ECOLOGICAL STUDIES ON THE KONDAKARLA AWA LAKE OF ANDHRA PRADESH

(A UGC Major Research Project)

FINAL TECHNICAL REPORT 2012-2015

By

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We express

Our Grateful Thanks

To

UNIVERSITY GRANT COMMISSION (UGC)

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INTRODUCTION

Wetlands have been intricately linked with humankind throughout the ages. The cultural, spiritual and economical importance of wetlands to indigenous communities is beyond words. No other type of ecosystem is so important to millions of migratory birds, fish, amphibians, insects, plants and trees.

Despite their importance and value, wetlands around the world are being modified or reclaimed. Wetlands can be ranked amongst the most highly threatened ecosystems on the planet and unfortunately the degradation and loss of wetlands are continuing. Worldwide, around 50% of wetlands are estimated to have disappeared since 1900 (Wetland Internationals, 2006).

Among various wetland types, freshwater lakes are of great economic, ecological and cultural importance, with billions of people depending directly on them for drinking water, food and their livelihood. Lakes have more complex and fragile ecosystems than rivers, as they do not have a self-cleaning ability. More than half the world's five million lakes and reservoirs face huge ecological threats that are endangering the global environment, experts have warned Chourey, (2001)

India is no exception to the global scenario. Indian wetlands are not only the home of a wide variety of plants and animals but they also provide livelihood to thousands of communities with a wide range of ecological services. Despite all these benefits from the wetlands, they have been mismanaged and are often neglected. Wetlands suffer from over-exploitation, overuse of their resources, drainage, alternative use and pollution. The Wildlife Institute of India's survey reveals that at present, only 50% of India's wetlands remain. They are

disappearing at a rate of 2% to 3% every year. The loss of one km^2 of wetlands in India will have much greater impact than the loss of one km^2 of wetlands in low population areas of abundant wetlands SACON, (2005a).

Unlike forests, wetlands do not have a proper managerial infrastructure in India. Biologically important wetlands have legal protection under "Protected Area Network" whereas most other wetlands in India do not have any legal protection to prevent their loss to alternative uses in development process. The problems and threats to wetlands are further accentuated due to different ownerships and varying administrative priorities with virtually no coordination between the ministries and other governing bodies.

The two major fresh water lakes of Andhra Pradesh, ***Kolleru*** and ***Kondakarla Awa*** are very prominent among the freshwater lakes of India. The latter, upon which the present project deals with, is the second largest in Andhra Pradesh, and is called ***Kondakarla Awa***, existing in the Visakhapatnam district was selected for the present study as the lake is now threatened with several factors and information on the lake is very meager.

The real challenge for the conservation of the second largest fresh water Lake Andhra Pradesh is to understand the management practices of the lake dependent communities and their impact on the change in ecological state of the lake. The Kondakarla Awa Lake, being a unique ecosystem, upon which several thousands of families are dependent for their livelihood, needs urgent conservation measures Chourey, (2001) for protecting it from the threats of pollution, siltation, eutrophication and encroachments. Thus, the present study is proposed to study the lake ecology with special reference to understand the impact of the lake use by different user groups and initiate a long term monitoring programme for its conservation, involving local youth, dependent

communities, educational institutions, and industry in the vicinity. The study was undertaken with the following five main objectives:

OBJECTIVES OF THE STUDY:

1. To determine the Ecological State of the lake by its(a) water and sediments Quality; (b)Biodiversity; (c)Siltation; (d) livelihoods and (e) Economy;

2. To identify different User groups of the lakes and document the use practices along with the best management practices;

3. To develop appropriate conservation models within the frame work of the National Wetlands Conservation Rules;

4. To develop plans for the establishment of an Educational Tourism programme involving local educational institutions;

5. To initiate developing a data base for ecological monitoring of the lake.

A BRIEF REVIEW:

Wetlands can be defined as land ecosystems that are strongly influenced by water, and or aquatic ecosystems with special characteristics. Wetlands can be found all over the world, from the Polar Regions to the tropics (Wetland Internationals, 2006) occupying about 6% of the world's land surface. Although various different classifications of wetlands exist, a useful approach is one provided by the Ramsar Convention on Wetlands. It divides wetlands into three main categories of wetland habitats: (1) marine/coastal wetlands; (2) inland wetlands and (3) man-made wetlands. The marine and coastal wetlands include estuaries, inter-tidal marshes, brackish, saline and freshwater lagoons, mangrove swamps, as well as coral reefs and rocky marine shores such as sea cliffs. Inland wetlands refer to areas such as lakes, rivers, streams and creeks, waterfalls, marshes, peat lands and flooded meadows. Lastly, man-made wetlands include canals, aquaculture ponds, water storage areas and even wastewater treatment areas (Schuyt and Brander, 2004; and Chourey, 2001).

The Ministry of Environment and Forests, Government of India (1990), estimated that India has about 4.1 million ha of wetlands (excluding paddy fields and mangroves) of which 1.5 million ha are natural and 2.6 million ha man made. Estimates of the total area given by WWF India and Asian Wetland Bureau (1993) are presented in the following

Table: 1.

AREA OF WETLANDS IN INDIA (figures in million ha)		
Area under paddy cultivation		40.9
Area suitable for fish culture	Fresh Water (1.6), Brackish water (2.6)	3.6
Area under capture fisheries		2.9
Mangroves		0.4
Estuaries		3.9
Backwaters		3.5
Man made impoundments		3.0
Rivers, including main tributaries (28,000 km)		
Canals and irrigation channels (113,000 km)		
Total Area of Wetlands (excluding rivers)		**58.2**

The predominant wetland types in India's geographical zones are (WWF-India and Asian Wetland Bureau, 1993):

1. **Tanks, Reservoirs,** and other water bodies of Deccan peninsula
2. **Backwaters** and **Estuaries** of the west coast of the peninsula
3. The vast **Saline Expanses** of Rajasthan and Gujarat (mainly Rann of Kuchchh)
4. **Freshwater Lakes** and **Reservoirs** from Gujarat eastwards through Rajasthan and Madhya Pradesh
5. **Deltaic Wetlands** (including **Mangroves**), **Lagoons**, and **Salt Swamps** of India's east coast
6. **Marshes, Jheels, Terai Swamps,** and **Chaur** lands of the Indo-Gangetic plains.
7. **Floodplain** of the Brahmaputra and the **Marshes** and **Swamps** in the hills of northeastern India
8. **Lakes** and **Rivers** of the montane (primarily palaearctic) region of Kashmir and Ladakh
9. Wetlands (primarily **Mangroves** associations and **Coral Reefs**) of India's island arcs.

Worldwide around 50% of wetlands are estimated to have disappeared since 1900, mostly occurred in the northern temperate zones and, since 1950s, tropical and sub-tropical wetlands have also been disappearing rapidly (www.wetlands.org). The amount of wetland lost is difficult to quantify, since the total area of wetland in the world is uncertain.

There are, however, some figures for individual countries which indicate the scale of the problem. The United States has lost some 87 million hectares (54%) of its original wetlands, primarily to agricultural production (Barbier *et al*., 1997).

Degradation of wetlands is associated with a wide range of environmental, social, and economic problems in the region Kaimowitz, (2001). The increasing human population and the resultant increased agricultural practices, along with unplanned land use undertaken in the country have led to gradual decline and deterioration of wetland resources Chourey, (2001).

Among wetlands fresh water lakes have unique place. Lakes provide humankind with many services: water for drinking, irrigation, fish, recreation, asthetic enjoyment, transportation and dilution of pollutants (Postel and Carpenter, 1997). These services are impaired by exploitation of lakes and their catchments lands. The goal of management should be to balance the uses of lakes with conservation measures to sustain ecosystem services over time, and protect the interests of the native subsistence communities. Focused research can provide understanding of lakes' ecological mechanisms that sustain ecosystem services; the causes of degradation of lakes and their catchments, and can provide methods and technologies for lake restoration (Carpenter and Lathrop, 1999). Twelve important kinds of wetland loss in India were identified by (Foote *et al*. 1996) and mechanisms believed to be causing them discussed:

(1) agricultural conversion, (2) direct deforestation, (3) hydrologic alteration, (4) inundation, (5) defoliation, (6) altered upper watersheds, (7) accumulative water demands, (8) water quality degradation, (9) wetland consolidation, (10) global climate change, (11) ground-water depletion and (12) exotic species and biodiversity.

India has listed 25 sites (677,131 hectares) as wetlands of International Importance under Ramsar Convention (www.ramsar.org, 2006),while another 34 wetlands were identified under national wetland conservation programme. The Directory of Indian Wetlands WWF and Asian Wetland Bureau, (1993) recorded 147 sites as important of which 68 are protected under the National Protected Area Network by the Wildlife (Protection) Act of 1972. SAC (Space Application Centre) and SACON jointly provided maps for the Indian inland wetlands (of >2.25 ha in size) for over 232 districts and listed 655 wetlands for conservation of which, 199 wetlands were proposed for recognition at international level as Ramsar sites SACON, (2005a).

SACON (2005b) ventured to propose a National Wetland Conservation Strategy and Action Plan and provided enough alarming data to warrant emergency measures by State Governments to reclassify wetlands as protected areas. The danger signals include high levels of chemical poison residues found in fish consumed by people, loss of water quality and threats to biodiversity Ananthakrishnan, (2005).

We urgently need to conserve India’s dwindling wetland resources. One way to do this is to practice integrated wetland management, which benefits both man and animal and maintains the ecological character of the ecosystem Gautam, (1997).

Both natural and social sciences should jointly contribute to an increased understanding of relevant processes and problems associated with wetland conservation strategies (Turner *et al.,* 2003b).

India is well known for the huge variance in its lakes, but the data is nebulous. There is no orderly or scientific census of lakes. Though, there is a distinction between fresh water lakes and brackish water lakes, just as the lakes of southern peninsular India are distinct from those of the Himalayan region and natural lakes from manmade reservoirs, there is no scientific evaluation (Reddy and Char, 2004).

Kolleru Lake is a largest fresh water lake in Andhra Pradesh. Sheshavatharam (1993) presented a review of work done on ecological status of Kolleru Lake. Anjaneyulu (2003) assessed environment quality of Kolleru Lake. The impact of fisheries on Lake Kolleru, a wetland ecosystem was analyzed by Seshagiri Rao (2003). Shivaji Rao (2003) presented a case study of conflict between development and environment of Kolleru Lake. A study by Nageswara Rao *et al*. (2004) provided unambiguous visual information on the alarming levels of human-induced environmental degradation of Kolleru lake.

Andhra Pradesh has 219 natural wetlands (1, 00,457 ha) and 19,020 artificial wetlands (4, 25,892 ha). SACON (2005a) has proposed 20 wetlands in Andhra Pradesh to be declared as Ramsar sites. The two major freshwater lakes of Andhra Pradesh, ***Kolleru and Kondakarla Awa*** are very prominent among the freshwater lakes of India. The former is considered the largest among the freshwater lakes, while the latter is the second largest in Andhra Pradesh. *Kondakarla Awa*, existing in the Visakhapatnam district of Andhra Pradesh was selected for the present study as the information on the lake is very meager and the most neglected lake by both the users and the state.

Venu (1981) was the first to report on the *Kondakarla Awa* lake and reported limnology of the lake with especial reference to aquatic macrophytes; Seshavatharam (1982) has reported the ecological state of the lake, while Rao (1984) reported on plankton and periphyton; Sankar (1992) studied on fish and fisheries; and Bharat lakshmi *et al*. (2001) on the Avian fauna. Chourey (2001) conducted an environmental impact assessment study on Kondakarla Awa wetland with reference to ecotourism development.

Studies on the socioeconomics and institutional aspects were totally absent and the information gap for effective ecological management is very wide. In view of these, the present study, ***Ecological Studies on Kondakarla Awa Lake of Andhra Pradesh*** was taken up.

METHODOLOGY

The present "**ECOLOGICAL STUDIES ON THE KONDAKARLA AWA LAKE OF ANDHRA PRADESH"** was carried out during September, 2012 to August, 2015. A freshwater lake, ***Kondakarla Awa***, the second largest of Andhra Pradesh was chosen for the study. The study was considered under four major parts: Determining the ***Ecological Status*** of the lake; Understanding the ***Socioeconomic Environment*** of the lake users and the impacts of use practices; developing a monitoring frame work; and to propose establishment of Educational tourism involving local educational institutions***.***

ECOLOGICAL STATUS OF KONDAKARLA AWA

The ecological status of the lake was determined based upon the state of the lake's major ecological components – Physico-chemical *Quality* of the lake waters and sediments; and the states of Lake Flora and Fauna. Towards this, a ***Sampling Approach*** was followed and five sampling stations were selected for the purpose.

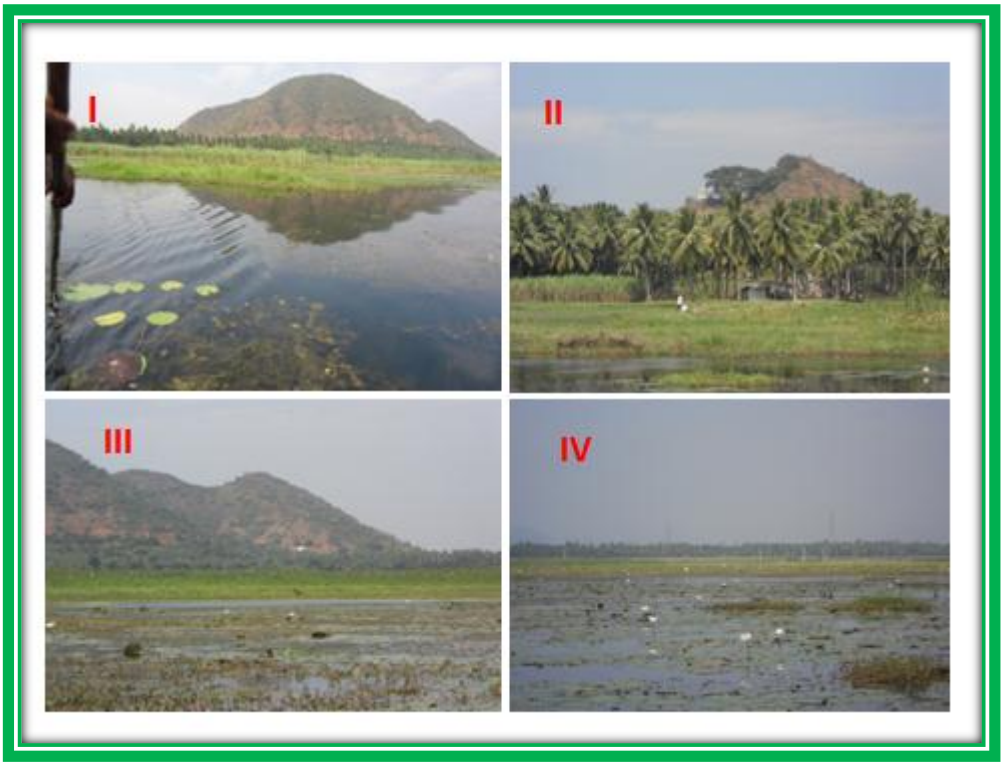
Selection of the Sampling Stations

Five sampling stations (or sites) were chosen across the wetland, which are situated along two main transects. Station V is situated in the centre of the wetland intercepting the two transects. Station I, II, III and IV are situated near the periphery of the wetland.

- **Stations I** - Station I is situated at the littoral zone of the lake at Kondakarla Andalapalli;
- **Stations II**- Station II is situated at the littoral zone of the lake at Vadrapalli village.
- **Stations III**- Station -III is situated at the littoral zone of the lake at Avasomavaram village.
- **Stations IV**- Station IV is situated at the littoral zone of the lake at H-Andalapalli

- **Stations V**- Station V is situated in the limnetic zone of the lake, at the centre of the wetland.

Plate: 1 Sampling Sations of Kondakarla awa lake



Sampling Frequency and Procedures

Monthly water samples were collected from five selected sampling stations between November, 2012 and October, 2014, and the sampling for physic - chemical analysis was done between 9:00 am to 11:00 am, in the second week of every month.

As water depth was low during the study period (ranging between 0 m to 1.76 m), water samples were collected directly using 1.5l plastic samplers. For Dissolved Oxygen (DO) analysis, samples were collected separately in narrow-mouthed glass-stoppered BOD bottles of 300 ml capacity without bubbling. The samples for chemical analysis were immediately transported to the laboratory. Sediment samples were collected with the help of a *Simple Scoop Sampler* and

were transferred to labelled polythene bags and brought to the laboratory for further processing and analysis.

Physico-chemical Analysis of Water

Physico-chemical parameters like Water Temperature, Depth, H^+ ion concentration (pH), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Nitrates (NO_3-N), Phosphates (PO_4-P), Potassium (K), Calcium Hardness **(Ca)**, Magnesium Hardness **(Mg)**, Sodium (Na), and Chloride (Cl) were analyzed following the Standard Methods of APHA (1995), NEERI (1988) and Adoni (1985).

(i) Temperature: Temperature of the surface water of the wetland was recorded by dipping a thermistor probe with 0.1°C sensitivity in the surface water for a few minutes.

(ii) Depth: Depth of the wetland was measured by lowering a graduated tape with a weight pendulum at its free end from a boat.

(iii) pH: pH of the samples was recorded by using a digital pH meter (Systronics).

(iv) Solids: Total solids, total suspended solids and total dissolved solids were analyzed by Gravimetric method (NEERI, 1988). Results were recorded as g/l.

a. **Total Solids (TS)**: Residue after the evaporation and subsequent drying in oven at temperature 105°C of a known volume of sample were recorded as total solids.
b. **Total Suspended Solids (TSS)**: Non-filterable residues left on the filter paper and further dried at 103 – 105°C were recorded as suspended solids.

(v) Total Dissolved Solids (TDS): The dissolved solids were determined from the difference of the total solids and the total suspended solids

(vi) Dissolved Oxygen (DO): Dissolved Oxygen was estimated by ***Winkler's Idometric method*** with Azide modification, immediately after sampling (APHA, 1995). Results were recorded as mg/l.

(vii) Biochemical Oxygen Demand (BOD): 5 days BOD at 20^{o}C was measured by the standard method of APHA (1995). Results were recorded as mg/l.

(viii) Nitrate (NO_3 –N)**:** Nitrate was determined by using the Phenol Disulphonic Acid (PDA) method and absorbance was measured at 410 nm using Spectrophotometer (APHA, 1995). Results were recorded as mg/l.

(ix) Phosphate (PO_4-P)**:** Phosphate was estimated by Stannous Chloride method and the absorbance was measured at 690 nm using a Spectrophotometer (APHA, 1995).

(x) Potassium (K): Potassium was measured by Flame Photometric method. After calibrating the Flame Photometer with standard solution of Potassium Chloride (10.0 µg K/ml) at 786 mµ, water samples were aspirated one by one and the readings were noted down as K mg/l (NEERI, 1988).

(xi) Total Hardness: Total Hardness was determined by EDTA Titrimetric method using dry powder of the dye Eriochrome Black T as an indicator (APHA, 1995). Results were recorded as mg/l.

(xii) Calcium Hardness: Calcium Hardness was estimated by EDTA Titrimetric method using Murexide Indicator (APHA, 1995). Values were recorded as Calcium hardness mg/l.

(xiii) Magnesium Hardness: Magnesium Hardness content was calculated by subtracting the value of Calcium hardness from value of total hardness. Results were recorded as Magnesium hardness mg/l.

(xiv) Sodium (Na): Sodium was measured by Flame Photometric method. After calibrating the Flame Photometer with standard solution of Sodium Chloride (10.0 µg Na /ml), water samples were aspirated one by one and reading was noted down as Na mg/l. (NEERI, 1988).

(xv) Chloride (Cl): Chloride was estimated by Argentometric method using Potassium Chromate indicator solution (APHA, 1995). Results were recorded as Cl mg/l.

Sediment Analysis

Sediment samples were analysed for pH, NO_3-N, PO_4-P, and K following the Standard Methods of APHA (1995), Stewart et al. (1974), Adoni (1985) and Trivedi (1987).

(i) pH: A fresh suspension of sediment sample with double distilled water was prepared (1:10 by volume) and the pH was recorded by using digital pH meter (Systronics).

(ii) Phosphate (PO_4-P): To one gm of air dried fine sediment sample, 200 ml of 0.002 NH_2SO_4 was added. The suspension was shaken for 30 minutes; then filtered through Whatman filter paper no.50, to get a clear solution (Adoni 1985). This filtrate was used for phosphate estimation using Stannous Chloride method (APHA, 1995).

(iii) Nitrate (NO_3-N)**:** To 50 gm of air dried fine sediment sample, 250 ml of Nitrate extraction solution (Copper Sulphate and Silver Sulphate) was added. After shaking the solution for 10 minutes 0.4 gm Ca $(OH)_2$ was added, followed by 1.0 gm of $MgCO_3$. This solution was shaken for 1 minute and filtered through Whatman filter paper No.50 (Adoni, 1985). Nitrate was estimated in the filtrate by phenol disulphonic acid method given by APHA (1995).

(iv) Potassium (K)**:** Potassium content in the soil was determined by the method described by Stewart et al (1974). To 25 gms of air dried fine sediment sample, 125 ml of 1 M ammonium acetate (NH_4OAC) solution (pH 7.0) was added, which was subsequently shaken. This solution was allowed to stand overnight. This extract was filtered through Whatman filter paper No.42 through Buchner funnel under light suction using multiple washings. The leachate was transferred to 250 ml volumetric flask, brought to volume with 1 M NH_4OAC and homogenized. Potassium in the solution was determined by Flame Photometric method (Stewart *et al*., 1974; NEERI, 1988).

Study of Biotic Parameters

In order to determine the biological state of the lake, the biotic parameters studied include Fecal Coliform, Phytoplankton, Zooplankton, Aquatic Macrophytes, and Fish and Avian fauna of the lake surrounds.

Fecal Coliform Bacteria: Fecal Coli form were analysed by Most Probable Number (MPN) method (APHA, 1995)The result was expressed in MPN/100 *ml*.

Plankton: Sampling for quali-quantitative analysis of plankton was done monthly from July 2003 to June 2004. Quali-quantitative analysis of plankton was done following the method given in Workbook on Limnology by Adoni (1985).

(i) Phytoplankton: One liter of water sample was taken in a glass bottle. 10 ml of Lugol's Iodine was added to the sample and this was allowed to stand for 24 hours. The supernatant (clear) liquid was taken out with the help of a pipette. The remaining sample was further concentrated to 100 ml. After shaking the concentrated sample, one drop (0.05 ml) was quickly put on a clear micro slide with the help of a standard dropper. The whole drop was covered with a cover glass. Phytoplanktons were counted species wise. Planktonic estimations were

worked out for 10 drops. Phytoplankton was identified using keys and monographs given in Adoni (1985) and APHA (1995).

Phytoplanktons were used as indicators to assess water quality in the wetland. Algal Genus Pollution Index (Palmer 1969) was used for rating wetland water for high or low organic pollution.

Table 2 : Algal Genus Pollution Index (Palmer 1969)*:

Genus	Index	Genus	Index
Anacystis	1	Micractinium	1
Ankistrodesmus	2	Navicula	3
Chlamydomonas	4	Nitzschia	3
Chlorella	3	Oscillatoria	5
Closterium	1	Pandorina	1
Cyclotella	1	Phacus	2
Euglena	5	Phormidium	1
Gomphonema	1	Scenedesmus	4
Lepocinclis	1	Stigeoclonium	2
Melosira	1	Syndra	2

*as given by Pearson, J. L. (1989)

According to this method, if there are 5 or more cells of a particular kind of algae on a slide, the alga must be identified and recorded. The index numbers of the algae are then added. Any algae that are not listed have a pollution factor of zero.

If the pollution index score is 20 or more, the score is evidence of high organic pollution. A score of 15-19 indicates probable organic pollution. Lower scores usually indicate less organic pollution, but they may also occur if something is interfering with algal growth.

(ii) Zooplankton: 25 liters of water sample was filtered through plankton net of Bolting Silk No. 25. The net plankton were transferred in 50 ml bottles and preserved in 5% formalin. Four drops of glycerin were added to it. Quali-

quantitative analysis of zooplankton was done using the same methods described for phytoplankton (Adoni, 1985).

(iii) Macrophytes: Samples of macrophytes for qualitative and quantitative studies were collected monthly, between July 2013 and June 2015 from all five sampling sites, using a wooden quadrate of 50 cm x 50 cm size. The quadrate was lowered into the water at random and all the plants falling within the area of the quadrate were uprooted by hand and packed in polythene bags and transported immediately to the laboratory for analysis. At each sampling site, four quadrates were studied following the methods outlined by Adoni (1985).

Fresh Weight: The uprooted macrophytes of each quadrate were washed to get rid of the adhering material. The extra water of the plant was blotted out with the help of filter paper. Plants of each quadrate were separated species wise and their fresh weight was noted, after weighing them.

Dry Weight: The known quantity of each species was dried in a hot air oven at 105 **±** 2^{o}C till a constant weight was obtained. After cooling it in a desiccator, dry weight was taken.

(iv) Fish: Information on fish was gathered with the help of the fishing community and their scientific identification was done with the help of Andhra Pradesh Fisheries Department.

(v) Birds Information on birds inhabiting the lake surrounds was obtained from villagers and from the records of the Divisional Forest Office of the Forest Department. The checklist of birds by Bharathlakshmi (2001) was used as an authentic source of information.(plate.2)

Plate: 2 Migratory birds in kondakarla awa:

a.Coot. *fulica atra* **b.** Cattle egret. *Bubulcus ibis* **c**. Cattle egre. *Bubulcus ibis* **d**. Red-Wattled lapwig. *Vanellus indicus* **e.** Pond heron. *Ardeola grayii* **f.** Small Blue kingfisher*. Alcedo atthis*

Estimates for Lake Sedimentation

To measure the annual sedimentation rate, eight silt trap pits were constructed around the wetland at four sites (two pits at each site) in the last week of May 2004. These sites were close to the agricultural fields of village Andalapalli - Site I; near hillock (west side of the wetland near Haripalem)- Site II; on the *Kaccha* road towards the wetland at Vadrapalli -Site III & near the agricultural fields of village Ava Somavaram- Site IV. The area of the pits was 25cm X 25cm. Depth of the pit was 15 cm at the top and 12 cm at the bottom, with a gradual slope of 3 cm. Inner surface of the pit was covered with a plastic sheet to trap the silt. This experiment was repeated twice. For the first time, reading was taken after the first monsoon showers in June 2004 and the experiment was

repeated in September 2004. Clear supernatant water was taken out after the rain and depth of the silt was measured with a scale.

SOCIOECONOMIC ENVIRONMENT OF KONDAKARLA AWA

Sampling and Sample Selection Criteria

Ten villages out of twenty (20) villages from the study area were selected for conducting socioeconomic analysis by using stratified random sampling. Village location, existing wetland use practices and land use pattern were the criteria for selection of sample villages.

Selection of sample villages was done on the basis of personal observations and secondary data regarding lake use practices, land uses and socioeconomic status of villages. Villages selected for the present study under each of below mentioned categories:

Category I – All the five villages in this category have similar socioeconomic environment land use pattern and agricultural practices. Thus, only one village **P. Nagvaram** was chosen randomly for the detailed study.

Category II – Since both the villages have same lake use and land use pattern only one village called **Bangariyapalem** was selected randomly for the detailed study under this category.

Category III – Since lake use practices and user groups dynamic under this category of direct user villages varies from village to village, all the seven villages *i.e.,* **Vadrapalli, Gollalapalem, Cheemalapalle, Avasomavaram, Avarajam, Kondakarla, Andalapalli**, were considered for socioeconomic analysis. Since Kondakarla and Andalapalli are twin village with no physical boundary socio-economic survey were conducted jointly.

Category IV- Since all the eight villages have same lake use practice (receives water from wetland through irrigation channel) and land use pattern, only one representative village *i.e*., **Jaggannapeta** was selected randomly.

Participatory Rural appraisal (PRA)

PRA was conducted as per guidelines given by Rajora (1998) and Chourey (2001). PRA was exercised to understand the following aspects.

- Local Dependency on the lake
- Lake Use Practices
- Socioeconomic, institutional and political scenario in the region
- Anthropogenic Activities in the catchment area affecting wetland ecosystem
- Traditional Wetland Management Practices

Process of PRA: Triangulation was used to increase the credibility of results. Findings from different methods, places, times and disciplines were assessed.

Table 3: Triangulation process in PRA

Sl. No.	Sources of Information	Key Techniques Used
1	Community	Mapping (Social and Natural Resource Mapping)
2	Small Homogenous Groups	Focus Group Discussions, Trend Analysis (Seasonal Calendar, Daily Activity Chart), Pair Wise Ranking.
3	Individuals	Key Informant's Interview, Transect Walk, Household Survey, Problem Ranking, Preference Ranking, The Informal Conversational Interview

A. Phase I: PRA was started in December 2003 from village Kondakarla. First phase of PRA lasted till June 2004, covering all ten study villages. First phase of PRA included the following exercises:

i) Mapping:

a. Social Mapping: Social map were drawn to illustrate individual households that make up the community. Different symbols and colors were used to show particular household-level characteristics i.e. type and size of the house, primary and secondary occupation, family size, educational and employment status, direct or indirect dependency on lake, sanitation facility, sources of drinking water. Results were cross checked by rapid door to door survey.

b. Natural Resource Mapping: Natural resource map were drawn to illustrate natural water bodies, water channels, agricultural land holdings, hillocks and other natural resources present in and around villages.

ii) Focus Group Discussion (FGD): FGDs were held with homogenous groups of all lake users *i.e*., farmers, fisher folk, washer folk, laborers and women groups. Participants were identified carefully to avoid biases, with the help of local leaders, key informants in the community and local NGOs. Semi-structured questionnaires were used to discuss issues related to socioeconomic dependence on lake, lake use practices, average annual incomes, seasonality, daily activities**,** socio-cultural importance of lake, changes in the wetland ecosystem, effect of lake degradation on livelihoods, traditional lake management practices (rules and regulations regarding lake use), conflicts with other lake users and their perception about lake development etc.

iii) Transect Walk: Transect walk along with the local experts were done to make personal observations and understand characteristics of the village environment.

iv) Key Informants' Interview: Interviews were conducted using semi-structured questionnaires, with representatives from all stakeholder groups (knowledge specialists) to gain insights on issues discussed in Focus Group

Discussions and also with the officials of the concerned line departments of the government (Irrigation; Forests; Fisheries; Revenue; Tourism).

v) Informal Conversational Interview: Informal conversations were held with individuals from various communities to understand about the general perceptions on various lake related issues.

B. Phase II

(i) Household Survey: Household surveys were carried out between April 2013 to June 2015, in all the study villages. Standardized open ended questionnaire were used Sample size was 10%.

Table 4: Sampling Frame for Household Surveys

User Groups		**% of total HH**
Farmers **(F)**	Big (landholding >5 acres)	10%
	Medium (land holding 3-5 acres)	
	Small (land holding <3 acres)	
Fisher folk	Only Fishing **(Fi)**	10%
	Also practicing agriculture **(FiF)**	
Washer folk **(W)**	Only washing	30%
	Practicing agriculture **(WF)**	
Cattle Rearers **(C)**		10%
Landless laborers **(LL)**		10%
Total		10%

Collection of Secondary Data

The secondary data on various aspects were collected from different sources. Census Record, Meteorological Data and Village Maps from the Mandal Revenue Offices of Atchutapuram and Munagapaka; Topo Scale Maps from the A.P. State Forest Department; Details about Kondakarla Ava Irrigation System, Map of Sarada River Basin, Details about WUA, G.O. regarding Ava water

distribution system from the Irrigation Department of the State – Anakapalle section; details about the fishing practices and the lake lease system from the concerned Mandal Revenue Offices, Fisheries Department and the Fishermen Cooperative Society; Ecotourism plans from the State Tourism department; Satellite images from Google Earth.com; Check list of Birds from Bharatalakshmi (2001).

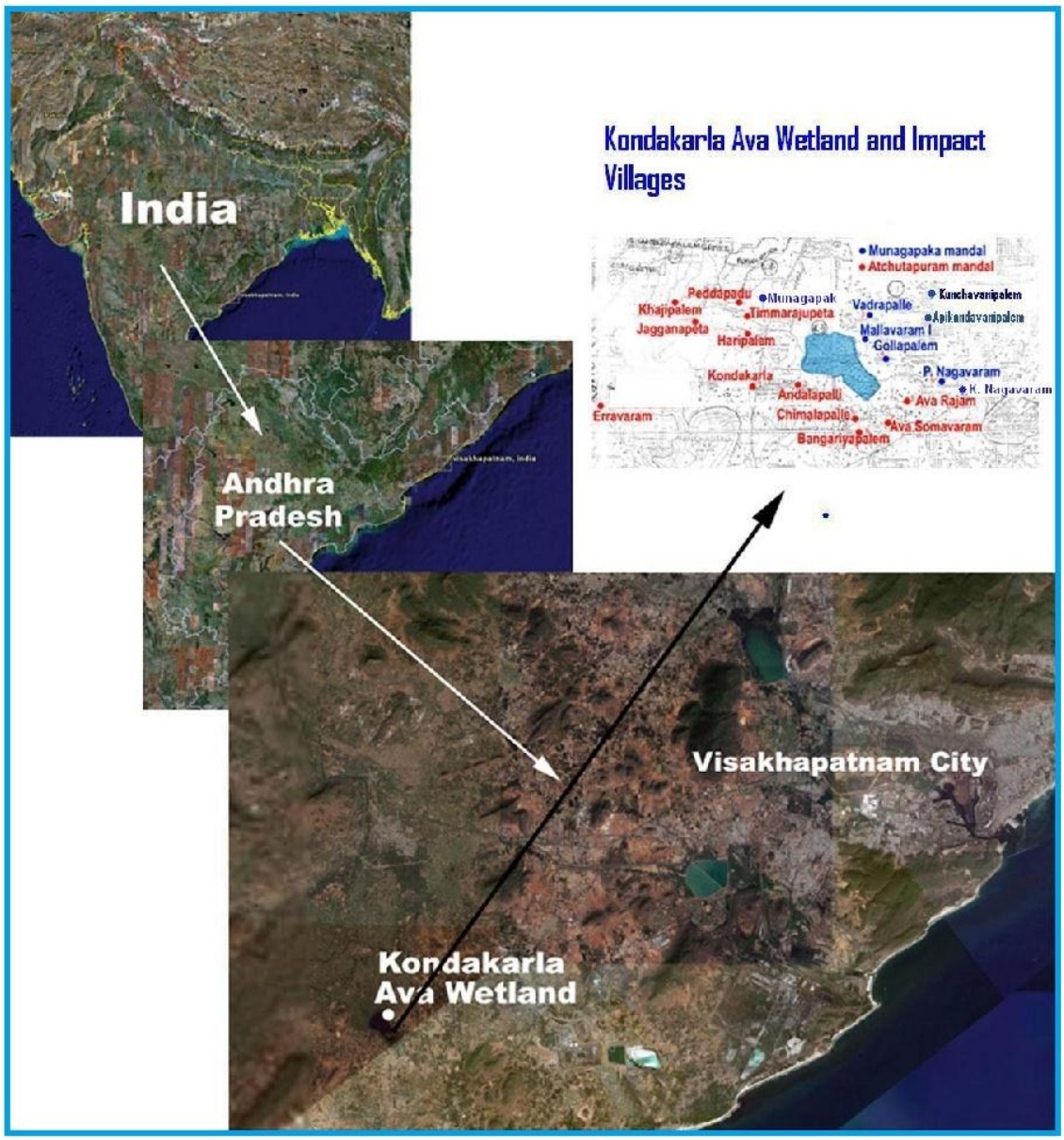
STATISTICAL TOOLS

Results obtained were analyzed statistically wherever necessary. The water and sediment quality data and other plant parameters involving representation of averages were subjected for analysis to estimate the Mean. Along with their Standard Deviation, Standard Error and Interval Estimates at 95% confidence level. Monthly values of abiotic and biotic parameters represent the Mean. Microsoft Excel tools were used to carry out the statistical analysis.

STUDY AREA

Kondakarla Awa wetland, a natural freshwater lake (stretches between latitudes 17°35'30" and 17° 36'02" N longitudes; 82° 59'27" and 83° 01'02" E) of *Visakhapatnam* district, Andhra Pradesh, India, was chosen as the main system for the study. The study area comprises of both the catchment and command areas along with the lake area (Fig. 1).

Fig. 1: A Map Showing Kondakarla Awa Wetland and Impact Villages .



Kondakarla Awa wetland, the second largest natural fresh water lake of Andhra Pradesh, is 50 km South west of *Visakhapatnam*, a port city on the East Coast of India, which is the second largest city in the state of Andhra Pradesh . The Kondakarla Awa wetland is a part of the Sarada riverine system and is classified as a perennial, warm, polymitic, euphotic, eutropic shallow fresh water lentic body. The wetland is named after a village, "Kondakarla", abutting the lake.

For the natives, the wetland is a livelihood source, while for the nearby towns and city people it is a getaway famous for avian diversity. During the British period, Kondakarla Awa Lake (wetland) was a famous tourist place and the Britishers used the place to hunt birds. The Raja (King) of Vizianagaram had built a rest house here, which is now the Zilla Parishad Bungalow.

This lesser known wetland is now assuming global significance, as a major stop over sites for many migratory birds in Andhra Pradesh. *Kondakarla Awa* wetland was as a conservation site by the Asian Wetland Bureau and World Wild Life Fund in 1993. It is recognized as a priority site for Integrated Protected Area System (IPAS) by the Andhra Pradesh State Forest Department. The Andhra Pradesh Tourism Development Corporation has included the wetland as an important site for ecotourism development.

The wetland system along with its catchment area and downstream area exist in the densely populated *Coastal Plains* region, where agriculture is the dominant land use. The soils are basically either *Silty sand* or *Sandy silt loams* and the vegetation belong to *Dry deciduous* type.

CLIMATE

The climate of the region can be considered as typical tropical with four distinct seasons as per classification of the Indian Meteorological Department. The four seasons along with their periods are given below:

- Winter Season: January – February
- Hot Weather Season: March, April, May
- South West Monsoon Season: June, July, August and September
- North East Monsoon Season: October, November, December

Rainfall and Temperature

The region receives a normal rainfall of 1069 mm (average rainfall of *Atchutapuram* and *Munagapaka* Mandals- Revenue Blocks), of which nearly 56.3% is contributed by the Southwest monsoon season and another 28.43% is received during the Northeast monsoon season. The rainy season thus, extends for nearly seven months (Fig. 2).

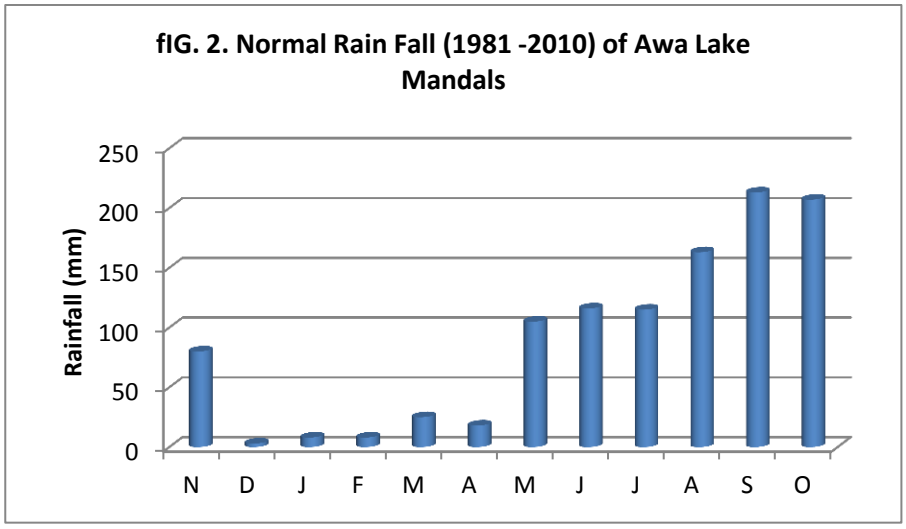
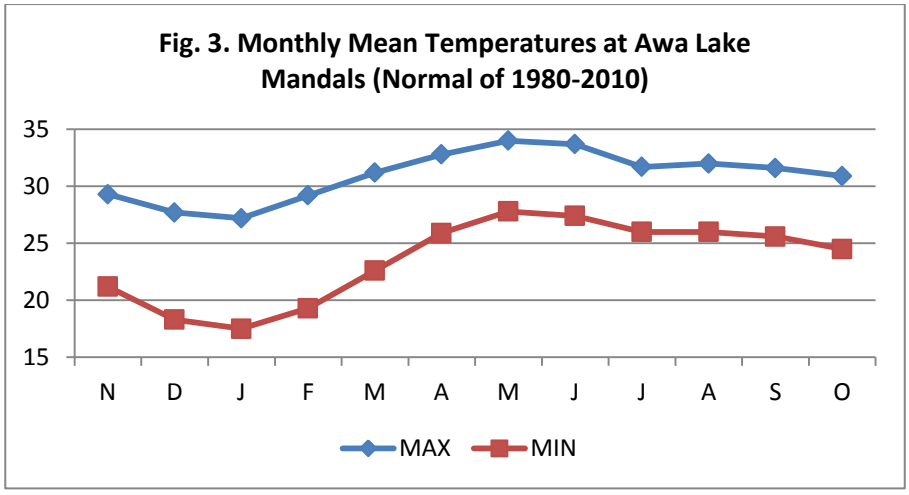


fIG. 2. Normal Rain Fall (1981 -2010) of Awa Lake Mandals



The mean maximum temperature has a normal range from 27.2°C in January to 34°C in May. The mean minimum temperature has a normal range between 17.5°C in January and 27.8°C in May. The normal of mean monthly maximum and minimum temperatures, and monthly rainfalls are presented in (Fig. 3).

Relative Humidity

The air is generally humid throughout the year. Throughout the southwest monsoon season, the humidity exceeds 80% while in the other seasons it ranges from 58% in March and 72% in December.

Special Weather Phenomena

Occasional storms and depressions originating in the Bay of Bengal, mostly during the post monsoon season, cross the region causing widespread heavy rain and strong winds. Thunderstorms occur commonly during the period of April to October, the thunderstorms during the summer and monsoon period occasionally being associated with squalls.

KONDAKARLA AWA: MORPHOLOGY AND HYDRAULIC PARTICULARS

The wetland has a rectilinear polygon shape. The Kondakarla Ava wetland has a total water spread of 753.93 ha. The basin is shallow, uniform with a gradual slope from the margin towards the center. The wetland has a

submergible area of 753.93 *ha* and attains a maximum depth of 3.5 m during rainy season and minimum depth of 1 m during summer with water storage capacity of 180.9 *Mcft,* at Full Tank Level (FTL) while around 858 Mcft of water annually flow from the lake (Table 5).

Ecological Zonation:

The wetland basin is shallow, and as described earlier the depth even in the peak season does not exceed 3.5 m. Therefore, the scope for vertical stratification is limited and light is never a limiting factor in the wetland and the entire wetland is euphotic and supports good vegetation. Ecological zones are not very distinct. The wetland being shallow shows no transition in its vegetation in the limnetic and littoral zones. Littoral zone is very broad. Profundal zones and tropholytic zones are absent. The entire wetland is occupied by floating leaved rooted macrophytes, rooted submerged macrophytes, free floating macrophytes and plankton.

Table: 5. Hydraulic Particulars of Kondakarla Awa
(***Source; AP State Irrigation Department***)

Feature	Details
Self Catchment Area	2538.19 ha
Submergible Area	753.93 ha
Mean Depth	1m (in Summer) -3.5m (in Rainy Season)
Storage Capacity at FTL	180.9 Mcft
Source of water	Rainwater, water from Sarda River and Anakapalli Awa through Krishnam-Raju Channel.
Annual Inflow from self catchment area	216 Mcft
Annual Inflow from Krishnam-Raju channel	642 Mcft
Water allocated for Kondakarla Awa irrigation channel to irrigate 607.87 ha	296 Mcft
Water allocated for Vadrapalli Lift Irrigation System to irrigate 133.2 ha	34.50 Mcft

CATCHMENT OF KONDAKARLA AWA WETLAND

Kondakarla Awa Wetland has a self catchment area of about 2538.19 ha. The wetland is sheltered by a small hill range on one side and a small hillock (in the altitudinal range of 100-300 m) on the other side, while the entire surrounds are the undulating plains of sandy to sandy loam soils, (except along the north west bank where it is bordered by river built plains of sandy silty loam of the Sarada river) which gradually declined in slope towards the Kondakarla Awa wetland washing all surface runoff into the wetland. In addition, the wetland receives water from Sarada River (a perennial river that originates in the Eastern Ghats) and Anakapalli Ava (a pond near Anakapalli town) through a human made inlet called Krishmnamaraju Channel. Wetland has a human made outlet, which is connected to irrigation channels that supply water to eight villages.

The catchment area comprises of 14 village habitations belonging to eight *panchayats* of two *Mandals* -Revenue Blocks (Table 3.5). Of these, six villages are wetland surrounding villages that borders with the wetland. Parts of *Kondakarla* and *Andalapalli* come under the downstream area and use water from the irrigation channel.

DOWNSTREAM OF KONDAKARLA AWA WETLAND

The *Downstream* region of the wetland is mostly situated parallel to the wetland on the West of the lake. This region also has almost similar topography, land and soils, as it also runs along with the Sarada river drainage system. The downstream region comprises mainly of eight villages belonging to seven different panchayats. The villages associated with the catchment and downstream areas of the Awa lake are presented in Table 6.

SOCIOECONOMIC ENVIRONMENT

Kondakarla Awa region is a rural area where agriculture is the main occupation, while fishing is limited to only wetland surrounding villages. The region is administratively divided into Two Mandals (*Atchutapuram* and *Munagapaka*) 13 Panchayats, 20 villages and several small habitations (Table 6).

The region supports a population of around 30,000. The region being close to the industrial area of Visakhapatnam and Anakapalli town, literacy levels are comparatively higher than other rural areas of Visakhapatnam district. The nearby sugar mills and Jaggery market at Anakapalli have profound influence on the agriculture of the region, and a greater part of the land is used for *Sugarcane* crop, which is a water intensive long-term crop.

Impact Villages

Based on their location and lake usage, the villages in the study area are classified into four categories. At the first level, the villages are grouped into Catchment villages and downstream villages. At the second level, four categories are identified, in which the ***first category*** is which can influence the lake (by contributing water) but do use the lake for any purpose; the ***second category*** is which can influence the lake (by contributing water) and use the lake for limited purposes; the ***third category*** is which can influence the lake (by contributing water) and use the wetland for varied purposes; and the ***fourth category*** is which can influence the lake (by receiving water for irrigation) but do not use the wetland for any other purpose. The types of use by different villages are shown in Table 6. The first three categories belong to catchment area, while the fourth category to the downstream area.

Table 6: Impact Villages of Kondakarla Awa

Sl. No	Panchayat	Village	Geo. graphical area	Net area Sown (ha)	Area under irrigation	population	Hh
1	Munagapaka	Munagapaka	1011	890.71	785	10028	2663
2	Vadarapalli	Vadrapalli	363	156.61	103	2338	623
3	Nagavaram	Mallavaram	785	34.52	0	1222	298
4	Nagavaram	Nagavaram	838	148.52	25.9	1821	467
5	Yerravaram	Yerravaram	310	203.15	138	1336	286
6	Jagganaptea	Jagganapeta	183	118.98	159	1028	286
7	Khajipalem	Khajipalem	149	124.64	108	1422	413
8	Pedapadu	Pedapadu	272	200.32	195	2308	658
9	Timmarajupeta	Timmarajupeta	156	136.72	129	1934	548
10	Haripalem	Haripalem	195	125.05	125	3476	920
11	Kondakarla	Kondakarla	456	203.15	117	1427	388
12	Kodakarrla	Andalapalli	435	119	76	2427	643
13	Cheemalapalli	Cheemalapalli	450	155	28	2410	641
14	Somavaram	Somavaram	512	117.17	52.2	2046	514

RESULTS

The ecological state of the lake was delineated, based on the state of various physical, chemical and biological parameters of the lake waters. These parameters were monitored for a period of two years, during 2012 - 2015, through monthly sampling at 14 selected sampling points of five stations of the lake. In the present report, results for the five main stations are reported as the mean of the sampling points of the station.

Physico-chemical Characteristics of the Lake Waters and sediments:

The Physicochemical characteristics of lake waters and sediments, for different months at the five sampling stations are presented in Tables 6 to 10. The parameters included Depth, Water Temperature, pH, Dissolved and Suspended Solids, DO, BOD, +-NO_3, PO_4 K, Ca, Mg, Na and CI. Similarly, biotic parameters include, fecal coliforms in the lake waters; planktonic composition and monthly variations; macrophytes present, and the results are presented in (Tables 6 to 10). In addition to these, a checklist of fish, amphibians, reptiles, and mammals recorded.

Depth of water has ranged from 0.12m to 1.98 m. The pH of the lake waters indicated that it is neutral to slightly alkaline and Sampling **Station V**, which was at the lake centre, showed relatively greater alkalinity, compared to other four sampling stations. In all the sampling stations, Total Suspended Solids (TSS) concentrations followed a similar annual trend. TSS were maximum (upto 2.32 g/l) during July in Station III, and thereafter declined steeply till November**.** Total Dissolved Solids (TDS) also had a more or less a similar annual trend, but the concentration levels appeared to vary widely between different sampling stations. Highest values for Total Solids (TS) were registered during

rainy months (except in case of Station V, where maximum value of TS was recorded during the month of March and the lowest during the winter months. The DO content of water was good throughout the year but there were no seasonal patterns. DO value of waters showed a fluctuation within the range of 5.7 mg/l at Station III in the month of January to 15.0 mg/l at Station V in September. The values of BOD have ranged from 0.3 mg/l at Station V during July, 2003 to 11.93 mg/l at Station I during March, 2004. The nitrate content of water was found to range from 0.46 mg/l at Station III during January to 3.70 mg/l at Station I during April. Highest values of Phosphate were recorded during the early summer season and suddenly declined by late summer. The lowest phase was during the winter months. The concentrations of Phosphate in the waters have ranged from 0.006 mg/l at Station III during December to 2.1 mg/l at Station I during April. The Potassium content of water ranged from 13.1 mg/l at Station I during January to 39.21 mg/l at Station II during October. Potassium content in the lake waters showed an annual trend with two peaks, the first peak occurred during the late monsoon month of October and the second peak during the summer months of March and April. The calcium hardness was found to vary from 38.6 mg/l during February at Station V to 122.2 mg/l during April at Station III. The magnesium hardness ranged between 32.0 mg/l at Station I during June to 75.6 mg/l at Station II during November. Unlike the Ca Hardness, Mg Hardness showed no conspicuous seasonal trend. Sodium content in the lake waters ranged from 58.2 mg/l at Station III during September. Though Station IV during December to 123.2 mg there appears to be no definite seasonal trend.The Chloride content of water was fairly high and ranged between 49.4 mg/l during November at Station IV to 214 mg/l during April at Station I.

Table 6: Physicochemical characteristics of water at Sampling Station I of Kondakarla Awa Wetland 2012-2014

Sl.No.	Month	Depth	T	pH	TS	TDS	TSS	DO	BOD	NO_3	PO_4	K	Ca	Mg	Na	Cl
		m	**^0C**	**H^+**	**g/l**	**g/l**	**g/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
1	***Nov***	1.17	26	7.6	0.55	0.39	0.16	8	4.7	0.98	0.012	23.8	120.6	53.4	103	126.5
2	***Dec***	1.77	23.5	8.21	1.1	0.74	0.36	7	4.8	1.16	0.02	14.1	80	56.8	89	90.5
3	***Jan04***	1.52	21.5	8.56	1.56	1.2	0.36	7.5	5.6	0.88	0.7	13.1	46.4	66.2	77.7	134.1
4	***Feb***	1.1	24	7.84	1.1	0.63	0.47	9.2	5.6	1.13	0.9	25.8	52.6	46.7	104	88.2
5	***Mar***	0.8	25	9.12	2.73	1.42	1.31	11.8	11.93	2.81	1	19.8	53.1	53	96.6	119
6	***Apr***	0.76	27	8.85	2.49	1.23	1.26	7.8	9.87	3.7	2.1	39.1	112.3	56.1	102	214
7	***May***	0.64	27	8.45	2	1.33	0.67	6.1	7.8	2.89	0.012	18	69	54.3	89.6	146.2
8	***June***	0.56	29.5	8.27	2.4	1.42	0.98	6.7	5.8	0.87	0.2	17.1	61.7	32	103	146.8
9	***Jul***	0.12	29	7.82	4.41	2.43	1.98	9.5	0.6	1.05	0.13	21.1	76	32.8	104.2	74.4
10	***Aug***	0.43	27	7.83	3.35	1.81	1.54	10.1	1.3	2.68	0.9	26.9	110.4	42	98.6	91.5
11	***Sep***	0.68	29	7.85	2.44	1.1	1.34	10.5	1.2	1.67	1	18.7	103	49.2	98.1	84.3
12	***Oct***	1.23	26	8.46	1.41	0.98	0.43	8.9	1.9	1.11	0.8	28.7	107.4	68.7	89.4	111
Mean		***0.9***	***26.21***	***8.24***	***2.12***	***1.22***	***0.9***	***8.59***	***5.09***	***1.74***	***0.65***	***22.18***	***82.71***	***50.93***	***96.27***	***118.9***
SD+_		***0.47***	***2.42***	***0.47***	***1.08***	***0.54***	***0.58***	***1.71***	***3.54***	***0.99***	***0.62***	***7.24***	***26.77***	***10.14***	***8.23***	***38.84***

Table 7: Physicochemical characteristics of water at Sampling Station II of Kondakarla Awa Wetland 2012-2014

No.	Month	Depth	T	pH	TS	TDS	TSS	DO	BOD	NO_3	PO_4	K	Ca	Mg	Na	Cl
		m	^0C	H^+	g/l	g/l	g/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	***Nov***	1.83	26	8.8	0.35	0.33	0.02	6.7	3.1	0.95	0.032	21	110.3	75.6	79.6	115.3
2	***Dec***	1.62	24	8.3	0.88	0.45	0.43	11	3.8	0.87	1.03	17.1	85.2	40.4	101.5	108.7
3	***Jan***	1.44	22	8.25	0.94	0.56	0.38	8	3.9	0.86	1.05	18.3	52.4	53.9	92.1	105
4	***Feb***	1.05	26	8.2	1.09	0.53	0.56	9	4.8	1.67	1.15	23.9	65.1	48.7	96	112
5	***Mar***	1.42	29.5	8.3	2.48	1.36	1.12	12.6	8.3	1.87	1.8	33.8	82	54.6	104.1	123.2
6	***Apr***	1.2	30	7.68	2.75	1.32	1.43	9.2	8.6	1.97	1.98	31	119.7	52.7	104	170.2
7	***May***	0.9	32	8.2	2.44	1.46	0.98	8.3	7.5	2.1	0.032	15	73	65	76	64.1
8	***June***	0.86	32	7.84	1.99	1.23	0.76	9.4	5.4	1.16	0.18	21.8	56.2	40	96	126
9	***Jul***	0.18	28	7.98	4.54	2.51	2.03	10.1	1.7	1.84	0.12	22.8	76	42	89.7	92.6
10	***Aug***	0.58	31	7.9	3.08	1.1	1.98	8.5	1.6	2.01	0.25	25.7	100.7	54.7	108.4	87.4
11	***Sep***	0.89	30	9.85	2.22	0.87	1.35	13.2	2.2	1.89	0.4	25.7	110.4	46.3	116.6	97.4
12	***Oct***	1.76	28	8.56	1.06	0.89	0.17	9.5	2.5	1.34	0.6	39.21	114.7	57.6	92.1	108.9
Mean		***1.14***	***28.21***	***8.32***	***1.98***	***1.05***	***0.93***	***9.63***	***4.45***	***1.54***	***0.72***	***24.61***	***87.14***	***52.63***	***96.34***	***109.2***
SD+_		***0.5***	***3.17***	***0.57***	***1.19***	***0.6***	***0.67***	***1.87***	***2.51***	***0.48***	***0.68***	***7.1***	***23.52***	***10.41***	***11.58***	***25.56***

Table 8: Physicochemical characteristics of water at Sampling Station III of Kondakarla Awa Wetland 2012-2014

No.	Month	Depth	T	pH	TS	TDS	TSS	DO	BOD	NO_3	PO_4	K	Ca	Mg	Na	Cl
		m	^0C	H^+	g/l	g/l	g/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	***Nov***	1.69	27.5	8.64	0.45	0.31	0.14	9.8	3.4	0.48	0.007	25.8	108.9	72.3	86.3	78
2	***Dec***	1.8	24	7.8	0.89	0.26	0.63	7.5	3.5	0.65	0.006	21.6	72.7	61.5	87	69
3	***Jan***	1.68	22	8	0.81	0.28	0.53	5.7	3.1	0.67	0.02	16.1	42.7	56.4	105.7	108.4
4	***Feb***	1.44	25	8	1.54	0.31	1.23	10.7	2.9	1.02	0.04	16	68.4	61.7	78.1	130.3
5	***Mar***	1.43	27	8.47	2.64	1.11	1.53	11.5	7.9	2.76	0.6	21.7	68	55.5	7.9	158.1
6	***Apr***	1.1	28	8.6	2.63	1.32	1.31	6.5	7.4	1.6	0.17	18.9	122.2	48	112.1	186.5
7	***May***	0.98	29	7.98	1.24	0.65	0.59	7.9	6.4	0.86	0.007	21.7	62.8	45.7	85.6	123.8
8	***June***	0.8	31.5	7.56	1.46	0.45	1.01	8	4.8	0.46	0.08	24.7	51	43.2	104.7	147.2
9	***Jul***	0.13	27	8.02	4.62	2.3	2.32	7.6	1.2	2.32	1.23	18.8	74.2	37.1	109	54.8
10	***Aug***	0.57	29	8.12	3.37	1.7	1.67	8.6	1.2	1.68	0.8	18.7	89.2	46	112.5	107
11	***Sep***	0.64	32.5	8.13	2.02	0.45	1.57	14.5	1.8	1.04	0.16	14	102.5	54.2	123.2	63.2
12	***Oct***	1.45	26	8.2	0.79	0.43	0.36	8	2.7	0.83	0.24	36.61	118.3	49	104	69.4
Mean		***1.14***	***27.4***	***8.13***	***1.87***	***0.8***	***1.07***	***8.86***	***3.86***	***1.2***	***0.28***	***21.2***	***81.7***	***52.6***	***101***	***108***
SD+_		***0.53***	***2.97***	***0.32***	***1.24***	***0.67***	***0.64***	***2.42***	***2.29***	***0.74***	***0.39***	***5.98***	***26.2***	***9.67***	***13.7***	***42.3***

Table 9: Physicochemical characteristics of water at Sampling Station IV of Kondakarla Awa Wetland 2012-2014

No.	Month	Depth	T	pH	TS	TDS	TSS	DO	BOD	NO_3	PO_4	K	Ca	Mg	Na	Cl
		m	^0C	H^+	g/l	g/l	g/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	***Nov***	1.56	28	8.67	0.41	0.27	0.14	8.9	2.8	0.68	0.018	19	112.3	59.3	78.1	49.4
2	***Dec***	1.54	25	8.2	0.61	0.26	0.34	8	2.9	0.85	0.012	18.5	76.4	54	58.2	54.2
3	***Jan***	1.45	23	7.96	0.81	0.24	0.57	6.2	3.4	0.68	0.1	20	42.2	54.8	84	98.7
4	***Feb***	1.26	24	8.67	1.87	0.42	1.45	7.5	3.1	0.89	1.01	24.6	72.3	52.6	105.2	87.6
5	***Mar***	1.26	26.5	7.84	2.31	0.96	1.35	10.2	7.5	2.5	0.83	38.8	91.7	60.8	89.3	208.4
6	***Apr***	0.86	29	7.2	1.77	1.1	0.67	7.2	6.8	3.06	0.051	23.1	115	48.9	107.9	198.2
7	***May***	0.85	30	8.11	2.22	1.12	1.1	7.4	5.9	1.12	0.018	14.7	78.4	32.6	105.7	188.4
8	***June***	0.54	34.5	8.46	1.21	0.64	0.57	11.5	5.1	0.76	0.14	16.1	47.9	41.7	78	170.1
9	***Jul***	0.19	30.5	7.82	2.87	0.98	1.89	7.8	0.9	1.23	0.008	19.8	104.2	48	74	86
10	***Aug***	0.38	30	8.22	2.6	1.15	1.45	7.1	1.1	1.78	0.015	23.7	90	70.2	89	121.3
11	***Sep***	0.56	30	9.14	1.73	0.35	1.38	12	1.6	1.76	0.08	21.8	104.3	48.5	102.5	134.2
12	***Oct***	1.46	27	7.89	0.9	0.25	0.65	12.7	1.8	0.62	0.56	35.8	115	59	103	136.4
Mean		***0.99***	***28***	***8.18***	***1.61***	***0.65***	***0.96***	***8.88***	***3.58***	***1.31***	***0.24***	***23***	***87.5***	***52.5***	***89.5***	***128***
SD+_		***0.49***	***2.9***	***0.51***	***0.81***	***0.39***	***0.54***	***2.18***	***2.24***	***0.78***	***0.36***	***7.32***	***24.8***	***9.72***	***15.7***	***54.4***

Table 10: Physicochemical characteristics of water at Sampling Station V of Kondakarla Awa Wetland 2012-2014

No.	Month	Depth	T	pH	TS	TDS	TSS	DO	BOD	NO_3	PO_4	K	Ca	Mg	Na	Cl
		m	^0C	H^+	g/l	g/l	g/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1	***Nov***	1.98	27.5	8.55	0.5	0.09	0.41	10.5	4.7	0.68	0.012	17	107.2	59.1	64.7	84
2	***Dec***	1.87	23	8.57	0.67	0.19	0.48	12.5	3.9	0.67	0.11	15	76.9	67	98.5	63.8
3	***Jan***	1.73	22	8.82	0.64	0.21	0.43	9.2	2.7	0.69	0.05	17	47.9	74	78.1	60.2
4	***Feb***	1.69	26	8.43	1.21	0.23	0.98	9.2	2.5	0.65	0.4	17.5	38.6	48.1	74	109.8
5	***Mar***	1.53	28	8.22	2.32	0.98	1.34	13.7	6.9	1.13	0.89	23.9	65.4	37.3	106.7	179.2
6	***Apr***	1.22	29	8.32	1.59	1.14	0.45	9.2	5.8	1.4	1.5	21.4	82.1	52.7	105	170.6
7	***May***	1.23	28	8.24	1.34	0.94	0.4	10.4	6.1	0.83	0.012	16	55.1	52.2	84.1	183.1
8	***June***	1.12	29	8.7	0.65	0.42	0.23	10.5	4.9	0.67	0.017	15.7	42	46	107.1	146.4
9	***Jul***	0.19	29	8.52	1.64	0.8	0.84	8.6	0.3	1.08	0.015	20.1	74	41.5	86.7	64
10	***Aug***	0.76	28	8.67	1.5	0.68	0.82	7.9	0.7	1.16	0.009	23.8	107.4	42.9	92	92.5
11	***Sep***	1.1	30	9.31	1.13	0.24	0.89	15	1.2	1.02	0.13	21	111	46.1	86	103
12	***Oct***	1.8	27	8.56	0.7	0.21	0.49	10.6	1.6	0.62	0.2	21.7	117.2	67.2	98.3	134.2
Mean		***1.35***	***27.2***	***8.58***	***1.15***	***0.51***	***0.64***	***10.6***	***3.44***	***0.88***	***0.28***	***19.2***	***77.1***	***52.8***	***90.1***	***116***
SD+_		***0.52***	***2.44***	***0.29***	***0.55***	***0.37***	***0.32***	***2.13***	***2.25***	***0.26***	***0.46***	***3.18***	***28.3***	***11.6***	***13.6***	***45.8***

Biological Quality of Waters:

Fecal *Coliform* Bacteria

The fecal *Coliform* population was examined in the water samples from all the five sampling stations and the data is presented in (Table 11). Among all, the stations, Station V exhibited very low level of contamination by the fecal coliforms. The MPN of the *Coliforms* per 100 ml, was high during the rainy season. The MPN of Fecal *Coliform* Bacteria, among the five sampling stations had a range from as low as 3/100 ml during March at Station V to a high of 240/100 ml at Stations II and III, during the months of August and June, respectively.

Table 11: Monthly Variations in Population Density of Fecal Coliform of Kondakarla Awa Wetland during 2012-14

Fecal Coliform Bacteria (MPN/100ml												
Station	**Month**											
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**
I	64	75	75	64	21	15	43	43	75	93	75	64
II	93	43	64	64	11	21	93	75	210	240	150	210
III	73	43	39	28	14	28	64	75	120	120	150	43
IV	75	75	64	43	11	39	150	240	120	150	150	120
V	39	39	21	20	3	11	21	20	23	150	75	23

Phytoplankton

The lake supports a rich variety of phytoplankton. During the study period (July 2013 to june 2015), a total number of forty two (42) genera of phytoplankton were observed and identified. Out of these, twenty two (22) belong to Chlorophyceae, seven (7) to Bascillariophyceae and twelve (12) to Myxophyceae. It was however noted that both quantitatively and quantitatively Chlorophyceae was the dominant one, followed by Myxophyceae. The various genera belonging to different Orders and Classes, identified from the lake waters are presented in (Table 12).

On the whole, the total phytoplankton showed a bimodal distribution with one peak in the winter season and another during the summer season the maximum density of Total Phytoplankton was recorded at Station IV as 112800/l during November.

Table 12: Monthly Variations in Population Density of Phytoplankton of Kondakarla Awa Wetland during 2012-13(Organism/l)

Station-I	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**
Volvocales	3880	1267	2760	850	2130	0	0	430	0	0	250	1160
Conjugales	5230	5680	1240	3570	10440	18900	19560	8564	0	280	320	4590
Cloroccales	1285	950	1590	1450	1170	8780	5890	12850	160	240	650	4250
Oedogoniales	1120	2670	3450	680	2250	1240	0	2430	0	0	150	870
Diatoms	20680	20200	23000	18760	12700	1080	6700	4305	100	470	870	4670
Chrooccales	7690	9880	9000	3670	21230	41800	37560	10680	180	650	5140	10200
Hormogoniales	31200	25800	24300	31000	40090	21500	18900	15340	0	450	3410	24500
Nostocales	8780	7540	5570	4320	5670	12880	4080	1440	0	0	240	2300
Total Phytoplankton	**79865**	**73987**	**70010**	**64300**	**95680**	**106180**	**92690**	**56039**	**440**	**2090**	**11030**	**52540**
Station-II												
Volvocales	2100	5690	2790	1120	0	0	0	0	0	0	0	270
Conjugales	6100	3780	3560	12600	15800	10900	8090	12000	110	210	1280	4680
Cloroccales	3270	4310	2250	12450	10500	12700	3200	2350	0	210	1200	12800
Oedogoniales	2570	3370	480	2540	1000	0	1200	1260	0	0	430	1260
Diatoms	15790	18700	27890	10800	12400	15600	14860	9560	230	480	2280	5680
Chrooccales	12700	18500	29460	18700	19870	29760	15600	10380	160	980	2800	6790
Hormogoniales	16700	8790	15700	25400	31700	19760	37800	11680	220	650	3500	9600
Nostocales	1780	1260	7680	4560	2300	5600	3240	2280	0	470	4590	8070
Total Phytoplankton	**61010**	**64400**	**89810**	**88170**	**93570**	**94320**	**83990**	**49510**	**720**	**3000**	**16080**	**49150**

Station-III	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**
Volvocales	860	1570	1890	0	0	560	0	0	0	0	430	0
Conjugales	3440	3290	4250	4110	12590	19800	10100	7500	340	870	1110	1760
Cloroccales	650	4380	12540	5680	15670	16840	6500	2670	120	540	1450	11760
Oedogoniales	3040	1560	1650	1170	870	1260	860	1090	0	0	560	1270
Diatoms	17890	25800	19800	17890	14500	10500	5680	2410	240	1140	8670	11900
Chrooccales	6120	1110	1360	5600	19800	15760	9750	5640	0	0	1120	2310
Hormogoniales	24300	30120	31500	22300	16800	15600	8790	7650	170	680	11280	25700
Nostocales	1110	7850	4580	2790	12540	2330	4750	1730	0	450	1120	3650
Total Phytoplankton	**57410**	**75680**	**77570**	**59540**	**92770**	**82650**	**46430**	**28690**	**870**	**3680**	**25740**	**58350**
Station-IV												
Volvocales	5500	4300	4100	1290	1110	870	0	560	0	0	650	1450
Conjugales	11290	4100	11500	8160	10230	1180	21700	7140	280	450	1650	8700
Cloroccales	21600	14500	5540	9700	19800	17880	11200	8760	250	430	4090	12450
Oedogoniales	1120	1150	1000	890	1240	760	830	980	0	0	1110	4210
Diatoms	28900	31000	19800	22900	15490	11900	16780	13120	270	350	5600	10300
Chrooccales	8690	9180	9000	3770	22230	31900	29560	10780	180	450	5240	10000
Hormogoniales	21200	25800	24300	21000	20090	21500	12900	5340	0	450	3410	14500
Nostocales	14500	12390	6580	9640	15640	12000	4230	2180	0	0	1190	6590
Total Phytoplankton	**112800**	**102420**	**81820**	**77350**	**105830**	**97990**	**97200**	**48860**	**980**	**2130**	**22940**	**68200**
Station-V												
Volvocales	2290	4120	1130	980	560	640	0	0	0	0	450	1640
Conjugales	11210	13460	3780	6540	21800	5670	6590	5000	210	430	5600	5200
Cloroccales	7180	3620	2110	7080	10990	6590	4420	3210	180	560	9600	5000
Oedogoniales	3070	1230	1150	1980	3080	3100	4570	2890	0	0	0	1500
Diatoms	21700	16700	15690	15980	6500	12450	3400	5000	200	670	5400	10940
Chrooccales	7190	1870	200	3150	13500	17800	9040	15640	0	470	4500	4160
Hormogoniales	7000	15690	11090	11870	19800	22560	21500	3680	230	650	5700	7680
Nostocales	4020	3270	5440	6210	10000	4100	5150	5000	0	590	1560	5780
Total Phytoplankton	**63660**	**59960**	**40590**	**53790**	**86230**	**72910**	**54670**	**40420**	**820**	**3370**	**32810**	**41900**

Zooplankton

In the present investigation, the zooplanktonic population was found composed of six major groups' viz. protozoa, Rotifera, Cladocera, Ostracoda, Copepoda and Insect larvae. During the study period, 66 species were recorded of which two (2) belong to protozoa, twenty six (26) to Rotifera, fifteen (15) to Cladocera, three(3) to Ostracoda, eleven(11) to Copepoda, and nine (9) to Insect larvae.

It was however noted that qualitatively Group Rotifera and quantitatively Group Copepoda were dominant. Rotifera and Cladocera formed the second and third quantitatively abundant zooplanktonic groups respectively. The various forms of zooplankton recorded during the study period are presented in (Table 13).

Table 13: Monthly Variations in Population Density of Zooplankton of Kondakarla Awa Wetland during 2012-13 (Organism/25l)

	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct
Station-I												
Protozoa	450	1200	3700	2200	670	430	540	0	0	70	90	110
Rotifera	2500	6400	4100	4100	5380	6340	7750	5110	60	50	990	1480
Cladocera	4900	5850	4780	1640	2150	3600	2560	5500	80	790	3400	3500
Ostracoda	60	250	160	180	210	60	40	110	0	230	350	110
Copepods	2150	4900	5900	3100	5900	14300	10300	6500	100	600	2490	2700
Insect Larvae	220	350	120	40	90	50	40	40	0	110	450	100
Total Zooplankton	**10280**	**18950**	**18760**	**11260**	**14400**	**24780**	**21230**	**17260**	**240**	**1850**	**7770**	**8000**
Station-II												
Protozoa	580	2300	4120	3300	1240	320	450	220	0	0	230	550
Rotifera	2800	6100	3800	4200	6890	7180	7106	4210	80	250	1180	2120
Cladocera	4890	6490	3000	3340	450	4270	3530	6700	120	780	2300	3500
Ostracoda	50	140	140	90	180	40	50	30	0	150	110	110
Copepods	2400	4300	5700	2500	5600	19800	18800	5600	120	850	2000	1900
Insect Larvae	140	210	170	40	110	40	40	30	70	100	570	140
Total Zooplankton	**10860**	**19540**	**16930**	**13470**	**14470**	**31650**	**29976**	**16760**	**390**	**2130**	**6390**	**8320**
Station-III												
Protozoa	760	2460	2400	0	1270	0	240	250	0	0	0	480
Rotifera	2550	7500	2800	3000	2800	6330	8660	6710	110	270	880	2400
Cladocera	4900	6090	3380	3340	1250	3310	2170	6500	0	490	2700	3000
Ostracoda	80	210	200	90	150	50	60	50	0	270	120	60
Copepods	3550	5600	6900	3300	5000	15480	12480	6110	120	800	4140	1700
Insect Larvae	230	60	80	30	50	50	60	50	0	110	430	190
Total Zooplankton	**12070**	**21920**	**15760**	**9760**	**25220**	**25220**	**23670**	**19670**	**230**	**1940**	**8270**	**7830**

	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct
Station-IV												
Protozoa	250	750	2300	560	1160	650	350	0	0	0	0	0
Rotifera	2800	6300	1980	3400	2670	6110	5590	5210	0	130	1180	1470
Cladocera	3900	5090	3380	3340	180	4100	3510	4100	0	490	2700	2500
Ostracoda	50	110	100	100	170	30	30	50	0	90	100	50
Copepods	2050	4600	4100	3300	6400	16500	14600	5300	110	750	200	2700
Insect Larvae	120	210	160	100	100	50	110	30	150	120	1100	180
Total Zooplankton	**9170**	**17060**	**12020**	**10800**	**10680**	**27440**	**24190**	**14690**	**260**	**1580**	**5280**	**6900**
Station-V												
Protozoa	540	1450	2270	640	0	670	430	320	0	0	0	430
Rotifera	2500	4300	2100	3200	5870	5400	6560	5210	0	250	980	2470
Cladocera	4900	6490	3780	2340	250	4300	2410	6500	0	590	3700	4500
Ostracoda	60	150	150	100	170	20	40	50	0	170	100	60
Copepods	2450	4600	6100	2300	5400	16870	11170	6300	100	700	2100	1700
Insect Larvae	120	150	150	50	100	50	50	30	50	120	600	100
Total Zooplankton	**10570**	**17140**	**14550**	**8630**	**11790**	**27310**	**20660**	**18410**	**150**	**1830**	**7480**	**9260**

Sediments Quality and Sedimentation

Sediment quality for its pH, and the nutrients like Nitrates, Phosphates and Potassium were analyzed for all the five stations and the results are presented in (Table 14). In addition to the sediments quality, the sedimentation load into the lake from external sources was assessed for four stations, which brings in water to the lake.

At all the four inlet channels of the lake, silt traps were fixed and the readings between two points of time were noted and the sedimentation load was estimated as increase in the thickness of the layer. This experiment was repeated twice. The initial reading was taken before the first monsoon showers in June and the final reading was taken after the monsoon in the November. This was repeated for the years 2013 and 2014, and the mean was reported as the annual load.

Site I, which was located close to the agricultural fields of village Andalapalli and the Average sedimentation recorded, was 1.0 cm. At **Site II** on the *Kaccha* road towards the wetland at Vadrapalli was 0.55 cm. At **Site III**, near the agricultural fields of village Ava Somavaram the average sedimentation was 1.05 cm. The Average sedimentation recorded at **Site IV** near hillock (west side of the wetland near Haripalem) was 1.8 cm.

Table 14: Physicochemical characteristics of Sediments of Kondakarla Awa Wetland 2012-2014

Station-I	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Mean**	**SD+_**
pH	7.75	8.02	7.98	7.89	8.3	8.27	8.23	8.27	8.34	8.12	8	8.1	8.11	0.18
Nitrate(mg/kg)	6.7	5.7	6.2	4.5	7.0	8.2	6.5	8.7	4.2	7.3	8.0	8.3	6.8	0.15
Phosphate(mg/kg)	0.87	0.89	0.78	0.82	1	1.14	1.23	1.35	1.84	0.85	0.7	1.14	1.05	0.31
Potassium(mg/kg)	14.1	16.1	17.07	17.8	24	26	17.1	18.8	12.2	22.1	19	21.9	18.84	4.03
Station-II														
pH	7.45	8.15	7.85	8.13	8.1	8.12	8.26	8.19	8.33	8.27	8	7.23	8.01	0.33
Nitrate(mg/kg)	0.98	0.95	0.78	1.21	1	0.92	0.43	0.82	0.57	0.8	0.9	0.76	0.84	0.20
Phosphate(mg/kg)	0.85	0.79	0.81	0.91	1	1.05	1.19	1.32	1.12	0.88	0.6	0.61	0.92	0.22
Potassium(mg/kg)	21.8	17.9	17.45	18	25	27	23	17	26.9	23	21	23.4	21.79	3.58
Station-III														
pH	8.12	8.12	8.02	7.98	8.1	8.16	8.32	8.23	8.24	8.54	8.2	7.32	8.11	0.28
Nitrate(mg/kg)	0.32	0.08	0.68	0.43	1	1.05	0.59	0.61	0.18	0.32	0.7	0.49	0.54	0.29
Phosphate(mg/kg)	0.54	0.53	0.48	0.49	0.7	0.86	1.1	1.05	0.65	0.75	0.4	0.98	0.71	0.23
Potassium(mg/kg)	6.08	16	14.07	16	18	28.9	21.1	21.1	14	21.1	19	24.6	18.33	5.81
Station-IV														
pH	8.17	8.14	8.05	8.04	8	8.07	8.21	8.23	8.21	8.23	8.3	8.21	8.16	O.09
Nitrate(mg/kg)	0.47	0.51	0.65	0.66	1.1	1.23	0.56	0.62	0.34	0.33	0.5	0.54	0.63	0.27
Phosphate(mg/kg)	0.62	0.59	0.72	0.81	0.8	0.79	0.87	1.12	0.45	0.69	0.7	0.73	0.74	0.16
Potassium(mg/kg)	12.2	14.1	15.06	21	20	32.1	23	15.1	23.9	22.1	13	22	19.46	5.79
Station-V														
pH	8.15	8.23	8.26	8.23	8.1	8.12	8.27	8.31	8.24	8.16	8.2	8.05	8.2	0.07
Nitrate(mg/kg)	0.49	0.37	0.41	0.42	1	0.82	0.45	0.48	0.46	0.48	0.6	0.53	0.54	0.18
Phosphate(mg/kg)	0.52	0.51	0.61	0.58	0.6	0.78	0.79	1.43	0.95	0.58	0.6	0.47	0.7	0.26
Potassium(mg/kg)	7.03	10.7	15.8	17	18	23.1	21	16	16.8	22.8	11	19	16.52	4.92

Table 15: Sedimentation at four study sites (in cm)

Month	Site			
	I	**II**	**III**	**IV**
June	1.5	0.8	1.1	2.1
September	0.5	0.3	0.5	1.5
Average	**1.0**	**0.55**	**1.05**	**1.8**

Aquatic Macrophytes

`The entire lake being shallow and eupotic, supports good macrophytic vegetation and appears to constitute only a littoral zone with an abundance of rooted macrophytes throughout, without any significant profundal and limnetic zones. Among the five sampling zones, Station 1 exhibited greater species diversity with 13 of the total 14 macrophytes recorded in the present study. *Typha aungustata* appeared as the most tolerant species and survived during the dry phase, whereas *Najas gramamiea* was found to be most dominant species among all aquatic macrophytes.

Among the five sampling zones, Station I exhibited greater species diversity with 13 of the total 14 macrophytes recorded in the present study. Station II followed Station I, with 11 species, followed by Stations IV, III and V with 8, 7 & 3 species respectively. Only three species were found to have distributed in all the five sampling stations viz., *Najas graminea, Hydrilla verticillata* and *Chara vulgaris*. All these three species are submerged macrophytes. Of all the submerged macrophytes, *Ottelia alismoides* is the only species, the distribution of which is limited to Station I, and is not found in any other sampling station. Station V is the only station which does not support any other macrophyte except submerged types (Table 16).

Table 16: Checklist of Aquatic Macrophytes of Kondakara Awa Wetland.

Sl.No.	Species Name	Vegetation Type	St.I	St.II	St.III	St.IV	St.V
1	***Scirpus articulatus***	Emergent	+	+	+	+	0
2	***Typha aungustata***		+	+	+	+	0
3	***Ipomoea aquatica***	With Floating Leaves	+	+	+	+	0
4	***Nymphaea nouchali***		+	+	+	+	0
5	***Nymphoides indicum***		+	+	0	+	0
6	***Neptunia oleracea***		+	0	0	0	0
7	***Ludwigia adscendens***		+	0	0	0	0
8	***Najas graminea***	Submerged	+	+	+	+	+
9	***Hydrilla verticillata***		+	+	+	+	+
10	***Chara vulgaris***		+	+	+	+	+
11	***Ottelia alismoides***		+	0	0	0	0
12	***Lemna perpusilla***	Free Floating	+	+	0	0	0
13	***Azolla filiculoides***		0	+	0	0	0
14	***Pistia Stratiotes***		+	+	0	0	0
	Total No. of species		**13**	**11**	**7**	**8**	**3**

The Palmer's pollution index score for the algal groups of the Kondakarla Awa Lake was 22 that indicated high organic pollution. Eight (8) of the 20 genera of indicators existed in these waters as shown in (Table 17).

Table: 17 Palmer's Index for Kondakarla Awa Lake

Class	Order	Genus	Palmer's Index Number
Chlorophyceae	**Volvocales**	***Pandorina***	**1**
		Chlamydomonas	**4**
	Chlorococcales	***Scenedesmus***	**4**
		Ankistrodesmus	**2**
	Conjugales	***Closterium***	**1**
Cyanophyceae	**Homogonales**	***Oscillatoria***	**5**
Bacillariophyceae	**Pennales**	***Navicula***	**3**
		Syndra	**2**
		Total	**22**

User groups of the lakes and Use practices

Kondakarla Awa Wetland provides various services to the local communities and is a multiple use system. It acts as the economic backbone of communities residing in the surrounding villages. The water from Awa is used for irrigating agricultural crops, for washing clothes and inland fishery. Marginal areas of the lake are used for paddy and sugarcane cultivation & also for feeding the village livestock. Additional usages include, use of aquatic plants and sediments for various purposes. Use of Awa for recreation is another important use of its resources. Other than its direct use values, the lake has several indirect use values like groundwater recharge, external ecosystem support, micro-climatic stabilization and nutrient retention. Apart from economic values it has an important socio cultural value for local communities.

Plate: 3 Lake use Activities

A. Agriculture fields **B&C.** Fishing activities **D.** Washing
E. Livestock rearing **F.** Flower collection**.**

LAKE USER GROUPS

Based on economic dependency on the lake and lake use practices, direct user groups have been classified into two categories *viz.* major and minor.

Major User Groups

These direct users of Kondakarla Ava Wetland are dependent primarily on lake resources for their livelihoods. Communities like farmers, fisher folk, washer folk, livestock rearers and landless agricultural laborers are included under this category. Survival of the lake is intricately linked to the survival of these communities.

Table 18: Number of Households of Major User Groups in the Study Area

Village Name	Total HH	Farmers	Fisher Folk	Washer folk	Livestock Rearer	Landless Laborer
Kondakarla-Andalapalli	724	283	68	21	241	225
Vadrapalli	469	282	58	11	215	56
Gollalepalem	156	107	0	0	64	43
Chamelapalli	340	89	0	8	256	22
Ava Somvaram	125	16	0	0	68	10
Ava Rajam	187	29	0	7	94	13
Bangariyapalem	42	8	0	0	10	6
Jagganpeta	212	164	0	0	189	25
Total	2255	978	126	47	1137	400
%	**100**	**43.76**	**5.58**	**2.08**	**50.42**	**17.7**

(i) Farmers

Farmers are direct intensive users of Kondakarla Awa Wetland, which is the major source of water for irrigation for the farmers. Downstream farmers are provided water through irrigation channels while farmers residing in upland areas draw water using either lift irrigation system, individual motors or manually. The most dominant lake user group is a miscellaneous community that comprises of members from all social groups. They are spread in all the fifteen user villages. Number of lake user farmer families residing in the study area are 978. Farmers have been considered under three categories *viz.*, small or marginal farmers with land holdings below 1 hectare, medium farmers with

land holdings between 1 to 2 hectare and large farmers with land holdings above 2 hectare. Medium farmers dominate the region.

Small farmers are subsistence farmers and are able to cultivate only one crop in Kharif (sown in June-July), which is just sufficient to fill the food needs of their families. For the rest of the year, these farmer families work on larger farmers' fields as agricultural labourers, especially during the second (Rabi) and third (Zaid) cropping seasons to earn their livelihoods. Unlike small farmers, middle and large farmers are involved in agricultural activities in their fields throughout the year and are the biggest users of lake water. Sometimes, marginal farmers take land on lease from large farmers annually for cultivation. In such an arrangement, the sharing of produce is done in the ratio of 50:50 with the owner.

Women work alongside their male counterparts. They are primarily involved in sowing, harvesting, weed removal and selling small produce like vegetables in the village market. Men are involved in field preparation, application of fertilizers and pesticides to the standing crops, transportation of harvested commodities and selling them in the market. Generally men take decisions regarding agricultural practices and inputs.

Annual income of farmers ranged between INR 10000 in case of small farmers to INR 150000, in case of large farmers.

Table 19: Number of Farmer Households Dependent on Kondakarla Wetland

Sl. No.	Village	Farmers (HH)					
		Total	Use of wetland water for irrigation				
			Dependent Families	Ava Channel	Lift Irrigation	Private Motors	Manual
1	Kondakarla-Andalapalli	393	283	283	0	20	4
2	Vadrapalli	282	282	0	282	30	0
3	Gollalepalem	107	60	0	30	20	10
4	Chamelapalli	295	89	0	0	35	54
5	Ava Somvaram	95	16	0	0	0	16
6	Ava Rajam	136	29	0	0	20	26
7	Bangariyapalem	38	9	0	0	2	8
8	Jagganapeta	164	164	164	0	0	0

(i) Fisher Folk

`Fisher Folk though relatively smaller in number are the most dependent user group of Kondakarla Awa. This fishing community is spread in three of the peripheral villages *viz*., Kondakarla, Andalapalli and Vadrapalli. There are total of 126 fisher folk households in the region. This community belongs to two sub castes *Vaddi* and *Chattibaliji*, both belonging to the Backward Caste (BC) Category. *Chattibalijies* are famous for preparing toddy as an alternative source of income. During peak season (February-June) they are involved only in fishing activities while during the lean season they also work as agricultural laborers. Some of the families have agricultural land and cultivate crops during Kharif season or have petty business like owing a teashop or pulling a rickshaw. Tourism also provides monetary benefits to this community through boating. They also have rights to sell water lilies. Fisher Folk carry out all fishing related

activities, whereas the role of fisher women is restricted to selling fish and water lilies in the village and other nearby markets.

Annual income per household from fishing ranged from INR30000 to 60000. Total income of the community during the tourist season is around INR 20000, which is distributed equally among all the households. Total annual income from selling water lilies is also very insignificant (around INR3000), which is given to their society.

Table 20: Number of Fisher Folk Households Dependent on Kondakarla

Sl. No.	Village Name	Fisher Folk		
		Total HH	Fishing + Agriculture	Fishing + Livestock Rearing
1	Kondakarla – Andalapalli	68	27	6
2	Vadrapalli	58	26	11
Total		**126**	**53**	**17**

(ii) Washer Folk

Washer Folk pursue washing clothes (of other villagers) as a source of their income. They are one of the poorest rural communities. They use Kondakarla Awa as a source of water and a place for washing clothes. There are 47 households of this community who reside in villages of Kondakarla-Andalapalli, Chimalapalli, Ava Rajam, Vadrapalli (Table 21). All the families in this community belong to one single caste, called *Rajak* or *Chakali*, who are legally classified as Backward Caste (BC). Both women and men work equally. Washer folk have received iron boxes, buckets and washing bowls under a government scheme called *Adarna*.

Some of the families have small agricultural landholdings. Some households own livestock, mainly pigs. Annual income of this group ranges from INR20000 to 30000. They are paid in terms of cash or food grain.

Table 21: Number of Washer Folk Households Dependent on Kondakarla

Sl. No.	Village Name	Washer Folk		
		Total	Washing + Agriculture	Washing + Livestock Rearing
1	Kondakarla-Andalapalli	21	8	2
2	Vadrapalli	11	0	0
3	Chamelapalli	8	0	4
4	Ava Rajam	7	0	0
Total		**47**	**8**	**6**

(iii) Livestock Rearers

Livestock rearing is a source of additional income for many families and also an insurance against adversity in all the study villages. There are 1137 households owning livestock spread across all the fifteen user villages. Most of them own cattle mainly, cows and buffaloes which are primarily reared for their milk, to meet household needs and for sale in local markets. Low-income households also rear goats for both milk and meat. Piggeries are also another source of additional income. Typically, goats and pigs are sold to meet emergency cash requirements. Livestock rearers depend on the lake mainly for animal feed and rarely for drinking water and bathing of cattle, especially during summer. Cattle live in a thatched shed locally known as *Paka*, constructed in the agricultural fields. Other animals are kept in sheds constructed inside the household premises. Women look after animals when they are at farm or at

home, whereas open grazing is under the purview of men. Annual income from livestock rearing ranged from INR5000 to 15000.

v. Landless Agriculture Laborers

Landless agricultural laborers are daily wage earners and work in agricultural fields, which are irrigated by lake water. They do not have any other alternate source of livelihood. This is also a diverse group formed by local people belonging to all social groups. There are 400 households of landless agricultural laborers spread across all the fifteen user villages. Both men and women perform labor work. Annual income of this user group ranged from INR15000 to INR36000 per household.

Vi. Minor User Groups

Other than a source of their livelihoods, all local communities use lake resources for various purposes like recreation, religious rituals and using the aquatic plants or wetland sediments etc.

USE PRACTICES

Fisheries:

Fishing is one of the most prominent activities inside the lake. Fisher Folk practice capture/culture of fisheries. Fisher folk from Kondakarla and Vadrapalli do not consider any revenue/administrative boundary, when it concerns fishing activities. There is no division of fishing area or any discrimination between the fishing communities based on them being from different villages. All the fishing activities are carried out collectively.

There are twenty (20) different types of fish presently found in the lake, of which five (5) are cultured (introduced) varieties while the remaining are native species. Fisher Folk go to the wetland for fishing twice in a day, once in the morning at around 5 am and another trip in the evening at around 4 pm.

Fisher women have the responsibility to sell the captured fish in their own village(s) and in nearby towns.

(i) Stocking

The primary annual source of fish seeds/spawns is the government hatchery located at Thandva (Narsipatnam Mandal), which are brought on subsidized rates in limited numbers and as per prevailing government regulations. Additional fish seeds are purchased from private hatcheries located at Parthipuram, Bikkavolu and Akiveedu. Overall number of seeds purchased from the government is around 25 lakhs while, seeds purchased from private hatcheries is around 20 lakhs. As per fisher folk only 50% of the introduced fish survive. Main introduced varieties include major Indian carps like *Labeo rohita, Cirrhinus mrigala*, *Catla catla* and Grass Carp.

Fish seeds / spawns are introduced into the lake in the month of August. Before stocking, approximately 1 ha in the central part of the lake, which is its deepest part, is cleared manually. The introduced fish are then allowed to grow till the month of February. During this period of six to seven months, fisher folk rely completely on local fish for their livelihood.

(ii) Fish Yield

The fish catch though is extremely uncertain and on an average during the peak season starting from February / March upto July, the catch per family is upto 6 kg. This decreases during the lean season (August to February) to upto 3 kgs. The total annual catch is estimated to be 193 tons.

Table 22: Seasonality and Fish Yield

	Fish	Local Name	Season	Catch	
				Kg/d/hd	Rs./kg
1	*Cirrhinus mrigala*	Mosu, Erramaila	Mar-Jul	3	20
2	*Catla catla*	Krishna bocchu	Mar-Jul	3	40
3	*Labeo rohita*	Sheelavathi, Ragandi	Mar-Jul	2-3	30
4	*Cyprinus carpio*	Bangarupapa	Mar-Jul	2	40
5	*Ctenopharyngdon idella*	Gaddi Chapa	Mar-Jul	2-3	45
6	*Hypopthalmichthyes molotix*	Silver	Mar-Jul	5	35
7	*Channa striatus*	Korramaina	W.Y.	5	120
8	*Channa orientalis*	Mattapilla, Mattagidsa	W.Y.	1.5	100
9	*Channa punctatus*				
10	*Clarius batrachus*	Marapu			
11	*Mystus bleekeri*	Jella	Mar-Jun	2-3	60
12	*Mystus keletius*				
13	*Mystus montanus*				
14	*Mystus vittatus*				
15	*Puntius chola*	Seshaparigi, Saina, Pettaperigi	Jan- July	1	20
16	*Puntius sarana*				
17	*Puntius sophore*				
18	*Puntius ticto*				
19	*Heteropneustes fossilis*	Ulinga	N A	NA	NA
20	*Anobas testudineus*	Gorasalu	W.Y.	2	30
21	*Anabas cobjius*				
22	*Macrognathus aral**	Bommadalu	W.Y.	1	-
23	*Macrognathus zebrinus*		N.A	N.A	-
24	*Glossogobius giuris*	Bullakokku	Mar-May	1	40
25	*Notopterus notopterus*	Mangla Katli	N. A	N.A	-
26	*Macrobrachium rosenbergii*	Chinna roiya	W.Y.	2-3	250

* *Macrognathus aral* has been included in IUCN Red List under Data Deficient (DD) category.

NA: Not available during the study period

Washing

Washing is another important activity, which is closely linked to the lake. There are four washing points located in Kondakarla-Andalapalli, Cheemalapalle, Ava Rajam and Vadrapalli. The total number of washing days and clothes washed per day varies from village to village and from family to family (Table 22).

(i) Washing Place

Washer folk have placed their washing stones in the peripheral shallow waters for washing. They also use the shore area to bleach, blue and starch the clothes. Mud furnaces (*Chulhas*) have also been constructed at the shore to boil water for cleaning clothes. Wastewater after use is drained directly into the lake. During 2003, when there was no water available in the lake the washer folk restricted their washing activity, to very few clothes on an urgent demand using ground water from village hand pumps.

(ii) Material Used for Washing

Various popular Indian brands of detergent cakes and powders viz. Rin, Surf, Nirma are used for washing clothes. Other than detergents bleach, blue and starch are also used by washer folk. The average quantity of material used village wise for washing is provided in (Table No 23).

Table 23: Washing Practices

Village	No of Hh	No of washing days at Ava / Hh/year	No of cloths washed/ day/Hh	Average quantity of material used for washing (kg/day/per Hh)				
				Detergent		Bleach	Blue	Starch
				Powder	Cake			
Vadrapalli	11	100	75	1.25	0.5	0.25	0.1	0.5
Kondakarla-Andalapalli	21	100	100	1.5	0.8	0.25	0.2	0.5
Cheemalapalle	8	40	100	1.5	0.5	0.5	0.1	0.5
Ava Rajam	7	30	200	3.0	1.2	0.25	0.1	1.0

(i) Seasonality

Generally washer folk use the lake throughout the year except during rainy days (as there is no shelter) and one month during January-February when they celebrate a festival called *Bellam Pandaga*.

Livestock Rearing

Villagers rear livestock primarily to augment their income. Usually villagers' own cows, bullocks, buffaloes, goats, pigs and chicken.

(i) Cattle Rearing

Livestock comprising cows and buffaloes are reared for their milk. On an average, number of milch animals per cattle rearer family is two and the average milk production per animal is 3 lit/day. Everyday, milk is sold to the village level Milk Producers Co-operative Society. The collected milk is then supplied through bulk milk centers to Visakha Dairy (a Visakhapatnam based Milk Co-Operative Society). The societies also provide valuable assistance to villagers in cattle rearing through proper guidance and also by providing health facilities to their livestock.

The practice of rearing bullocks for agriculture related activities are decreasing. Farmers use bullocks for effective tillage and transportation of agricultural commodities from one place to another. In recent times, farmers have started preferring hiring a tractor on a daily basis rather than maintaining bullocks throughout the year.

The fodder needs of cattle are met primarily through agricultural waste and fodder grass. Cattle mainly subsist on paddy straw. Large and medium farmers who own cattle also grow Pearl Millet, Red Gram and *Pilli Pesara* to meet the green fodder requirements for their cattle. Small farmers and landless cattle rearers are entirely dependent on the green grass available in the marginal wetland areas as a source of green fodder for their cattle. Generally green grass are cut and then taken to cattle sheds (*Paka*), but during the summer season when agricultural land holdings are free, cattle are allowed to graze directly in the marginal wetland areas. Cattle mostly depend on bore well water for drinking and bathing. Lake water is also used occasionally as a source of drinking water and for bathing cattle especially in villages of Gollalapalem, Cheemalapalle and Ava Rajam.

(ii) Goat and Sheep Rearing

Goats and Sheep are reared for their milk and meat. Milk is consumed in the household, whereas the goats and sheep are sold outside for their meat in cash. Groups of cattle are also used for *Manda*. Number of goats per family ranged from 2-60. In Gollalapalem village, goat and sheep rearing is the main occupation. Common lands serve as grazing grounds for both, goat and sheep.

(iii) Piggeries

Poor families raise pigs as a source of additional income. The pigs are raised to be sold outside and are not slaughtered inside the village. The number of pigs ranged from 2-4 per household. Piggery is a common income generating activity among the washer folk. Pigs are fed with normal food including cooked rice and pulses. Water lily tubers collected from the wetland are also fed to the pigs. During the summer, pigs are taken to swampy areas located at the western side of the lake where they are fed on rotten water lily tubers.

(iv) Poultry

Poultry is an activity indulged in by almost all villagers, with the exception of a few vegetarian families, for household consumption. They mainly feed on soaked pearl millet and cooked rice. Few large farmers in Kondakarla village, practice large scale commercial poultry.

Recreation

Kondakarla Awa was a famous tourist destination during the British period. During this time, the Raja (King) of Vijayanagaram built a rest house for visitors near Kondakarla village, now turned into the Zilla Parishad Bungalow. Various birds and blooming water lily flowers were the primary attractions for the visiting populace. British people also used to frequent the place for hunting birds. Though AP Tourism Development Corporation Limited has already included the lake as one of the important sites for eco-tourism development presently it is just an ignored recreation site attracting mostly local tourists from nearby villages and towns. The major reasons behind this being lack of publicity and basic amenities for tourists.

Local village communities, especially those belonging to Kondakarla and Vadrapalli have taken small but visible measures, to promote tourism in their respective villages. These include construction of a clean mud road up to the lake by Kondakarla Gram Panchayat at Kondakarla, construction of a concrete jetty by Vadrapalli Gram Panchayat and construction of two guest rooms by the local DWACRA groups at Vadrapalli. A mud road connecting the lake to Kondakarla village was built under the Food for Work Program. Many palm trees were cleared to expand the existing path.

Flow of tourists throughout the year is negligible except during the festive season of *Karthik Masam*. *Karthik Masam*, a month in the Hindu calendar, arrives during the month of October-November, and is traditionally the picnic season. Huge crowds can be seen on Sundays and Mondays during this period. The maximum number of visitors visiting the lake during this period reaches up to 1000 per day. The main attraction for tourists is boating. Other attractions include visit to various temples located in nearby villages. Very few tourists who visit the lake during the remainder of the year comprise of nature lovers, bird watchers and students from educational institutions.

The fisher folk community is the major beneficiary of tourism activities in the lake. They take tourists for boating using their traditional boats, known as "*doma*", charging Rs.100-150 per trip for 4 to 5 persons. Two sub communities of fisher folk take charge of boating on a yearly rotational basis.

There are no management practices or regulations regarding tourism activities. Tourists bring their packaged food and throw the litter mainly comprising of plastics, nearby or sometimes into the lake. Vehicles are also brought near the lake. Impact of these unregulated tourist activities can be easily observed in the local bird behavior. Whenever there are large crowds of tourists, sometimes it becomes very difficult to locate even a single "lake" bird.

Figure 4: Seasonality of Usage of Kondakarla Awa Wetland

Wetland Usage	Month											
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Agriculture												
Fishing												
Washing												
Live stock rearing												
Plants & sediments												
Tourism												

Peak	Moderate	Lean

DISCUSSION

In case of the present study on lake, the major problems appear to be high siltation, pollution from agricultural fields and habitations situated in the self catchment area of the lake and also from the mass use of wetland peripherals for washing clothes.

The soils of the self catchment area being sandy silt loams get easily eroded with every rain as the area is with meager vegetation cover. The vegetation in this region has been subjected to severe exploitation for fuel and other needs. So is the case with the areas of wetland periphery, where the tree cover is totally absent because of clear felling. Thus, the rate of erosion is very high and contributes to the siltation of the lake. Trees were cut near Andalapalli-Kondakarla village to construct mud roads for tourists. Encroachments in peripheral areas by farmers have replaced littoral vegetation mainly rooted emergent plants either with paddy or sugarcane. This has affected natural filtration of silt by peripheral vegetative strip.

Siltation of the wetland is highest at Stations IV, which is connected to the inlet receiving waters from the river Sarda and self catchment area as well. Due to the silt accumulation, the water holding capacity at Station IV has reduced to a large extent that the wetland bed is exposed for 4 to 6 months every year, where even cultivation is done during that period.

Silt is likely to be rich in sorbed nutrients and organic matter, which can become available to algae or macrophytes either immediately or at some much later time. Silt loading also contributes directly to loss of volume and to an increase in the area of shallow sediments. The development of substantial shallow area can foster further spread of macrophytes and their attendant epiphytic and filamentous algae (Cook *et al*., 1993).

In addition to the nutrient load from the siltation, the agricultural runoffs from the wetland peripherals and the cultivation in the exposed wetland bed add considerable quantities of chemical fertilizers to the lake waters causing nutrient enrichment. An analysis of the chemical fertilizers used by the farmers at the lake periphery revealed that the farmers are using high quantities than the recommended dosage for the given soil conditions, particularly, in case of the two dominant crops, paddy and sugar cane (upto 181% excess in case of Paddy in Kondakarla-Andalapalli Village). Since the excess waters of these agricultural fields are drained back into the lake, a good portion of the excess chemical fertilizers may potentially reach the lake. The nitrates and phosphate levels in the lake waters at Stations II, III and IV, are high during the monsoon months, which can be attributed to agricultural runoff, while at Station I, it was during the early summer months (March, April), which may be due to discharge of soaps and detergents.

Washing of clothes at the lake edge is one of the major activities and provides livelihoods for several families. About 47 families are dependent on this activity that runs throughout the year. Each family use at least 2.6 to 5.5 kg/d of soaps and detergents, and it is estimated that annually around 20 tons of soaps, detergents and bleaches enter into the lake waters affecting the water quality.

Another pollutant from the self catchment area is fecal contamination. All the catchment area villages have no proper sanitation facilities and open defecation is prevalent. Besides this, the livestock population also is high in these villages and all these contribute fecal pollution to the wetland. During the summer, pigs are taken to swampy areas located at the western side of the wetland where they are fed on rotten water lily tubers.

Fortunately, the wetland has additional input of water from the river Sarada, which enables the use of wetland waters to several downstream villages. Thus, though the lake has an annual water storage capacity of 180.9 Mcft, the waters that flow out from the lake is around 858 Mcft / annum. Thus, to a certain extent, both dilution and washout mechanisms are helping the lake to absorb the pollution load, especially of dissolved type. But, these mechanisms could not help the siltation and nutrient enrichment problems to much extent.

When compared with the studies of Venu (1981), the lake depth has declined drastically. Apart from the siltation other reasons of decreased depth were excessive pumping of water and flow diversion for irrigation, which exacerbated the negative drought impact. DO, BOD, Ca, Mg and Nitrate concentrations have increased than during the times of pre-1981. Similarly when compared with the report of Rao (1984), the lake waters have high chloride concentrations.

Several other studies also have suggested indicator species for different aspects of water quality. Pearson (1989) suggests that excess of nitrogen encourages dominance of Volvox and states that decreasing species diversity coupled with increasing densities of diatoms indicate pollution. Venkateswarlu and Reddy (l987) reports that greater diversities of *Cyanophyceae and Euglenophceae* indicate organically polluted habitats. Based on these reports, the planktonic composition of the present lake can be considered as organically polluted and moving towards eutrophy.

In case of Zooplankton, the present state has lower densities and lower species diversity when compared with the state reported by Rao (1984) as given under.

Table : 24 Study on Zooplankton in Kondarla Awa Lake

Zoooplankton	Rao (1984)		Present	
	Sp	Biomass per 50 l	Sp	Biomass no/50 l
Protozoa	1	-	2	0-8240
Rotifera	29	250-17450	25	220-17320
Cladocera	14	405 – 30850	15	160-13400
Ostracoda	3	25-1250	3	0-700
Copepods	13	3400-41900	11	200-36900
Insect Larvae	9	25-1000	9	100-2200
Total Zooplankton	69	3175-43775	65	300-63300

Further, the composition of the biotic strata, and the presence of certain indicator species as described earlier, also indicate that the lake is in the accelerating phase of eutrophication. The changed water quality, noxious growth of rooted vegetation, and the decreased water holding capacity of the wetland due to siltation has affected the fish populations and thereby the fishery activity in the wetland.

About 26 varieties of fish were reported from the lake, of which six were cultured varieties and the remaining was local. As per the perception of the fisher folk, about three local varieties of fish have disappeared from the lake after the drought. The fish yield has decreased to a half in the recent three decades. For the past ten years, Red Spot disease (a viral) has been noticed in the fishes, especially in the native varieties. This disease is believed to be enhanced by polluted waters.

Excessive growth of macrophytes is also a major problem. Macrophytes offer substrata for an array of insects, molluscs and other invertebrate fauna, and thereby contribute to the species diversity of a water body. Nevertheless,

the presence of weeds is considered to be undesirable from fisheries point of view. They accumulate large quantities of inorganic nutrients early in the season, depriving the phytoplankton of their share of nutrients. The floating vegetation utilizes the incident solar radiation for its photosynthesis and makes it unavailable to the phytoplankton communities. Submerged weeds provide shelter for minnows and weed fishes which compete with major carps for food. Excessive growth of macrophytes cause high rate of decomposition of dead plants at the bottom, creating anaerobic conditions. Problems are further confounded, if the water surface is matted by the floating vegetation which prevents light penetration.

Bharat Lakshmi *et al*. (2001) reported the presence of 106 species of birds from Kodakarla Lake region. The number of species and the numbers of individual species have sharply declined as per the perception of the local community, and were also evident from the reports of the local staff of the state forest department.

Decreased fish densities and absence of arborial habitats at the lake peripherals are considered as the major reasons for the decreased avian diversity. The frequency of visits of migratory birds also has decreased alarmingly, perhaps due to the change in water quality and lack of arborial habitats. Removal of trees from the wetland peripherals is the main reason for decreased arborial habitats.

The above discussion reveals that the lake's ecology is at threat from all dimensions and needed urgent measures of restoration. It is clear that pollution from both point and non-point sources has to be controlled for protecting wetlands from further degradation and protecting biota for conservation and human utilization.

An integrated approach to land, water and ecosystems gives an opportunity for balancing water for humans and nature (Falkenmark and Rockstrom, 2004). However, the tendency among policy-makers and general public is to see water mainly as a technical issue, which is a barrier to sustainable development. Contrastingly, ecological management of water looks at all the links among living and nonliving resources, rather than considering single issues in isolation. Instead of developing a management plan for one issue, it focuses on the multiple activities occurring within specific areas that are defined by the ecosystem. (US Ocean Commission Report, 2004).

As per the needs of Kondakarla Awa, its Ecological Management should have following five objectives:

I- Increasing Storage Capacity

II- Maintaining availabilities of adequate water to sustain multiple use system and environmental flow, throughout the year

III- Improving and maintaining water quality by controlling pollution from point and non point sources

IV- Control of excessive growth of macrophytes

V- Sustaining conservation activities

But the high cost of some advanced techniques for wetland conservation and management has produced pressure on the economy of developing countries. Therefore it is necessary to search for creative, cost-effective and environmentally sound strategies for wetland conservation.

As mentioned earlier, the first management objective should be increasing storage capacity of the lake that has been reduced to a great extent due to its siltation. It has affected the availability of water required for its multiple uses. Desiltation can be carried out to increase removal of silt manually from

peripheral areas and mechanically from the central areas of lake as preferred by local communities. Desiltation of the lake at Stations I, II, III and IV every year can be done during the summer months and on participatory basis by conducting *Shramdaan*. Various government initiated rural development schemes i.e. Food for Work Program, National Rural Employment Guarantee Scheme, can also support this activity.

Plate:4 Wetland activities conducted in Kondakarla Zilla Parshad High School

Encroachments of the lake bed areas should also be removed by Revenue Department. Afforestation in the catchment areas and Development of Buffer Strips around the lake periphery could help control further soil erosion and sedimentation. Communities preferred Model III (mixed type). In this model all responsibility and benefits will be given to the family for plantation on their

private lands like Field boundaries, home compound. Whereas, for common lands like Waste lands, Lake bunds, Road sites, Foot hill areas women groups, unemployed youth and land less laborers can be involved in plantation, protection and selling of the produces. A part of the profit from selling of the produce can be used to pay to these groups and another part of the profit can be used for lake conservation activities. Initial technical and monetary support can be provided by the Forest Department. Afforestation around the lake periphery has an added advantage of providing arborial habitats to attract the avian fauna.

The availability of adequate water in the lake throughout the year for sustaining human usages and for maintaining the environmental flow is essential. Excessive use of lake water for irrigation by both upstream and downstream farmers has caused a real problem to the lake ecosystem. The Government scheme of free electricity supply for irrigation in Andhra Pradesh has accelerated this unwise use practice. The availability of adequate water in the lake throughout the year can only be achieved by controlled withdrawal of water and its efficient use. The Government Order (GO) No. 758 Revenue, dated 31st March 1879 which specifies the rules and regulations regarding timely operations of the inlet and outlet channels should be implemented strictly. This GO can also be used for controlling excessive lifting of water by upstream farmers because it clearly directs that a minimum water level of 2.02 m below the present crest of Kalingula should be maintained throughout the year.

Traditional soil and moisture conservation practiced by farmers should be promoted to enhance efficient use of water. Farmers should also be encouraged to grow less water consuming crops in place of water intensive crops like paddy and sugarcane, when water level is very low especially during Rabi and Zaid seasons.

Given the options of alternative crops, farmers agreed to grow drought resistant varieties of rice, but were not much interested in other suggested alternative crop varieties as some of them are less profitable or were difficult to manage. Downstream farmers rejected to choose any alternative crops because they feared that this may lead to no / restricted water supply to their villages during the Rabi season. Proper negotiation and awareness creation among farmers in this regard is essential to tackle this issue.

Apart from achieving the objective of availability of adequate water throughout the year, improving and maintaining good water quality is another challenging task, which requires control of excessive nutrient loading from both point and non-point sources.

SUMMARY

The two major fresh water lakes of Andhra Pradesh, ***Kolleru*** and ***Kondakarla Awa*** are very prominent among the freshwater lakes of India. The latter, upon which the present project deals with, is the second largest in Andhra Pradesh, and is called ***Kondakarla Awa***, existing in the Visakhapatnam district was selected for the present study as the lake is now threatened with several factors and information on the lake is very meager. Being a unique ecosystem, upon which several thousands of families are dependent for their livelihood, needs urgent conservation measures Chourey, (2001) for protecting it from the threats of pollution, siltation, eutrophication and encroachments. Thus, the study was undertaken with the following five main objectives:

OBJECTIVES OF THE STUDY:

6. To determine the Ecological State of the lake by its(a) water and sediments Quality; (b)Biodiversity; (c)Siltation; (d) livelihoods and (e) Economy;

7. To identify different User groups of the lakes and document the use practices along with the best management practices;

8. To develop appropriate conservation models within the frame work of the National Wetlands Conservation Rules;

9. To develop plans for the establishment of an Educational Tourism programme involving local educational institutions;

10. To initiate developing a data base for ecological monitoring of the lake.

The study was considered under four major parts: Determining the ***Ecological Status*** of the lake; Understanding the ***Socioeconomic Environment*** of the lake users and the impacts of use practices; developing a monitoring frame work; and to propose establishment of Educational tourism involving local educational institutions***.*** Ten villages out of twenty (20) villages from the study area were selected for conducting socioeconomic analysis by using stratified random sampling.

PRA (Participatory Rural Appraisal) was conducted to understand the following aspects: (1) Local Dependency on the lake; (2) Lake Use Practices; (3) Socioeconomic, institutional and political scenario in the region; (4) Anthropogenic Activities in the catchment area affecting wetland ecosystem; and (5) Traditional Wetland Management Practices.

The Kondakarla Awa wetland is a part of the Sarada riverine system and is classified as a perennial, warm, polymitic, euphotic, eutropic shallow fresh water lentic body. The wetland is named after a village, "Kondakarla", abutting the lake. *Kondakarla Awa* wetland was as a conservation site by the Asian Wetland Bureau and World Wild Life Fund in 1993. It is recognized as a priority site for Integrated Protected Area System (IPAS) by the Andhra Pradesh State Forest Department. The Andhra Pradesh Tourism Development Corporation has included the wetland as an important site for ecotourism development.

. The soils are basically either *Silty sand* or *Sandy silt loams* and the vegetation belong to *Dry deciduous* type. The region receives a normal rainfall of 1069 mm; The mean maximum temperature has a normal range from 27.2^{o}C in January to 34^{o}C in May. The mean minimum temperature has a normal range between 17.5^{o}C in January and 27.8^{o}C in May.

The wetland has a rectilinear polygon shape. The Kondakarla Ava wetland has a total water spread of 753.93 ha. The basin is shallow, uniform with a gradual slope from the margin towards the center. The wetland has a submergible area of 753.93 *ha* and attains a maximum depth of 3.5 m during rainy season and minimum depth of 1 m during summer with water storage capacity of 180.9 *Mcft,* at Full Tank Level (FTL) while around 858 Mcft of water annually flow from the lake.

Kondakarla Awa Wetland has a self catchment area of about 2538.19 ha. In addition, the wetland receives water from Sarada River (a perennial river that originates in the Eastern Ghats) and Anakapalli Ava (a pond near Anakapalli town) through a human made inlet called Krishmnamaraju Channel. Wetland has a human made outlet, which is connected to irrigation channels that supply water to eight villages.

The ecological state of the lake was delineated, based on the state of various physical, chemical and biological parameters of the lake waters. These parameters were monitored for a period of two years, during 2012 - 2015, through monthly sampling at 14 selected sampling points of five stations of the lake. In the present report, results for the five main stations are reported as the mean of the sampling points of the station.

The pH of the lake waters indicated that it is neutral to slightly alkaline; TSS were maximum (upto 2.32 g/l) during July in Station III, and thereafter declined steeply till November**;** Total Dissolved Solids (TDS) also had a more or less a similar annual trend; DO value of waters showed a fluctuation within the range of 5.7 mg/l at Station III in the month of January to 15.0 mg/l; The calcium hardness was found to vary from 38.6 mg/l during February at Station V to 122.2 mg/l during April at Station III; The Chloride content of water was fairly

high and ranged between 49.4 mg/l during November at Station IV to 214 mg/l during April at Station I. The MPN of Fecal *Coliform* Bacteria, among the five sampling stations had a range from as low as 3/100 ml during March at Station V to a high of 240/100 ml at Stations II and III, during the months of August and June, respectively.

The lake supports a rich variety of phytoplankton. During the study period (July 2013 to june 2015), a total number of forty two (42) genera of phytoplankton were observed and identified. Out of these, twenty two (22) belong to Chlorophyceae, seven (7) to Bascillariophyceae and twelve (12) to Myxophyceae. It was however noted that both quantitatively and quantitatively Chlorophyceae was the dominant one, followed by Myxophyceae.

The zooplanktonic population was found composed of six major groups' viz. protozoa, Rotifera, Cladocera, Ostracoda, Copepoda and Insect larvae. During the study period, 66 species were recorded of which two (2) belong to protozoa, twenty six (26) to Rotifera, fifteen (15) to Cladocera, three(3) to Ostracoda, eleven(11) to Copepoda, and nine (9) to Insect larvae.

At all the four inlet channels of the lake, silt traps were fixed and the readings between two points of time were noted and the sedimentation load was estimated. Among the five sampling zones, Station 1 exhibited greater species diversity with 13 of the total 14 macrophytes recorded in the present study. *Typha aungustata* appeared as the most tolerant species and survived during the dry phase, whereas *Najas gramamiea* was found to be most dominant species among all aquatic macrophytes.

Kondakarla Awa Wetland provides various services to the local communities and is a multiple use system. It acts as the economic backbone of

communities residing in the surrounding villages. The water from Awa is used for irrigating agricultural crops, for washing clothes and inland fishery. Marginal areas of the lake are used for paddy and sugarcane cultivation & also for feeding the village livestock. Additional usages include, use of aquatic plants and sediments for various purposes. Use of Awa for recreation is another important use of its resources.

The most dominant lake user group is a miscellaneous community that comprises of members from all social groups. Number of lake user farmer families residing in the study area are 978. There are total of 126 fisher folk households in the region. During peak season (February-June) they are involved only in fishing activities while during the lean season they also work as agricultural laborers. There are 47 households of washermen community; There are 1137 households owning livestock spread across all the fifteen user villages. Most of them own cattle mainly, cows and buffaloes which are primarily reared for their milk, to meet household needs and for sale in local markets.

Kondakarla Awa was a famous tourist destination during the British period. Local village communities, especially those belonging to Kondakarla and Vadrapalli have taken small but visible measures, to promote tourism in their respective villages. These include construction of a clean mud road up to the lake by Kondakarla Gram Panchayat at Kondakarla, construction of a concrete jetty by Vadrapalli Gram Panchayat and construction of two guest rooms by the local DWACRA groups at Vadrapalli. A mud road connecting the lake to Kondakarla village was built under the Food for Work Program. Many palm trees were cleared to expand the existing path.

Flow of tourists throughout the year is negligible except during the festive season of *Karthik Masam*. *Karthik Masam*, a month in the Hindu calendar,

arrives during the month of October-November, and is traditionally the picnic season. The fisher folk community is the major beneficiary of tourism activities in the lake. They take tourists for boating using their traditional boats, known as "*doma*", charging Rs.100-150 per trip for 4 to 5 persons. Two sub communities of fisher folk take charge of boating on a yearly rotational basis.

In case of the present study on lake, the major problems appear to be high siltation, pollution from agricultural fields and habitations situated in the self catchment area of the lake and also from the mass use of wetland peripherals for washing clothes. Siltation of the wetland is highest at Stations IV, which is connected to the inlet receiving waters from the river Sarda and self catchment area as well. Due to the silt accumulation, the water holding capacity at Station IV has reduced to a large extent that the wetland bed is exposed for 4 to 6 months every year, where even cultivation is done during that period.

In addition to the nutrient load from the siltation, the agricultural runoffs from the wetland peripherals and the cultivation in the exposed wetland bed add considerable quantities of chemical fertilizers to the lake waters causing nutrient enrichment. Further, the composition of the biotic strata, and the presence of certain indicator species indicated that the lake is in the accelerating phase of eutrophication. The changed water quality, noxious growth of rooted vegetation, and the decreased water holding capacity of the wetland due to siltation has affected the fish populations and thereby the fishery activity in the wetland. Excessive growth of macrophytes cause high rate of decomposition of dead plants at the bottom, creating anaerobic conditions. Problems are further confounded, if the water surface is matted by the floating vegetation which prevents light penetration.

As per the needs of Kondakarla Awa, its Ecological Management should have following five objectives:

VI- Increasing Storage Capacity

VII- Maintaining availabilities of adequate water to sustain multiple use system and environmental flow, throughout the year

VIII- Improving and maintaining water quality by controlling pollution from point and non point sources

IX- Control of excessive growth of macrophytes

X- Sustaining conservation activities

A participatory management model has been recommended to achieve the objectives of the sustainable use and ecological management of the lake.

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Annexure -III

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002.

FINAL REPORT OF THE WORK DONE ON THE MAJOR RESEARCH PROJECT.
(Report to be submitted within 6 weeks after completion of each year)

1	**Project Report No.**	Final Report
2	**UGC Reference No**	F. No.41-1086/2012 Dt. 26-07-2012
3	**Period of report: from**	2012 to 2015
4	**Title of research project**	"Ecological studies on the kondakarla awa lake of Andhra Pradesh"
5	**(a) Name of the Principal Investigator:** **(b)Dept. (c)University/College Where work has progressed:**	Prof.K.Kameswara Rao Dept of Environmental Sciences , Andhra University Visakhapatnam-530003
6	**Effective date of starting of the project**	01-09-2012
7	**Grant approved and expenditure incurred during the period of the report:** **a.Total amount approved Rs.** **b.Total expenditure Rs.** **c.Report of the work done (Please attach a separate sheet)**	 2012-2015 Rs.13,61,300 Rs.13,61,300 [Please See 7 (ii)]
i)	**Brief objectives of the project**	
	1. To determine the Ecological State of the lake by its(a) water and sediments Quality; (b)Biodiversity; (c)Siltation; (d) livelihoods and (e) Economy; 2. To identify different User groups of the lakes and document the use practices along with the best management practices; 3. To develop appropriate conservation models within the frame work of the National Wetlands Conservation Rules; 4. To develop plans for the establishment of an Educational Tourism programme involving local educational institutions; 5. To initiate developing a data base for ecological monitoring of the lake.	
(ii)	**Work done so far and results achieved and publications, if any, resulting from the work (Give details of the papers and names of the journals in which it has been published or accepted for publication**	

	(iii) Has the progress been according to original plan of work and towards achieving the objective. if not, state reasons	**YES**
	(iv).Please indicate the difficulties, if any, experienced in implementing the project	-
	(v)If project has not been completed, please indicate the approximate time by which it is likely to be completed. A summary of the work done for the period (Annual basis) may please be sent to the Commission on a separate sheet	Not Applicable
	(vi) If the project has been completed, please enclose a summary of the findings of the study. Two bound copies of the final report of work done may also be sent to the Commission	Two Copies of the FTR submitted
	(vii) Any other information which would help in evaluation of work done on the project. At the completion of the project, the final report should indicate the output, such as (a) Manpower trained (b) Ph. D. awarded (c) Publication of results(d) othe rimpact,if any	a) One Research Scholar and 3 M.Sc. Students. b) The project fellow is now submitting her thesis. c) Two publications were communicated. d) Other Impacts: • Awa lake club was initiated at Kondakarla school to create awareness among the natives; • Lake conservation plan was shared with the Lake's user groups.

SIGNATURE OF THE PRINCIPAL INVESTIGATOR

REGISTRAR/PRINCIPAL

Annexure -V

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

STATEMENT OF EXPENDITURE IN RESPECT OF MAJOR RESEARCH PROJECT

1	**Name of Principal Investigator :**	Dr.Prof K.Kameswara Rao
2	**Dept. of University/College:**	Dept of Environmental Sciences Andhra University Visakhapatnam -5300043
3	**UGC approval Letter No. and Date:**	F.41-1086/2012 Dated.26-07-2012
4	**Title of the Research Project:**	"Ecological studies on the kondakarla awa"
5	**Effective date of starting the project:**	01-09-2012
6 (a)	**Period of Expenditure:**	01-09-2012 – 26-07-2015
6 (b)	**Details of Expenditure:**	

S.No.	Item	Amount Approved Rs.	Expenditure Incurred Rs.
i.	**Books & Journals**	60,000	60,000
ii.	**Equipment**	2,00,000	2,00,000
iii.	**Contingency**	95,000	95,000
iv.	**Field Work/Travel (Give details in the pro forma at Annexure VI).**	1,50,000	1,50,000
v.	**Hiring Services**	1,50,000	1,50,000
vi.	**Chemicals & Glassware**	1,50,000	1,50,000
vii.	**Overhead**	9,23000	9,23000
viii.	**Any other items (Please specify)**	-	-

6(c)	**Staff: Date of Appointment**	**01-11-2012**			
S.No.	**Item**	**From**	**To**	**Amount proved Rs.**	**Expenditure Incurred Rs.**
1	**Honorarium to PI**	-	-	-	-
2	**<u>Project Fellow:</u> i)Non-GATE/Non-NET Rs.14000/-pm for initial 2 years and Rs. 16000/-p.m for 3rd Year**	**1.11.2012**	**31.06.2015**	**5,28,000**	**5,28,000**

1. It is certified that the appointment (s) have been made in accordance with the terms and conditions laid down by the commission

2. It as a result of check or adult objection some irregularities is noticed at later date, action will be taken to refund, adjust or regularize the objected amount.

3. Payments@ revised rates shall be made with arrears on the availability of additional funds

4. It is certified that the grant of **Rs.12,60,400(Rupees Twelve lakhs sixty thousand and four Hundred only)** received from the University Grants Entitle Commission under the scheme of support for Mjor Research Project(MRP) Entitled "***Ecological Studies on the Kondakarla Awa Lake of Andhra Pradesh"***. **Vide UGC letter No. F.41-1086/2012(SR) dated 26-07-2012** has been Fully utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission

SIGNATURE OF PRINCIPAL INVESTIGATOR

SIGNATURE REGISTRAR/ PRINCIPAL (Seal)

Annexure -VIII

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002.

PROFORMA FOR SUBMISSION OF INFORMATION AT THE TIME OF SENDING THE FINAL REPORT OF THE WORK DONE ON THE PROJECT

1	**Name and address of the Principal investigator**	**Dr.Prof.K.Kameswara Rao, Residential: 402, S.S Classic Apartments. Opp. Andhra Bank, Lawsons Bay Colony, Visakhapatnam-530017**
2	**Name & Address of the Institution**	**Andhra University Dept. of Environmental Sciences, VISAKHAPATNAM – 530 003.**
3	**UGC approval no. and date**	**F.No.41-1086/2012 Dt. 26-07-2012**
4	**Date of implementation**	**01-09-2012**
5	**Tenure of the project**	**Three years from 2012-2015**
6	**Total grant allocated**	**13,61,300**
7	**Total grant received**	**12,60,400**
8	**Final expenditure**	**13,61,300**
9	**Title of the Project**	**"Ecological studies on the Kondakarla awa lake of Andhra Pradesh"**
10	**Objects of the Project**	
	1. To determine the Ecological State of the lake by its(a) water and sediments Quality; (b)Biodiversity; (c)Siltation; (d) livelihoods and (e) Economy; 2. To identify different User groups of the lakes and document the use practices along with the best management practices; 3. To develop appropriate conservation models within the frame work of the National Wetlands Conservation Rules; 4. To develop plans for the establishment of an Educational Tourism programme involving local educational institutions; 5. To initiate developing a data base for ecological monitoring of the lake.	
11	**Whether objectives were achieved**	**YES**
12	**Achievements from the project**	
	i. A Management monitoring frame work for determining the ecological state of the lake is demonstrated. ii. A Participating management model has been recommended to achieve the objectives of the sustainable use and ecological management of the lake by the entire user group.	
13	**Summary of the findings,(in 500 words)**	

The two major fresh water lakes of Andhra Pradesh, ***Kolleru*** and ***Kondakarla Awa*** are very prominent among the freshwater lakes of India. The latter, upon which the present project deals with, is the second largest in Andhra Pradesh, and is called ***Kondakarla Awa***, existing in the Visakhapatnam district was selected for the present study as the lake is now threatened with several factors and information on the lake is very meager. Being a unique ecosystem, upon which several thousands of families are dependent for their livelihood, needs urgent conservation measures Chourey, (2001) for protecting it from the threats of pollution, siltation, eutrophication and encroachments. Thus, the study was undertaken with the following five main objectives:

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1. To determine the Ecological State of the lake by its(a) water and sediments Quality; (b)Biodiversity; (c)Siltation; (d) livelihoods and (e) Economy;

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The study was considered under four major parts: Determining the ***Ecological Status*** of the lake; Understanding the ***Socioeconomic Environment*** of the lake users and the impacts of use practices; developing a monitoring frame work; and to propose establishment of Educational tourism involving local educational institutions***.*** Ten villages out of twenty (20) villages from the study area were selected for conducting socioeconomic analysis by using stratified random sampling.

PRA (Participatory Rural Appraisal) was conducted to understand the following aspects: (1) Local Dependency on the lake; (2) Lake Use Practices; (3) Socioeconomic, institutional and political scenario in the region; (4) Anthropogenic Activities in the catchment area affecting wetland ecosystem; and (5) Traditional Wetland Management Practices.

The Kondakarla Awa wetland is a part of the Sarada riverine system and is classified as a perennial, warm, polymitic, euphotic, eutropic shallow fresh water lentic body. The wetland is named after a village, "Kondakarla", abutting the lake. *Kondakarla Awa* wetland was as a conservation site by the Asian Wetland Bureau and World Wild Life Fund in 1993. It is recognized as a priority site for Integrated Protected Area System (IPAS) by the Andhra Pradesh State Forest Department. The Andhra Pradesh Tourism Development Corporation has included the wetland as an important site for ecotourism development.

. The soils are basically either *Silty sand* or *Sandy silt loams* and the vegetation belong to *Dry deciduous* type. The region receives a normal rainfall of 1069 mm; The mean maximum

temperature has a normal range from 27.2^{o}C in January to 34^{o}C in May. The mean minimum temperature has a normal range between 17.5^{o}C in January and 27.8^{o}C in May.

The wetland has a rectilinear polygon shape. The Kondakarla Ava wetland has a total water spread of 753.93 ha. The basin is shallow, uniform with a gradual slope from the margin towards the center. The wetland has a submergible area of 753.93 *ha* and attains a maximum depth of 3.5 m during rainy season and minimum depth of 1 m during summer with water storage capacity of 180.9 *Mcft,* at Full Tank Level (FTL) while around 858 Mcft of water annually flow from the lake.

Kondakarla Awa Wetland has a self catchment area of about 2538.19 ha. In addition, the wetland receives water from Sarada River (a perennial river that originates in the Eastern Ghats) and Anakapalli Ava (a pond near Anakapalli town) through a human made inlet called Krishmnamaraju Channel. Wetland has a human made outlet, which is connected to irrigation channels that supply water to eight villages.

The ecological state of the lake was delineated, based on the state of various physical, chemical and biological parameters of the lake waters. These parameters were monitored for a period of two years, during 2012 - 2015, through monthly sampling at 14 selected sampling points of five stations of the lake. In the present report, results for the five main stations are reported as the mean of the sampling points of the station.

The pH of the lake waters indicated that it is neutral to slightly alkaline; TSS were maximum (upto 2.32 g/l) during July in Station III, and thereafter declined steeply till November**;** Total Dissolved Solids (TDS) also had a more or less a similar annual trend; DO value of waters showed a fluctuation within the range of 5.7 mg/l at Station III in the month of January to 15.0 mg/l; The calcium hardness was found to vary from 38.6 mg/l during February at Station V to 122.2 mg/l during April at Station III; The Chloride content of water was fairly high and ranged between 49.4 mg/l during November at Station IV to 214 mg/l during April at Station I. The MPN of Fecal *Coliform* Bacteria, among the five sampling stations had a range from as low as 3/100 ml during March at Station V to a high of 240/100 ml at Stations II and III, during the months of August and June, respectively.

The lake supports a rich variety of phytoplankton. During the study period (July 2013 to june 2015), a total number of forty two (42) genera of phytoplankton were observed and identified. Out of these, twenty two (22) belong to Chlorophyceae, seven (7) to Bascillariophyceae and twelve (12) to Myxophyceae. It was however noted that both quantitatively and quantitatively Chlorophyceae was the dominant one, followed by Myxophyceae.

The zooplanktonic population was found composed of six major groups' viz. protozoa, Rotifera, Cladocera, Ostracoda, Copepoda and Insect larvae. During the study period, 66 species were recorded of which two (2) belong to protozoa, twenty six (26) to Rotifera, fifteen (15) to Cladocera, three(3) to Ostracoda, eleven(11) to Copepoda, and nine (9) to Insect larvae.

At all the four inlet channels of the lake, silt traps were fixed and the readings between two points of time were noted and the sedimentation load was estimated. Among the five sampling zones, Station 1 exhibited greater species diversity with 13 of the total 14 macrophytes recorded in the present study. *Typha aungustata* appeared as the most tolerant species and survived during

the dry phase, whereas *Najas gramamiea* was found to be most dominant species among all aquatic macrophytes.

Kondakarla Awa Wetland provides various services to the local communities and is a multiple use system. It acts as the economic backbone of communities residing in the surrounding villages. The water from Awa is used for irrigating agricultural crops, for washing clothes and inland fishery. Marginal areas of the lake are used for paddy and sugarcane cultivation & also for feeding the village livestock. Additional usages include, use of aquatic plants and sediments for various purposes. Use of Awa for recreation is another important use of its resources.

The most dominant lake user group is a miscellaneous community that comprises of members from all social groups. Number of lake user farmer families residing in the study area are 978. There are total of 126 fisher folk households in the region. During peak season (February-June) they are involved only in fishing activities while during the lean season they also work as agricultural laborers. There are 47 households of washermen community; There are 1137 households owning livestock spread across all the fifteen user villages. Most of them own cattle mainly, cows and buffaloes which are primarily reared for their milk, to meet household needs and for sale in local markets.

Kondakarla Awa was a famous tourist destination during the British period. Local village communities, especially those belonging to Kondakarla and Vadrapalli have taken small but visible measures, to promote tourism in their respective villages. These include construction of a clean mud road up to the lake by Kondakarla Gram Panchayat at Kondakarla, construction of a concrete jetty by Vadrapalli Gram Panchayat and construction of two guest rooms by the local DWACRA groups at Vadrapalli. A mud road connecting the lake to Kondakarla village was built under the Food for Work Program. Many palm trees were cleared to expand the existing path.

Flow of tourists throughout the year is negligible except during the festive season of *Karthik Masam*. *Karthik Masam*, a month in the Hindu calendar, arrives during the month of October-November, and is traditionally the picnic season. The fisher folk community is the major beneficiary of tourism activities in the lake. They take tourists for boating using their traditional boats, known as "*doma*", charging Rs.100-150 per trip for 4 to 5 persons. Two sub communities of fisher folk take charge of boating on a yearly rotational basis.

In case of the present study on lake, the major problems appear to be high siltation, pollution from agricultural fields and habitations situated in the self catchment area of the lake and also from the mass use of wetland peripherals for washing clothes. Siltation of the wetland is highest at Stations IV, which is connected to the inlet receiving waters from the river Sarda and self catchment area as well. Due to the silt accumulation, the water holding capacity at Station IV has reduced to a large extent that the wetland bed is exposed for 4 to 6 months every year, where even cultivation is done during that period.

In addition to the nutrient load from the siltation, the agricultural runoffs from the wetland peripherals and the cultivation in the exposed wetland bed add considerable quantities of chemical fertilizers to the lake waters causing nutrient enrichment. Further, the composition of the biotic strata, and the presence of certain indicator species indicated that the lake is in the accelerating phase of eutrophication. The changed water quality, noxious growth of rooted vegetation, and the

	decreased water holding capacity of the wetland due to siltation has affected the fish populations and thereby the fishery activity in the wetland. Excessive growth of macrophytes cause high rate of decomposition of dead plants at the bottom, creating anaerobic conditions. Problems are further confounded, if the water surface is matted by the floating vegetation which prevents light penetration. As per the needs of Kondakarla Awa, its Ecological Management should have following five objectives: I- Increasing Storage Capacity II- Maintaining availabilities of adequate water to sustain multiple use system and environmental flow, throughout the year III- Improving and maintaining water quality by controlling pollution from point and non point sources IV- Control of excessive growth of macrophytes V- Sustaining conservation activities A participatory management model has been recommended to achieve the objectives of the sustainable use and ecological management of the lake.	
14	**Contribution to the society (give details)**	
	The study helps in the protection and conservation of the 2nd fresh water lake of Andhra Pradesh and also suggest mechanism to enhance the livelihood opportunities for the lake dependent communities.	
15	**Whether any PhD. enrolled/produced out of project**	Project fellow is now submitting her thesis.
16	**No. of publications out of the project (Please attach re-prints)**	Two publications were communicated

SIGNATURE OF THE PRINCIPAL INVESTIGATOR

REGISTRAR/PRINCIPAL

Annexure-IX

ज्ञान-विज्ञान विमुक्तये

PROFORMA FOR SUPPLYING THE INFORMATION IN RESPECT OF THE STAFF APPOINTED UNDER THE SCHEME OF MAJOR RESEARCH PROJECT

UGC FILE NO. F. 41-1086/2012(SR) **(HRP)** **YEAR OF COMMENCEMENT** 01 09 2012

TITLE OF THE PROJECT : "ECOLOGICAL STUDIES ON KONDAKARLA AWA LAKE OF ANDHRA PRADESH"

1.	Name Of the Principal Investigator :	Prof./Dr. K. KAMESWARA RAO				
2.	Name of the University/College	COLLEGE OF SCIENCE & TECHNOLOGY ANDHRA UNIVERSITY				
3.	Name of the Research Personnel appointed	VARALAKSHMI N.R. PACHARI				
4.	Academic qualification	S.No.	Qualifications	Year	Marks	%age
		1.	~~M.A./M.Sc./M.Tech.~~	2012		78%
		2.	M.Phil			
		3.	Ph.D.			
5.	Date of joining	NOVEMBER 1st.				
6.	Date of Birth of Research Personnel	08-09-1988				
7.	Amount of HRA, if drawn					
8.	Number of Candidate applied for the post	2				

CERTIFICATE

This is to certify that all the rules and regulations of UGC Major Research Project outlined in the guidelines have been followed. Any lapse on the part of the University will liable to terminate of said UGC project.

Principal Investigator
Dr. K. Kameswara Rao
Professor
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Head of the Department
Dept. of Environmental Science
Andhra University
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Registrar/Principal
PRINCIPAL
A.U. College of Science & Tech
VISAKHAPATNAM

Annexure -IV

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

STATEMENT OF EXPENDITURE INCURRED ON FIELD WORK
(Period from 2012-2015)

Name of the Principal Investigator: Dr. Prof K.Kameswara Rao

Name of the Place visited	Duration of the Visit		Mode of Journey	Expenditure Incurred(Rs)
Kondakarla awa lake and surrounding villages	November 2012 to march 2013	18 days (mandatory)	a)By road journey from Visakhapatnam to kondakarla awa junction b)Boat hiring from awa lake surrounding	1,50,000
	April 2013 to march 2014	41days (mandatory)		
	April 2014 to march 2015	41days (mandatory)		
	April 2015 to June 2015	12days (mandatory)		

Certified that the above expenditure is in accordance with the UGC norms for Major Research Projects

SIGNATURE OF PRINCIPAL INVESTIGATOR

SIGNATURE OF REGISTRAR/ PRINCIPAL (Seal)