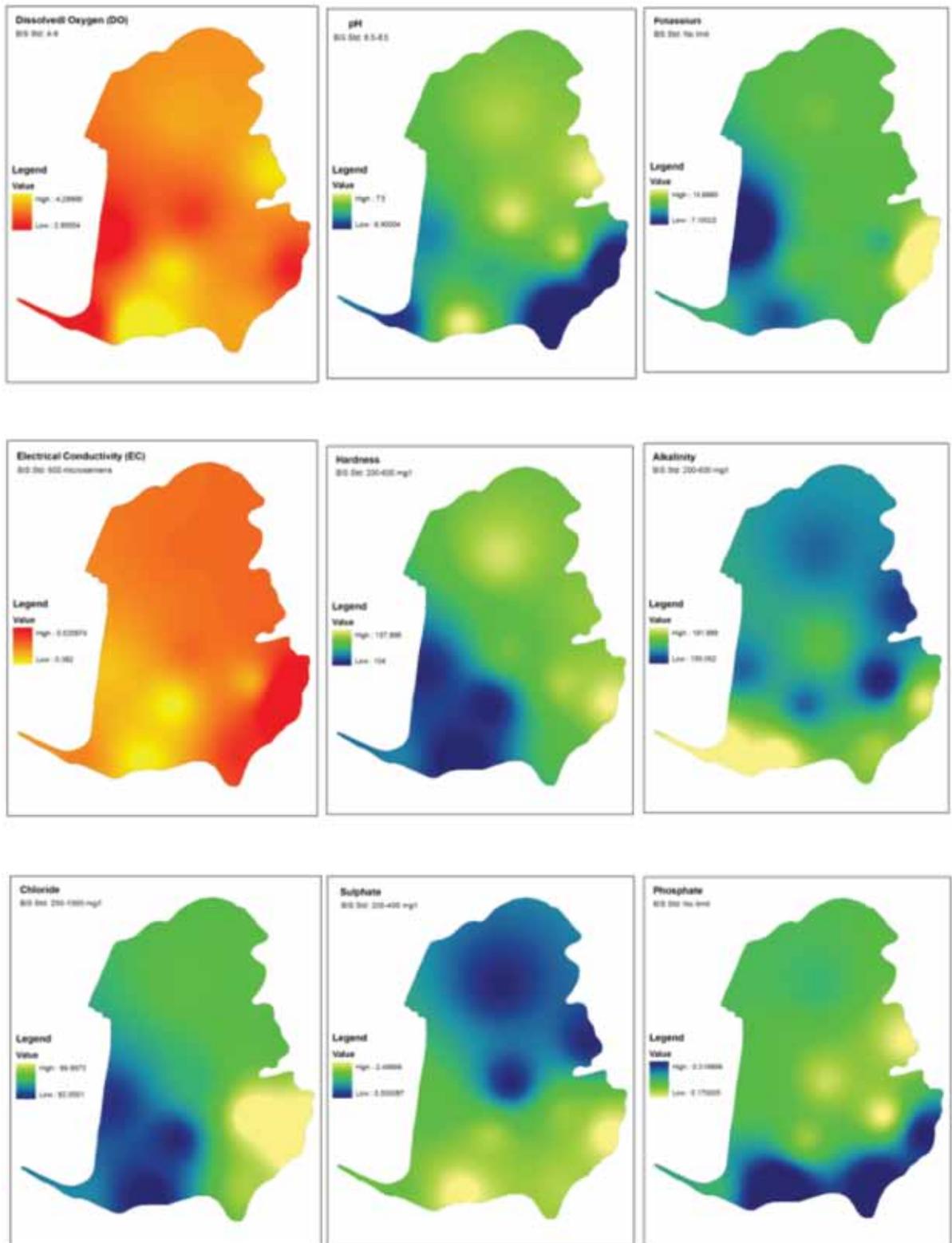
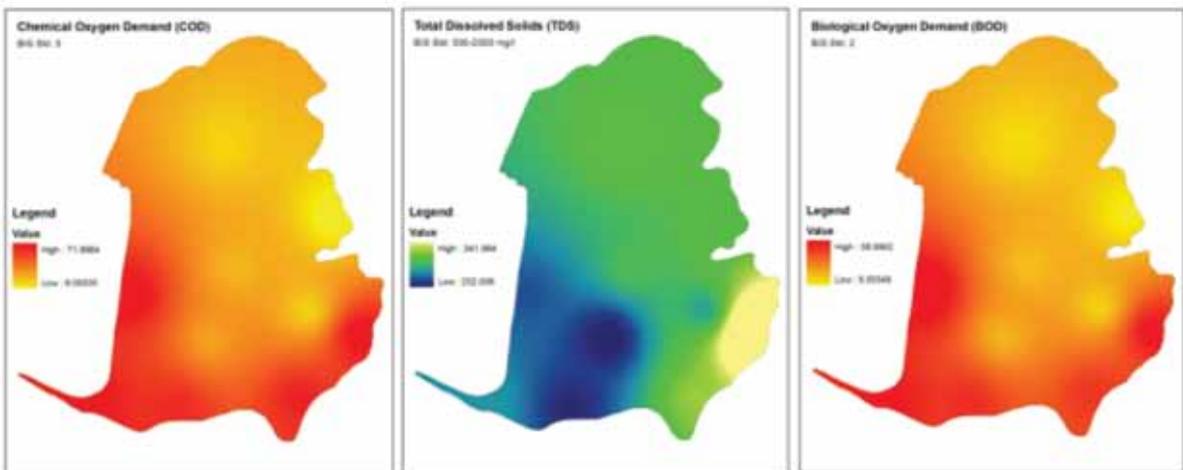
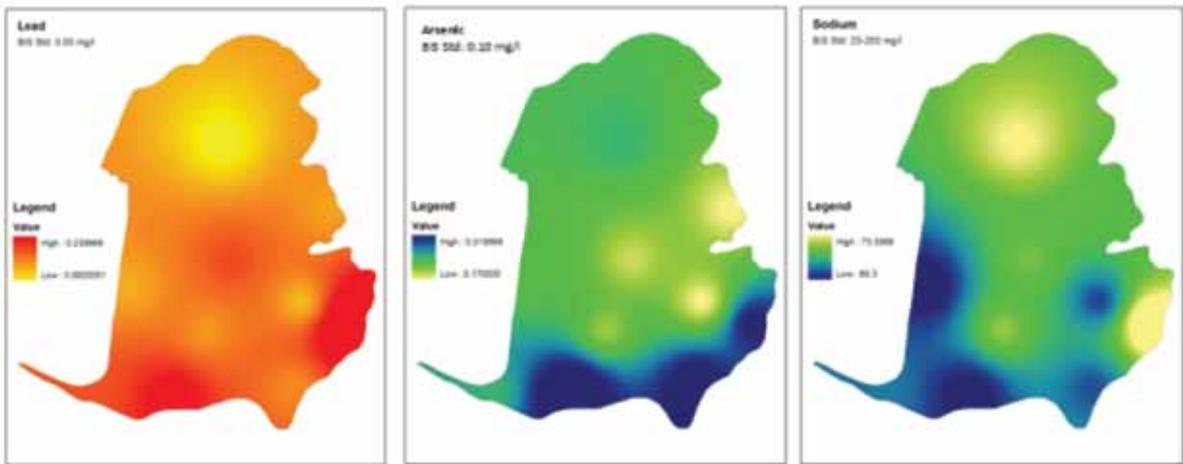
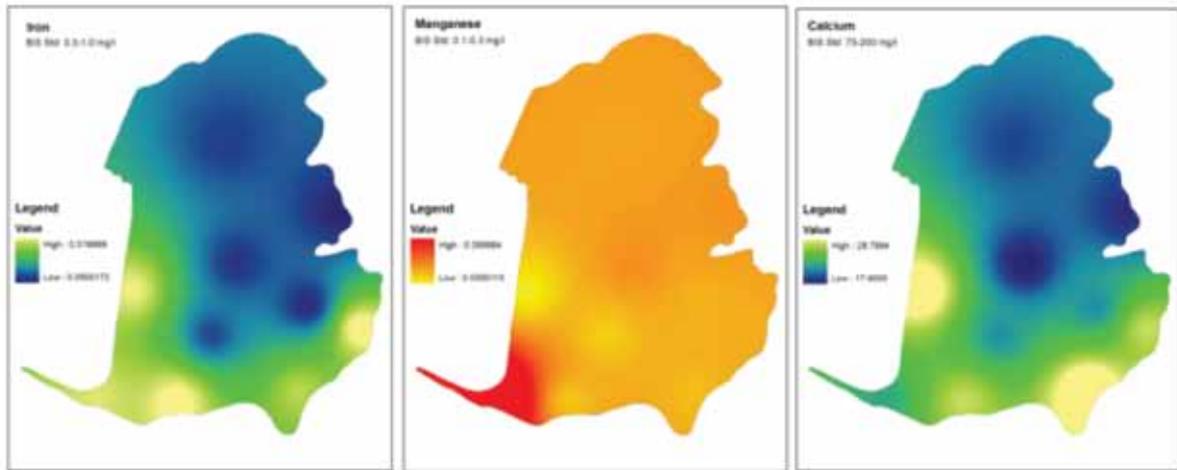
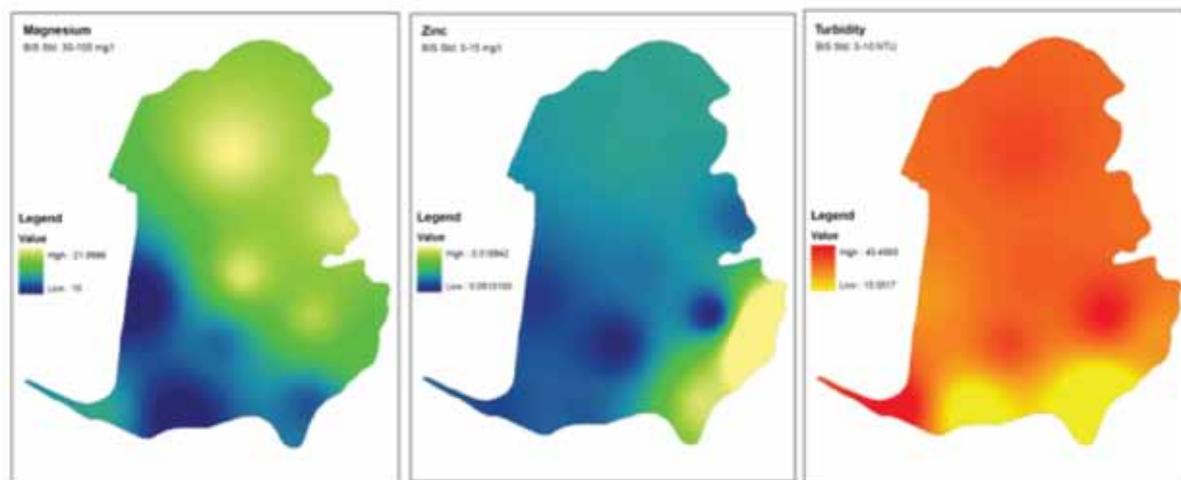


Figure 5: Mapping the Water Quality of Ousteri for Various Parameters







calcium content (22.6 mg/l) and alkaline eutrophic nature of the water, the class bacillariophyceae dominates, with highest capacity. The presence of the low available phosphorous and high organic phosphorous in the surface water is indicative of the highly eutrophic nature of the wetland. An abundance of nutrients and a favourable pH promote the growth of aquatic macrophytes and phytoplankton. The resultant dense growth of macrophytes and phytoplankton can reduce the oxygen levels in the surface water, creating unfavourable conditions for the survival of certain fish.

7.3. Land Use and Land Cover Status of Ousteri and its Environs

The Landsat satellite image of Ousteri was taken for the period of 2014, with 30 metre pixel resolution. The imagery was classified into four land-use/land cover classes, namely water body, settlements, vegetation/agriculture and scrub/fallow. A radius of 5–8 km around the wetland was considered for comparison and assessment of land use changes (Figure 6–7 and Table 16–17).

The following sources of information were used for the assessment:

1. Landsat 8 OLI satellite data of Path: 142 and Row: 52, acquired in September 2014
2. Survey of India Open series Map No. C44B13 and C44B9
3. Erdas Imagine 2011 – Image processing software
4. Global positioning system

The satellite data was downloaded from the USGS website. The study area, consisting of Ousteri and an area of 5–8 km around the wetland was demarcated from the satellite imagery. As the pixel size was 30 metres, the classification was done at a scale of

1:50,000. Unsupervised classification was performed with 50 classes. The class name for each group of pixels was assigned interactively and recoded. Field verification was done with the classified map and post-classification corrections were also made. There are only four land use and land cover classes: 1) water body, 2) settlement, 3) agriculture/vegetation, and 4) scrub/fallow. Accuracy assessment was also done to estimate the overall accuracy of the classification, individual class and kappa statistics (Table 16). A radius of 5–8 km around the wetland was considered in the LU/LC study to understand the present status of LU/LC and estimate any radical changes in the region. Focusing on the entire drainage basin has been a difficult task within the given time because finding a drainage basin involves: (i) digitisation of all drainage streams from different toposheets, (ii) merging all the streams, and (iii) preparation of a drainage basin. This is an area for future work.

The land use and land cover status of the water body and its environs show that vegetation/agriculture occupy most of the land, followed by scrub/fallow land. The settlement class, seen mainly in the southeast side of the wetland, occupies a considerable area of land (see Table 17). Apart from Ousteri, few more natural water bodies also consume a significant amount of land in this region. The Gingee River flows southwest of the wetland. The land use system around Ousteri is chiefly occupied by agricultural land systems and human settlements.

Analysis of information on the cropping pattern reveals that apart from paddy, casuarina is also a major crop in the adjoining areas of the wetland. As a commercial plant, casuarinas can generate income from the third year of planting onwards. It is a drought-

Table 9: List of Avifauna Species Recorded in and around Ousteri

Sl. No.	Common name	Scientific name	Status IUCN
1	Little Grebe	<i>Tachybaptus ruficollis</i>	LC
2	Great White Pelican	<i>Pelecanus onocrotalus</i>	LC
3	Spot-billed Pelican	<i>Pelecanus philippensis</i>	NT
4	Little Cormorant	<i>Phalacrocorax niger</i>	LC
5	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	LC
6	Great Cormorant	<i>Phalacrocorax carbo</i>	LC
7	Darter	<i>Anhinga melanogaster</i>	NT
8	Grey Heron	<i>Ardea cinerea</i>	LC
9	Indian Pond Heron	<i>Ardeola grayii</i>	LC
10	Little Heron	<i>Butorides striata</i>	LC
11	Purple Heron	<i>Ardea purpurea</i>	LC
12	Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	LC
13	Greater Egret	<i>Casmerodius albus</i>	LC
14	Intermediate Egret	<i>Mesophoyx intermedia</i>	LC
15	Little Egret	<i>Egretta garzetta</i>	LC
16	Cattle Egret	<i>Bubulcus ibis</i>	LC
17	Great Bittern	<i>Botaurus stellaris</i>	LC
18	Black Bittern	<i>Dupetor flavicollis</i>	LC
19	Painted Stork	<i>Mycteria leucocephala</i>	NT
20	Asian Openbill	<i>Anastomus oscitans</i>	LC
21	Woolly-necked Stork	<i>Ciconia episcopus</i>	LC
22	Black Headed Ibis	<i>Threskiornis melanocephalus</i>	NT
23	Black Ibis	<i>Pseudibis papillosa</i>	LC
24	Eurasian Spoonbill	<i>Platalea leucorodia</i>	NT
25	Greater Flamingo	<i>Phoenicopterus ruber</i>	NT
26	Lesser Flamingo	<i>Phoenicopterus minor</i>	NT
27	Common Poachard	<i>Aythya ferina</i>	LC
28	Cotton Pygmy-Goose	<i>Nettapus coromandelianus</i>	LC
29	Eurasian Wigeon	<i>Anas penelope</i>	LC
30	Common Teal	<i>Anas crecca</i>	LC
31	Gargany Teal	<i>Anas querquedula</i>	LC
32	Mallard	<i>Anas platyrhynchos</i>	LC
33	Northern Pintail	<i>Anas acuta</i>	LC
34	Northern Shoveler	<i>Anas clypeata</i>	LC
35	Spot-billed Duck	<i>Anas poecilorhyncha</i>	LC
36	Unidentified Duck	<i>Anas sp.</i>	LC
37	Besra	<i>Accipiter virgatus</i>	LC
38	Shikra	<i>Accipiter badius</i>	LC
39	Black Eagle	<i>Ictinaetus malayensis</i>	LC
40	Crested Serpent Eagle	<i>Spilornis cheela</i>	LC
41	White-bellied Sea Eagle	<i>Haliaeetus leucogaster</i>	EN
42	Black Kite	<i>Milvus migrans</i>	NT
43	Black-shouldered Kite	<i>Elanus caeruleus</i>	LC
44	Brahminy Kite	<i>Haliastur indus</i>	LC
45	Eurasian Marsh Harrier	<i>Circus aeruginosus</i>	LC
46	Pallid Harrier	<i>Circus macrourus</i>	NT
47	Pied Harrier	<i>Circus melanoleucus</i>	LC
48	Osprey	<i>Pandion haliaetus</i>	LC
49	Common Kestrel	<i>Falco tinnunculus</i>	LC
50	Grey Francolin	<i>Francolinus pondicerianus</i>	LC
51	Indian Peafowl	<i>Pavo cristatus</i>	LC
52	Common Coot	<i>Fulica atra</i>	LC
53	Common Moorhen	<i>Gallinula chloropus</i>	LC
54	Purple Swampphen	<i>Porphyrio porphyrio</i>	LC
55	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	LC
56	Bronze-winged Jacana	<i>Metopidius indicus</i>	LC
57	Pheasant Tailed Jacana	<i>Hydrophasianus chirurgus</i>	LC
58	Grey-headed Lapwing	<i>Vanellus cinereus</i>	LC

Contd...

Sl. No.	Common name	Scientific name	Status IUCN
59	Red-wattled Lapwing	<i>Vanellus indicus</i>	LC
60	Yellow-wattled Lapwing	<i>Vanellus malabaricus</i>	LC
61	Grey Plover	<i>Pluvialis squatarola</i>	LC
62	Little Ringed Plover	<i>Charadrius dubius</i>	LC
63	Common Redshank	<i>Tringa totanus</i>	LC
64	Marsh Sandpiper	<i>Actitis hypoleucos</i>	LC
65	Green Sandpiper	<i>Tringa ochropus</i>	LC
66	Wood Sandpiper	<i>Tringa glorioles</i>	LC
67	Black-winged Stilt	<i>Himantopus himantopus</i>	LC
68	Black-bellied Tern	<i>Sterna acuticauda</i>	EN
69	Black-naped Tern	<i>Sterna sumatrana</i>	LC
70	Common Tern	<i>Sterna hirundo</i>	LC
71	River Tern	<i>Sterna aurantia</i>	NT
72	Whiskered Tern	<i>Chlidonias hybridus</i>	LC
73	White-winged Tern	<i>Chlidonias niger</i>	LC
74	Dunlin	<i>Calidris alpina</i>	LC
75	Broad Billed Sandpiper	<i>Limicola falcinellus</i>	LC
76	Curlew Sandpiper	<i>Calidris ferruginea</i>	LC
77	Spoon Billed Sandpiper	<i>Eurynorhynchus pygmeus</i>	CE
78		<i>Philomachus pugnax</i>	LC
79	Little Stint	<i>Calidris minuta</i>	LC
80	Common Snipe	<i>Gallinago gallinago</i>	LC
81	Rock Pigeon	<i>Columba livia</i>	LC
82	Laughing Dove	<i>Streptopelia senegalensis</i>	LC
83	Red Collared Dove	<i>Streptopelia tranquebarica</i>	LC
84	Spotted Dove	<i>Streptopelia chinensis</i>	LC
85	Rose-ringed Parakeet	<i>Psittacula krameri</i>	LC
86	Chestnut-winged Cuckoo	<i>Clamator coromandus</i>	LC
87	Common Hawk Cuckoo	<i>Hierococcyx varius</i>	LC

Sl. No.	Common name	Scientific name	Status IUCN
88	Drongo Cuckoo	<i>Surniculus lugubris</i>	LC
89	Pied-crested Cuckoo	<i>Clamator jacobinus</i>	LC
90	Asian Koel	<i>Eudynamis scolopacea</i>	LC
91	Blue-faced Malkoha	<i>Phaenicophaeus viridirostris</i>	LC
92	Greater Coucal	<i>Centropus sinensis</i>	LC
93	Lesser Coucal	<i>Centropus bengalensis</i>	LC
94	Barn Owl	<i>Tyto alba</i>	LC
95	Spotted Owlet	<i>Athene brama</i>	LC
96	Indian Nightjar	<i>Caprimulgus asiaticus</i>	LC
97	Asian Palm Swift	<i>Cypsiurus balasiensis</i>	LC
98	Crested Tree-swift	<i>Hemiprocne coronata</i>	LC
99	House Swift	<i>Apus affinis</i>	LC
100	Black-capped Kingfisher	<i>Halcyon pileata</i>	LC
101	Common Kingfisher	<i>Alcedo atthis</i>	LC
102	Pied Kingfisher	<i>Ceryle rudis</i>	LC
103	Stork-billed Kingfisher	<i>Halcyon capensis</i>	LC
104	White-breasted Kingfisher	<i>Halcyon smyrnensis</i>	LC
105	Blue-tailed Bee-eater	<i>Merops philippinus</i>	LC
106	Chestnut-headed Bee-eater	<i>Merops leschenaulti</i>	LC
107	Green Bee-eater	<i>Merops orientalis</i>	LC
108	Indian Roller	<i>Coracias benghalensis</i>	LC
109	Common Hoopoe	<i>Upupa epops</i>	LC
110	Coppersmith Barbet	<i>Megalaima haemacephala</i>	LC
111	White-cheeked Barbet	<i>Megalaima viridis</i>	LC
112	Black-rumped Flameback	<i>Dinopium benghalense</i>	LC
113	Common Flameback	<i>Dinopium javanense</i>	LC

Contd...

Sl. No.	Common name	Scientific name	Status IUCN
114	Indian Pitta	<i>Pitta brachyura</i>	LC
115	Ashy-crowned Sparrow	<i>Eremopterix griseus</i>	LC
116	Rufous-winged Bushlark	<i>Mirafra assamica</i>	LC
117	Barn Swallow	<i>Hirundo rustica</i>	LC
118	Pacific Swallow	<i>Hirundo tabitica</i>	LC
119	Red-rumped Swallow	<i>Hirundo daurica</i>	LC
120	Bay-backed Shrike	<i>Lanius vittatus</i>	LC
121	Southern Grey Shrike	<i>Lanius meidionalis</i>	LC
122	Black-hooded Oriole	<i>Oriolus xanthornus</i>	LC
123	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	LC
124	Ashy Drongo	<i>Dicrurus leucophaeus</i>	LC
125	Black Drongo	<i>Dicrurus macrocercus</i>	LC
126	White-bellied Drongo	<i>Dicrurus caerulescens</i>	LC
127	Ashy Wood Swallow	<i>Artamus fuscus</i>	LC
128	Brahminy Starling	<i>Sturnus pagodarum</i>	LC
129	Common Myna	<i>Acridothores tristis</i>	LC
130	Rosy Starling	<i>Sturnus roseus</i>	LC
131	House Crow	<i>Corvus splendens</i>	LC
132	Jungle Crow	<i>Corvus macrorhynchos</i>	LC
133	Rufous Treepie	<i>Dendrocitta vagabunda</i>	LC
134	Common Wood Shrike	<i>Tephrodornis pondicerianus</i>	LC
135	Common Iora	<i>Aegithina tiphia</i>	LC
136	Red-vented Bulbul	<i>Pycnonotus cafer</i>	LC
137	White-browed Bulbul	<i>Pycnonotus luteolus</i>	LC
138	Jungle Babbler	<i>Turdoides striatus</i>	LC
139	White-headed Babbler	<i>Turdoides affinis</i>	LC

Sl. No.	Common name	Scientific name	Status IUCN
140	Tawny-bellied Babbler	<i>Dumetia hyperythra</i>	LC
141	Paradise flycatcher	<i>Terpsiphone paradisi</i>	LC
142	White-browed Fantail	<i>Rhipidura aureola</i>	LC
143	Blyth's Reed Warbler	<i>Acrocephalus dumetorum</i>	LC
144	Greenish Warbler	<i>Phylloscopus trochiloides</i>	LC
145	Common Tailorbird	<i>Orthotomus atrogularis</i>	LC
146	Pied Buschat	<i>Saxicola caprata</i>	LC
147	Indian Robin	<i>Saxicoloides fulicata</i>	LC
148	Oriental Magpie Robin	<i>Copsychus saularis</i>	LC
149	Paddyfield Pipit	<i>Anthus rufulus</i>	LC
150	Ashy Prinia	<i>Prinia socialis</i>	LC
151	Franklin's Prinia	<i>Prinia hodgsonii</i>	LC
152	Jungle Prinia	<i>Prinia sylvatica</i>	LC
153	Plain Prinia	<i>Prinia inornata</i>	LC
154	Grey Wagtail	<i>Motacilla cinerea</i>	LC
155	White-browed Wagtail	<i>Motacilla maderaspatensis</i>	LC
156	Yellow Wagtail	<i>Motacilla flava</i>	LC
157	Thick-billed Flowerpecker	<i>Dicaeum agile</i>	LC
158	Tickell's Flowerpecker	<i>Dicaeum erythrorhynchos</i>	LC
159	Loten's Sunbird	<i>Nectarinia lotenia</i>	LC
160	Purple Sunbird	<i>Nectarinia asiatica</i>	LC
161	Purple-rumped Sunbird	<i>Nectarinia zeylonica</i>	LC
162	House Sparrow	<i>Passer domesticus</i>	LC
163	Baya Weaver	<i>Ploceus philippinus</i>	LC
164	Black-headed Munia	<i>Lonchura malacca</i>	LC
165	Scaly-breasted Munia	<i>Lonchura punctulata</i>	LC
166	Indian Silverbill	<i>Lonchura malabarica</i>	LC

The list of flora and fauna species given in the above table are based on the primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

Table 10: List of Butterflies Species Recorded in and around Ousteri

Sl.No	Common Name	Scientific Name	IUCN Status
1	Blue Mormon	<i>Papilio polymnestor</i>	ENDEMIC
2	Common Banded Peacock	<i>Papilio crino</i>	ENDEMIC
3	Common Jay	<i>Graphium doson</i>	DD
4	Common Mormon	<i>Papilio polytes</i>	LC
5	Common Rose	<i>Pachliopta aristolochiae</i>	DD
6	Crimson Rose	<i>Pachliopta hector</i>	ENDEMIC
7	Lime Butterfly	<i>Papilio demoleus</i>	DD
8	Southern Birdwing	<i>Troides minos</i>	ENDEMIC
9	Tailed Jay	<i>Graphium agamemnon</i>	DD
10	Common Emigrant	<i>Catopsilia pomona</i>	DD
11	Common Jezebel	<i>Delias eucharis</i>	LC
12	Common Grass yellow	<i>Eurema hecabe</i>	LC
13	Common Gull	<i>Cepora nerissa</i>	LC
14	Common Wanderer	<i>Pareronia valeria</i>	DD
15	Crimson Tip	<i>Colotis danae</i>	DD
16	Great Orange Tip	<i>Hebomoia glaucippe</i>	DD
17	Mottled Emigrant	<i>Catopsilia pyranthe</i>	DD
18	Psyche	<i>Leptosia nina</i>	DD
19	Small Grass Yellow	<i>Eurema brigitta</i>	LC
20	Small Orange Tip	<i>Colotis etrida</i>	DD
21	Spotless Grass Yellow	<i>Eurema laeta</i>	DD
22	White Orange Tip	<i>Ixias marianne</i>	LC
23	Yellow Orange Tip	<i>Ixias pyrene</i>	DD
24	Angled Castor	<i>Ariadne ariadne</i>	DD
25	Baronet	<i>Euthalia nais</i>	DD
26	Chocolate Pansy	<i>Precis iphita</i>	DD
27	Common Bush Brown	<i>Mycalis perseus</i>	DD
28	Common Castor	<i>Ariadne merione</i>	DD
29	Common Crow	<i>Euploea core</i>	LC
30	Common Evening Brown	<i>Melanitis leda</i>	DD
31	Common Leopard	<i>Phalanta phalantha</i>	DD
32	Common Sailer	<i>Neptis hylas</i>	DD
33	Common Sergeant	<i>Athyma perius</i>	DD
34	Danaid Eggfly	<i>Hypolimnas misippus</i>	DD
35	Dark Blue Tiger	<i>Tirumala septentrionis</i>	DD
36	Double-branded Crow	<i>Euploea sylvester</i>	ENDEMIC
37	Glassy Tiger	<i>Parantica aglea</i>	DD
38	Great Eggfly	<i>Hypolimnas bolina</i>	DD
39	Lemon Pansy	<i>Junonia lemonias</i>	DD
40	Peacock Pansy	<i>Junonia almana</i>	LC
41	Plain Tiger	<i>Danaus chrysippus</i>	DD
42	Striped Tiger	<i>Danaus genutia</i>	DD
43	Tawny Coster	<i>Acraea violae</i>	LC
44	Yellow Pansy	<i>Junonia hierta</i>	LC
45	African Babul blue	<i>Azonus jesus</i>	DD
46	Banded Blue Pierrot	<i>Discolampa ethion</i>	DD
47	Common Cerulean	<i>Jamides celeno</i>	DD
48	Common Pierrot	<i>Castalius rosimon</i>	LC

Contd...

Sl.No	Common Name	Scientific Name	IUCN Status
49	Common Silverline	<i>Spindasis vulcanus</i>	DD
50	Dark Cerulean	<i>Jamides bochus</i>	DD
51	Plains Cupid	<i>Chilades pandava</i>	DD
52	Slate Flash	<i>Rapala manea</i>	DD
53	Tiny Grass Blue	<i>Zizula hylax</i>	DD
54	Zebra Blue	<i>Lepotes plinius</i>	DD
55	Brown Awl	<i>Badamia exclamationis</i>	DD
56	Bush Hopper	<i>Ampittia dioscorides</i>	DD

Sl.No	Common Name	Scientific Name	IUCN Status
57	Chestnut Bob	<i>Iambrix salsala</i>	DD
58	Common Banded Owl	<i>Hasora chromus</i>	DD
59	Common Grass Dart	<i>Taractrocera maevius</i>	DD
60	Dark Palm Dart	<i>Telicota ancilla</i>	DD
61	Indian Palm Bob	<i>Suastus gremius</i>	DD
62	Indian Skipper	<i>Spialia galba</i>	LC
63	Rice Swift	<i>Borbo cinnara</i>	DD

The list of flora and fauna species given in the above table are based on the primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

Table 11: List of Ichthyofauna Species Recorded in and around Ousteri

Sl. No.	Common Name	Scientific Name	IUCN Status
1	Catla	<i>Catla Catla</i>	DD
2	Tilapia	<i>Oreochromis mossambica</i>	DD
3	Striped Snakehead	<i>Channa striatus</i>	DD
4	Rohu	<i>Labeo rohita</i>	LC
5	Karnataka Labeo	<i>Labeo calbasu</i>	LC
6	Mrigal	<i>Cirrhinus mrigala</i>	LC
7	Striped Dwarf Catfish	<i>Mystus vittatus</i>	LC
8	Stinging catfish	<i>Heteropneustes fossilis</i>	DD
9	Asiatic snake head	<i>Channa orientalis</i>	DD
10	Spotted Snake head	<i>Channa punctatus</i>	DD
11	Giant snake head	<i>Channa marulius</i>	LC
12	Indian Shortfin eel	<i>Anguilla bicolor</i>	NT

Sl. No.	Common Name	Scientific Name	IUCN Status
13	Grass carp	<i>Ctenopharyngodon idella</i>	DD
14	Common carp	<i>Cyprinus carpio</i>	VULNERABLE
15	Indian Potassi	<i>Pseudeutropius atherinoides</i>	DD
16	Silver carp	<i>Hypophthalmichthys molitrix</i>	NT
17	Prawn	<i>Fenneropenaeus indicus</i>	DD
18	Striped Spiny ee	<i>Macrognathus pancalus</i>	LC
19	Mosquito fish	<i>Gambusia affinis</i>	LC
20	Sleepy goby	<i>Glossogobius giuris</i>	LC
21	Magur	<i>Clarias batrachus</i>	LC
22	Orange chromide	<i>Etroplus maculatus</i>	DD
23	Green chromide	<i>Etroplus suratensis</i>	LC
24	Gangetic mystus	<i>Mystus cavasius</i>	LC

The list of flora and fauna species given in the above table are based on the primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

Table 12: List of Herpetofauna Species Recorded in and around Ousteri

Sl.No	Common Name	Scientific Name	IUCN Status
Frogs			
1	Common Indian Toad	<i>Duttaphrynus melanostictus</i>	LC
2	Water Skipper or Skipper Frog	<i>Euphlyctis cyanophlyctis</i>	LC
3	Indian Pond or Green Frog	<i>Euphlyctis hexadactylus</i>	LC
4	Cricket Frog	<i>Fejervarya mudduraja</i>	LC
5	Indian Bull Frog	<i>Hoplobatrachus tigerinus</i>	LC
6	Indian Burrowing Frog	<i>Sphaerotheca breviceps</i>	LC
7	Ornate Narrow-mouthed Frog	<i>Microhyla ornata</i>	LC
8	Narrow-mouthed Frog	<i>Ramanella variagata</i>	LC
9	Lesser or Marbled Balloon Frog	<i>Uperodon systoma</i>	LC
Turtles			
1	Indian Starred Tortoise	<i>Geochelone elegans</i>	LC
2	Indian Black Turtle	<i>Melanochelys trijuga</i>	NT
3	Indian Flapshell Turtle	<i>Lissemys punctata</i>	LC
Lizards			
1	Snake Skink	<i>Lygosoma punctatus</i>	DD
2	Common Supple Skink	<i>Eutropis macularius</i>	DD
3	Common Brahminy Skink	<i>Eutropis carinata</i>	LC
4	Termite Hill Gecko	<i>Hemidactylus triedrus</i>	DD
5	Southern House Gecko	<i>Hemidactylus frenatus</i>	LC

Sl.No	Common Name	Scientific Name	IUCN Status
6	Fan-throated Lizard Sitana	<i>Sitana ponticeriana</i>	LC
7	Bark Gecko	<i>Hemidactylus leschnaulti</i>	DD
8	Common Garden Lizard	<i>Calotes versicolor</i>	DD
9	Indian Chameleon	<i>Chamaeleon zeylanicus</i>	LC
10	Indian Monitor Lizard	<i>Varanus bengalensis</i>	LC
Snakes			
1	Brahminy Worm Snake	<i>Ramphotylops braminus</i>	DD
2	Common Sand Boa	<i>Gongylophis conicus</i>	DD
3	Red Sand Boa	<i>Eryx johnii</i>	DD
4	Indian Rock Python	<i>molurus molurus</i>	DD
5	Indian Bronze Back	<i>Dendrelaphis tristis</i>	DD
6	Common Vine snake	<i>Ahaetulla nasuta</i>	DD
7	Striped-keelback	<i>Amphiesma stolata</i>	DD
8	Common Cat Snake	<i>Boiga trigonota</i>	DD
9	Checkered Keelback	<i>Xenochrophis piscator</i>	DD
10	Indian Wolf Snake	<i>Lycodon aulicus</i>	DD
11	Indian Kukri	<i>Oligodon arnensis</i>	DD
12	Indian Rat Snake	<i>Ptyas mucosa</i>	DD
13	Spectacled Cobra	<i>Naja naja</i>	LC
14	Russell's Viper	<i>Daboia russelii</i>	LC
15	Saw -scaled Viper	<i>Crotalus horridus</i>	LC

The list of flora and fauna species given in the above table are based on the primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

Table 13: List of Mammals Species Recorded in and around Ousteri

Sl. No.	Common Name	Scientific Name	IUCN Status
1	Spotted deer	<i>Axis axis</i>	LC
2	Jackal	<i>Canis aureus</i>	LC
3	Jungle cat	<i>Felis chaus</i>	DD
4	Common mongoose	<i>Herpestes edwardsii</i>	LC
5	Black naped hare	<i>Lepus nigricollis</i>	LC
6	Bonnet macaque	<i>Macaca radiata</i>	LC
7	Indian porcupine	<i>Hystrix indica</i>	LC
8	Three-striped palm squirrel	<i>Funambulus palmarum</i>	LC
9	Bandicoot rat	<i>Bandicota indica</i>	LC
10	Indian pangolin	<i>Manis crassicaudata</i>	ENDANGERED
11	Asian Palm Civet	<i>Paradoxurus hermaphroditus</i>	LC
12	Mice	<i>Mus sp</i>	LC
13	Short-nosed Fruit Bat	<i>Cynopterus brachyotis</i>	LC
14	Flying fox	<i>Pteropus conspicillatus</i>	VULNERABLE

The list of flora and fauna species given in the above table are based on the primary survey and also compiled from Alexander and Sivasankar (2013); Chari and Abbasi (2003); Murugesan et al. (2013), Padmavathy et al. (2010); Sacon (2011).

tolerant crop and is capable of surviving for several days without water. It is a less labour-intensive crop and therefore, it can be cultivated in a labour-scarce region as well. As the groundwater level around the wetland is also relatively better than other areas, the growth of casuarina is well suited to the region. It is also planted around the other crops as shelter belts. It is able to withstand heavy wind. So, farmers prefer to cultivate casuarinas not only for income but also to minimise cultivation efforts. Moreover, there is also a decent demand for its output, as it is widely used in various ways, such as in construction, households, industries, festivals and meetings.

Table 14: Hydrology and Structures Associated with Ousteri

Features	Particulars
Ayacut	1568 ha(3855 acres)
Free Catchment Area	10.36 sq.km
Intercepted catchment	5.18 sq.km
Combined Catchment	15.54 sq.km
Capacity of the Wetland	540 million ft ³
Average yield	0.169 Mm ³ /sq.km
Full Tank Level	+14.184 m
Maximum Water Level	+14.184 m
Top Bund Level	+16.504 m
Free Board	2.02 m
Gross Storage	15.29 mm ³
Live Storage	15.29 mm ³
Dead Storage	Nil
Type of bund	Earthen bund
Length of bund	727.5 m
Slide Slope (i) Front	1.5:1
(ii) Rear	2:1
Type of weir	Broad crested weir
Length of weir	24.50 m
Crest level of weir	+11.894
Max. discharge capacity	92.99 cumecs

Next to casuarina, coconut is another important commercial crop planted by the farmers. Growing coconut yields sustained revenue to the farmers. Cashew is another major commercial crop grown widely in this region for many years. In fact, the soil in this region is well suited for the growth of cashew. It is also a drought-tolerant crop, giving unrelenting revenue to farmers. Apart from the above crops, paddy, banana, and sugarcane are also cultivated in pockets where suitable irrigation facilities are available. Based on personal interviews with farmers, it is understood that the land under paddy cultivation in the Puducherry region is slowly reducing, owing to various reasons, including lack of water availability, labour scarcity, uneconomical farming practices, poor yield, unpredictable and erratic monsoon, and lack of interest among the younger generations to practice agriculture. Thus, a majority of paddy growing in the area is now slowly being converted for sugarcane (a water-intensive crop) and casuarina (a less water-intensive crop) cultivation. A detailed study

Figure 6: False Color Composite of Ousteri and its Environs during 2014

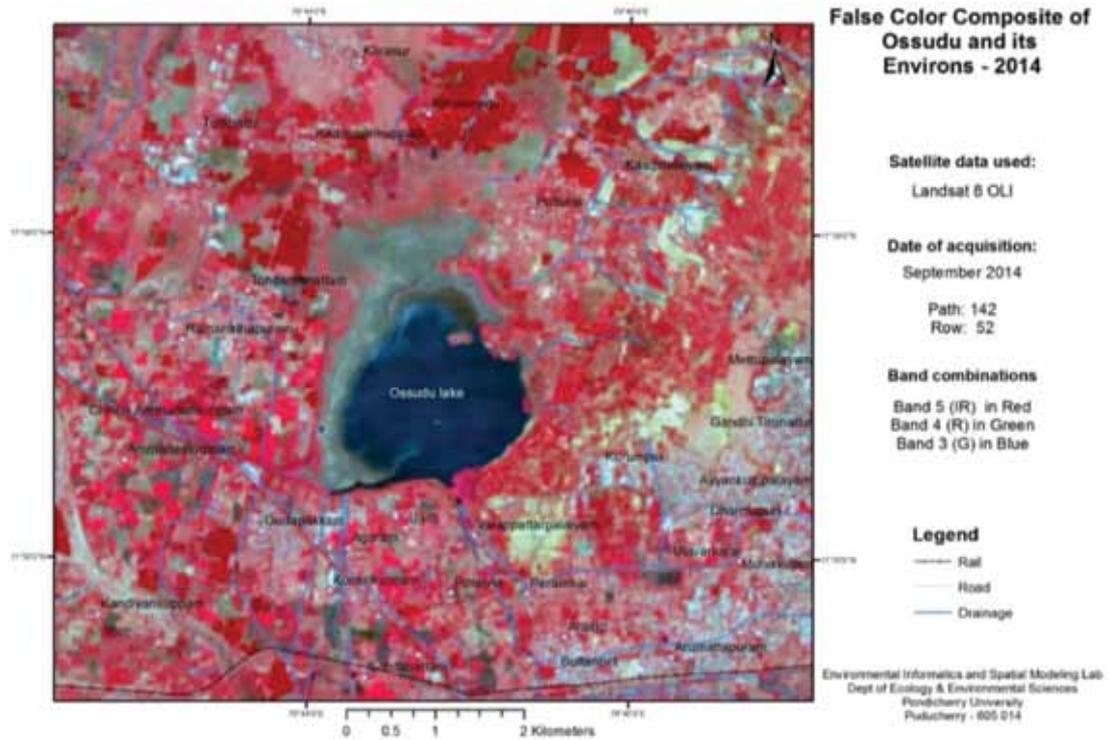


Figure 7: Land Use and Land Cover Map of Ousteri and its Environs during 2014

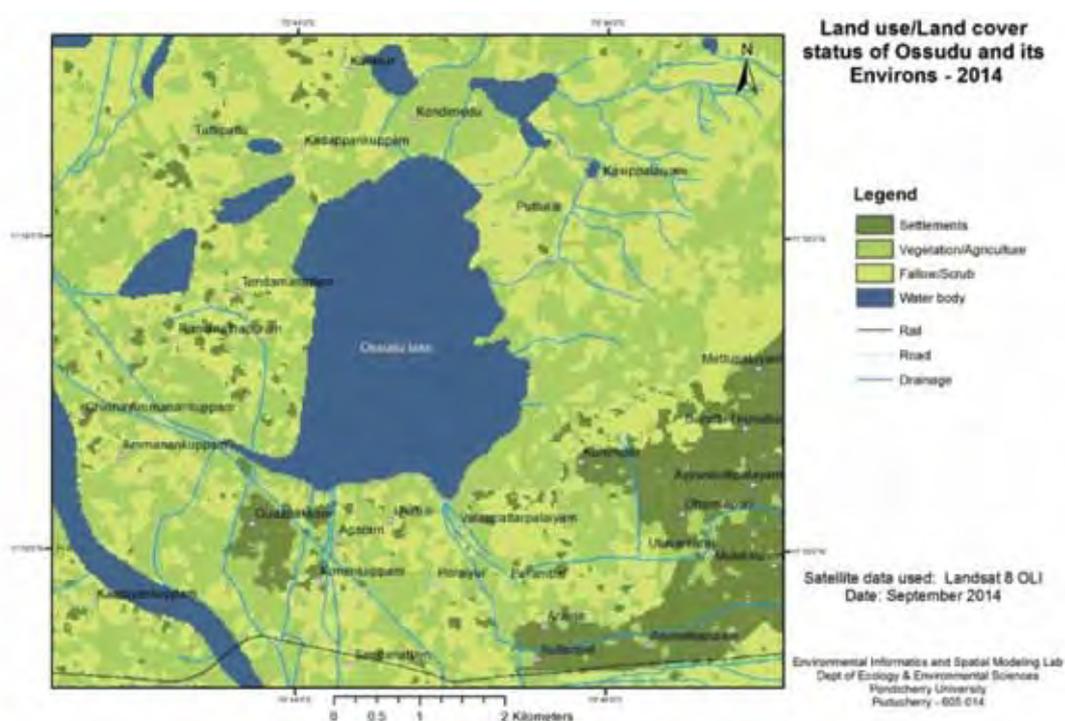


Table 15: Water Quality Assessment – Ousteri (2014)

Parameters	Values recorded		Average	BIS standards	
	Low	High		Low	High
pH	6.9	7.5	7.29	6.5	8.5
EC	382	521	420.9	600 μ s	600 μ s
TURBIDITY	15	40.5	31.11	5(NTU)	10(NTU)
HARDNESS	104	138	123.6	200 mg/l	600 mg/l
CALCIUM	17.6	28.8	22.64	75 mg/l	200 mg/l
MAGNESIUM	10	21.5	16.75	30 mg/l	100 mg/l
SODIUM	66.3	73.6	69.34	20 mg/l	200 mg/l
POTASSIUM	7.1	11	8.89	No limit	
CHLORIDE	154	192	168	250 mg/l	1000 mg/l
PHOSPHATE	0.17	0.32	0.22	No limit	
ALKALINITY	154	192	168	200 mg/l	600 mg/l
SULPHATE	0.5	2.5	1.65	200 mg/l	400 mg/l
IRON	0.05	0.32	0.185	0.3 mg/l	1.0 mg/l
COPPER	0	0	0	0.05 mg/l	1.5 mg/l
MANGANESE	0.03	0.39	0.105	0.1 mg/l	0.3 mg/l
ZINC	0.051	0.319	0.103	5 mg/l	15 mg/l
LEAD	0.082	0.24	0.132	0.05 mg/l	0.05 mg/l
ARSENIC	0.17	0.33	0.22	0.10 mg/l	0.10 mg/l
CADMIUM	0	0	0	0.003 mg/l	0.003 mg/l
CHROMIUM	0	0	0	0.05 mg/l	0.05 mg/l
TDS	252	342	280	500 mg/l	2000 mg/l
COD	8	72	45	5	5
BOD	5	59	30.6	2	2
DO	2.9	4.3	3.55	4	6

Source: *Primary Survey***Table 16: Accuracy Assessment - 2014**

	Waterbody	Settlement	Agri./Veg.	Scrub/Fallow	Total
Waterbody	22	0	0	3	25
Settlement	0	21	0	4	25
Agri./Veg.	0	0	23	2	25
Scrub/Fallow	2	0	1	22	25
Total	24	21	24	31	100

Producer accuracy:

Waterbody – 91.67%,
 Settlement – 100%,
 Agri./Veg. – 95.83%,
 Scrub/ Fallow – 70.97%

User accuracy:

Water – 88.00%,
 Settlement – 84%,
 Agri./Veg. – 92%,
 Scrub/ Fallow – 88%

Overall classification accuracy: 88%**Overall Kappa Statistics: 0.84**

is required to assess the change in water demand due to this shift in the cropping pattern of this region.

When an outline of Ousteri was traced based on the 1:50,000 scale from the Survey of India Toposheets on top of Google earth, it is found that the northern side of the wetland (where water is not available during the summer season) is being used for agricultural purposes, compared to other areas. Although we see encroachment inside the wetland, it is not possible to accurately estimate the extent. However, it has been confirmed through field visits, that encroachment of the wetland has taken place due to land area being used for agricultural purpose. The encroachment took place long back, and the high-resolution images of 2005 and 2015 confirm this as well (Figure 8–10). Agglomeration of settlements around the wetland is common. However, the majority of settlements are located on the southeastern side of the wetland.

The land use and land cover activities closer to the wetland appear to have an effect on the wetland morphology, water quality and ecosystem services. Thus, two buffers of 500 and 1000 metres were created around the wetland boundary. Based on the buffer

Table 17: Land use and Land cover status of Ousteri and its environs during 2014

Sl. No	Class Name	Area during 2014 (in ha)
1.	Waterbody	1148.85
2	Settlements	767.43
3	Vegetation/Agriculture	2621.88
4	Scrub/Fallow	2310.57

Table 18: Proximity Analysis of Land use and Land cover status around the Ousteri in 2014

Sl. No.	Class Names	Within 500 metres	Within 1000 metres
		Area (ha)	Area (ha)
1	Waterbody	27.67	74.11
2	Settlements	34.83	102.69
3	Vegetation/Agriculture	446.49	884.7
4	Scrub/Fallow	247.23	568.89

Figure 8: Ousteri boundary traced from SOI topo sheet overlaid on Google earth high-resolution image showing the water level in two different periods and land use activities inside the wetland. A) Image acquired on January 2005, the oldest high-resolution image available for this wetland, B) Image acquired on January 2015, the latest high-resolution image available for this wetland. Other yellow polygons indicate the status of a few natural tanks around the Ousteri. (1)



Figure 9: Ousteri boundary traced from SOI topo sheet overlaid on Google earth high-resolution image showing land use activities inside the wetland at the eastern side on January 2005. (2)

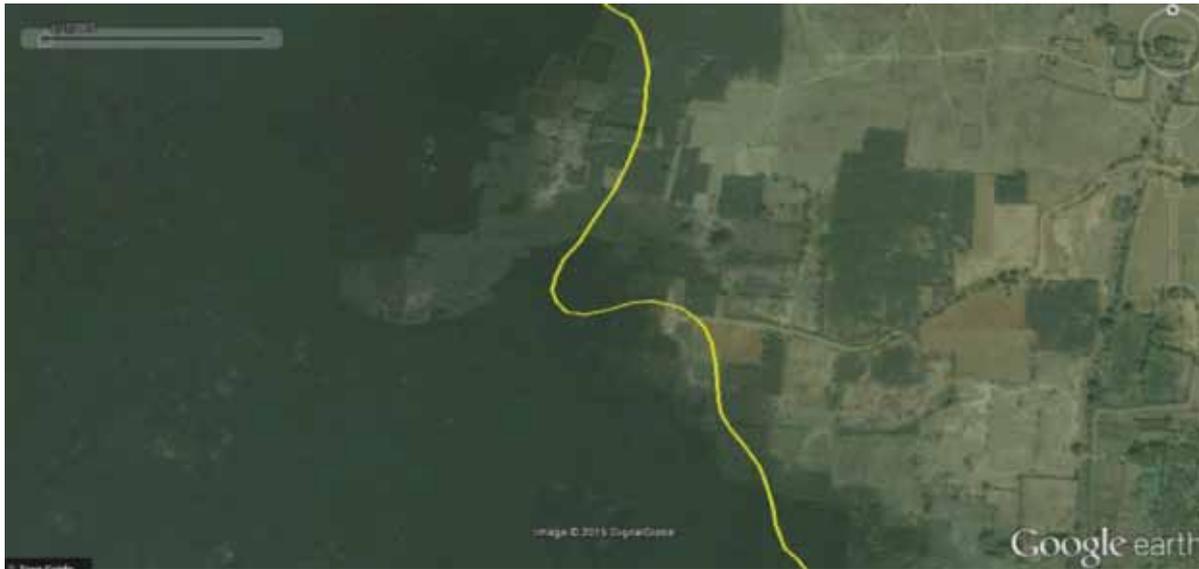


Figure 10: Ousteri boundary traced from SOI topo sheet overlaid on Google earth high-resolution image showing land use activities inside the wetland at the eastern side in January 2014. (3)



distance, the land use and land cover details were clipped. The land use and land cover activities within 500 metres and within 1000 metres are given in Table 18 (also see Figure 11 and 12). Around Ousteri, agriculture/vegetation is the major land use, occupying more than 50% of the area in 500 metres and 1000 metres buffer zones. Fallow/scrub is the second largest land use class, occupying 247.23 ha in the 500 metre buffer zone and

568.89 ha in 1000 metre buffer zone. The area under settlements and water bodies are much less, compared to the other two classes. Finding the status of land use and changes around the wetland boundary to a distance of 500 and 1000 m will give an understanding of the factors responsible for the degradation of the wetland.

The delineation of the wetland boundary, if carried out by officials from the revenue department

of two states, may together prepare a boundary of this wetland using advanced technology such as Total Station or Differential Global Positioning System (DGPS), in order to get better information related to encroachment and reclamation. This would be helpful to decision-makers for conserving such water bodies.

7.4. Topographic Analysis

Topographic analysis based on the Shuttle Radar Topography Mission (SRTM) 1 Arc Second (30 m pixel size) data reveals that 76% of the area in and around Ousteri falls under the 10–30 m elevation category (see Table 19 and 20). About 0.01% of the area comes

Table 19: Extent of area in each elevation category in Ousteri and its environs (10 m interval)

Class Interval in metres	Area in hectare	%
- 7 – 0	1.0	0.01
0 – 10	512.7	7.36
10 - 20	3918.6	56.28
20 - 30	1372.5	19.71
30 - 40	543.6	7.81
40 - 50	395.5	5.68
50 - 60	197.9	2.84
60 - 71	20.5	0.29

Table 20: Extent of Area in each Elevation Category in Ousteri and its Environs (5 m interval)

Class Interval in metres	Area in hectare	%
- 7 – 0	1.0	0.01
0 – 5	45.0	0.65
5 – 10	467.7	6.72
10 – 15	2293.6	32.94
15 – 20	1625.0	23.34
20 – 25	693.7	9.96
25 – 30	678.8	9.75
30 – 35	313.2	4.50
35 – 40	230.4	3.31
40 – 45	207.7	2.98
45 – 50	187.8	2.70
50 – 55	149.0	2.14
55 – 60	48.9	0.70
60 – 65	18.8	0.27
65 – 71	1.7	0.02

under less than zero metres and 0.29% come under more than 60 metres elevation (see Figure 13–15). The slope analysis reveals that Ousteri and its environs fall under lower slope categories, ranging from zero degrees

Figure 11: Land use and Land cover details within 500 m around the Ousteri in 2014

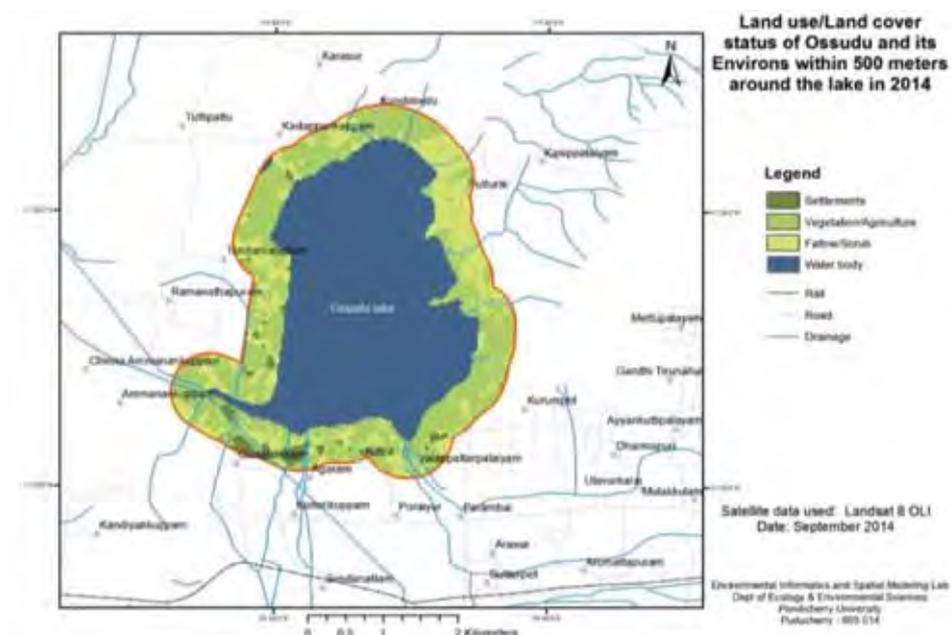


Figure 12: Land use and Land cover details within 1000 m around the Ousteri in 2014

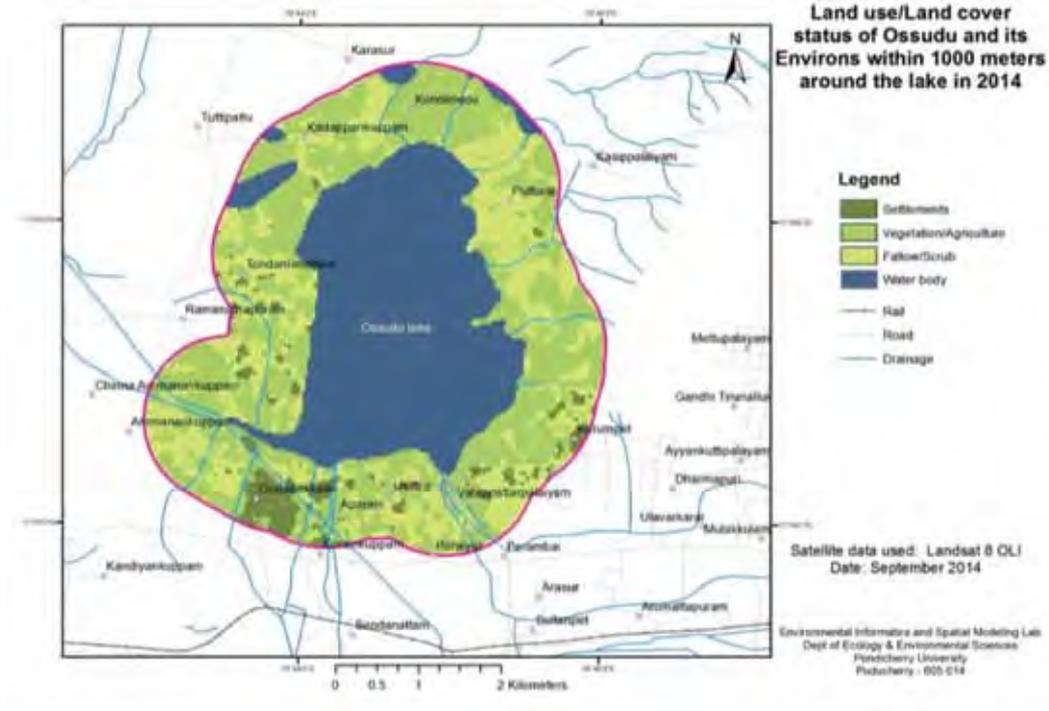


Figure 13: Elevation details of Ousteri and its environs

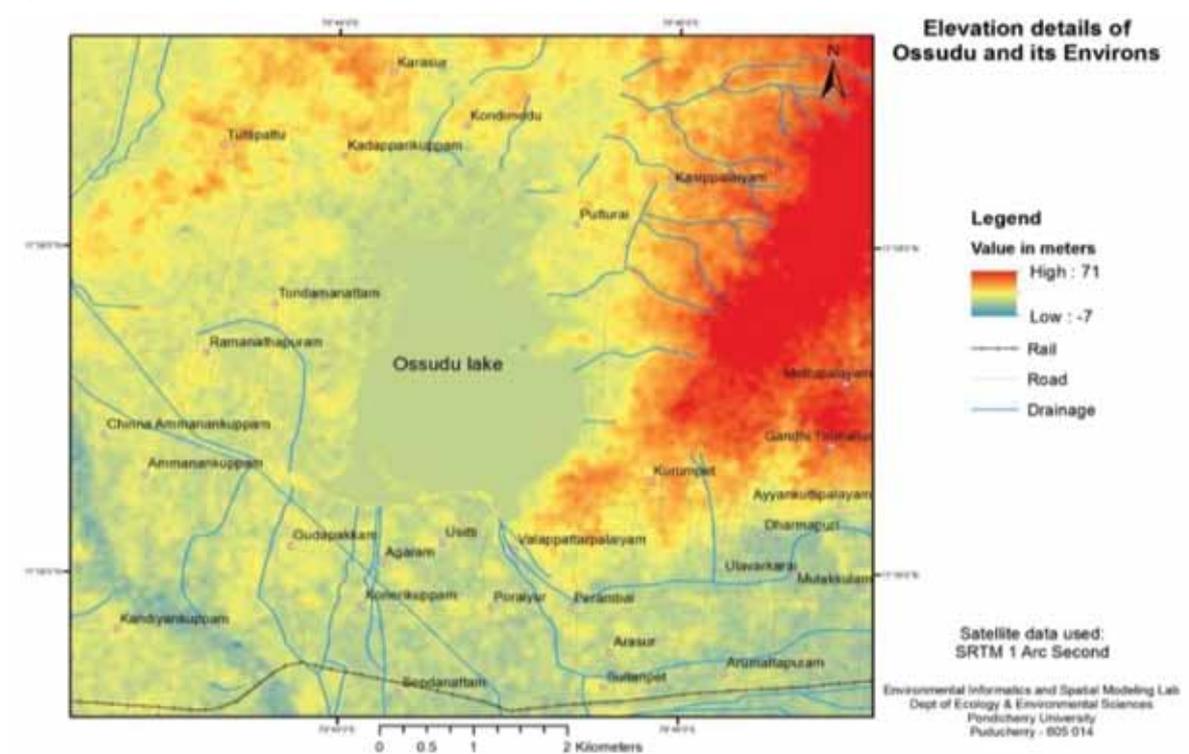


Figure 14: Elevation details of Ousteri and its environs (5 metres interval)

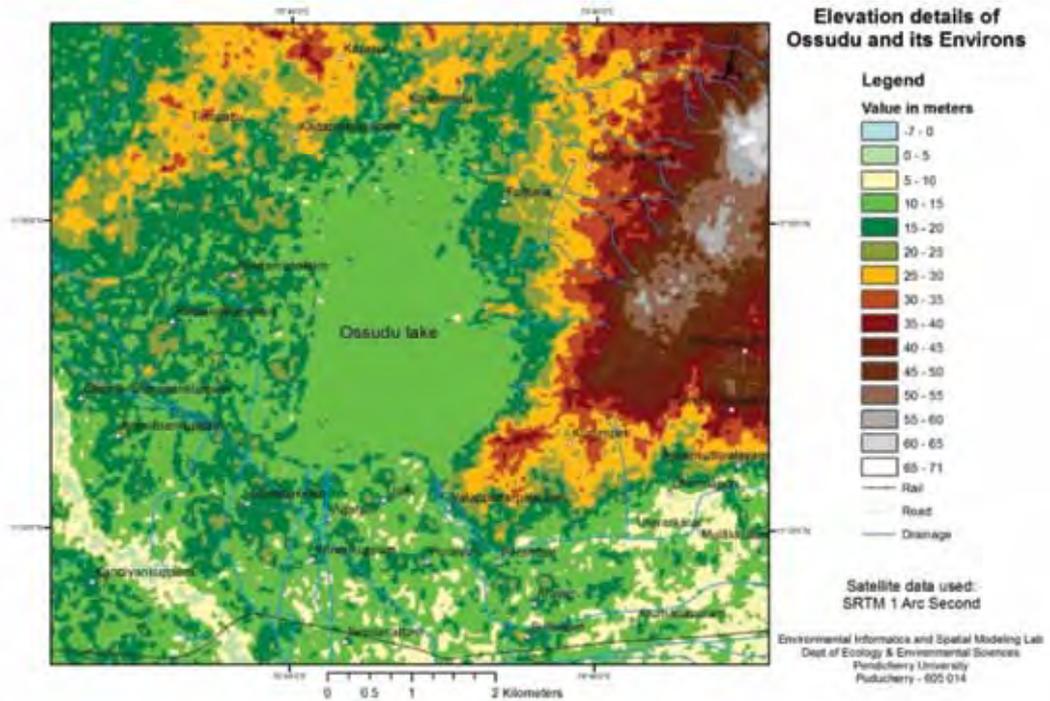


Figure 15: Elevation details of Ousteri and its environs (10 metres interval)

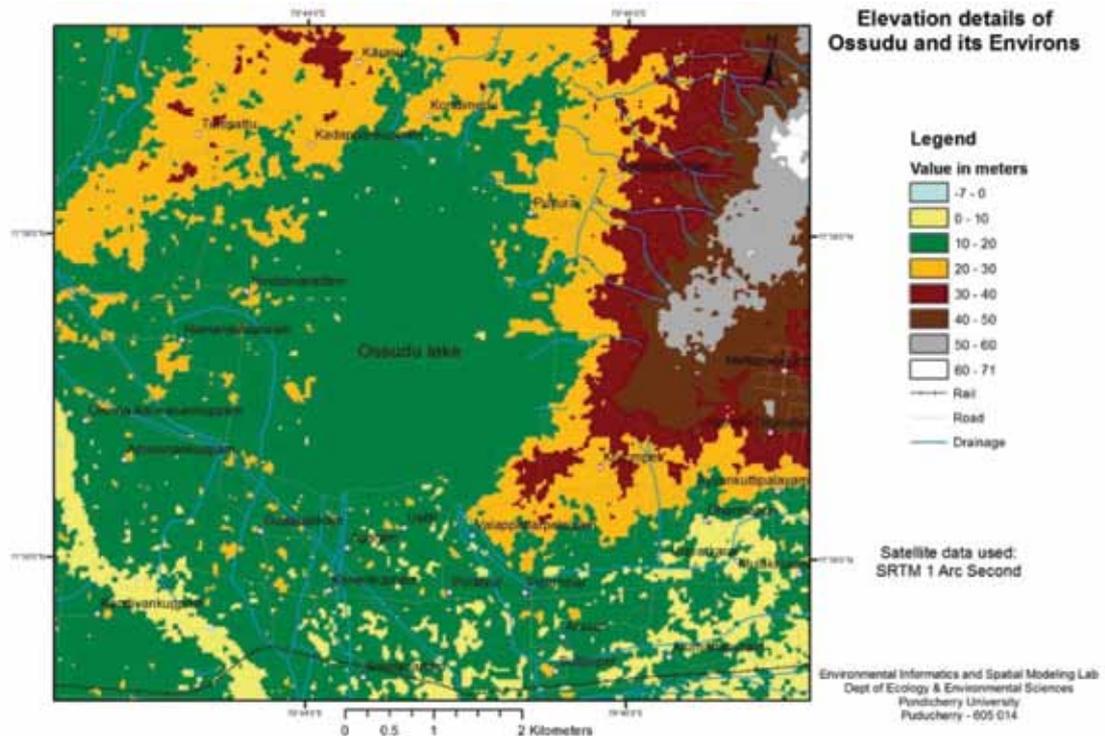


Table 21: Analysis of slope of Ousteri and its Environs

Slope Interval in degrees	Area in hectare	%
0 - 0.5	809.6	11.63
0.6 - 1.0	487.3	7.00
1.1 - 2.5	2785.6	40.01
2.6 - 5.0	2378.0	34.15
5.1 - 10.0	496.4	7.13
10.1 - 16.1	5.7	0.08

to 16.1 degrees (see Table 21). About 11.63% of the area belongs to the 0.0.5 degree deep sloppy area where Ousteri is located (Figure 16). More than 90% of the area belongs to 0–5 degree slope categories. Because of this condition, runoff in this region is very low during normal rainfall. However, an erratic downpour can cause severe runoff if the soil is fallow or barren in the absence of vegetative cover. The shaded relief map prepared based on the SRTM elevation data also illustrates the topographic conditions of this region (see Figure 17).

Ousteri depends on its entire catchment for about 70% of its water recharge. The free catchment is 10.36 km₂, while the intercepted catchment is 5.18 km₂. Given this settling, the geo-morphology and land use pattern in the catchment is expected to influence

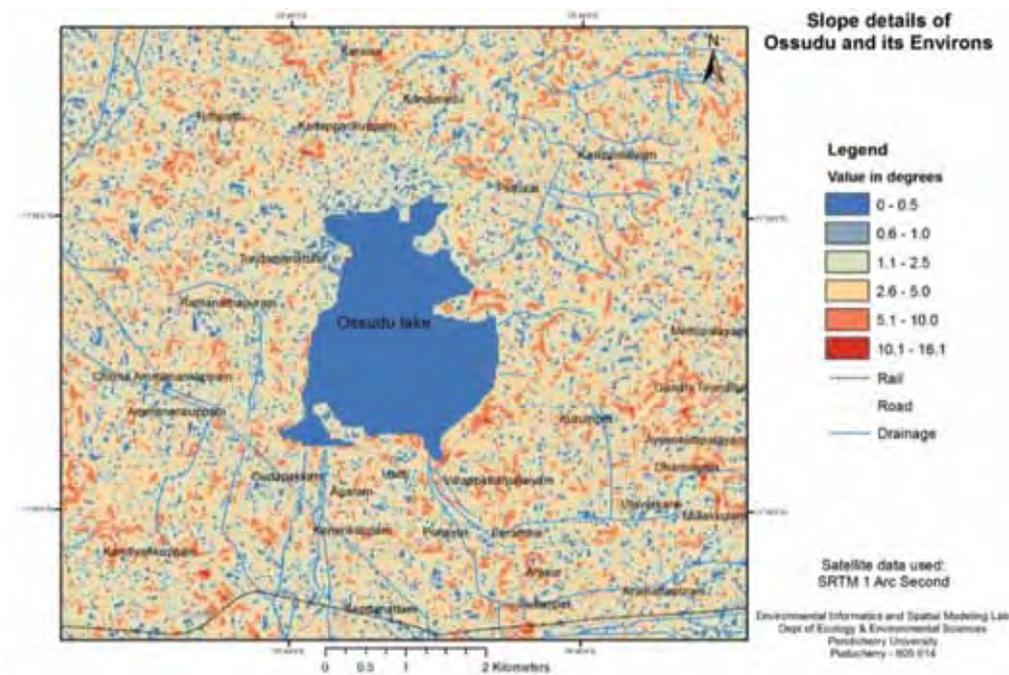
the water quality of the wetland to a great extent. Also, the influx of water from the Veedur reservoir as stream flow can significantly affect the quality of the water in Ousteri. This may have a profound influence on the thermal and chemical regimes of the habitats within the wetland.

Considering the elevation contours of 40 m and 20 m above mean sea level, especially towards the north and northeast, there is a potential risk from agricultural runoff that is rich in nutrients, pesticides and sediments, which contaminates the solid and water in the wetland. Agriculture practice in the wetland and its surrounding areas contributes fertilisers and pesticides, apart from disrupting the roosting grounds of birds and destroying their habitat. A few satellite ponds, found scattered around the north and northwest of Ousteri, are extensively infested with invasive weeds and grasses. Some of the ponds near Katterikuppam and Sedarapet are used for cultivation of paddy (*Oryza Sativa*) and sugarcane (*Sacharrum sp.*). Plantations in the catchment area are chiefly that of *Casuarina sp.* and *Cocos nucifera*, occupying almost 15% of the landscape of the wetland.

7.5. Settlements

The predominant settlements in the Puducherry

Figure 16: Slope details of Ousteri and its environs



region are Villianur, Sedarapet and Katterikuppam. The rest of the settlements falling under Tamil Nadu zone are found in Netapakkam, Agaram, Karasur, Kadaperikuppam and Poothurai. Although much of the residential zone is situated along with the agricultural land cover in these villages, the present encroachment scenario along the wetland has extended to the neighbouring villages. The encroachment along the villages has increased due to real estate activities and infrastructural developments, thereby resulting in the watershed zone being converted to farmland in the Ousteri wetlands. This scenario is widely observed in the Puducherry region; in the Tamil Nadu zone, more common property (such as fallow land with grasses) is available under the control of the Forest Department. The conversion of farmland for infrastructural development could even be correlated with the data obtained from the revenue department of land registrations done in both Tamil Nadu and Puducherry region (see Tables 22–28).

7.6. Industrialisation

Over a period of time, Ousteri has seen an economic transition in terms of industrial and urban activities. Rapid industrialisation and urbanisation generated not only various social benefits such as income and employment, but also negative externalities such as pollution, affecting the quality of the water body. There

has been industrial activity going on around the wetland for many years (see Table 29). The two prominent industrial belts are located in the northwestern portion of the wetland and in the southeastern part, along the road connecting Ousteri and Puducherry city. Anecdotal evidences suggest that as Ousteri has already become hyper-eutrophic due to agricultural runoff containing fertilisers and pesticides, it hardly has the resilience to survive the onslaught of industrial pollution.

The effluents originating from the industrial clusters in the Sedarapet panchayat under the Villianur commune are the major source of pollution. More than 50% of the industrial establishments of the Puducherry region are concentrated in the Sedarapet industrial area. The Comprehensive Environmental Assessment of Pollution Index (CEPI), prepared by the Central Pollution Control Board, along with the Indian Institute of Technology, Kanpur, categorises the many industrial units in Sedarapet area as ‘red category’ units. As we have already indicted, the final destination of the pollutants, including heavy metals, is invariably Ousteri wetland.

7.7. Imminent Threats and Imperatives

Ousteri is now facing threats from many fronts: land reclamation, intensive agriculture in and around the wetland with over-use of groundwater, improper management of fertilisers and pesticides, overgrazing

Figure 17: Shaded relief of Ousteri and its environs

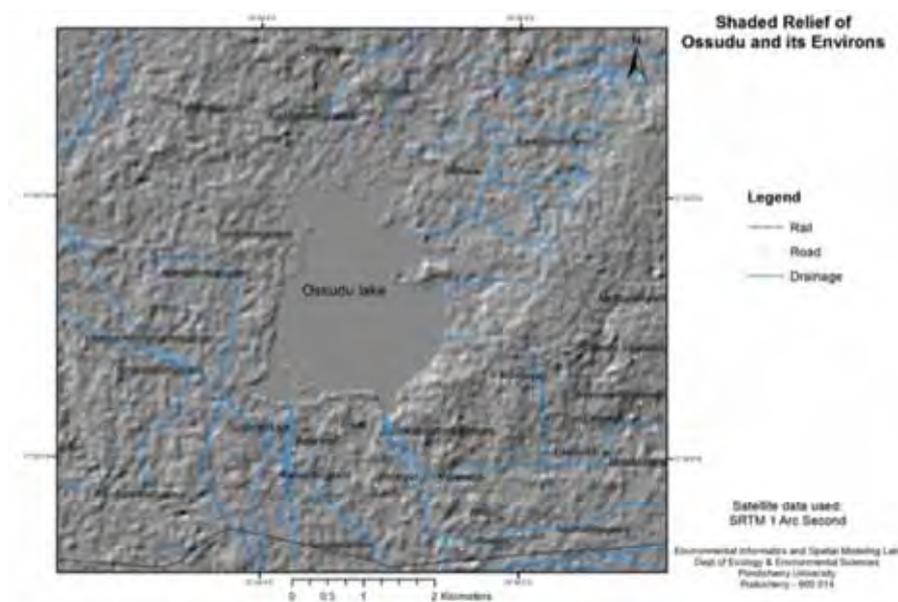


Table 22: Puducherry Ground Particulars for the land located within 100 metres from Ousteri based on utilisation - Thondamanatham Revenue Village

Serial No:	Registered Survey No:	Total Extent as per record H.A.Ca	Type of Land	State on ground Particulars	Remarks
1	121	0.20.50	Government Property	Channel	
2	122	0.56.50	Government Property	Wetland & Channel	
3	123	0.40.00	Government Property	Wetland & Channel	
4	124	0.30.50	Government Property	Wetland & Channel	
5	129	0.49.50	Government Property	Wetland & Channel	
6	137	0.33.50	Government Property	Wetland & Channel	
7	138	0.45.50	Government Property	Wetland & Channel	
8	143	0.23.50	Government Property	Wetland & Channel	
9	144	0.36.50	Government Property	Wetland & Channel	
10	125	1.46.00	Government Property	Channel	
11	126/2	0.51.50	Individual Owned Property	Casurina Cultivation	
12	126/5	0.13.00	Individual Owned Property	Casurina Cultivation	
13	126/6	0.14.00	Individual Owned Property	Casurina Cultivation	
14	126/8	0.33.00	Individual Owned Property	Casurina Cultivation	
15	126/9	0.11.00	Individual Owned Property	Casurina Cultivation	
16	127/1Pt	0.53.00	Individual Owned Property	Casurina Cultivation	only part of the survey no. is covered
17	127/3	0.57.00	Individual Owned Property	Casurina Cultivation	
18	127/4	0.60.00	Individual Owned Property	Casurina Cultivation	
19	128/3Pt	0.57.50	Individual Owned Property	Casurina Cultivation	only part of the survey no. is covered
20	128/6Pt	0.25.00	Individual Owned Property	Paddy cultivation	only part of the survey no. is covered
21	130/6	0.18.50	Individual Owned Property	Sugarcane Cultivation	
22	130/7	0.43.50	Individual Owned Property	Paddy cultivation	
23	131/8	0.44.00	Individual Owned Property	Paddy cultivation	
24	131/7	0.55.00	Individual Owned Property	Sugarcane Cultivation	
25	142/1Pt	0.31.50	Individual Owned Property	Paddy cultivation	only part of the survey no. is covered
26	142/2	0.27.00	Individual Owned Property	Paddy cultivation	
27	142/4	0.14.00	Individual Owned Property	Paddy cultivation	
28	142/5	0.15.00	Individual Owned Property	Sugarcane Cultivation	
29	142/6	0.17.00	Individual Owned Property	Paddy cultivation	
30	142/8	0.17.00	Individual Owned Property	Paddy cultivation	
31	142/9	0.03.50	Individual Owned Property	Paddy cultivation	

Source: Office of Village Administrative Officer's of Pondicherry

Table 23: Puducherry Ground Particulars for the land located within 100 metres from Ousteri based on utilisation - Ramanathapuram Revenue Village

Serial No:	Registered Survey No:	Total Extent as per record H.A.Ca	Type of Land	State on ground Particulars	Remarks
1	5-Apr	0.42.00	Government Property	Paddy cultivation	
2	5	0.28.00	Government Property	Channel	
3	6	0.27.00	Government Property	Channel	
4	7	0.36.00	Government Property	Channel	
5	27	0.28.50	Government Property	Channel	
6	28	0.28.50	Government Property	Channel	
7	29	0.31.00	Government Property	Channel	
8	8	0.15.50	Individual Owned Property	Paddy cultivation	
9	8	0.21.10	Individual Owned Property	Paddy cultivation	
10	8	0.19.50	Individual Owned Property	Paddy cultivation	
11	8	0.30.00	Individual Owned Property	Paddy cultivation	
12	8	0.37.00	Government Property	Channel	
13	8	0.17.50	Government Property	Kuttai	
14	8	0.03.00	Individual Owned Property	Casurina cultivation	
15	8	0.18.00	Individual Owned Property	Casurina cultivation	
16	9	0.28.50	Individual Owned Property	Paddy cultivation	
17	9	0.28.50	Individual Owned Property	Paddy cultivation	
18	9	0.34.50	Individual Owned Property	Paddy cultivation	
19	9	0.08.00	Individual Owned Property	Paddy cultivation	
20	9	0.16.00	Individual Owned Property	Paddy cultivation	
21	12	0.54.00	Individual Owned Property	Paddy cultivation	
22	12	0.15.50	Government Property	Channel	
23	26	0.44.50	Individual Owned Property	Casurina cultivation	
24	26	0.25.00	Individual Owned Property	Sugarcane Cultivation	
25	26	0.77.50	Individual Owned Property	Sugarcane Cultivation	
26	30	0.31.50	Individual Owned Property	Casurina cultivation	
27	30	0.29.50	Individual Owned Property	Casurina cultivation	
28	30	0.60.00	Individual Owned Property	Casurina cultivation	
29	31	0.08.50	Individual Owned Property	Paddy cultivation	
30	31	0.08.50	Individual Owned Property	Casurina cultivation	
31	31	0.28.00	Individual Owned Property	Casurina cultivation	
32	31	0.43.10	Individual Owned Property	Casurina cultivation	
33	31/3	0.32.50	Individual Owned Property	Paddy cultivation	
34	153Pt	1.52.50	Government Property	Channel	
35	154/12Pt	0.04.50	Individual Owned Property	Casurina cultivation	
36	154/13Pt	0.33.00	Individual Owned Property	Paddy cultivation	

Contd...

Serial No:	Registered Survey No:	Total Extent as per record H.A.Ca	Type of Land	State on ground Particulars	Remarks
37	154/14	0.04.00	Individual Owned Property	Casurina cultivation	
38	172	0.49.50	Government Property	Channel	
39	173/1	0.51.00	Individual Owned Property	Paddy cultivation	
40	173/2	0.60.00	Individual Owned Property	Paddy cultivation	
41	173/3	0.28.50	Individual Owned Property	Paddy cultivation	
42	173/4	0.13.00	Individual Owned Property	Paddy cultivation	
43	173/5	0.14.00	Individual Owned Property	Sugarcane Cultivation	
44	173/6	0.11.00	Individual Owned Property	Paddy cultivation	
45	173/7	0.47.00	Individual Owned Property	Paddy cultivation	
46	173/8	0.19.50	Government Property	Channel	
47	189/1	0.23.50	Individual Owned Property	Paddy cultivation	
48	189/2	0.31.00	Individual Owned Property	Paddy cultivation	
49	189/3	0.07.00	Government Property	Channel	
50	189/4	0.13.50	Individual Owned Property	Paddy cultivation	
51	189/5	0.14.00	Individual Owned Property	Paddy cultivation	
52	189/6	0.28.00	Individual Owned Property	Paddy cultivation	
53	189/7	0.96.50	Individual Owned Property	Paddy cultivation	
54	191/1	0.01.00	Government Property	Channel	
55	191/2	0.47.50	Individual Owned Property	Paddy cultivation	
56	191/3	0.10.50	Individual Owned Property	Paddy cultivation	
57	191/4	0.37.00	Individual Owned Property	Paddy cultivation	
58	191/5	0.23.00	Individual Owned Property	Paddy cultivation	
59	191/6A	0.08.00	Individual Owned Property	Paddy cultivation	
60	191/6B	0.16.00	Individual Owned Property	Paddy cultivation	
61	191/7	0.24.50	Individual Owned Property	Paddy cultivation	
62	192/1	0.13.00	Individual Owned Property	Paddy cultivation	
63	192/3	0.22.00	Individual Owned Property	Paddy cultivation	
64	192/4	0.09.50	Individual Owned Property	Paddy cultivation	
65	192/5	0.08.00	Individual Owned Property	Paddy cultivation	
66	192/6	0.03.00	Individual Owned Property	Paddy cultivation	
67	192/7	0.20.00	Individual Owned Property	Paddy cultivation	
68	192/8	0.66.00	Individual Owned Property	Paddy cultivation	
69	192/11	0.48.00	Individual Owned Property	Paddy cultivation	
70	192/12	0.61.00	Individual Owned Property	Paddy cultivation	
71	193/1	0.18.00	Individual Owned Property	Paddy cultivation	
72	193/2	0.18.00	Individual Owned Property	Paddy cultivation	
73	193/3	0.35.00	Individual Owned Property	Paddy cultivation	
74	193/4	0.10.00	Individual Owned Property	Indian Kanoon	

Contd...

Serial No:	Registered Survey No:	Total Extent as per record H.A.Ca	Type of Land	State on ground Particulars	Remarks
75	193/5	0.11.00	Individual Owned Property	Indian Kanoon	
76	193/6	0.36.00	Individual Owned Property	Paddy cultivation	
77	193/7	0.14.00	Individual Owned Property	Paddy cultivation	
78	193/8	0.27.00	Individual Owned Property	Paddy cultivation	
79	193/9	0.21.00	Individual Owned Property	Paddy cultivation	
80	193/10	0.20.00	Individual Owned Property	Paddy cultivation	
81	193/11	0.39.00	Individual Owned Property	Sugarcane Cultivation	
82	193/12	0.04.50	Government Property	Channel	
83	193/13	0.13.00	Individual Owned Property	Sugarcane Cultivation	
84	194/1	0.28.00	Individual Owned Property	Sugarcane Cultivation	
85	194/2	0.26.00	Individual Owned Property	Sugarcane Cultivation	
86	194/3	1.12.00	Individual Owned Property	Paddy cultivation	
87	194/4	0.35.00	Government Property	Channel	

Source: *Office of Village Administrative Officer's of Pondicherry*

by cattle, illegal fishing, and poaching of wild animals and birds. Encroachment in the form of agricultural practice and illegal dumping of solid wastes are on the rise. As a result, growth of macrophyte and plankton aggravate the status of eutrophication in the wetland.

The activities associated with agriculture and urban land use brought about dramatic ecological changes, affecting the quality of Ousteri in terms of:

1. Direct destruction of natural habitats
2. Increased nutrients in the wetland through increased erosion, agriculture runoff and waste disposal
3. Increased natural resource utilisation such as groundwater exploitation, over-utilisation of disposal services, etc.

The above pressures cause significant stress on the aquatic ecosystem of Ousteri. Large influxes of phosphorous, generated primarily from agricultural activities and detergents, remain critical management issues. The presence of agricultural fields around the wetland has contributed significant amount of N, P, K and pesticides through runoff.

Ousteri has also witnessed industrial waste being dumped surreptitiously by red-category industries. Altered land use, coupled with accelerated and diversified human interventions, have resulted in degradation, depauperation, and dwindling of the wetland area of Ousteri.

7.7.1. Geo-Environmental Impacts

A geo-environmental impact assessment reveals that the soils around Ousteri are prone to sheet erosion,

gully erosion and industrial pollution. Water demand in Puducherry has exceeded the supply during the last few years. Some 7000 tube wells in the Puducherry region extract close to 122 mm³ of subterranean water to irrigate a net area of approximately 14,600 hectares. In order to sustain groundwater use, conservation of surface water bodies such as Ousteri assumes greater importance. Ousteri serves as an important shield against salinity intrusion by keeping the underground aquifer replenished in spite of excessive extraction by a large number of tube wells. The trend of shrinkage in the water spread area and reduction in depth of the wetland must be reversed to enable Ousteri to harvest rain water adequately.

7.7.2. Industrial Hazards

Parts of the highly dense industrial estates of Pillayarkuppam, Kirumampakkam, Kattukuppam, Thattanchavadi, Mettupalayam, Kurumbapet and Sedarapet lie on the Ousteri watershed. The ponds and wells situated within the watershed region are found to be polluted (see Annex 2 for the list of RED category industries). For example, extensive studies on the groundwater quality of Pillayarkuppam and Kirumampakkam reveal the following:

1. In 100% of the samples, total dissolved solids (TDS) levels exceeded the permissible limits of drinking water standards
2. Hardness surpassed the permissible limits for drinking water in 72% of samples

Table 24: Puducherry Ground Particulars for the land located within 100 metres from Ousteri based on utilisation - Koodapakkam Revenue Village

Serial No:	Registered Survey No:	Total Extent as per record H.A.Ca	Type of Land	State on ground Particulars	Remarks
1	45/3Pt	1.39.50	Individual owned Property	Coco Land Theme Park	Children's Park, Only part of the survey number is covered
2	45/5	0.23.00	Individual owned Property	Coco Land Theme Park	Swimming Pool
3	45/6	0.20.05	Individual owned Property	Coco Land Theme Park	Bar shop
4	46	0.41.520	Government Property	Road (Milk booth, out-stn. Police booth, petty shop)	
5	47	0.48.00	Government Property	Road	
6	48	0.50.00	Government Property	Road	
7	49	0.45.50	Government Property	Road	
8	50	0.46.00	Government Property	Road	
9	51	0.52.50	Government Property	Road	
10	52	0.09.00	Government Property	Channel	
11	43	0.59.50	Government Property	Channel	
12	53/1	0.07.00	Individual owned Property	Sugarcane Cultivation	
13	53/4	0.17.00	Individual owned Property	Sugarcane Cultivation	
14	53/5Pt	0.88.00	Individual owned Property	Sugarcane Cultivation	Only part of the survey is covered
15	53/2Pt	0.48.00	Individual owned Property	Layout	Only part of the survey is covered
16	53/3Pt	0.19.50	Individual owned Property	Sugarcane Cultivation	Only part of the survey is covered
17	54/1	0.58.50	Individual owned Property	Sugarcane Cultivation	
18	54/2	0.31.00	Individual owned Property	Sugarcane Cultivation	
19	54/3	0.27.00	Individual owned Property	Sugarcane Cultivation	
20	54/4	0.22.00	Individual owned Property	Sugarcane Cultivation	
21	55/1Pt	0.54.00	Individual owned Property	Casurina plantation	Only part of the survey is covered
22	55/2Pt	0.26.50	Individual owned Property	Sugarcane Cultivation	Only part of the survey is covered
23	56/1	0.39.00	Individual owned Property	Groundnut Cultivation	
24	56/2Pt	1.62.00	Individual owned Property	Casurina plantation	Only part of the survey is covered

Source: *Office of Village Administrative Officer's of Pondicherry*

- Several other parameters – sulphate, phosphorous, total dissolved solids (TDS) etc. – were above the permissible limits in a majority of cases
- Most alarmingly, we found high levels of heavy metals in the surface and groundwater samples. Arsenic,

Cadmium and Lead were the toxins occurring above permissible limits.

- All the harmful negative externalities affect the Ousteri watershed, posing a threat to the long-term sustainability of the wetland.

Table 25: Puducherry Ground Particulars for the land located within 100 metres from Ousteri based on utilisation - Olavaikal Revenue Village

Serial No:	Registered Survey No:	Total Extent as per record H.A.Ca	Type of Land	State on ground Particulars	Remarks
1	1	0.77.00	Government Property	Road	
2	2	0.18.50	Government Property	Channel	
3	2	0.50.00	Individual owned Property	Sugarcane Cultivation	
4	2	0.72.00	Individual owned Property	Sugarcane Cultivation	
5	3	0.12.50	Individual owned Property	Approach Road	Land belongs to Lakshminarayana medical college and hospital
6	3	0.52.00	Individual owned Property	Approach road with Arch	Land belongs to Lakshminarayana medical college and hospital
7	3	0.46.00	Individual owned Property	Approach road	Land belongs to Lakshminarayana medical college and hospital
8	3	0.19.00	Individual owned Property	Vacant Land	Land belongs to Lakshminarayana medical college and hospital
9	3/10A	0.06.37	Individual owned Property	Vacant Land	Land belongs to Lakshminarayana medical college and hospital
10	3/10B	0.06.30	Individual owned Property	Vacant Land	Land belongs to Lakshminarayana medical college and hospital
11	3/10C	0.06.30	Individual owned Property	Vacant Land	Land belongs to Lakshminarayana medical college and hospital
12	3	0.18.00	Individual owned Property	Vacant Land	Land belongs to Lakshminarayana medical college and hospital
13	3	0.33.00	Government Property	Channel	
14	3	0.03.50	Government Property	Sugarcane Cultivation	
15	3	0.05.50	Government Property	Barren land	

Source: *Office of Village Administrative Officer's of Pondicherry*

The reconnaissance of the study revealed that feeder channels and the Suthukenni check dam had become practically defunct, due to lack of maintenance of the check dam, and lack of proper stone or concrete revetments along the channels. Encroachment of the wetland shore, both near the check dam and along the channels, was rampant. Moreover, the people in the ayacut (command area) of the wetland have shifted to borewell irrigation from canal irrigation. As a result,

the incentive for managing the wetland among the conventional users has gradually declined, which has an adverse consequence on the sustainable management of the wetland.

7.7.3. Food Nexus

The avifauna of Ousteri is affected by the depletion of food, in terms of illegal fishing, encroachment, cattle grazing, human disturbance and pollution of the

Table 26: Puducherry Ground Particulars for the land located within 100 metres from Ousteri based on utilisation - Ousteri Revenue Village

Serial No:	Registered Survey No:	Total Extent as per record H.A.Ca	Type of Land	State on ground Particulars	Remarks
1	1	0.31.50	Individual owned Property	Sugarcane Cultivation	
2	1	0.33.00	Individual owned Property	Sugarcane Cultivation	
3	1	0.09.00	Individual owned Property	Sugarcane Cultivation	
4	1	0.09.00	Individual owned Property	Sugarcane Cultivation	
5	1	0.36.50	Individual owned Property	Sugarcane Cultivation	
6	1	0.093.00	Individual owned Property	Sugarcane Cultivation	
7	1	0.08.50	Individual owned Property	Sugarcane Cultivation	
8	1	0.09.50	Individual owned Property	Sugarcane Cultivation	
9	1	0.09.00	Individual owned Property	Sugarcane Cultivation	
10	4	1.40.50	Individual owned Property	Sugarcane Cultivation	
11	6	0.21.50	Individual owned Property	Sugarcane Cultivation	
12	6	0.19.50	Individual owned Property	Sugarcane Cultivation	
13	6	0.14.00	Individual owned Property	Sugarcane Cultivation	
14	6	0.18.00	Individual owned Property	Sugarcane Cultivation	
15	6	0.20.50	Individual owned Property	Sugarcane Cultivation	
16	6	0.15.00	Individual owned Property	Sugarcane Cultivation	
17	6	0.50.00	Individual owned Property	Sugarcane Cultivation	
18	2	0.32.50	Government Property	Channel	
19	3	0.27.00	Government Property	Channel	
20	5	0.34.50	Government Property	Channel	
21	7	0.34.50	Government Property	Channel	
22	9	0.40.50	Government Property	Road	
23	10	0.38.50	Government Property	Road	
24	28	0.57.50	Government Property	Road	
25	29	0.53.00	Government Property	Road	
26	30	0.60.00	Government Property	Road	
27	31	0.54.00	Government Property	Road	
28	32	0.46.50	Government Property	Road	
29	41	0.28.50	Government Property	Road	
30	42	0.26.00	Government Property	Road & well	
31	11	0.01.00	Individual owned Property	Sugarcane Cultivation upland	
32	11	0.70.00	Individual owned Property	Sugarcane Cultivation	
33	11	0.20.00	Individual owned Property	Sugarcane Cultivation upland	
34	11	0.43.00	Government Property	Channel	

Contd...

Serial No:	Registered Survey No:	Total Extent as per record H.A.Ca	Type of Land	State on ground Particulars	Remarks
35	11	0.29.00	Individual owned Property	Sugarcane Cultivation upland	
36	17	0.54.00	Individual owned Property	Sugarcane Cultivation	
37	17	0.02.00	Government Property	Channel	
38	17	0.97.50	Individual owned Property	Sugarcane Cultivation	
39	16	0.34.50	Individual owned Property	Paddy cultivation	
40	16	0.02.50	Government Property	Channel	
41	16	0.1.49.00	Individual owned Property	Sugarcane Cultivation	
42	12	0.02.50	Individual owned Property	Sugarcane Cultivation upland	
43	12	0.18.50	Individual owned Property	Sugarcane Cultivation	
44	12	0.24.00	Individual owned Property	Sugarcane Cultivation, motor shed	
45	12	0.01.00	Individual owned Property	Sugarcane Cultivation upland	
46	14	0.26.50	Government Property	Channel	
47	14	0.1.50.00	Individual owned Property	Sugarcane Cultivation, motor shed	
48	26/2A	3.83.52	Individual owned Property	Sugarcane Cultivation, motor shed	
49	26/2B	0.27.48	Individual owned Property	Sugarcane Cultivation	
50	27/1	0.80.30	Individual owned Property	Sugarcane Cultivation	
51	27/2	0.30.00	Individual owned Property	Sugarcane Cultivation	
52	27/3	0.32.50	Individual owned Property	Sugarcane Cultivation	
53	27/4	0.33.00	Individual owned Property	Sugarcane Cultivation	
54	27/5	0.24.00	Government Property	Sugarcane Cultivation	
55	27/6	0.12.00	Individual owned Property	Sugarcane Cultivation	
56	27/7	0.11.50	Individual owned Property	Sugarcane Cultivation	
57	33/1Pt	1.87.50	Individual owned Property	Sugarcane Cultivation	Only part of the survey number is covered
58	34/1	0.16.50	Individual owned Property	Sugarcane Cultivation	
59	34/2	0.32.00	Individual owned Property	Sugarcane Cultivation	
60	34/4	1.13.00	Individual owned Property	Sugarcane Cultivation	
61	34/5	0.16.00	Government Property	Farmhouse with fish growing	
62	34/6	0.02.50	Individual owned Property	Sugarcane Cultivation	
63	34/7	0.18.00	Government Property	Channel	
64	40/1	1.08.50	Government Property	Temple site	1. Veeran koil 2. Ayyanar kovil 3. Mariamman kovil 4. Mariamman kovil

Source: Office of Village Administrative Officer's of Pondicherry

Table 27: Tamil Nadu State on Ground Particulars for the lands located within 100 Metres from Ousteri based on Utilisation - Poothurai Revenue Village

Serial No:	Registered Survey No.	Total Extent as per record H.A. Ca	State on ground particulars
1	341-1	0.52.5	all type
2	341-2	0.45.0	Casuarina
		0.45.0	Eucalyptus tree
3	342-1	0.03.0	Urachi onriya salai (Road)
4	342-2	0.58.5	Road
5	337-1	0040	Empty
6	337-2	0.20.5	kovil
7	337-3	0.01.0	Road
8	330	0.30	Urachi onriya salai (Road)
9	329-1	1.37.0	Empty
10	329-2	0.72.5	Eucalyptus tree
11	328-1	0.03.0	Empty
12	328-2	0.04.0	Empty
13	328-3	0.05.5	Empty
14	328-4	0.02.0	Empty
15	328-5	0.02.0	Empty
16	328-6	1.05.5	Empty
17	328-7	0.33.0	Empty
18	328-8	1.06.0	Empty
19	326-1A	0.28.5	Many types (gardening)
20	326-1B	0.36.5	Many types (gardening)
21	326-2	0.06.5	Empty
22	326-3	0.03.0	Empty
23	326-4	0.03.0	Empty
24	326-5	0.13.0	Empty
25	326-6	0.09.0	many types (gardening)
26	326-7	0.35.0	many types (gardening)
27	326-8A	0775	many types (gardening)
28	326-8B	0.045	many types (gardening)
29	326-8B2	004.0	many types (gardening)
30	326-8B3	0.17.5	many types (gardening)
31	326-8B4	0.05.5	many types (gardening)
32	326-8B5	0.59.5	many types (gardening)
33	326-8B6	0.09.5	many types (gardening)
34	326-8B7	0.09.5	many types (gardening)
35	326-8B8	0.09.5	many types (gardening)
36	326-9	0.17.0	many types (gardening)
37	326-10A	0.08.5	many types (gardening)
38	326-10A2	0.10.5	many types (gardening)
39	108-1	0.28.0	many types (gardening)
40	108-2	3.00.0	many types (gardening)
41	109-1	0.40.0	Casuarina
42	109-2A	0.02.5	Casuarina
43	109-2B	0.17.0	Empty
44	109-2C	0.03.5	Casuarina
45	109-3	0.10.0	Empty
46	109-4	2.18.0	Empty
47	109-5	0.21.0	Empty
48	109-6	0.30.0	Empty
49	109-7	0.33.0	Empty
50	109-8	0.10.0	Empty
51	109-9	0.14.5	Empty
52	109-10	0.44.0	Casuarina
53	109-11	0.82.5	Coconut 0.06.0 Casuarina 0.74.0

Contd...

Serial No:	Registered Survey No.	Total Extent as per record H.A. Ca	State on ground particulars
54	112-1A	0.13.5	Empty
55	112-1B	2.22.5	Empty
56	112-2A	0.27.0	Empty
57	112-2B	0.27.0	Empty
58	112-3A	0.07.0	Empty
59	112-3B	1.01.0	Empty
60	112-3C	0.05.0	Empty
61	112-3D	0.03.0	Empty
62	112-4	0.12.0	Empty
63	113-1	0.47.0	Casuarina
64	113-2	0.53.0	Casuarina
65	113-3	0.30.0	Empty
66	113-4	0.10.5	Empty
67	113.-5	0.07.5	Empty
68	113-6A	0.80.0	Empty
69	113-6B	0.23.0	Empty
70	113-7A	0.34.0	Eucalyptus tree 0.10.0; Casuarina 0.24.0
71	113-7B	0.07.5	Empty
72	113-7c	0.15.0	Casuarina
73	113-7D	0.15.0	Casuarina
74	113-7E	0.13.5	Casuarina
75	113-7F	0.10.0	Casuarina
76	113-7G	0.10.0	Casuarina
77	133-8A	0.23.0	Empty
78	113-8B	0.13.0	Empty
79	113-8C	0.13.0	Empty
80	120-1	0.19.0	Casuarina
81	120-2	0.40.0	Empty
82	120-3A	0.28.0	Casuarina
83	120-3B	0.36.5	Casuarina
84	120-4	0.16.5	Empty
85	120-5	0.16.5	Empty
86	120-6	0.81.0	Eucalyptus tree 0.22.0 Casuarina 0.59.0
87	120-7	1.70.0	Empty
88	128-1A	0.15.0	coconut 0.07.0

Serial No:	Registered Survey No.	Total Extent as per record H.A. Ca	State on ground particulars
89	128-1B	0.15.0	Casuarina 0.06.0
90	128-C	0.06.0	Casuarina 0.06.0
91	128-2	0.16.5	Casuarina
92	128-3A	0.26.0	Empty
93	128-3B	0.17.5	Empty
94	128-4	0.26.0	Casuarina
95	129-1	0.11.0	Casuarina
96	129-2	0.14.0	Casuarina
97	129-3	0.23.0	Casuarina
98	129-4	0.23.5	Casuarina
99	129-5A	0.22.5	Casuarina
100	129-5B	0.22.5	Casuarina
101	129-5C	0.07.0	Casuarina
102	129-6	0.51.5	Casuarina
103	129-7	0.29.5	Casuarina
104	129-8	0.56.0	Empty
105	131-1	0.15.0	Empty
106	131-2	0.93.0	Eucalyptus tree 0.13.0 Casuarina 0.67.0
107	131-3	0.62.0	Casuarina
108	1314A	0.045	Casuarina
109	131-4B	0.08.0	Casuarina
110	131-4B2	0.01.0	Teak tree 0.01.0
111	131-4C	0.04.5	Teak tree 0.04.0
112	131-5	0.15.0	Casuarina
113	131-6	0.09.5	Casuarina
114	131-7	0.24.0	Coconut 0.10.0
115	131-8	0.22.0	Teak tree
116	131-9	0.29.0	Casuarina 0.28.0
117	131-10	0.69.0	Casuarina
118	131-11	0.99.0	Casuarina
119	131-12	0.30.0	Casuarina
120	131-13	0.10.0	Casuarina
121	132-1	0.21.0	Empty
122	132-2	0.39.0	Casuarina
123	132-3	0.02.5	Casuarina
124	132-4	0.03.0	Casuarina
125	132-5	0.03.5	Empty

Contd...

Serial No:	Registered Survey No.	Total Extent as per record H.A. Ca	State on ground particulars
126	132-6	0.06.5	Empty
127	132-7	0.03.5	Aiyanar kovil
128	132-8A	0.46.0	Casuarina
129	132-8B	0.42.0	Casuarina
130	132-9A	0.06.0	Casuarina
131	132-9B	0.06.5	Casuarina
132	132-10	0.19.5	Casuarina
133	132-13	0.06.5	Casuarina
134	133-1	0.67.0	Empty
135	133-2	0.04.0	Empty
136	133-3	0.09.0	Empty
137	133-4	0.16.0	Empty
138	133-5	0.07.0	Empty
139	133-6	0.09.5	Empty
140	133-7	0.08.5	Empty
141	133-8	0.13.0	Empty
142	133-9	0.13.5	Empty
143	133-10A	0.12.5	Empty
144	133-10B	0.15.0	Empty
145	101-1	0.32.5	Empty
146	101-2	0.27.5	Empty
147	101-3	0.31.5	Empty
148	101-4	0.21.5	Empty
149	101-5	0.02.5	Empty
150	101-6	0.02.5	Empty
151	101-7	0.02.0	Empty
152	101-8	0.03.0	Empty
153	101-9	0.03.0	Empty
154	101-10	0.03.5	Empty
155	101-11	0.03.5	Empty
156	101-12	0.03.5	Empty
157	103.1	0.66.0	Empty
158	103-2	0.14.0	Empty
159	103-3	0.39.0	Empty
160	103-4	0.30.0	Empty
161	103-5	0.54.0	Empty
162	103-6	0.21.0	Empty
163	103-7	0.10.0	Empty
164	103-8	0.10.0	Empty

Serial No:	Registered Survey No.	Total Extent as per record H.A. Ca	State on ground particulars
165	103-9A	0.24.5	Empty
166	103-9B	0.09.0	Empty
167	103-10	0.06.0	water flow way
168	103-11	0.31.0	wetland water catchment area
169	102-1	2.80.5	Empty
170	120-2	0.01.0	water flow way
171	90-1	0.24.0	Empty
172	90-2	0.09.0	Empty
173	90-3	0.20.5	Empty
174	90-4	0.01.0	water spread area
175	90-5	0.69.0	Empty
176	90-6	0.06.5	Empty
177	89-1	0.36.0	coconut 0.02.0
178	89-2	0.81.5	coconut 0.08.0
179	89-3	0.16.0	Empty
180	89-4	0.58.5	Empty
181	89-5	0.64.5	Empty
182	89-6	0.54.0	Empty
183	88-1	0.03.0	Empty
184	88-2	0.09.5	Empty
185	88-3	0.10.0	Empty
186	88-4	0.18.0	Empty
187	88-5	0.20.0	Empty
188	88-6	0.20.0	Empty
189	88-7	0.92.5	Empty
190	28-1	0.41.0	Empty
191	28-2	0.20.0	Empty
192	28-3	0.09.0	Empty
193	28-4	0.10.0	Empty
194	28-5	0.14.0	Empty
195	28-6	0.13.0	Empty
196	27-1	0.03.0	Empty
197	27-2	0.01.5	Empty
198	27-3	0.12.0	Empty
199	27-4	0.31.0	Empty
200	27-5	0.30.5	Empty
201	27-6	0.13.0	Empty

Contd...

Serial No:	Registered Survey No.	Total Extent as per record H.A. Ca	State on ground particulars
202	27-7	0.27.0	Empty
203	27-8	0.09.0	Empty
204	27-9	0.09.5	water catchment area
205	27-10	0.28.0	Empty
206	27-11	0.15.0	Empty
207	27-12	0.29.0	Empty
208	26-1	0.69.0	water catchment area
209	26-2	0.07.0	Empty
210	26-3	0.02.5	Empty
211	26-4	0.02.5	Empty
212	26-5	0.02.0	Empty
213	26-6	0.06.5	Empty
214	26-7	0.06.5	Empty
215	26-8	0.06.0	Empty
216	26-9	0.06.0	Empty

Source: *Office of Village Administrative Officer's of Tamil Nadu*

Table 28: Tamil Nadu State on Ground Particulars for the lands located within 100 Metres from Ousteri based on Utilisation – Perambai Revenue Village

Serial No:	Registered Survey No:	Total Extent as per record H.A. Ca	State on ground particulars
1	52	0.31.0	Highway
2	7	4.15.0	Multiple variety 4.00.0
3	6-1	0.62.0	Multiple variety
4	6-2	1.68.0	Multiple variety 1.67.0
5	5-1	7.43.0	Multiple variety 7.00.0
6	5-2	0.05.0	Empty
7	4	10.37.5	Multiple variety 5.00.0
8	2	4.25.0	Multiple variety 4.00.0
9	11	0.38.0	Highway

Source: *Office of Village Administrative Officer's of Tamil Nadu*

7.7.4. Encroachment

The wetland is deeper in the southeast portion and shallower towards the northwest. A variety of grasses

Serial No:	Registered Survey No.	Total Extent as per record H.A. Ca	State on ground particulars
217	26-10	0.07.5	Empty
218	26-11	0.03.0	Empty
219	26-12	0.02.5	Empty
220	26-13	0.02.0	Empty
221	26-14	0.18.0	Empty
222	26-15	0.08.0	Empty
223	26-16	0.08.0	Empty
224	26-17	0.07.5	Empty
225	26-18	0.07.5	Empty
226	15-1	0.13.5	Casuarina
227	15-2	1.36.0	Casuarina
228	15-3	0.16.0	Casuarina
229	15-4	0.08.0	Casuarina
230	15-5	0.08.0	Casuarina
231	15-6	1.14.5	Casuarina
232	15-7	0.96.0	Casuarina

with the reproductive activities of the fisheries and the waterfowl. It also contributes fertilisers and pesticides to the water, harming its quality.

7.7.5. Poaching of Wildlife

Though prohibited, illegal fishing and poaching of birds in Ousteri is widely reported. Informal discussions with the villagers also confirm this, although there is no data on the extent to which illegal fishing and poaching takes place in the region. Reliable sources revealed that there is significant demand for the meat of wild animals and birds, especially in the liquor shops in Puducherry. Therefore, illegal poaching fetches a good amount of income to the poachers who are willing to take the risk. Illegal poaching can be controlled with the help of the villagers if they are provided with adequate incentives.

7.7.6. Grazing

Grazing by domestic animals in and around Ousteri is a common practice (Table 30). Excessive grazing of littoral vegetation by domestic animals may adversely affect bird life by destroying their habitats. The suitable management action of Ousteri requires an economically integrated approach that examines the distinctive ecological and environmental characteristics of Ousteri. Settlement patterns, history and the

Table 29: Industrialisation of the neighbouring zones of Ousteri in the Puducherry Region

No	Village	Total Ayacut / Command Area	Plots & Industries	Present Ayacut / Command Area	Ousteri Supply	Canal Supply	Remarks
1	Koodapakkam	87.84	0.69	87.15	100%	0%	
2	Olavaikal	150.79	1.43	149.36	100%	0%	
3	Ousteri	168.27	2.28	166.00	100%	0%	
4	Villianur	265.35	245.35	20.00	100%	0%	
5	Odiampet	337.83	40.16	297.67	0%	100%	
6	Kompakkam	107.28	11.88	95.14	0%	100%	Town survey
7	Kurumbapet	88.51	15.15	79.36	100%	0%	
8	Olandai	26.41	15.87	10.54	0%	100%	Town survey
9	Ozhukarai	166.05	92.93	73.12	100%	0%	TS Progress
10	Reddiarpalayam	139.32	126.18	13.14	100%	0%	TS Progress
	Total	1537.65	551.91	985.73			

Source: *Public Works Department, Puducherry*

potential environmental effects must also be considered for designing a comprehensive management strategy of Ousteri. To achieve this, extensive ecological, hydrological and geological aspects of Ousteri were examined, along with the opinion of different stakeholders involved with the wetland.

8. Stakeholder Analysis

We conducted opinion surveys among different stakeholders of the wetland, consisting of bureaucrats, government officials, academicians, representatives from local bodies, representatives of non-governmental organisations, and villagers in both Puducherry and Tamil Nadu. Almost all the stakeholders claim that Ousteri generates ecosystems belonging to the four types

classified in the TEEB report (2010): a) Provisioning (food, freshwater, genetic resources); b) Regulating (climate regulation, flood control, detoxification); c) Supporting (soil formation, nutrient cycle, pollination, primary production, oxygen production, provision of habitat); and d) Cultural (spiritual, recreational, aesthetic, communal, symbolic). Stakeholder analyses reveal that accelerated and increasingly diversified human land use changes in the Ousteri catchment appear to have led to a gradual degradation of the wetland. The prime factors contributing to the sharp decline in the number of birds sighted at Ousteri are depletion of food caused by illegal fishing, encroachments, cattle grazing, and pollution of the wetland (Figure 20).

According to the stakeholders, before the start of the 1990s, farmers of nearly 20 villages used to depend

Table 30: Cattle owned and grazed in the Ousteri zone by both Tamil Nadu and Puducherry villagers

Categories	Puducherry				Tamil Nadu		
	Ousteri Revenue Village	Koodapakkam village	Thondamanatham village	Ramanathapuram Village	Poothurai Village	Perambai Village	Kadaperikuppam Village
Cow	100	2000	318	333	1508	206	200
Buffaloes	NIL	10	NIL	NIL	NIL	NIL	0
Goats	250	2500	200	800	1053	155	180
Sheep	NIL	NIL	NIL	170	75	NIL	90

Source: *Office of Village Administrative Officer's of Pondicherry and Tamil Nadu*

on Ousteri for irrigation. At present, only 10 villages depend on it for irrigation: Koodapakkam, Agaram, Olavaikal, Konerikuppam, Poraiyur, Sedanatham, Ousteri and Vazipettapalayam (Puducherry), Kadaperikuppam and Poothurai (Tamil Nadu). The remaining land cover, not irrigated by Ousteri water, depends on the borewells sunk within the wetland watershed. Farmers have been increasingly shifting from surface to borewell-based irrigation for two reasons. Firstly, the government has been subsidising the cost of sinking borewells and the electrical power used in drawing borewell water. Secondly, it is more convenient for farmers to pump water from their borewells at will, instead of having to adjust their work to the convenience of government staff employed to operate sluices which release Ousteri water. Most of the stakeholders stated that sustained groundwater use in the region depends largely on whether Ousteri is being managed in an efficient, equitable and sustainable manner in the coming years.

The stakeholders pointed out that commensal fishing is not a major occupation of the people living around Ousteri, but that it provided a source of income for some of the households in the surrounding villages. Once the wetland was declared a bird sanctuary, the fishing activity has been almost prohibited. The shallow banks of the wetland sport rich and luxurious grasses. The local people feed their cattle on these grasses almost throughout the year. Also, they cut and use reeds and grasses that grow in and around the wetland for the purpose of thatching the huts. Ipomoea, which grows profusely in the wetland, is used for fencing the houses and agriculture fields. Other than fish, some people harvest snails, which thrive along the water supply channels and banks of the wetland. These snails are known to have some medicinal benefits.

Ousteri generates extra-marginal aesthetic benefits when it is full during the monsoons. It has a great potential for development as a picnic spot. While the efforts of improving the recreational attraction of Ousteri have included restaurants, boathouses, water fountains, trekking and other attractions, they seem to be of no value, since most of the facilities created are not being maintained properly. The officials of the Puducherry tourism department pointed out that an interdepartmental coordination is required for proper management of the wetland in general and the facilities created for recreational purpose in particular. Investment towards improvement of the basic requirements of a tourism site needs to be pipelined properly. The migratory birds should be well protected

by creating an environment of a bird sanctuary, which seems to be missing even at the planning level in both Tamil Nadu and Puducherry. Rural development could aid in conservation of the wetland in a more effective manner. Since tourists visit only the Puducherry zone at present, the stakeholders believe that in order to attract tourists in the Tamil Nadu zone, proper planning has to be initiated, executed and achieved in the coming years.

What are the economic impacts of changes in the ecological, hydrological, socio-economic and institutional changes taking place in and around Ousteri wetland? In the following section, we focus on estimating the economic impact of changes in ecosystem services caused by various changes in the wetland. Since most of the ecosystem services that have both direct and indirect impacts on the welfare of the households are non-market in nature, we estimate such economic impacts in terms of monetary values by using appropriate non-market valuation techniques.

9. Estimating the Economic Value of Ecosystem Benefits

As we have already discussed, Ousteri wetland supplied all four types of ecosystem services, namely, provisioning, regulating, supporting, and cultural services. Many households in the neighbouring 10 villages benefitted from these services both directly and indirectly in the past. After the wetland was declared a bird sanctuary, the households could no longer access most of these benefits. We conducted focus group discussions and informal interviews with many stakeholders and identified the benefits that are currently utilised and those that are foregone due to conservation efforts. In the following section, we deal with estimating both the gains and losses under the conservation regime, in terms of monetary values.

9.1. Estimating Recreational Benefits

After the wetland was declared a bird sanctuary, a major direct use value derived from the wetland throughout the year has been recreational benefits. Interactions with the Puducherry tourist department officials revealed that the number of tourists visiting the tourist spots in the wetland has been rising over a period of time. It should however be noted that data on the number of tourists is not readily available from any source. Since the Puducherry tourism department does not collect any entrance fee from tourists, we have no information on the total number of tourists visiting the wetland

on an annual basis. However, the tourism department maintains data on the number of tourists hiring recreational boats (see Table 31) as well as the total revenue generated from renting out the boats (see Table 32a). Available data suggests that both the number of tourists hiring boats as well as the revenue generated have increased between 2012 and 2013, with a slight decline between 2013 and 2014, especially for the period from January–August each year (see Figure 21).

The existing secondary data is not sufficient to estimate the economic value of the total consumer surplus enjoyed by the tourists. Alternatively, we used a different approach to estimate: a) the approximate number of tourists visiting the wetland during 2014–15; and b) the value of the travel cost incurred by tourists that reflects the lower-bound value of their maximum willingness to pay for recreational benefits. In order to estimate the approximate number of visitors to the site, we did a complete enumeration of the visitors on 10 days during September, 2014 till April, 2015. Based on the total number of visitors during these 10 days, we estimated the average number of visitors, which is equivalent to 257 (see Table 32b and Figure 22). Based on this value, the total number of visitors is predicted to be 93,805 during 2014–15. Although this prediction may not accurately reflect the actual number of visits that could take place in the reference year, it is the alternative method of calculation that gives us the

Table 31: Number of Visitors (month-wise) who Hired Boats in Ossudu Wetland (2012 -2014)

Months	2012	2013	2014
January	1556	2763	2982
February	1107	1453	1303
March	1176	1657	1408
April	2374	1969	1606
May	4068	3012	3213
June	1526	1856	1088
July	1255	1232	1345
August	1610	1310	1870
September	1145	1391	NA
October	1088	1058	NA
November	1016	869	NA
December	1750	2480	NA
Total	19671	21050	14815 (till August)

Source: Department of Tourism, Puducherry

‘proxy’ for the actual visits. It is suggested that in the future, the tourism department should initiate measures to collect data on visits made by tourists to the wetland.

We also conducted well-structured interviews among all the visitors on two days (out of the 10 days) and estimated the travel cost incurred by visitors. The visitors utilise different modes of transportation (see Table 33). The expenditure, including cost of travel and all other expenses on site, incurred by an average visitor is estimated to be ₹49.00 per visit (see Table 34 and Figure 24, 25 and 26). In addition, we elicited the maximum willingness to pay (WTP) for improvements in tourism facilities in the site, such as installing garbage bins, improvements in the children’s playground,

Table 32a: Revenue Generated by the Boathouse (in ₹*), Ousteri, Puducherry

Months	2012	2013	2014
January	79020	147510	159210
February	51540	78300	68320
March	55440	89770	70400
April	117600	93430	94930
May	165210	141850	168800
June	62580	85350	52750
Total for 6 months	531300	636210	614320

*₹.50/per person for 1 hour boat raid.

Source: PTDC, Ousteri.

Table 32b: Details about the Enumeration among the Visitors on 10 days from September, 2014 -April, 2015

Date of Enumeration	Number of Visitors
16th September, 2014	287
22nd October, 2014	227
3rd November, 2014	216
24 November, 2014	265
25th December, 2014	292
1st January, 2015	306 (Complete Survey)
18th February, 2015	259
3rd March, 2015	242
30th March, 2015	207 (Complete Survey)
9th April, 2015	269
Total	2570.00

parking facilities, improving the conditions of the restaurants and boating facilities etc., to be carried out during the next five years. The entrance fee was used as a payment vehicle and on an average, the visitors were willing to pay ₹12.00 as a nentrance fee. So, the total value of the recreational benefits per person per visit is estimated to be ₹61.00 (i.e. ₹49 as actual cost incurred + ₹12.00 as additional WTP value). Based on this value, the total value of the recreational benefits enjoyed by all the visitors during the year 2014–15 is estimated to be ₹5722105 (at 2014 prices). We have used only the simplified version of the 'zonal travel cost' model to estimate the willingness to pay value for recreational benefits. Since all our visitors went exclusively to the site, we have not encountered any problem that could arise from multiple visits (which would also require employing 'random utility' modelling). Estimating the opportunity cost was a difficult task and future research needs to be devoted to this aspect.

9.2. Estimating Irrigation Benefits

The major ecosystem benefit of the wetland to the agriculture sector comes in the form of water for irrigation. As we have already seen, around 10 villages are utilising groundwater for agricultural purposes. Secondary data on cropping patterns, number of crops, number of farmers, size of land holding, etc., has been used to assess the status of agricultural operations in these villages. The farmers in the villages utilise a significant amount of groundwater, recharged by Ousteri, for irrigation purposes. They can cultivate paddy, a water-intensive crop, for two seasons: *kuruvai* (June to September) and summer crop (January to April) every year. Some of the farmers reported that they could cultivate a third crop, usually, dry-irrigated crops such as groundnut, gingili and tapioca, due to availability of additional groundwater in this region. So, additional availability of groundwater in the wetland region does have a positive impact on farm income in

Table 33: Modes of Transportation by the Visitors to Ousteri

Area	Bike	Bus	School Van	Car	By Walk	Total Households
Koodapakkam	3	0	0	0	0	3
Muthuraipalaiyam	6	0	0	0	0	6
Pathukannu	4	0	0	0	3	7
Puducherry	39	3	7	1	0	50
Ramanathapuram	5	0	0	0	0	5
Setharapet	42	3	4	0	0	49
Villianur	17	0	0	0	0	17
Villupuram	3	0	0	0	0	3
Total	119	6	11	1	3	140

Source: *Primary Survey*

Table 34: Details about Number of Visitors (Two days) and Travel Cost Incurred

Origin	Adults	Children	Visitors total (for two days)	Per day average	Total exp.	Avg. Expenditure
Koodapakkam	6	7	13	7	80	6
Muthuraipalaiyam	9	4	13	7	850	65
Pathukannu	11	10	21	11	120	6
Puducherry	134	109	243	122	13490	56
Ramanathapuram	10	8	18	9	520	29
Setharapet	95	47	142	71	7580	53
Villianur	40	15	55	28	1710	31
Villupuram	6	2	8	4	1000	125
Total	311	202	513	257	25350	49

Source: *Primary Survey*.

the neighbourhood villages. However, the secondary data sources do not reveal anything about the quantity of groundwater being used for irrigation. In order to estimate the marginal agricultural benefits from groundwater recharge function, we collected relevant information on groundwater used by conducting primary surveys among the farmers in Kadapperi and Poothurai villages. We selected 20 farmers using purposive sampling². Out of 20 sample farmers, 13 farmers own land in the western part of Ousteri and cultivate water-intensive crops such as paddy and sugarcane; these farmers are called 'treatment group' farmers. The remaining 7 farmers, i.e. the 'control group' farmers, cultivate land in other villages far from Ousteri. Selecting 20 farmers in two villages that are located far apart provides us 'with' and 'without' scenarios, so that we can estimate the marginal differences in the agricultural benefits of groundwater recharged by the wetland. Although both types of farmers utilise groundwater for cultivation purposes, the farmers in the wetland command have an advantage of cultivating water-intensive crops for the second cropping season and also benefit from a third crop. The farmers in the control group have difficulty getting groundwater for second and third crops. Therefore, they adopt certain coping mechanisms such as cultivating non-water intensive crops (e.g. groundnut, vegetables, etc.), reducing irrigation for the second crop, and keeping the land fallow during the third crop. So, the net farm income of the farmers in the wetland command is assumed to be greater than that of the farmers in the control group. An independent t-sample test suggests that the average size of land holding of the wetland-bed farmers (1.43 acres) and the farmers in the control group (1.85 acres) is not statistically significantly different from each other and therefore, the farmers' categories are comparable. We assumed that other things remaining the same, the differences in the net farm income across the two categories of farmers can be treated as the marginal benefit from groundwater availability enhanced by the wetland. In order to estimate such marginal benefits, we computed a production function using information

on net farm income, size of the land owned, size of the land cultivated in *kuruvai* and *summer* seasons, cost of cultivation, amount of irrigation per week etc. The results suggest that other things remaining the same, additional availability of groundwater, equivalent to one hour of pumping, leads to an increase in the net farm income by ₹28.75³ (see Table 35). This implies that the farmers in the wetland command derive an extra-marginal benefit of ₹5862.64 per acre (as farm income) due to additional pumping of groundwater. The revenue records obtained from Tamil Nadu and Puducherry governments suggest that totally, around 1961.03 acres (or 793.52 ha) of ayacut area in 10 villages under the wetland command is cultivated with groundwater. So, the total marginal benefit from groundwater use for agricultural purposes in all seven villages is estimated to be ₹1,14,96,813.01 per annum (at 2014 prices). Since most of the farmers are marginal and small farmers, the extra-marginal benefit from groundwater use is significant, in terms of welfare implications.

9.3. Estimating Biodiversity and Ecosystem Benefits

As we have already seen, conservation efforts by both the governments have deprived a number of ecosystem benefits to the neighbouring villagers who utilised direct use values of the wetland. We could not fully understand the following: a) the nature of the ecosystem benefits foregone by individual households due to conservation efforts; and b) the economic value of the foregone benefits. However, the households may still prefer protecting the biodiversity and would place a monetary value on the ecosystems that they could potentially utilise from biodiversity protection. In order to elicit the preferences for biodiversity protection, we conducted household surveys among the selected sample households in those villages which are located closer to the wetland.

We selected 200 sample households from seven villages, based on the village level demographic data available from the village administrative officers. We have also used voters' list, provided by the State Election Commission, to draw the sample households.

² Indeed, we aimed for surveying at least 40 farmers but non-response, attrition and resistance from some of the farmers resulted in conducting survey that is complete in all respects only among 20 farmers.

³ It should be noted that the number of hours of pumping of groundwater per irrigation in the Ousteri bed is comparatively lesser than that of far-away villages due to easy availability of groundwater in the Ousteri-bed. This means that more hours of pumping per irrigation is required for farmers in the control group and therefore, interpreting the marginal benefits in terms of number of hours of pumping will be misleading. However, we found that the number of hours of pumping per irrigation (i.e. 3–4 hours per irrigation per acre) does not significantly differ much across both categories of farmers but the number of irrigation among the wetland-bed farmers (75.46 irrigations per year) is found to be significantly greater than that of the farmers in the control group (i.e. 51.42 irrigations per year). This is due to the fact that the control group farmers cultivate only dry-irrigated crops for the second season and the land is fallow during the third season. An independent t-sample test also confirms the above results.

Table 35: Irrigation benefits from Ousteri Wetland

Farmers	Number of Farmers		Size of Landholding (in acres)	Total Number of Irrigation (two seasons)	Total Hours of Electricity Used (two Seasons)	Net Farm Income (in ₹)
Cultivating in Ousteri bed	13	Mean	1.43	75.46	584.53	29576.92
		Std. Deviation	0.94	7.81	353.77	16309.30
Cultivating in other areas	7	Mean	1.85	51.42	450.00	23714.28
		Std. Deviation	1.06	16.76	252.78	8769.53
Total	20	Mean	1.58	67.05	537.45	27525.00
		Std. Deviation	0.98	16.29	321.80	14160.24

Source: *Primary Survey*

It should be noted that our sample households (200 households) constitute 3.2% of all 6,230 households in the seven villages selected. We interviewed adults in the households and in our sample, we have 73.5% male respondents 26.5% female respondents. Out of 200 sample households, the percentage sample in each villages ranges from 11.5% (Koodapakkam) to 17.5% (Olavaikkal).

Out of the total households sampled, 128 households (i.e. 64%) reported that 10 years back, they used direct benefits from the wetland that include bathing, washing clothes and washing vessels (see Table 37–41). The households reported at least one particular benefit as a 'primary benefit'. Some of the households recalled that they utilised additional benefits along with the primary benefit at times.

Among the sample households, 47 households (23.5%) utilised the wetland for taking a bath, followed by 39 households (19.5%) who utilised it primarily for washing clothes, and 37 households (18.5%) reported utilising the wetland for washing cattle, agricultural implements and vehicles (e.g. tractors). A total of 72 sample households (36%) revealed that they have not directly benefited from the wetland.

Open grazing was widely practiced in Ousteri about 10 years back. Livestock from the neighbouring villages benefited largely from open grazing. In the past, livestock from 50% of the sample households depended on fodder from the wetland, especially during the dry season. Over 66% of the sample households collected grass and other types of fodder from the wetland, and used them for cattle feeding. Since they are restricted from entering the wetland at present, they claim to now spend an average of ₹2000.00 per year on fodder. Some of the sample households (10%) collected fuelwood for cooking purposes in the past, but have switched over

to LPG now. Few households harvested lotus flowers from the wetland and sold them in Puducherry city on a commercial basis. These households reported that they could earn an income ranging from ₹200 to ₹500 per day from selling lotus, but presently, they are not allowed to harvest lotus flower.

Another major benefit enjoyed by the households was fish. Interaction with the villagers revealed that the village panchayats used to sell fish in the wetland through auctions every year. Auctioning of fish fetched them ₹50,000 to ₹60,000, annually. The income earned from fish sales was used for providing local public goods (such as a community hall) in these villages. Apart from selling the fish through auctions, individual households caught fish for subsistence purposes as well. Around 110 sample households (55%) reported that they caught fish and used it for consumption purposes in the past. Presently, only 24 households (12%) reported to catch fish for consumption purposes occasionally. All the 110 households which depended on fish from the wetland in the past now purchase fish from the market, which costs ₹620 per household per month (at 2014 prices). This implies that in case these households were allowed to continue to catch fish from the wetland, they would gain an economic welfare equivalent to ₹620 per month.

It should be noted that conservation measures by the governments deprived the households of many of the ecosystem benefits they enjoyed in the past. As a result, the economic welfare enhanced by the availability of various ecosystem benefits in the past is lost at present. However, many households have gradually become adaptive to the loss of ecosystem benefits and opted for various alternative measures to partially compensate for their welfare loss. For example, alternative employment opportunities in the non-farm

sector (such as in the industrial and service sectors) and general increase in the household income considerably reduced their dependency on the ecosystem benefits of the wetland. Similarly, many of the households got piped water supply and bathrooms in their homes and therefore, they were no longer dependent on the 'in-situ' benefits of the wetland, such as bathing and washing clothes. In recent years, the governments have introduced and expanded several welfare schemes for the rural households, which improved their general economic conditions and significantly reduced their dependency on the wetland for their livelihoods. Most of the households still prefer to have access to the biodiversity benefits from the wetland.

In order to estimate the households' expected economic benefits due to biodiversity protection,

Table 36: Distribution of Sample Households

Name of the Village	Number of Sample Households	Per centage	Cumulative Per centage
Usteri	27	13.5	13.5
Koodapakkam	23	11.5	25
Ramanathapuram	31	15.5	40.5
Olavaikkal	35	17.5	58
Thondamanatham	30	15	73
Poothurai	29	14.5	87.5
Kadaperikuppam	25	12.5	100
Total	200	100	

Source: *Primary Survey*

Table 37: Different Types of Use Values that the Households in the Villages Consumed in the Past - I

Name of the Village	Washing Cattle, Vehicles	Washing Cloths	Religious Purpose	Taking Bath	Number of Households Used for Any One of the purposes	Did Not Use	Total
Usteri	7	6	2	4	19	8	27
Kadaperikuppam	2	5	0	4	11	12	23
Ramanathapuram	6	11	3	5	25	6	31
Olavaikkal	8	5	0	11	24	11	35
Thondamanatham	7	3	0	10	20	10	30
Poothurai	5	4	0	13	22	7	29
Kadaperikuppam	2	5	0	0	7	18	25
Total	37	39	5	47	128	72	200

Source: *Primary Survey*

Table 38: Different Types of Use Values that the Households in the Villages Consumed in the Past -II

Name of the Village	Taking Bath	Washing Cloths	Washing Vessels	Washing Cattle, Vehicles	Religious Purpose	Did Not Use	Total
Usteri	4	6	3	2	4	8	27
Kadaperikuppam	1	5	1	0	4	12	23
Ramanathapuram	3	11	3	3	5	5	31
Olavaikkal	2	5	6	0	11	11	35
Thondamanatham	4	3	3	0	10	10	30
Poothurai	1	4	4	0	13	6	29
Kadaperikuppam	2	5	0	0	0	18	25
Total	17	39	20	5	47	70	200

Source: *Primary Survey*

we administered a contingent valuation (CV) survey among the sample households to elicit the preferences of these households. We followed all the major CV guidelines (NOAA, 1993) in order to elicit valid and reliable answers from the households. We developed a realistic CV scenario based on interactions with different stakeholders, focus group discussions, pre-testing the interview schedule in the field and conducting pilot studies among select households (see Annex 3 for interview schedule used in our survey). One of the major aims of the CV survey was to measure the preferences of the households to have access to the ecosystem benefits from protection of biodiversity in the wetland. Rather than estimating the economic value of each benefit that the household would prefer, which also may differ across different households both in terms of quantity and quality, we described the CV scenario to the households and asked them to make the

best judgement on the basis of their own preferences. In the CV survey, it is assumed that the households have better knowledge about the ecosystem benefits they prefer as well as the economic values of any disutility associated with their decision.

The CV scenario included in our survey described the proposed improvements in the wetland (drawn mainly from the management plan with the budget prepared by SACON, 2012), institutional arrangements between different stakeholders to access certain benefits (e.g. how to harvest the lotus/fish, who has to harvest, how to share the benefits from it, etc.), payment vehicle (annual payment to the Wetland fund specially created for conservation purposes), duration of the proposed arrangement (i.e. 5 years from now) and reminders about the budget constraints and substitute ecosystem services. In the following section, we discuss the results of the CV survey.

Table 39: Different Types of Use Values that the Households in the Villages Consumed in the Past -III

Name of the village	Grazing	Collecting grass/ Fodder from Ousteri	Collecting Fuel-wood	Collecting Lotus from Ousteri
Usteri	17	23	6	3
Koodapakkam	8	19	1	4
Ramanathapuram	17	23	4	8
Olavaikkal	10	21	3	4
Thondamanatham	10	15	4	6
Poothurai	21	12	2	7
Kadaperikuppam	17	20	0	4
Total	100 (50%)	133 (66.5%)	20 (10%)	36 (18%)

Source: *Primary Survey*

Table 40: Number of Households Benefited from Fish in the Ousteri in the Past

Name of the Village	Catch Fish	No Catch	Total
Usteri	20	7	27
Kadaperikuppam	15	8	23
Ramanathapuram	14	17	31
Olavaikkal	24	11	35
Thondamanatham	16	14	30
Poothurai	3	26	29
Kadaperikuppam	18	7	25
Total	110 (55%)	90 (45%)	200

Source: *Primary Survey*.

Table 41: Number of Households Catching Fish from Ousteri Wetland at Present

Name of the Village	Catching fish	No Catch	Total
Usteri	2	25	27
Kadaperikuppam	0	23	23
Ramanathapuram	6	25	31
Olavaikkal	3	32	35
Thondamanatham	4	26	30
Poothurai	0	29	29
Kadaperikuppam	9	16	25
Total	24	176	200

Source: *Primary Survey*

We found that the sample households generally prefer to protect the wetland for sustainable use and are also willing to pay for having access to some of the use benefits that they find valuable. Our survey results suggest that 167 sample households (83.5%) are willing to pay a positive amount from their income for improvements in the wetland and to have access to some of the use benefits (See Table 42). An average household is willing to pay a maximum of ₹392.80 (or approximately ₹393) per year (at 2014 prices) for protecting the wetland. The WTP value ranges between ₹0 and ₹3000 per annum (see Table 43). Among the sample households, 33 households (16.5%) are not willing to pay any positive amount. Although they prefer to protect the wetland for future use, they cited genuine reasons for their decision not to pay for it.

The reasons include: lack of household income, free-riding by other households, etc. Among those who are willing to pay, a maximum number of households (44 households or 22% of the total number of households) are willing to pay ₹500 per year. Around 98% of the sample households are willing to pay up to ₹1000.00 per year and only 2% households are willing to pay between ₹1000.00 and ₹3000.00 (see Table 43). The WTP values across villages suggest that the villages that are located closer to the wetland fetch a relatively higher WTP value, compared to the villages located far away from the wetland. This implies that while improvements in the management of the wetland would bring in significant additional benefits to all the villages, the villages that are located closer to the wetland are expected to benefit more than those located farther away from the wetland (see Table 44).

Estimating the 'total economic value' of the direct ecosystem benefits from the households' average WTP value is important. It can be done by extrapolating the

Table 42: Descriptive Statistics- Willingness to Pay Values

Total Sample of Household	200
Mean	392.8
Median	300
Mode	500
Std. Deviation	383.6
Range	3000
Minimum	0
Maximum	3000

Source: Primary Survey

average WTP value to the total number of households in all the villages around the wetland. The total number of households in all the seven villages is 6,230 and average WTP value is ₹392.8 per annum. Therefore, the total economic value of the direct ecosystem benefits enjoyed by the households in all the seven villages is estimated to be ₹24,47,144.00 per annum (at 2014 prices). The net present value (NPV) of the benefits for the 5-year period (at 6% discount rate) comes to ₹59,03,376.43. The NPV suggests that protecting the wetland on a sustainable basis and making the households harvest the direct ecosystem benefits can generate significant amount of economic welfare to the region. In other words, if the households are restricted from accessing the ecosystem benefits, then the society will lose real economic welfare equivalent to ₹5903376.43 during the next five years.

The total economic value of all three benefits, namely recreational, irrigation and biodiversity protection, is equivalent to ₹1,96,66,062.00 per year. The net present value of the benefits reaches ₹8,28,80,098.21 ($r=6$, $N=5$) or 83.00 million (at 2014 prices).

Table 43: Number of Households Willing to Pay Different Values

Max WTP Value	No. of Households	Valid %	Cumulative %
0	33	16.5	16.5
100	9	4.5	21
150	8	4	25
160	1	0.5	25.5
200	22	11	36.5
250	1	0.5	37
300	30	15	52
400	20	10	62
450	1	0.5	62.5
500	44	22	84.5
600	8	4	88.5
800	3	1.5	90
1000	16	8	98
2000	3	1.5	99.5
3000	1	0.5	100
Total	200	100	

Source: Primary Survey

Table 44: Distribution of Households Across Villages and their Willingness to Pay Values

Name of the Village	Number of Respondents	Mean	Std. Deviation	Median	Maximum
Usteri	27	474.44	665	200	3000
Koodapakkam	23	439.13	208	500	1000
Ramanathapuram	31	324.19	436	150	2000
Olavaikal	35	437.14	239	400	1000
Thondamanatham	30	378.33	401	300	2000
Poothurai	29	470.69	278	400	1000
Kadaperikuppam	25	212.00	196	150	500
Total	200	392.80	384	300	3000

Source: *Primary Survey*

10. Conclusions

The results show that the economic value of even a very limited number of ecosystem benefits, i.e. recreational benefits, groundwater irrigation and biodiversity protection, currently derived from Ousteri can be significant. The conservation measures initiated by the governments and the existing negative externalities such as industrial pollution, encroachment and siltation, reduced the number of as well as the size of ecosystem benefits currently utilised by different stakeholders. Most of the people living around the wetland were willing to pay for conservation of the wetland, with the expectation that they could maximise their expected benefits by using ecosystem benefits from the wetland as complementary goods/services in their consumption. Although the traditional users of the region have been denied access to ecosystem benefits due to conservation measures, involving the local people in managing the wetland and allowing them to share some of the benefits would create a win-win situation to the users and the governments.

Cooperation between the people and the governments can minimise the transaction costs (such as monitoring cost) of wetland management. Such a cooperative institutional mechanism comes in the form of 'payment for ecosystem services' (PES), which embeds incentives for the stakeholders to protect the wetland in an efficient, equitable and sustainable basis in coming years.

11. Policy Inputs

11.1. Scenario A: Business as Usual

After the TN government announced the wetland as a sanctuary in 2014, conservation became the sole objective and as a result, many of the ecosystem benefits accessed by the people in the past are no longer available for current use. Pollution from industrial activities mainly in the upstream areas of the wetland continues to be a major cause for concern. While we know that industrial pollution is a serious issue, we do not have the necessary information on the quantity and the nature of pollutants released by activities. Informal interactions with the industry representatives in the Sedarapet industrial complex suggest that the industrialists are willing to cooperate with the officials to control pollution. Therefore, an immediate step to protect the wetland is to estimate the quantity of effluents and the cost of minimising and eliminating the toxic effluents, and to ensure institutional arrangements to increase cooperation between the industry and government in order to treat effluents effectively in the coming years. Apart from pollution, in recent years, other forms of negative externalities are caused by various other sources as well, such as a medical institute located on the northwestern bank of Ousteri (Figure 18). The institute owns a total of 46 acres of land and is dependent on groundwater for its day-to-day requirements. The campus has three borewells to pump groundwater; the water is stored in a sump with a capacity of 5 lakh litres and an overhead tank with a capacity of 30,000 litres. The institute also generates bio-medical wastes and wastewater, which are channelled through incineration and effluent treatment plants. However, the stakeholders still raise concerns over the adverse consequences of groundwater extraction and medical waste generated on the bank of the wetland.

Apart from the medical institution, an amusement park is situated on the southern bank of the wetland since 2007 (see Figure 19). Although valid data on the quantity of water used in the park is not available, we understand that a significant amount of groundwater is being pumped to meet huge water requirements in the park. The accelerated extraction of groundwater and release of bio-medical waste and bio-effluents provide an indication of the worsening situation of the wetland. Objections were raised by around 21 NGOs and other ecological centres like SACON against such actions, claiming that activities on the bank of the wetland would hamper the long-term sustainable well-being of not only the wetland and its ecosystems but also that of the people of the region. Appropriate actions need to be initiated to control pollution, regulate groundwater use and curb illegal dumping of solid wastes in the vicinity of the wetland, so that the wetland can be managed efficiently in an inter-temporal basis. Similarly, desiltation activities within the wetland need to be initiated so that the silt deposit that also contains heavy metals and other pollutants can be removed from the wetland and the water holding capacity can be enhanced. The siltation activities need to be sensitive so

that the rich ecology of the wetland is not disturbed. In order to prevent soil erosion and siltation in the future, watershed protection measures in the upper catchment areas, especially with the help of villagers and farmers, can be undertaken. The Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS) will have to be effectively utilised to carry out watershed protection measures.

11.2. Scenario B: The 'Middle Path'

Scenario B is associated with a 'middle-path' where pollution from the industrial units is controlled. This would improve the water quality in the wetland and at the same time, the people in the neighbouring villages would be allowed to access certain important ecosystem benefits (such as fish, lotus, and other in-situ uses) that they enjoyed before conservation efforts were initiated. Because of restricted access, the entire cooperative spirit of the villagers in managing the wetland had been crowded-out. For example, as long as the villagers benefited from the wetland, they were able to collectively act in curbing illegal fishing and poaching of wild animals and birds by the outsiders. Once the forest departments took over the wetland management, the collective spirit of the people eroded. So, an effective management of the wetland can be achieved only by involving the local people in managing the wetland

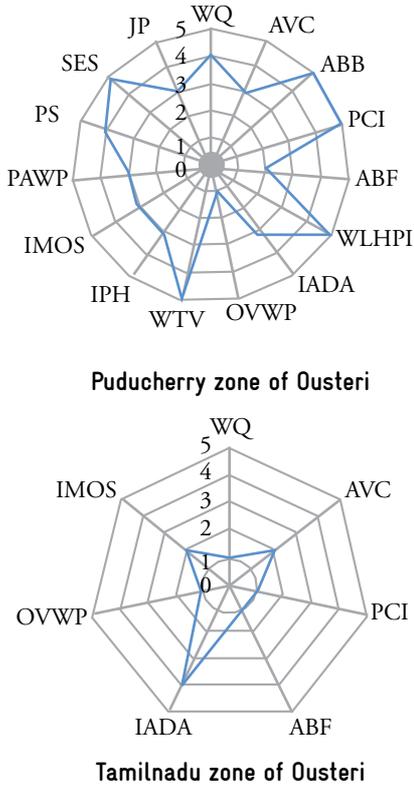
Figure 18: Pictures representing the Medical College and Hospital established in the neighbourhood of Ousteri



Figure 19: Pictures representing the water games operated in the Pogo Land amusement park located adjacent to the Ousteri

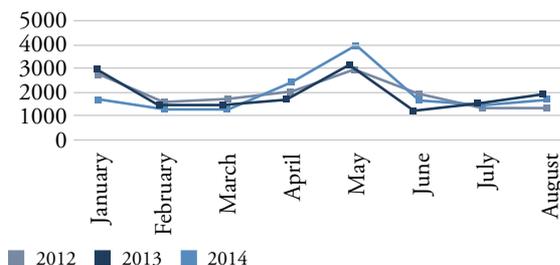


Figure 20: The results of stakeholder opinion over ecosystem services provided by Ousteri wetland system across the Puducherry zone and Tamil Nadu zone



[WQ, water quality; AVC: aquatic vegetation coverage; ABB: aquatic botany biodiversity; PCI: plant community integrity; ABF: achievement of buffer function; WLHPI: Wildlife /faunal habitat protection and improvement; IADA: intensity of anthropogenic disturbance activities; OVWP: output value of wetland products; WTV: wetland tourism value; IHP: increase of house price in the surrounding area of wetlands; IMOS: integrity of management operating system; PAWP: Stakeholders feedback on wetland protection; PS: public satisfaction; SES: scientific education service; JP: job provision]

Figure 21: Number of visitors to Ousteri from January to August (2012-2014)



and letting them share some of the important benefits resulting from management. Similarly, the improved water supply programme proposed (i.e. 50 MLD per day for 3 months a year) by the Puducherry government to supply drinking water for people in Puducherry in the future, along with improved tourism benefits, can be sustained only if a cooperative management regime is introduced in the coming years.

11.3. Scenario C: Willingness to Pay

In order for the stakeholders to participate in managing the wetland, one needs to understand the preferences of the stakeholders in relation to different levels of improvement in the wetland. Tourists prefer improvements in the tourism facilities in the wetland,

Figure 22: Total Number of Visitors in Ousteri

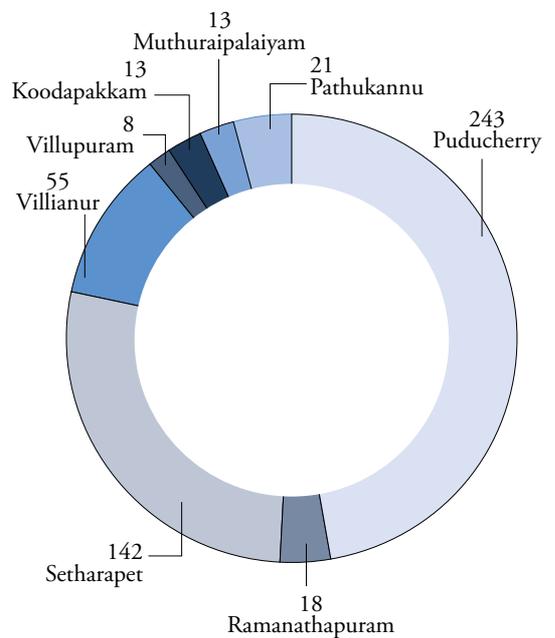


Figure 24: Average Expenditure of Visitors

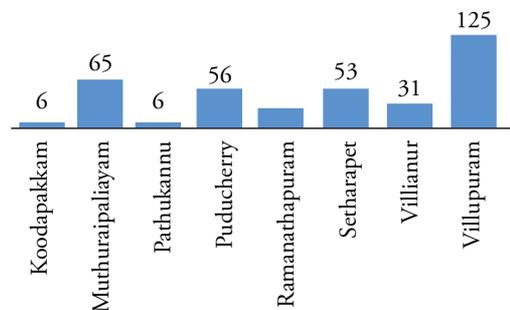


Figure 25: Mode of Transportation by the Visitor Households

Average Expenditure and Total Number of Visitors in Ousteri (in ₹)

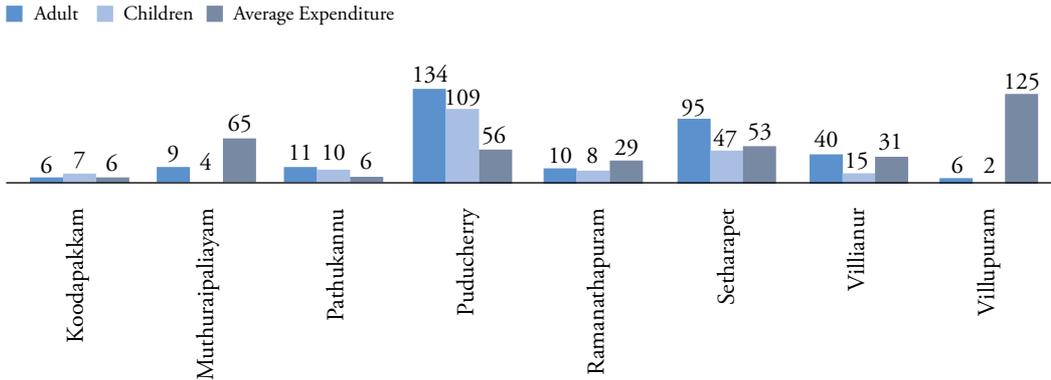
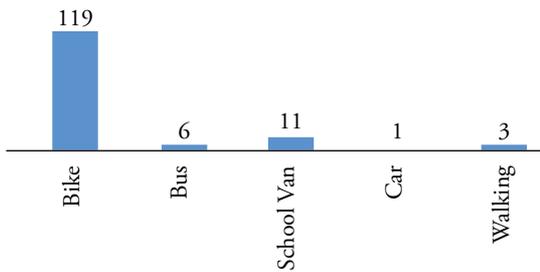


Figure 26: Visitor's Mode of Transportation



which are already established for recreational purposes. Apart from improving the facilities in the existing spots in the Puducherry side, the tourists and the villagers prefer to introduce tourism facilities on the Tamil Nadu side of the wetland. Since tourists are willing to pay additional amounts for improved facilities, the cost of improvements can be met by increasing the entrance fee without reducing the consumer surplus enjoyed by the tourists. Strict eco-tourism principles need to be followed as well. Informal discussions with the industrialists suggest that they are willing to participate in pollution control measures, provided the cost of doing so is shared by all the polluters on an equitable basis. They also prefer if the governments help them establish pollution control facilities with adequate know-how and subsidies. The farmers who are benefited from the wetland in terms of groundwater irrigation see clear benefits from improvements in the wetland and therefore, they are also willing to follow certain practices, such as reduced use of chemical fertilisers, pesticides and groundwater. The farmers are willing to reduce the use of chemical fertilisers provided they are

allowed to extract soil and algae from the wetland, which are considered a close substitute for the above inputs. So, participation of the stakeholders depends mainly on the new institutional arrangements that provide opportunities for the stakeholders to have access to ecosystem benefits of the wetland on a sustainable basis.

11.4. Scenario D: Stakeholder Cooperation

Cooperation among the stakeholders is vital for the efficient management of the wetland. Without such cooperation, the condition of the wetland can deteriorate over a period of time. If the governments alone are responsible for managing the wetland, then the transaction costs of doing so will be exorbitant high. For example, monitoring and curtailing illegal activities such as dumping of solid waste and poaching of birds by the governments alone may be too costly. But cooperation between the governments and the villagers can create a win-win outcome. Such a cooperative solution can emerge from incentive-based institutional arrangements such as payment for ecosystem services (PES), which has been successfully implemented in managing environmental resources in other parts of the country (e.g. Shukomajri watershed in Haryana).

FUTURE RESEARCH

The future research may focus on the following aspects:

a. A detailed study on developing a comprehensive 'environmental accounting' for the Ousteri wetland needs to be initiated. Existing secondary data is acutely scarce to develop such a comprehensive accounting system and therefore, initiating the accounting exercise will help planners/policymakers generate the required data over a period of time.

b. Appropriate institutional arrangements required for managing the wetland collectively by important stakeholders need to be devised. For example, 'payment for ecosystem services' (PES) is

considered more effective in managing the wetland on a cost-effective basis as well as in terms of generating maximum benefits to the stakeholders on a sustainable basis. However, institutional arrangements for implementing PES are complicated and therefore, more research is needed in this area.

c. Due to non-availability of information and lack of cooperation from the users causing different types of externalities (such as pollution from industries and the hospital), we were not able to focus on the institutions and resources needed for addressing various negative externalities causing deterioration of the wetland. Future research should focus on the above issue in a systematic manner.

REFERENCES

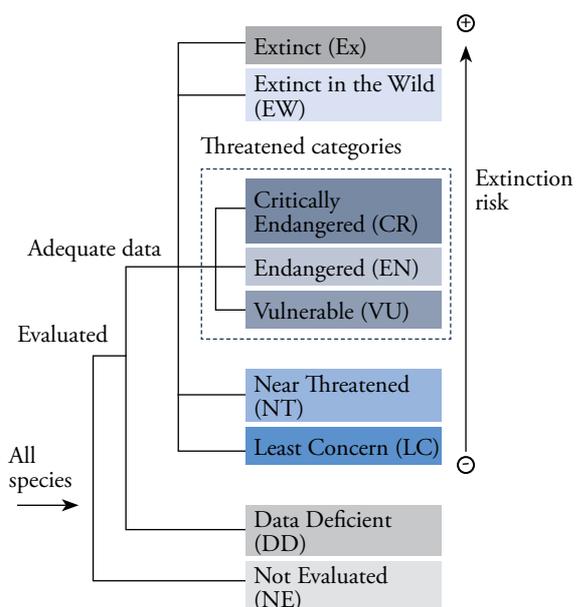
- Abbasi, S A and K B Chari (2008). *Environmental Management of Urban Lakes: With Special Reference to Oussudu*, Discovery Publishing House, New Delhi.
- Acharya, Gayatri (2000). 'Approaches to Valuing the Hidden Hydrological Services of Wetland Ecosystems,' *Ecological Economics*, 35: 63 – 74.
- Alexandar , R. and R. Sivasankar, (2013) Diversity of Fish Fauna and Their Threats in Ousteri, Puducherry, India, *World Journal of Zoology*, 8 (2):154-158.
- Barbier, Edward (2013). 'Valuing Ecosystem Services for Coastal Wetland Protection and Restoration: Progress and Challenges,' *Resources*, 2: 213–230.
- Barbier, E. B., M. Acreman and D. Knowler (1997), Economic Valuation of Wetlands: A Guide for Policy Makers and Planners. Gland, Switzerland: Ramsar Convention Bureau
- Brander, Luke M., Raymond j G M Florax and Jan E. Vermaat (2006). 'The Empirics of Wetland Valuation: A Comprehensive Summary and a Meta-Analysis of the Literature,' *Environmental and Resource Economics*, 33:223 – 250.
- Brendan,Fisher, Kerry Turner, Matthew Zylstra, Roy Brouwer, Rudolf deGroot, Stephen Farber, Paul Ferraro, RhysGreen, David Hadley, Julian Harlow, Paul Jefferiss,Chris Kirkby, Paul Morling, Shaun Mowatt, Robin Naidoo, Jouni Paavola, Bernardo Strassburg, Doug Yu, and Andrew Balmford (2011). 'Ecosystem Services and Economic Theory: Integration for Policy-relevant Research Ecosystem', *Ecological Applications*, 18: 2050 – 20.
- Chari K B and S A Abbasi (2007). 'Socio-Economic Implications of the Oussudu Lake (Pondicherry, India),' *Hydrological Journal*, 30 (3 and 4): 77 – 90.
- Chari, K B and S A Abbasi (2003). Fish fauna of Ousteri, Puducherry, *Indian Journal of Fish*, 50 (1): 97–101.
- Chattopadhyay, Kunal (2001). 'Environmental Conservation and Valuation of East Calcutta Wetlands,' In: http://coe.mse.ac.in/eercprep/fullrep/wetbio/WB_FR_KunalChattopadhyay.pdf
- Das, T K., B. Moitra, A. Raychaudhuri, T. Jash, S. Ghosh and A. Mukherjee (2000). 'Degradation of Water Bodies and Wetlands in West Bengal: Interaction with Economic Development,' In: http://irade.org/eerc/pdf/WB_FR_TKDas.pdf
- De Groot, Rudolf, Mishka Stuij, Max Finlayson, and Nick Davidson (2006). *Valuing Wetlands: Guidance for Valuing the Benefits Derived from Wetland Ecosystem Services*, RAMSAR Technical Report No. 3, Gland, Switzerland.
- de la Hera, A. Fornés, J.M. and Bernués, M., (2011). 'Ecosystem services of inland wetlands from the perspective of the EU Water Framework Directive implementation in Spain', *Hydrological Sciences Journal*, 56 (8): 1656–1666.
- Farber S C, Costanza R, Wilson M A, (2002). 'Economic and Ecological Concepts for Valuing Ecosystem Services', *Ecological Economics*, 41(3): 375–392. doi: 10.1016/S0921-8009(02)00088-5.
- Ghermandi, A., J. C. J. M. van den Bergh, , Henri L. F. de Groot and Paulo A. L. D. Nunes (2010). 'Values of Natural and Human-made Wetlands: A Meta-Analysis,' *Water Resources Research*, 46: pW12516.
- Mukherjee, Sacchidananda and M. Dinesh Kumar (2012). 'Economic Valuation of a Multiple Use Wetland Water System: A Case Study from India,' *Water Policy*, 14:80 – 98.
- Murugesan, M., Rachna Chandran, B. Anjan Kumar Prusty and P.R.Arun. (2013) Avifauna of the Ousteri and its Environs, Puducherry, India and Conservation Concerns. *Bird Population*, 12: 19–29.
- Padmavathy, A., R. Alexander and M. Anbarashan,(2010) Diversity of Birds in Ousteri Wetland, Puducherry, India. *Our Nature*, 8: 247–253.
- Ramachandra T V and R. Rajinikanth (2011). 'Economic Valuation of Wetlands', Technical Report 101, Indian Institute of Science, Bangalore.
- SACON (Salim Ali Centre for Ornithology and Natural History) (2011). *Comprehensive Management Action Plan for Conservation of Oussudu Sanctuary, Puducherry*, Final Report Submitted to The Department of Forests and Wildlife, Government of Puducherry.
- Sagoff, Mark (2011). 'The Quantification and Valuation of Ecosystem Services,' *Ecological Economics*, 70: 497 – 502.
- Shapiro, Julie and Andras Baldi (2014). 'Accurate Accounting: How to Balance Ecosystem Services and Diservices', *Ecosystem Services*, 7: 201 – 202.
- Verma, Madhu (2001). 'Economic Valuation of Bhoj Wetlands for Sustainable Use'. In: http://coe.mse.ac.in/eercprep/fullrep/wetbio/WB_FR_MadhuVerma.pdf.
- Zhu Lin, Yunhu Chen, Huili Gong, Weiguo Jiang, Wenji Zhao, Yanfang Xiao (2011). 'Economic Value Evaluation of Wetland Service in Yeyahu Wetland Nature Reserve, Beijing', *Chinese Geographical Science*, 21(6): 744–752.

ANNEX 1

Categorising Species:

As a conservation initiative, the International Union for Conservation of Nature (IUCN) Global Species Programme working with the IUCN Species Survival Commission (SSC) has been assessing the conservation status of species, subspecies, varieties, on a global scale for the past 50 years. The main aim of this process is to high spot taxa threatened with extinction, and thereby promote their conservation (<http://www.iucnredlist.org>).

The following are the IUCN Red list categories and criteria



Source: <http://www.iucnredlist.org/about/introduction>

Description of each categories according to IUCN (2012)

(The description to each category is given here per se from the IUCN RED LIST CATEGORIES AND CRITERIA Version 3.1, Second Edition).

EXTINCT (EX) A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be

over a time frame appropriate to the taxon's life cycle and life form.

EXTINCT IN THE WILD (EW) A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

CRITICALLY ENDANGERED (CR) A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.

ENDANGERED (EN) A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.

VULNERABLE (VU) A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.

NEAR THREATENED (NT) A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

LEAST CONCERN (LC) A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

DATA DEFICIENT (DD) A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied,

and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

NOT EVALUATED (NE) A taxon is Not Evaluated when it has not yet been evaluated against the criteria.

ANNEX 2

List of Red Category Industry in Villianur commune

S.No	Name of the Factory	Size	Category
1	ACE Glass Containers Ltd	L	R
2	Alpha Tech Industrial	S	R
3	ANR Industries	S	R
4	ARK Golden India Pvt Ltd	S	R
5	ATC Chemicals Ltd	M	R
6	Balaji Oil and Black Carbon Private Ltd	S	R
7	Basic Chemicals & Industrials	S	R
8	Basic Chemicals & Intermediates	S	R
9	Chem Tech Industries	S	R
10	Classic Aluminium Company	S	R
11	Deccan Extrusion (P) Ltd	S	R
12	E.I.D Parry (I) Ltd	S	R
13	Enteeyes Paper & Board Mills (P) Ltd	S	R
14	Fine Automotive & Indust Rial Radiators Private Ltd	S	R
15	G.G. Organics Private Ltd	S	R
16	Golden Friction Modifier	S	R
17	Goldenl Products	S	R
18	Hi Tech Precision Enginners	S	R
19	High Care Products	S	R
20	Hindustan Lever Ltd.,(Toilet Soap Division)	S	R
21	Hindustan National Glass And Industries Ltd.,	L	R
22	Indian Oil Corporation	S	R
23	Indian Synthetic Polymer Specialaties	S	R
24	JBA Chemicals	S	R
25	JBA Steel	S	R
26	JBA Steels	S	R
27	Kaveri Alloy Casting (P) Ltd	S	R
28	Kaveri Alloy Castings (P) Ltd	S	R
29	Kaveri Alloy Cstings (P) Ltd	S	R
30	Kaveri Chemicals Indsutries	S	R
31	Lakshmi Metallurgicals (India) Pvt Ltd	S	R

S.No	Name of the Factory	Size	Category
32	Larsen & Toubro Ltd (Moulds & Moulding Unit)	M	R
33	Larsen & Toubro Ltd (Transmission Line Div)	M	R
34	Larsen And Toubro Ltd - Form Work Unit	L	R
35	Lebracs Rubber Lining (P) Ltd	S	R
36	Machdo Chemicals (P) Ltd	S	R
37	Magi Eco Revivers	S	R
38	Magnum Metal Products	S	R
39	Mahaveer Surfactants (P) Ltd	S	R
40	Matrim Pressure Castings	S	R
41	Metro Chemicals	S	R
42	Metro Chemicals	S	R
43	New Horizon Sugar Mill	L	R
44	New India Associates	S	R
45	Nithya Packaging Pvt Ltd	M	R
46	Paulsons Ltd	S	R
47	PDC Auto Comp	S	R
48	Petrogel (India)(P) Ltd (Unit I)	S	R
49	Pondicherry Co-Operative Milk Producers Union Ltd.,	L	R
50	Pondicherry Special Economic Zone Company Ltd.	S	R
51	Pondy Petro Products (P) Ltd	S	R
52	Praram Industries Private Limited	M	R
53	Premer Distilleries(P)	S	R
54	Premier Chemical Industries	S	R
55	Qualilty Flourides (P) Ltd	S	R
56	Quality Fluorides (P) Ltd	S	R
57	Ramachandra Education Trust	L	R
58	Rishab Intermediates Pvt Ltd	S	R
59	S.S. Fab	S	R
60	Sandeep Victor Lubricants	S	R
61	Schenider Prototyping India (P) Ltd.,	M	R
62	SG Industries	S	R

Contd...

S.No	Name of the Factory	Size	Category
63	Shree Makaleswar Plastics Pvt. Ltd	S	R
64	Sica Breweries Ltd	M	R
65	SISCO Latex (P) Ltd	S	R
66	SK V Chemicals	S	R
67	Skol Breweries Ltd	S	R
68	Sona Cashew Resins	S	R
69	Sona Meta Chem	S	R
70	South India Polymers	S	R
71	Sree Udhyam Chemicals	S	R
72	Sri Krishna Chemicals	S	R
73	Sri Saarbati Steel Tubes Limited	M	R
74	SS Riverra Indsutries	S	R
75	Suja Empoyes Ancillaries	S	R
76	Suja Rubber Industries(P)Ltd	S	R
77	Supreme Cashew Products	S	R
78	Surya Enterprises	S	R
79	United Die Castings (P) Ltd.	S	R
80	United Spirits	S	R
81	Victory Organic	S	R
82	Vilma Castings	S	R
83	Alpha Tech Industrial	S	R
84	ANR Industries	S	R
85	ARK Golden India Pvt Ltd	S	R
86	ATC Chemicals Ltd	M	R
87	Balaji Oil And Black Carbon Private Ltd	S	R
88	Basic Chemicals & Industrials	S	R
89	Basic Chemicals & Intermediates	S	R
90	Chem Tech Industries	S	R
91	Classic Aluminium Company	S	R
92	Deccan Extrusion (P) Ltd	S	R
93	Enteeyes Paper & Board Mills (P) Ltd	S	R
94	Golden Friction Modifier	S	R
95	Goldenl Products	S	R
96	HI Tech Precision Enginners	S	R
97	E.I.D Parry (I) Ltd	S	R
98	Fine Automotive & Indust Rial Radiators Private Ltd	S	R

S.No	Name of the Factory	Size	Category
99	G.G. Organics Private Ltd	S	R
100	Golden Friction Modifier	S	R
101	Goldenl Products	S	R
102	HI Tech Precision Enginners	S	R
103	High Care Products	S	R
104	Hindustan Lever Ltd.,(Toilet Soap Division)	S	R
105	Hindustan National Glass And Industries Ltd.,	L	R
106	Indian Oil Corporation	L	R
107	Indian Synthetic Polymer Specialaties	S	R
108	JBA Chemicals	S	R
109	JBA Steel	S	R
110	JBA Steels	S	R
111	Kaveri Alloy Casting (P) Ltd	S	R
112	Kaveri Alloy Castings (P) Ltd	S	R
113	Kaveri Alloy Cstings (P) Ltd	S	R
114	Kaveri Chemicals Indsutries	S	R
115	Lakshmi Metallurgicals (India) Pvt Ltd	S	R
116	Larsen & Toubro Ltd (Moulds & Moulding Unit)	M	R
117	Larsen & Toubro Ltd (Transmission Line Div)	M	R
118	Larsen And Toubro Ltd - Form Work Unit	L	R
119	Lebracs Rubber Lining (P) Ltd	S	R
120	Machdo Chemicals (P) Ltd	S	R
121	Magi Eco Revivers	S	R
122	Mahaveer Surfactants (P) Ltd	S	R
123	Matrim Pressure Castings	S	R
124	Metro Chemicals	S	R
125	Metro Chemicals	S	R
126	New Horizon Sugar Mill	L	R
127	New India Associates	S	R
128	Nithya Packaging Pvt Ltd	M	R
129	Paulsons Ltd	S	R
130	PDC Auto Comp	S	R
131	Petrogel (India)(P) Ltd (Unit I)	S	R

Contd...

S.No	Name of the Factory	Size	Category
132	Pondicherry Co-Operative Milk Producers Union Ltd.,	L	R
133	Pondicherry Straw Board Mills (P) Ltd	S	R
134	Pondy Petro Products (P) Ltd	S	R
135	Praram Industries Private Limited	M	R
136	Premer Distilleries(P)	S	R
137	Premier Chemical Industries	S	R
138	Qualilty Flourides (P) Ltd	S	R
139	Qualilty Flourides (P) Ltd	S	R
140	Ramachandra Education Trust	L	R
141	Rishab Intermediates Pvt Ltd	S	R
142	S.S. Fab	S	R
143	Sandeep Victor Lubricants	S	R
144	Schenider Prototyping India (P) Ltd.,	M	R
145	SG Industries	S	R
146	Shree Makaleswar Plastics Pvt. Ltd	S	R
147	SICA Breweries Ltd	M	R
148	SISCO Latex (P) Ltd	S	R
149	SK V Chemicals	S	R
150	Skol Breweries Ltd	S	R
151	Sona Cashew Resins	S	R
152	Sona Meta Chem	S	R
153	South India Polymers	S	R
154	Sree Udhyam Chemicals	S	R
155	Sri Krishna Chemicals	S	R
156	Sri Saarbati Steel Tubes Limited	M	R
157	Suja Rubber Industries(P)Ltd	S	R
158	Sunbeam Generators	S	R
159	Supreme Cashew Products	S	R
160	Surya Enterprises	S	R
161	United Die Castings (P) Ltd.	S	R
162	United Spirits	S	R
163	Varadha Steels	S	R
164	Veena Tex Chem Industries	S	R
165	Victory Organic	S	R
166	Vilma Castings	S	R
167	Ace Glass Containers Ltd	L	R

S.No	Name of the Factory	Size	Category
168	Alpha Tech Industrial	S	R
169	ANR Industries	S	R
170	ATC Chemicals Ltd	S	R
171	Balaji Oil And Black Carbon Private Ltd	S	R
172	Basic Chemicals & Industrials	S	R
173	Basic Chemicals & Intermediates	S	R
174	Chem Tech Industries	S	R
175	Classic Aluminium Company	S	R
176	Deccan Extrusion (P) Ltd	S	R
177	E.I.D Parry (I) Ltd	S	R
178	Enteeyes Paper & Board Mills (P) Ltd	S	R
179	Fine Automotive & Indust Rial Radiators Private Ltd	S	R
180	G.G. Organics Private Ltd	S	R
181	Golden Friction Modifier	S	R
182	Goldenl Products	S	R
183	HI Tech Precision Enginners	S	R
184	High Care Products	S	R
185	Hindustan Lever Ltd.,(Toilet Soap Division)	S	R
186	Hindustan National Glass And Industries Ltd.,	S	R
187	Indian Oil Corporation	S	R
188	Indian Synthetic Polymer Specialaties	S	R
189	JBA Chemicals	S	R
190	JBA Steel	S	R
191	JBA Steels	S	R
192	Kaveri Alloy Casting (P) Ltd	S	R
193	Kaveri Alloy Castings (P) Ltd	S	R
194	Kaveri Alloy Cstings (P) Ltd	S	R
195	Kaveri Chemicals Indsutries	S	R
196	Lakshmi Metallurgicals (India) Pvt Ltd	S	R
197	Larsen & Toubro Ltd (Moulds & Moulding Unit)	M	R
198	Larsen & Toubro Ltd (Transmission Line Div)	M	R

Contd...

S.No	Name of the Factory	Size	Category
199	Larsen And Toubro Ltd - Form Work Unit	S	R
200	Lebracs Rubber Linning (P) Ltd	S	R
201	Machdo Chemicals (P) Ltd	S	R
202	Magi Eco Revivers	S	R
203	Magnum Metal Products	S	R
204	Mahaveer Surfactants (P) Ltd	S	R
205	Matrim Pressure Castings	S	R
206	Metro Chemicals	S	R
207	Metro Chemicals	S	R
208	New Horizon Sugar Mill	S	R
209	New India Associates	S	R
210	Nithya Packaging Pvt Ltd	M	R
211	Paulsons Ltd	S	R
212	PDC Auto Comp	S	R
213	Petrogel (India)(P) Ltd (Unit I)	S	R
214	Pondicherry Co-Operative Milk Producers Union Ltd.,	S	R
215	Pondicherry Special Economic Zone Company Ltd.	S	R
216	Pondy Petro Products (P) Ltd	S	R
217	Praram Industries Private Limited	S	R
218	Premer Distilleries(P)	S	R
219	Premier Chemical Industries	S	R
220	Qualilty Flourides (P) Ltd	S	R
221	Quality Fluorides (P) Ltd	S	R
222	Ramachandra Education Trust	L	R
223	Rishab Intermediates Pvt Ltd	S	R

S.No	Name of the Factory	Size	Category
224	S.S. Fab	S	R
225	Sandeep Victor Lubricants	S	R
226	Schenider Prototyping India (P) Ltd.,	S	R
227	SG Industries	S	R
228	Shree Makaleswar Plastics Pvt. Ltd	S	R
229	SICA Breweries Ltd	M	R
230	SISCO Latex (P) Ltd	S	R
231	SK V Chemicals	S	R
232	Skol Breweries Ltd	S	R
233	Sona Cashew Resins	S	R
234	Sona Meta Chem	S	R
235	South India Polymers	S	R
236	Sree Udhyam Chemicals	S	R
237	Sri Krishna Chemicals	S	R
238	Sri Saarbati Steel Tubes Limited	M	R
239	SS Riverra Indsutries	S	R
240	Suja Empoyes Ancillaries	S	R
241	Suja Rubber Industries(P)Ltd	S	R
242	Sunbeam Generators	S	R
243	Supreme Cashew Products	S	R
244	Surya Enterprises	S	R
245	United Die Castings (P) Ltd.	S	R
246	United Spirits	S	R
247	Varadha Steels	S	R
248	Veena Tex Chem Industries	S	R
249	Victory Organic	S	R
250	Vilma Castings	S	R

ANNEX 3

Economic Valuation of Ecosystem Valuation: A Case Study of Ousteri Wetland
Interview Schedule

Information	
Date of Survey	/ /
Survey Starting Time	
Name of the State	Response 1=Puducherry, 2=Tamil Nadu <input type="text"/>
Name of the Village	
Name of the Taluk /Block	
Name of the Panchayat / Hamlet	
Name of Head of the Household (HH)	
Address	
Mobile No.	
Survey closing time	

A. General Household Information

Sl. No	Name of Family Member	Relation to HH	Age (yrs.)	Gender (Male/Female)	Educational Status	Occupational Status
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

1 - Religion (Put the code into the box)

Hindu (1)	Christian (2)	Muslim (3)	Jain (4)	Others (specify) (5)	<input type="text"/>
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2 - Social Groups (Put the code into the box)

General / Forward caste (1)	Backward classes (2)	Most Backward classes (3)	Scheduled caste (4)	Scheduled Tribe (5)	<input type="text"/>
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B- Environmental Awareness

1. How do you rate the following environmental problems in your area?

Environmental Problem	Severe	Important	Not Important	Don't Know
Solid waste				
Water Pollution				
Water supply				
Sanitation				
Degradation of water bodies				
Deforestation				
Deterioration of grazing land				
Drainage/stagnant water				
Flooding/ Inundation				
Groundwater depletion				
Groundwater salinity				
Air pollution				

2. Any other problem? _____

3. Where does your/other households' sewage go?

Sewage to Backyard (1)	Sewage going to canal/ nallah (2)	Sewage going to agricultural field (3)	Any other –Specify (4)	<input type="text"/>
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4. Where does you/your village dump solid waste?

Dustbin in the street (1)	On the street/ road (2)	Barren Field (3)	<input type="text"/>
------------------------------	----------------------------	---------------------	----------------------

5. Is any of your household waste going to Ousteri lake?

6. Do you have toilet facilities in your home? **YES / NO**

C- Ousteri Benefits Details**(1). Surface water (past/present)**

1. How far is the Ousteri Lake from your residence? _____

2. Do (did) you use surface water from Ousteri lake? **Yes / No**

3. If yes, for what purpose do (did) you collect water from the lake?

Purpose	Irrigation Purpose (1)	Cattle Purpose (2)	Bathing/Washing (3)	Anyother (specify) (4)
Past				
Present				

- 4. If for irrigation purpose, how many acres of land are (were) irrigated at present?
- 5. If for irrigation purpose, how many acres of land are (were) irrigated in the past?
- 6. How frequently do (did) you use water for irrigation purpose from the Ousteri lake?
- 7. For how many years you have (had) been utilizing water from Ossudu lake?
- 8. What crop(s) do (did) you cultivate?

Name of the Crops			
Season 1 (acres)			
Season 2 (acres)			
Annual income (₹)			

- 9. If you are not using irrigation water at present, when did you utilize water for irrigation last? _____
- 10. What crops did you cultivate 10 years back?

Crops			
Season 1 (acres)			
Season 2 (acres)			
Annual income (₹)			

- 11. If there is a reduction in irrigated area, why there is a reduction? _____
- 12. Did you pay any money to government for using water from Ousteri Lake?
- 13. Do you observe any changes in the governance of Ousteri Lake at present? **Yes/No**
If yes, what changes? _____
- 14. In what way, the change (i.e. forest department managing the lake) is good or bad

D-Groundwater

- I. Public tap/ tank (for household purpose) **Yes/ No**
- II. Own bore wells/ Open well (for household) **Yes/ No**
- III. Buying water from others **Yes/ No**

I Public tap / Tank

- 1. Do you use public tap/ tank water for drinking purpose? **Yes/ No**
If Yes, what purpose _____

- 2. When does water come from?

Morning (1)	Afternoon (2)	Evening (3)	<input style="width: 80px; height: 20px;" type="text"/>
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3. How many kodams do you collect water from public tap/ tank per day?

At Present <input type="text"/>	Before 5 years <input type="text"/>
------------------------------------	--

4. Do you pay for public tap/ tank water? **Yes/ No**

5. If yes, how much do you pay? _____ per month/ Year (specify)

6. Do you find any difference in public water quality between 5 years back and now? **Yes/ No**

7. What changes do you see –in terms of quality.....in terms of quantity-----.

8. Any other expenses on public water? ₹ per month.

II Bore-wells/ Open wells

1. Do you have your own bore-well? **Yes/No**

2. When did you install your bore well/ Open well?

3. On an average, how much water do you collect from own bore well/open wells for drinking purpose?

At Present <input type="text"/>	Before One year <input type="text"/>
------------------------------------	---

3. Do you use groundwater for irrigation purpose? **Yes/No**

	Acres
Season 1 (Rainy)	
Season 2 (Summer)	
Season 3 (Winter)	

4. Do you use electricity for pumping groundwater? **YES/No**

5. How much do you pay for electricity per year? ₹.....

6. Do you use diesel for pumping water? **Yes/No**

7. How much do you pay for diesel per month? ₹.....

8. Any expense on bore-well deepening: when ?----- ₹ -----

9. Do you observe any difference in bore water/ well water between 10 years before and now? **Yes/ No**

10. If yes, in terms of quantity.....

11. In terms of quality.....

III Buying Water

1. Do you buy or obtain water from others? **YES/NO**

2. For what purpose did you buy for?

Irrigation (1)	Drinking purpose (2)	Evening (3)	<input type="text"/>
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3 Do you pay any charges for the use of water from others? Yes/ No

4. If yes, what is the mode of payment?

Mode of payment	Measurement	Please tike respective box
Cash (in ₹)		
Kind	1/4, 2/3 of cultivation	
Anyother(specify)		

D. Benefits used from Ousteri Lake

1. Do you know Ousteri Lake is announced as sanctuary both in Puducherry and Tamil Nadu? **Yes/ No**

2. If yes, how and when did you come to know? _____

3. What benefits from Ousteri Lake were used by villagers in the past (10 years back)? **Yes/No**

4. What benefits do they use at present?

5. What changes in the benefits observed between:

Past _____

Present _____

6. Could you list some of problems that the Ousteri Lake experience at present?

7. What advantages and disadvantages are there with the water staying in the lake throughout the year now?

a. Advantages _____

b. Disadvantages: _____

IV. Grazing

1. How many cattle you own?

S.No	Name of the cattle	Population in numbers
1	Cow	
2	Buffalos	
3	Goat	
4	Sheep	
5	Hen	
6	Anyother(specify)	

1. What type of grazing would you utilize (d) for your cattle?

Open Grazing (1)	Cattle farm (2)	Any other (3)	<input type="text"/>
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2. Where do (did) you collect grass/fodder?

Ousteri Lake (1)	Dealers (2)	Grazing lands (3)	<input type="text"/>
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3. If you manage cattle farm, where do (did) you buy grass/fodder? _____

4. How much quantity bought and price paid for grass/fodder from the market?

Quantity <input type="text"/>	Price <input type="text"/>
--------------------------------------	-----------------------------------

5. Are (were) your cattle grazing directly in the Ousteri lake? **Yes/ No**

6. If yes, how many days your cattle goes (went) to Ousteri Lake per week? _____

7. In Ousteri lake, how many days per week would (did) you collect grass? _____

8. How frequently do (did) you collect grasses from Ousteri Lake? _____

9. Whether you will wash the cattle in Ousteri Lake? **Yes/ No**

10. Any change in milk, manure, income from cattle

Milk	
Manure	
Income	
Cattle	
Anyother (Specify)	

V. Direct Benefits

1. Do (did) you collect grass/fodder from Ousteri lake and sell it? **YES/No**

2. If yes, for how much do (did) you sell? ₹.....per month

3. Do (did) you collect fuelwood from Ousteri Lake area? **Yes / No**

4. What is (was) the market value of fuelwood do you collect from the Ousteri Lake? _____

5. Do (did) you use fuel-wood for commercial purpose? **Yes/ No**

If yes how much per week ₹ _____

Did you collect fuel-wood in the past?

6. Do you collect lotus from the Ousteri Lake? **Yes/ No**

If yes, do you use the lotus for commercial purpose **Yes/ No**

If yes, monthly income from sale of lotus ₹ _____

Did you collect lotus in the past? _____

7. Do you collect medicinal plants from Ousteri Lake **Yes/ NO**

If yes, what is the name of medicinal plants? _____

Did you collect medicinal plant in the past? _____

8. Purpose of taking medicinal plant?

a) Commercial B) Personal use c) Any other _____

9. What is the value of medicinal plant that you sell per month? ₹ _____

10. Do you harvest any other product (such as, wood) from Ousteri Lake? **Yes/No**

If yes, _____

11. Do you catch fish Ousteri Lake? **Yes / No**

12. What is the value of fish per month? ₹ _____

13. Did you catch fish in the past? **YES/NO**

14. What are species do you catch from Ousteri Lake at present per month? *Please mention from below table*

Fish kg (1)	Crab kg (2)	Prawn kg (3)	snail kg (4)	Frog kg (5)	Birds (6)	Anyother (7)	<input type="text"/>
----------------	----------------	-----------------	-----------------	----------------	--------------	-----------------	----------------------

In the past (10 years back)

Fish kg (1)	Crab kg (2)	Prawn kg (3)	snail kg (4)	Frog kg (5)	Birds (6)	Anyother (7)	<input type="text"/>
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15. For what purpose would catch these species from Ousteri Lake?

Commercial (1)	Food (2)	Anyother (3)	<input type="text"/>
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16. If commercial, how much will you earn per month? _____

17. Do you use any raw material from Ousteri Lake for making basket, agricultural implements etc.? **Yes/ No**

18. If yes, the value in ₹ _____

19. Please mention from the below table how you use Ousteri Lake?

Taking bath (1)	Washing Cloths (2)	Washing Vessels (3)	Washing cart (4)	Washing Motor cycle (5)	Anyother (6)	<input type="text"/>
--------------------	-----------------------	------------------------	---------------------	----------------------------	-----------------	----------------------

20. At present, what change do you see in terms of accessing the benefits?

No Access	Less access	More access
<input type="text"/>	<input type="text"/>	<input type="text"/>

VI. Indirect Benefits

21. Did you get any benefits from tourism department? **Yes/ No**

22. If yes, what type of benefits _____

23. Do you benefit from tourism activities in Ousteri Lake? **Yes /No**

If yes, how _____

24. Do you have any retail shops nearer to Ousteri Lake? **Yes/ No**

If yes, what kind of shop do you have? _____

VII. Negative Externalities

1. Do you lose any accessibility of benefits derived from Ousteri Lake after forest department taken? **Yes/ No**

Irrigation (1)	Catching fish, crab etc (2)	access to bath (3)	Poaching birds (4)	Anyother (specify) (5)	<input type="text"/>
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2. Whether you village suffers a problem of dumping solid waste? **Yes/ No**

If yes what kind of Problems _____

3. Do you have any pollution problem from industries nearer to your village? **Yes/ No**

If yes, what kinds of pollution adversely affect your village?

Air Pollution (1)	Water Pollution (2)	Noise Pollution (3)	Anyother (specify) (4)	<input type="text"/>
----------------------	------------------------	------------------------	---------------------------	----------------------

4. Measures like fencing of Ousteri Lake had adversely affected your village? **Yes/ No**

If yes, in what way _____

5. Do you have any problems after tourism activities are taken places in Ousteri Lake? **Yes/No**

6. When the access to benefits of Ousteri Lake was denied to the villagers, what alternative livelihood options do you have?

7. Are you better off with the current options? **YES/NO**

E. Co-operation to protect Ousteri Lake

Whom do you think the sole right to manage the Ousteri lake to be entrusted with?

Both the Governments	Community (Panchayats)	Lake Authority	NGOs with people	Any other
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

8. In what way would you like to take part in conserving Ousteri Lake?

Choices	Please tick below boxes
Individually, village as a whole	
Co-operate with other villages	
Co-operation with Governments	
Co-operation with NGO's	
Anyother (specify)	

9. Do you agree to take part in sharing benefits from Ousteri Lake? **Yes/ NO**

10. What kind of benefits do you want to share?

Benefits		Fish	Grazing	Lotus	Medicinal plants	Irrigation	Any other
Nature of Arrangement	Option1						
	Option2						
	Option3						

11. Suppose the lake is protected and the benefits from the lake (such as revenue from fish, revenue from tourism and revenue from other products) are shared with the village people protecting the lake. Do you vote for this proposal? **Yes/ NO**

12. If benefits are shared, in what way it should be shared:

Benefit Sharing Arrangements	Benefits to be shared among villages	Benefits to be shared among communities within the villages	Benefits to be shared among the individual participants	Any other
How much share (%)?				

13. Since you have said that your household will be willing to share the benefits from the conservation of the wetland, please tell us if your household will be willing to accept ₹1000.00 (₹2000, ₹3000, ₹5000) as compensation per year to protect the lake for the next five years? **YES/ NO**

14. If NO, will your household be willing to accept ₹500.00 per month? **YES/ NO**

15. If YES, will you be willing to accept ₹2000.00? **YES/ NO**

16. What is your households' minimum willingness accept compensation per year? ₹.....

17. Willingness to Pay:

1. Would your household be willing to offer labour to protect the lake?

2. If so, how much labour (number of days) per month? _____

3. Would you like to pay some 'kind' for protection of lake? If so, what is the 'kind' (like paddy) and how much per year?

1. The measures to improve the Ousteri Lake (sanctuary) involve costs and these costs are met out from public money. Since the improvements are going to benefit a large number of beneficiaries of the Lake, do you agree that the beneficiaries are responsible for contributing towards the cost of improving the Lake? **YES/ NO**

If **No** what is the reasons _____

If **YES**, then do you think that your household is also responsible for **contributing money** for the improvement of the Wetland? **YES/NO**

If **NO**, what are the reasons? _____

Attributes	Current status Status-Quo	Alternative 1 (Moderate Level)	Alternative 2 (Higher Level)
Land Area of the marsh and Encroachment	Current Level	Encroachment Removed	Entire Encroachment Removed
Industrial Pollution	Current level	Partial Treatment	Complete Treatment
Poaching	Current Level	Eliminated Partially	Eliminated Completely
Solid Waste Dumping	Current Level	Partial Control	Complete Control
Waste water treatment and ground water quality	Current Level	Secondary Treatment	Tertiary Treatment
Biodiversity Protection (birds, plants, reptiles, etc)	Low level (subject to vulnerability)	Moderate level (better from current level with less vulnerability)	High level (highest level of protection with no vulnerability)
Access to Ecosystem benefits (fish, lotus, bathing, etc)	Current status with No Access	Restricted Access	Full Access with Regulation
Cost	₹0.00	₹----- per year	₹-----per year
I prefer (tick the appropriate)	Status Quo Option	Option A	Option B
Maximum Willingness to Pay for Protecting the wetland, per annum			₹.....

Since you have said that your household will be willing to contribute to the fund for the conservation of the wetland, please tell us if your household will be willing to contribute ₹1000.00 (₹2000, ₹3000, ₹5000) per year to the fund for the next five years? **YES/ NO**

If **NO**, will your household be willing to pay ₹500.00 per month? **YES/ NO**

If **YES**, will you be willing to pay ₹2000.00? **YES/ NO**

What is your households' maximum willingness to pay per year? ₹.....

Please note that the amount that you are willing to pay will have to be paid from your household income which may be limited and similarly, the amount may be used for other alternative purposes in the household. Considering this, would you be willing to revise your WTP value? **YES/NO**

If YES, what is your revised WTP value? ₹ per year.

F- Agricultural Information

1. Do you have agricultural land? **Yes/ No**
If yes (Please answer the below question)
2. Land ownership

No.	Category	Owned (in acres)	Leased In (acres)	Leased Out (in acres)	Area cultivated during seasons		
					Rainy (June-Oct)	Winter (Nov-Feb)	Summer (Feb / March-May)
1	Wet land						
2.	Dry land						
3.	Irrigated wet land						
4	Irrigated dry land						

3. Cropping Pattern

S.No	Name of the Crop	Area in acre	Crops grown as Pure (P) / mixtures (M) / intercrop (IC) (Tick)	Do you use FYM/ organic manure for this crop	Do you like to use chemical fertilizers for this crop	What is the yield (Kg/Ac)	What % of the yield is sold
1	Paddy- Kharif						
2	Paddy- Rabi						
3	Sugarcane						
4	Casuarinas						
5	Groundnuts						
6	Eucalyptus						
7	coconuts						
8	Teak tree						
9							
10							

4. Is your agricultural field located 100 metres from Ousteri Lake? **Yes/ No**
5. Are you utilizing bore well for agriculture purpose? **Yes/ No**

6. Farm Income from Crop production

Goods	Annual/ Bi- annual Income
Paddy	
Hey	
Sugarcane leave	
Groundnuts	
Any other (Specify)	

G- General asset Information

1. Is your house Owned / Rented / Leased / Any Other?
If rented how much_____

2. Which types of house do you living?

Earth/ Mud (1)	Cements (2)	Tiles (3)	Any Other (4)	<input type="text"/>
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3. Does your household owned following domestic asset, farm asset etc.,

	Name of Asset	Total Number owned		Total Number owned	Total Number owned
	Domestic		11	Washing Machine	
1	Cooker/ Gas Stove		12	Sofa set	
2	Refrigerator		13	Sewing Machine	
3	Radio		14	Mosquito nets	
4	Tape recorder		15	Others *	
5	Television			Farm Assets	
6	DVD Player		16	Hoes	
7	Mobile phone		17	Spades/shovel	
8	Fixed phone		18	Ploughs	
9	Computer		19	Sprayer pump	
10	Mixer-Grinder		20	Irrigation pump	

5. Do you have any other income sources other than agriculture? **Yes / No**
If yes, how much_____

6. What is the average monthly expenditure regular consumption item?
(Including house rent, electricity & water bill exchange durable items.)

7. What is your monthly income of your household from ALL sources?

8. Can you indicate your average monthly expenditures by category in rupees?

Category	Average cash expenses per month
Food	
Beverages and tobacco	
Clothing	
Education, recreation and entertainment	
Housekeeping, household equipment and appliances	
Dwelling maintenance	
Investment in housing	
Transport (car, bicycle, bus, train) and communication	
Health and personal care	
Other (specify _____)	

India a biodiversity hotspot

India is one of the megadiverse countries in the world. It faces unique circumstances as well as challenges in the conservation of its rich biological heritage. With only 2.4% of the world's geographical area, her 1.2 billion people coexist with over 47,000 species of plants and 91,000 species of animals. Several among them are the keystone and charismatic species. In addition, the country supports up to one-sixth of the world's livestock population. The rapid growth of her vibrant economy, as well as conserving natural capital, are both essential to maintaining ecosystem services that support human well-being and prosperity.

To demonstrate her empathy, love and reverence for all forms of life, India has set aside 4.89% of the geographical space as Protected Areas Network. India believes in “वसुधैव कुटुम्बकम्” i.e. “the world is one family”.

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