ECOSYSTEM VALUATION OF WETLANDS: A CASE STUDY OF VELLAYANI LAKE

by

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(2011 - 21 - 108)

THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"ECOSYSTEM VALUATION OF WETLANDS: A CASE STUDY OF VELLAYANI LAKE"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled **"ECOSYSTEM VALUATION OF WETLANDS: A CASE STUDY OF VELLAYANI LAKE"** is a record of research work done independently by Ms. Aswathy Vijayan under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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ASWATHY VIJAYAN.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

%	-per cent
/	-per
AGC	-Agricultural College
CoA	-College of Agriculture
CPWD	-Central Public Works Department
CS	-Consumer Surplus
CVM	-Contingent Valuation Method
E	-East
et al.	-Co workers/Co authors
Fig.	-Figure
GIS	-Geographical Information System
GPS	-Global Positioning System
ha.	-Hactre
HPF	-Hedonic Price Function
HPM	-Hedonic Pricing Method
ie.	-That is
KAU	-Kerala Agricultural University
km.	-Kilometer
KSLUB	-Kerala State Land Use Board
KSPCB	-Kerala State Pollution Control Board
KWA	-Kerala Water Authority
m.	-Metre
MA	-Millennium Ecosystem Assessment
MLD	-Million Liters per day
N	-North
No.	-Number
PC	-Principal Component
PCA	-Principal Component Analysis
PRA	-Participatory Rural Appraisal

Rs.	-Rupees
sqkm	-Square kilometer
TC	-Total Coliform
TCM	-Travel Cost Method
TEV	-Total Economic Value
TFC	-Total Fecal Coliform
TGF	-Trip Generating Function
WSS	-Water Supply Scheme
WTP	-Willingness to Pay
$Year^{-1}$	-per year

DEDICATED TO VELLAYANI LAKE

Introduction

1. INTRODUCTION

An ecosystem is a dynamic complex of plant, animal and microorganism communities and the nonliving environment, interacting as a functional unit. Human beings are an integral part of ecosystems. A well defined ecosystem has strong interactions among its components and weak interactions across its boundaries (MA, 2003). Ecosystems provide several benefits to people that can be called as ecosystem services. It includes a) provisioning services such as food and water b) regulating services such as flood and disease control c) cultural services such as spiritual, recreational and cultural benefits d) supporting services such as nutrient cycling that maintain the conditions for life on earth. Agricultural land, homegarden land, forest land, dry land, wetlands etc. are the important type of ecosystems. Among all these, wetlands are the earth's most important and productive resources and therefore been termed the "kidneys of the landscape and biological supermarkets" (Barbier *et al*., 1997). Ramsar Convention on Wetlands defines wetlands as "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres". They are very important ecosystems, providing essential and highly valuable life supporting functions to millions of people and provide goods and services to the world outside the wetland also.

But demographic pressures obviously had resulted in scarcity and conflict for the goods and services provided by wetland ecosystems. The conversion of natural ecosystems into human managed land uses are results of greed for higher level of welfare to meet the short term and immediate demand of people without considering the sustainability. So wetlands are among the most important but threatened environmental resource. Management of wetlands requires attention to ecological integrity of the systems, social well being and security as well as economic efficiency so as to foster sustainable utilisation and conservation of the resources. The need for their wise use and conservation stems from the recognition of high value goods and services which these ecosystems provide to the society (Maltby, 2003).

Understanding the economic value of nature and the services it provides to humanity are of immense importance for local, national, and global policy and decision making. Despite the increasing recognition of the need to conserve wetlands, losses have continued. One main reason is that, wetlands throughout the world are considered by many to be of little or no value, or even at times to be of negative value. This lack of awareness on the value of wetlands caused considerable wetland loss. Thus it has become obvious that quantifying and integrating these services into decision making will be crucial for sustainable development (Turner *et al.*, 2010).

1.2 LEGAL FRAMEWORK IN WETLAND PROTECTION

In India the total wetland area estimated is 15.26 mha., which is around 4.63 per cent of total geographical area (ISRO,2011). With rapid population rise and increasing pressure on water resources, the need to conserve these wetland resources assumes much importance. At present conservation and wise use of wetlands is being ensured through various legal instruments like legislations, policies and plans in India. The Government of India is implementing the National Wetlands Conservation Programme (NWCP) in close collaboration with the State/Union Territories since the year 1985-86. Under this programme, one hundred and fifteen wetlands have been identified which require urgent conservation and management interventions. India is also a signatory to the Ramsar Convention on Wetlands and the Convention of Biological Diversity. The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Governments that join the Convention are expressing their willingness to make a commitment in helping to reverse the history of wetland loss and degradation. In India twenty six wetlands have been declared as Ramsar sites with three of them in Kerala. In the state, The Kerala Conservation of Paddy Land and Wetland Act was implemented in 2008 to conserve the paddy land and wetland and to restrict the conversion or reclamation thereof, in order to promote growth in the agricultural sector and to sustain the ecological system.

1.3 VELLAYANI LAKE

Kerala state is well known for its wetlands with a total area of 1,60,590 ha. (ISRO, 2011). It consists of inland wetlands like freshwater lakes and coastal wetlands. In Thiruvananthapuram, the capital city of Kerala, the total wetland area is 5942 ha. (ISRO, 2010) with Vellayani lake, as the only fresh water source. There is no salt water intrusion into it. This pristine lake is a source of potable water, is considered as sacred for religious functions, supports the people through livelihood generation and other life supporting functions.

But owing to rapid development activities and indiscriminate use of the lake, it is subjected to acute pressure. The lake is increasingly facing several anthropogenic stresses like reclamation, encroachment, sand mining and pollution. Vellayani lake is neither declared as wetlands of international importance under Ramsar convention of wetlands nor as wetland of national importance under NWCP. Naturally the degradation and loss of this lake is not properly taken care of. The unsustainable use and over exploitation of the lake resulted in 54 per cent reduction area of water body from 1978 to 2011. The major reason for the degradation of lake and the wetland loss is mainly the lack of awareness on the ecological and economic value the lake provided to the society.

An understanding of the value of wetland ecosystems and their proportionate contribution is crucial while deciding on conservation and development priorities related to land use and the allocation of scarce water resources. Therefore, the value of the goods and services that the Vellayani lake provide to the society is a critical consideration. The failure to take this value into account is often a major factor behind the policy decisions concerned with the Vellayani lake, that lead to its over-exploitation or excessive degradation. So it is high time that the value of Vellayani lake be understood and proper management interventions to be developed, to conserve this wetland system. In this context, the present study attempts to estimate the Total Economic Value (TEV) of the Vellayani lake freshwater ecosystem.

1.4 OBJECTIVE OF THE STUDY

In order to achieve the general objectives, specific objectives has to be framed. The following specific objectives had been identified to achieve the general objectives.

1. To assess the TEV of the wetland ecosystem of Vellayani lake by stakeholder analysis.
2. To quantify the level of dependence of local communities on the lake for their livelihood and socio cultural services.
3. To forecast the aggregate demand for products and services.
4. To assess the anthropogenic forces affecting the sustainability of the system.

1.5 NATURE AND SCOPE OF THE STUDY

Valuation of wetland ecosystem services is relatively recent phenomenon. It has become obvious that quantifying and integrating these services into decision making will be crucial for sustainable development. The public nature of Vellayani lake and lack of proper institutional monitoring resulted in the destruction or substantial modification of the lake. At present, the lake is under heavy pressure due to externalities from various users. Policy interventions at institutional level are needed to address the sustainability issues and to prevent negative externalities and market failures. For this an integrated wetland research for estimating the value of the lake is essential for evolving the lake management strategies. It is expected that the outcome of the research will be useful for planners and policy makers to develop a socially acceptable, environmentally sound and economically feasible strategy for the management of the Vellayani lake and its ecosystem.

1.6 LIMITATIONS OF THE STUDY

No human effort is free from limitations. This study is no exception. The Vellayani lake provides multitude of ecosystem services. Being a doctoral research constrained by time and money and taking into consideration the particular terrain of the area, exhaustive valuation of the lake including ground water recharge could not be done and there is scope for further research. Every attempt has been made to make the study scientific but paucity of data had restricted in evaluating all the services. Only those services which could be quantified with limited time and resources were selected for study. So the value of the Vellayani lake will possibly be more than that presented in this thesis. Further the objectivity of the data collected through surveys is limited to the extent the respondents were able to recollect from memory without recall bias. However, every effort was made to minimize the error by cross checking the information provided.

1.7 ORGANISATION OF THE THESIS

The thesis is organised in five chapters. The first chapter 'introduction' explains the importance of the topic, objectives, scope and limitation of the study. The second chapter, 'review of literature' deals with findings of the related studies in line with the objectives of the study. Third chapter 'materials and methods' describe the area of study and methodology adopted for analysis. Fourth chapter 'results and discussion' discusses the results of the study to draw specific inferences and the final chapter 'summary' briefly summarizes the work done and salient findings, explains the implications based on the results of the study and also suggests future areas of research.

Review of Literature

2. REVIEW OF LITERATURE

This chapter presents a comprehensive review of past works relevant to the present study. An attempt has been made to throw light on the present status, strengths and weakness of the existing studies on the topic, from the point of view of methodology as well as relevance. The review of literature is categorized into the following sections.

2.1 Wetland Ecosystems

2.1.1. Wetlands in India

2.1.2. Wetlands in Kerala

2.1.3. Wetlands in Thiruvananthapuram

2.2 Anthropogenic forces affecting sustainability of ecosystems

2.3 Ecosystem services of wetlands

2.4 Vellayani lake ecosystem

2.4.1 History of the lake system

2.4.2 Fishing and stock enhancement programme

2.4.3 Threats for sustainability of the lake

2.5 Importance of valuation of ecosystem services

2.6 Total Economic Value (T E V) of wetlands

2.6.1 Classification of T E V

2.6.2 Components of T E V

2.7 Wetland valuation methods

2.7.1 Classification of Ecosystem Valuation Methods

2.7.2 Types of valuation methods

2.7.3 Case studies on wetland valuation

2.1 WETLAND ECOSYSTEMS

2.1.1 Wetlands in India

Wetlands in India are distributed in different geographical regions ranging from Himalayans to Deccan plateau. They are classified into different types based on their origin, vegetation, nutrient status, thermal characteristic like Glaciated Wetlands, Tectonic Wetlands, Oxbow Wetlands, Lagoons, Crater

Wetlands, Salt Water Wetlands, Urban Wetlands, Ponds/Tanks, Man-made Wetlands, Reservoirs, Mangroves, Coral reefs, and Creeks (GOI, 2007).

Like any other place in the world, there is a looming threat to the aquatic biodiversity of the Indian wetlands as they are often under a regime of unsustainable human pressures. Sustainable management of these assets therefore is highly relevant (ISRO, 2010).

In India the total wetland area estimated is 15.26 mha, which is around 4.63 per cent of the geographical area of the country. Indian Space Research Organisation (2011) had mapped total 2,01,503 wetlands in India. In addition, 5,55,557 small wetlands (<2.25 ha) have also been identified.

2.1.2 Wetlands in Kerala

Geomorphologically, the wetlands in Kerala may be divided among five major systems at the broadest level as marine, estuarine, riverine, lacustrine and palustrine. Due to the unique physical characteristics endowed by the state like backwater systems and a diverse terrain of high land, midland and low land within a thin strip of landmass of about 38,864 sq km, there exists much ambiguity in the classification of wetlands. Thus, major classes and types of wetlands are redefined keeping the Ministry of Environment and Forests classification system as the standard. Accordingly the following major wetland classification system is suggested by the detailed study on wetlands of Kerala by CED (2003), and is given in Table1.

Table 1. Classification Scheme for Wetlands of Kerala State

Class of wetlands	Wetland type
Inland wetland	Fresh water lakes
	Fresh water swamps
	Reservoirs
	Large ponds
Coastal wetlands	Estuaries/Backwaters
	Mangrove forests
	Kol Kuttanad and pokkali wetland systems
	Coastal swamps
	Mud flats
	Aquaculture ponds
	Islets (*thuruthu*)

Kerala is well known for its wetlands. Though small in size, Kerala is a land affluent in water sources with forty four rivers draining the land, of which forty one are west flowing and three flow East. Apart from these forty four rivers, their tributaries and distributaries, countless number of streams and rivulets crisscross the land making it green and fertile. Total wetland area of the state is estimated as 1,60,590 ha (ISRO, 2011).

2.1.3. Wetlands in Thiruvananthapuram District

According to ISRO (2010) the area estimates of different wetland categories of Thiruvanathapuram district is represented in Table 2.

Table 2. Area Estimates of Wetlands in Thiruvananthapuram district

Sl no	Wetland category	Number of wetlands	Total wetland area (ha.)	% of wetland area	Open water	Open water
					Post monsoon area (ha.)	Pre monsoon area (ha.)
I.	**Inland wetland-natural**					
1	Lakes/ponds	1	247	4.16	247	246
2	Waterlogged	14	41	0.69	24	25
3	River/stream	24	1590	26.76	1506	1232
II.	**Inland wetlands man made**					
1	Reservoirs /Barrages	4	1501	25.26	1199	1231
2	Tanks/ponds	51	104	1.75	41	22
	Total Inland	94	3483	58.62	3017	2756
III.	**Coastal wetlands**					
1.	Lagoons	19	1531	25.77	1392	1324
2.	Sand/beach	15	543	0.00	0	0
	Total coastal	34	2074	34.90	1392	1324
	Sub total	128	5557	93.52	4409	4080
IV.	Wetlands(<2.25ha),mainly tanks	385	385	6.48	0	0
	Total	513	5942	100.00	4409	4080

2.2 ANTHROPOGENIC FACTORS AFFECTING SUSTAINABILITY OF ECOSYSTEMS

According to Barbier (1993) tropical wetlands are increasingly disappearing as a result of development decisions. Common examples are the conversion of mangrove swamps to fish ponds, diverting water away from river floodplains, draining wetlands for agriculture and other land uses, and over-loading wetlands with pollution.

Gawler (1998) reported that the threats to wetlands often involve major issues of equity among stakeholders, and addressing these issues can be an effective first step towards resolving the threats to biodiversity. Co-management is an important tool for conflict management and even resolution.

Brinson and Malvarez (2002) examined the status of temperate zone freshwater wetlands and reported that most wetland loss had resulted from conversion to agriculture and other land uses. This had been particularly prevalent in the USA Midwest, where wet prairies and deciduous swamp forests were made arable simply by clearing and draining. Eutrophication, toxicity and fire suppression also contribute to wetland degradation. Toxic metals and pesticides contaminate wetlands, particularly in urban and intensively farmed areas.

Wetlands are very sensitive and vulnerable systems and over 60 per cent of the European wetlands had been destroyed by mankind since the beginning of the 20^{th} century (Global Nature Fund, 2004). Many of the remaining areas are imminently threatened by nutrient enrichment and water abstraction. Intensive agriculture is one of the greatest threats to the lakes and lagoons.

Deforestation in the wetland catchment is a threatening factor through increase of soil erosion leading to drastic changes in sedimentation processes and occurrence of eutrophication. Use of fertilizers and chemical nutrients in rice fields is another cause of eutrophication and pollution of the water resources of the wetland. Most importantly, the conflict among different stakeholders is the major hindering factor in effective conservation of the wetland (IUCN, 2004).

Abila (2005) reviewed the biodiversity of Lake Kanyaboli and the associated wetland and reported that one of the major threats Lake Kanyaboli currently faces is over exploitation of its fish. The ongoing swamp reclamation and conversion pose several environmental and socio-economic problems. The most immediate effect of reclamation is habitat loss and associated cascading environmental effects.

Pattanaik and Reddy (2007) studied the Ansupa lake ecosystem and reported that the large scale deforestation in Saranda hill causes severe erosion in the catchment area. Heavy siltation had reduced the lake into a shallow wetland. Organic pollution from human settlements is also polluting the periphery. Further, the over exploitation of fishery resource and poaching of water birds are major threats to sustainability of lake.

Wetlands are threatened and are fast disappearing (Singh and Moirangleima, 2009). About 50 per cent of the world's wetlands have been lost in the last century, primarily through drainage for intense agriculture, overgrazing, over fishing, excess hunting, urban development and water system regulation. Wetlands in India are among the least protected ecosystems and are threatened and fast disappearing.

Reclamation and conversion of wetlands for agricultural development, human settlement and industrial development is one of the biggest threats to wetland conservation and management. Increasing human population and change from subsistence to commercial exploitation of wetland resources continue to exert increasing pressure on limited water resources resulting in the decline of the quality of regulating, provisioning, cultural and supporting services provided by wetlands (Mafumbo, 2010).

According to Kang (2010), in India, lakes and wetlands are in extremely bad shape and are in varying degrees of environmental degradation. Despite knowing their environmental, social and economic significance, city planners have wilfully neglected and destroyed these water bodies. Today these water bodies are encroached, full of sewage and garbage. Because of unplanned urbanization, much of the landscape around the lakes had been covered by impervious surfaces. As a result, instead of rainwater, it is the sewage and effluents that are filling up urban water bodies.

Deka *et al.* (2011) studied the change in freshwater lake of ‘Deepor Beel’ wetland of Assam, India, using LANDSAT TM data. Field observation shows that the ecosystem is facing both natural as well as anthropogenic threats. The analysis of satellite data from 1991-2010 revealed that the wetland ecosystem is shrinking from year to year. It had been observed from the field study that the ecosystem is facing both natural as well as anthropogenic threats. Rapid urbanization, illegal settlements and industries establishment around the wetland are accelerating the waste and pollution problems of the ecosystem. Degradation and loss of wetlands are directly linked to drainage for agriculture, industry, urban and tourism development.

Mezgebe and Raju (2011) analysed long-term lake level changes and its repurcursions of lake Chamo in Ethiopia and reported that the major threats for the sustainability of the lake are waste management, lake side filleting, over fishing and destructive fishing and car washing.

According to Bhattacharya (2012), unsustainable use of groundwater in the East Kolkata wetlands due to rapid urbanization, agricultural and industrial development had posed a risk of land subsidence. The gradual reduction in hydrological regimes within the wetlands had reduced its capacity to recycle wastes and attenuate floods. There had been a rapid change in biodiversity associated with the wetlands due to changes in hydrological regimes and land use.

A study on Lotak lake which is regarded as the ‘lifeline of the people of Manipur’ by Singh and Moirangleima (2012) revealed that the lake is under severe stress mainly due to human interventions like the construction of Ithai Barrage Dam, weed infestation, pollution, encroachment, overexploitation of resources and siltation thereby causing flooding of the agricultural fields and villages, decrease in fisheries production and loss of biodiversity. The resultant impacts on the livelihoods of the lake dwellers showed change in their occupational structure and income, increase in unemployment and health problems.

Water bodies had been a victim of unplanned urbanization in India. There are number of threats water bodies are facing today ranging from pollution and encroachment to cultural misuse. According to Kang (2013) despite knowing the environmental, social and economic significance, the water bodies are being continuously ignored in India. Today these water bodies are encroached by the land mafia, full of sewage and garbage thanks to apathetic urban authorities.

Because of unplanned urbanization, much of the landscape around the lakes has been covered by impervious surfaces.

2.3 ECOSYSTEM SERVICE OF WETLANDS

Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions (Costanza *et al*., 1997).

The ecosystem services have time value *i.e.*, the economic values of ecosystem services may change over time. The value may be reduced (Kreuter *et al*., 2001) or a service becoming more highly valued as understanding of its importance increases (Farber *et al*., 2002).

Based on the Millennium Ecosystem Assessment framework (2003), ecosystem services from wetlands can be categorised into four broad categories. The categories are 1) Provisioning services. These are essentially the products obtained from wetland ecosystems such as fresh water and fish for human consumption.2) Regulating services. These are essentially the benefits to humans attributable to the regulation of ecosystem processes such as water treatment and local climate regulation 3) Supporting services. These services underpin the production of all other ecosystem services such as nutrient cycling, water cycling, and provisioning of habitat. 4) Cultural services. These are typically non-material benefits received by people from direct and indirect interactions with wetlands such as recreation, aesthetic values, spiritual benefits and enhancements in knowledge.

Boyd and Banzhaf (2006) define ecosystem services in a more restricted way, as a component of nature directly enjoyed, consumed or used to yield human well being. Wetland ecosystems provide many benefits that contribute to human well-being. These include fish and fibre, water supply, water purification, climate regulation, flood regulation, coastal protection, recreational opportunities and, increasingly, tourism. The livelihoods of people living in, or on the borders of, wetlands often depend partially or entirely on these wetland ecosystem services.

Ecosystem services are the specific results of those processes that either directly sustain or enhance human life (as does natural protection from the sun's harmful UV rays) or maintain the quality of ecosystem goods (Brown *et al*., 2006).

Fisher *et al.* (2009) indicated that by understanding the key characteristics of ecosystem services we can better manage, maintain or evaluate them. Ecosystem services are not homogenous across the land scape and they are not static phenomenon. This spatio-temporal dynamics is a characteristic that help in understanding and classifying the ecosystem services.

Turpie *et al*. (2010) reported that ecosystem services had traditionally been disaggregated into goods (products), services (ecosystem functions) and attributes (structure, diversity, rarity, etc.).

Holland *et al*. (2011) highlighted the benefits of spatially and temporally replicated monitoring surveys of ecosystem services that employ consistent reporting metrics and sampling methodologies through time. Such monitory surveys of ecosystem can be used for mapping the distribution of multiple ecosystem services.

Ecosystem services are the benefits that nature provides to people. Ecosystem services provide innumerable services that are underestimated in most economic development decisions; however, these services contribute to development objectives and in realising quality of life goals (Government of Alberta, 2011).

Young and Potshin (2011) defined ecosystem services as the contributions that ecosystems make to human well-being. They are seen as arising from the interaction of biotic and abiotic processes, and refer specifically to the 'final' outputs or products from ecological systems. That is, the things directly consumed or used by people. Following common usage, the classification recognises these outputs to be provisioning, regulating and cultural services, but it does not cover the 'supporting services'.

According to Walls and Riddle (2012) private market values of ecosystem services are from activities like grazing and timber production. In addition to these the natural landscapes can have recreational value, offer flood protection, purify drinking water supplies, safeguard bird and wildlife habitat, sequester carbon, and regulate the climate. These public benefits from nature have come to be known as ecosystem services. Fundamental to the provision of ecosystem services in a region is its underlying biodiversity, i.e. the wealth and variety of plants, animals, and microorganisms.

A systematic approach to ecosystem service flow quantification was emerged by Bagstad *et al*. (2013). The approach, which is an agent-based model, is termed “Service Path Attribution Networks” (SPANs). These models expand on ecosystem services classification terminology introduced by other authors. Conceptual elements needed to support flow modelling include a service's rivalness, its flow routing type and whether the benefit is supplied by an ecosystem's provision of a beneficial flow to people or by absorption of a detrimental flow before it reaches them.

According to Barbier (2013) the various benefits provided by an ecosystem via its structure and functions are what is meant by ecosystem services or in other words “ecosystem services are the direct or indirect contributions that ecosystems make to the well-being of human populations”. A wide range of valuable goods and services to humans arise in myriad ways via the structure and functions of an ecosystem. Ecosystem structure and functions describe the components of an ecosystem and its biophysical relationship regardless of whether or not humans benefit from them.

Serna-Chavez *et al.* (2014) highlighted how the spatial characteristics of the flow between provisioning services and the benefiting areas are specific to each service. They also presented the generic frame work for analysis of spatial flow of ecosystem services. Further they pointed out that understanding the spatio temporal characteristics of production, flow and delivery to the beneficiaries and accounting the process pinpointing them are crucial to make the ecosystem service concept operational.

2.4 VELLAYANI LAKE ECOSYSTEM

2.4.1 Evolution and History of the Lake System

Nair *et al*. (1980) cited by Azis (1989) traced the geological evolution of the Vellayani Lake. Owing to the extensive alterations caused by the anthropogenic activities they found it difficult to trace the morphological changes caused by the quaternary transgression that occurred in the distant past. During the period the tidal water reached much inward along the lower basin of Karamana river and also along the basin of its then existing tributary from the South. Protected all around by steep hills the area of the tributary basin had been totally submerged, transforming itself into an extensive shallow water body. Tidal incursion and the consequent flood situation had prompted meandering in the course of the main river also. Subsequent to the regression of the sea, later the deeper portions of the tributary became the Vellayani Lake.

According to Raghunandan (1995) a country residence (present agricultural college) was built at Vellayani by Her Highness Maharani Pooradam Thirunal Sethu Lekshmi Bayi in 1930 in the banks of the lake. She was the then Regent Maharani of Travancore. Vellayani was selected due to its scenic beauty and proximity to the city, which was about 8 km away from Trivandrum but far removed from the active concerns of the town though near enough to command its convenience. The palace was named “Lalindoch”. Kovalam and Vellayani were the two most favorite palaces of Maharani and her family.

The main sources of water in Vellayani lake are direct rainfall over the lake and surface run off. Further, there are evidences of a substantial input from base flow. Lithological sequence of the lake catchment is indicative of aquifer strata capable of holding large quantities of ground water (Soman and Chattopadhyay, 2004). The catchment of the lake is quite rugged and dissected.

2.4.2 Fishing and Stock Enhancement Programmes

According to Sandhya (2003) of the different types of nets in operation, in Vellayani lake encircling nets are more efficient in terms of fish abundance while gill nets are selective. Gill nets are more efficient in terms of weight of fish caught than other two nets. Cast nets are most frequently used nets in the lake.

Viswanathan (2010) reported that ADAK had launched a fish stock enhancement programme in Vellayani lake and Indian major carp fingerlings were introduced. Indian major carps do not occur naturally in the lake. The species started occurring in the commercial catches in the gill nets and the surrounding nets in three months after stocking. The overall growth performance of the fishes points to the suitability of the lake for fish stock enhancement and added income to the fisher folk depending on it.

Gopal (2010) reported that the fish stock enhancement programme was expected to utilise the high productivity of the lake and enhance fish production and there by livelihood of the fisherman folk depending on the lake for subsistence. The study further revealed that the lake has good productivity both in quality and quantity. Hence it is highly recommended for stocking with planktivorous fishes for stock enhancement.

According to Rajeela (2011) the physical parameters like atmospheric water, sediment, temperature, depth, transparency and P^H of the lake was optimum for fish growth. The nutrient level indicated that the lake is free from organic pollution. So Vellayani lake has huge potential to support fish stocks and the fish stock enhancement programme has to be continued.

The productivity of the lake is ideal for the continuation of fish stock enhancement programme. The plankton population and organic carbon also indicate the health status of the lake. Diversity of benthos is high in the lake bottom and suitable for growth of aquatic organisms like fishes (Kumar, 2011).

A study by Athira (2011) indicated that the species Catla had good growth potential in Vellayani lake however they are not naturally breeding and sustaining population hence the necessary measures to sustain the stock of the species should be taken thereby ensuring the improvement of livelihood of fisherman depending on the lake.

Lekshmi (2012) revealed that the Vellayani lake is not a highly polluted water body. The study further revealed that there was great diversity of protozoan in the lake and suggested the possibility of using protozoan effectively for bio monitoring programmes.

Sabeena (2012) reported that the population of benthic communities indicated the health of water body. The lake has rich diversity of benthic fauna suitable for sustaining bottom feeding aquatic organisms.

According to Sajid (2012) there had been increase in the fishing effort and the efficiency of the gear which is removing the fishes from the lake as soon as they are recruited in to and before achieving their growth potential. The fishers should impose self regulation to release the young ones back and allow them to grow to its growth potential. The absence of Catla in the commercial catches indicated heavy fishing pressure on the stock.

Most of the fishermen used gill nets locally called "Pattuvala" in the night for fishing. To increase the efficiency of the fishing operations few enterprising fishermen introduced encircling gillnets locally called as "Vaanguvala" operated in the day time (Kiran *et al*., 2013).

2.4.3 Threats for Sustainability of Lake

Aziz (1989) reported that the Vellayani lake and its environment had been subjected to extensive developmental activities. The present reservoir, Kannukali chal, pumphouses are testimony for the manmade alteration in the lake ecosystem. The dewatering of the lake had adversely affected the water tables in the nearby wells creating water shortage during drought.

Anilkumar (1999) reported that the Vellayani lake had underwent rapid physical transformation due to human intervention. Unscientific agricultural practices and the lack of any conservation practices posed severe diverse problems to the ecosystem of the Vellayani lake basin which included soil degradation accelerated soil erosion flooding etc.

Vellayani lake is extensively used by local people for their livelihood. The lake is enriched with the growth of a variety of flora and fauna. The impact of anthropogenic pressure on the lake seems quite high and hence a constant monitoring of this water body is essential (Radhika *et al.*, 2004).

TOKAU (2005) reported that the paddy cultivation in Vellayani lake had affected the lake sustainability. The fishermen of the lake were traditional, so technical support should be given to them.

KAU (2009) prioritised the problems faced by Vellayani lake and reported that sand mining was the most important threat faced by the Vellayani lake followed by pollution and encroachment. Further they reported that the waste disposal by private agencies had intensified the pollution.

According to Sobha *et al*. (2011) the mining is posing threat of decrease in ground water recharge and increase in turbidity by intervening with the natural filtering system.

2.5 IMPORTANCE OF VALUATION ECOSYSTEM SERVICES OF WETLANDS

The basis of the economist's approach to measure importance is by measuring people's preferences. Economic valuation in the environmental context is about measuring the preferences of people for an 'environmental good' (that is the willingness to pay, in this case to conserve biodiversity), or against an 'environmental bad' (willingness to accept for a loss of biodiversity). Valuation is therefore of the preferences held by people: the valuation process is necessarily anthropocentric (Randall, 1988) since as far as we are aware no other species demonstrates relative utility through the medium of a monetary numeraire.

According to Barbier (1993) economic valuation of tropical wetlands represents an important area for furthering our understanding of the role of natural systems in economic development. Too often, development decisions are made without any assessment of the economic impacts, resulting wetland alteration and conversion. The costs of such decisions become often apparent with irreversible consequences and borne by those in developing economies that can least afford it.

Economic valuation can be defined as the attempt to assign quantitative values to the goods and services provided by environmental resources. The economic value of any good or service is generally measured in term of what we are willing to pay for the commodity, less what it costs to supply it (Babu *et al.*, 2002). Where an environmental resource simply exists and provides us with products and services at no cost, it is our willingness to pay alone which describes the value of the resource in providing such commodities, irrespective of the fact whether we make any payment for it.

Valuation is defined by the Millennium Ecosystem Assessment (2003) as the process of expressing a value for a particular good or service in terms of something that can be counted, often money, but also through methods and measures from other disciplines (sociology, ecology and so on).

Until the economic value of ecosystem goods and services is acknowledged in environmental decision-making, they will implicitly be assigned a value of zero in cost benefit analyses, and policy choices will be biased against conservation. Despite a growing recognition of the importance of ecosystem services, their value is often overlooked in decision-making, and, to date, that value has not been well quantified(National Academy of Sciences,2004).

Economic valuation reflects people and society's values and these values are frequently partial and imperfect. The lack of markets for many environmental goods and services is now slowly changing and increasing opportunities exist for people to express their desires via market forces. These acts include donations to conservation groups, buying property with specific environmental attributes, making payments for environmental services, purchasing ecotourism trips, and demanding more environmentally friendly products. Since not all environmental goods can be turned into private markets, the evolution of economic valuation and active markets is an important step, but not a panacea for all environmental management issues. However, the evolution of markets provides extremely useful information for improved policy making (Dixon, 2008).

Kumar and Sukdev (2009) reported that valuation can help to reveal the relative importance of different ecosystem services, especially those not traded in conventional markets. Valuing ecosystem services and comparing the benefits associated with conservation of natural areas with the benefits from conversion can provide useful information for setting priorities in a variety of contexts, such as development decisions in urban areas and conservation planning at the national or local scale.

Wetlands are recognised as being valuable ecosystems which provide water, food and raw materials, services such as flood attenuation and water purification, and intangible values such as cultural and religious value (Turpie *et al.*, 2010). In some areas, they can be particularly important for peoples' livelihoods. Despite this, and legislation to protect them, they are increasingly threatened, with more than half the world's wetlands having been lost already. Wetlands are degraded beyond the socially optimal extent due to market failure (where markets do not reflect true values or costs) and government failure (perverse incentives, lack of well-defined property rights leading to open access and ignorance of decision makers as to the value of wetlands). Economic valuation helps to compare the real costs and benefits of ecosystem use and degradation, and allows more balanced decision-making regarding the protection and restoration versus degradation of wetlands. This facilitates optimal decision-making which maximises societal well-being.

There are three essential steps in the ecosystem service valuation sequence: (1) identify the service, (2) quantify the service flows, and (3) monetize those flows. Disciplines that assess biophysical processes, such as ecology, biogeochemistry, and hydrology, play the central role in moving from identification to quantification, while economics provides the link from service quantification to monetization (Jenkins *et al*., 2010).

One of the most promising ways of placing aquatic ecosystems on the water agenda is by economic valuation of services sustained by ecosystems. In this way ecosystem services can be compared to those in other sectors and internalised in decision-making processes. Also, economic valuation of ecosystems serves several other purposes than attempting to internalise externalities and secure efficient decisions (Korsgaard and Schou, 2010)

According to Pascual and Muradian (2010) valuation exercises should ideally acknowledge the existence of alternative, often conflicting, valuation paradigms, and be explicit about the valuation paradigm that is being used and its assumptions.

2.6 TOTAL ECONOMIC VALUE (TEV) OF WETLANDS

The TEV is classified by various authors in different ways. The classification of TEV and components of TEV are discussed below.

2.6.1Classification of T E V

The economic values associated with wetland goods and services can be categorized into distinct components of the T E V according to the type of use.

Direct use values are derived from the uses made of a wetland's resources and services. Indirect use values are associated with the indirect services provided by a wetland's natural functions. Non use values of wetlands are unrelated to any direct, indirect or future use, but rather reflect the economic value that can be attached to the mere existence of a wetland (Pearce and Turner, 1989).

There are two main categories of TEV, use value

s and non-use values. TEV does not, provide an exhaustive assessment of the value of environmental resources to society. It measures the extent to which goods and services provided by ecosystems impinge on the welfare of society, as direct determinants of individual well-being, or via production processes (Turner and Georgiou, 2003). Individual values including recreational and amenity values, as well as non-use value arise as environmental systems influence the production and cost functions of other marketed goods and services. The effects of this influence on the prices of other inputs and marketed goods and services translate into changes in individuals' welfare.

Economic values are usually distinguished as use and non-use values. Economic use values of wetlands comprise the direct use of a wetland's goods, such as the consumption of fish for food, trees for fuel wood or as a building material, and water for drinking, cooking and washing (Schuyt and Brander, 2004). Use values also include the indirect use of a wetland's services, such as water retention capacity and nutrient recycling. Option value is defined as the value of a wetland to humans to preserve an environment as a potential benefit for them in the future. The non-use value of a wetland refers to the non-instrumental value, not associated with use.

Value generated by ecosystems can be disaggregated into different types using the Total Economic Valuation framework as consumptive or non-consumptive direct use value, indirect use value, option value and non-use value (Turpie *et al.*, 2010).

According to Eppink *et al*. (2014) the non use value can be further divided into philanthropic value and altruism to biodiversity. The philanthropic value consists of bequest value and altruistic value, and the altruism to biodiversity is composed of existence value.

2.6.2 Components of T E V

Quasi-option value refers to the value of information secured by delaying a decision, where outcomes are uncertain and where there is opportunity to learn by delay. In the context of uncertainty and irreversibility, it may pay to delay making a decision to commit resources (Barbier, 1989).

Total economic value is given by the sum of a number of components Total Economic Value (TEV) =Direct-use value + Indirect-use value + Option value + Existence value (Adger *et al.*,1994).

The existence value is the value that people derive from the knowledge that something exists, even if they never plan to use it. Individuals attach value from the fact that the ecosystem resource will be passed on to future generations (Loomis *et al.*, 2000).

The T E V measures the extent to which goods and services provided by ecosystems impinge on the welfare of society, as direct determinants of individual well-being, or via production processes (Turner and Georgiou, 2003).

Bequest value is the value derived from the desire to pass on values to future generations, that is, our children and grandchildren (deGroot *et al*., 2006). It is derived from the existence of an ecosystem resource, even though an individual has no actual or planned use of it.

Option value is the value that people place on having the option to use a resource in the future even if they are not current users. These future uses may be either direct or indirect. In the context of ecosystems and their services, option value describes the value placed on maintaining ecosystems and their component species and habitats for possible future uses, some of which may not yet be known (Plottu and Plottu, 2007).

Individuals make actual or planned use of an ecosystem service which is known as the direct use value (DEFRA, 2007). This can be in the form of consumptive use which refers to the use of resources extracted from the ecosystem (e.g. food, timber) and non-consumptive use, which is the use of the services without extracting any elements from the ecosystem (e.g. recreation,). These activities can be traded on a market or can be non-marketable i.e. there is no formal market on which they are traded (e.g. recreation or the inspiration people find in directly experiencing nature).

2.7 METHODS OF ECOSYSTEM VALUATION.

This section covers two aspects, classification of evaluation method and types of valuation methods.

2.7.1 Classification of Ecosystem Valuation Methods

Munasinghe (1993) proposed three possible approaches in the environmental valuation. They are (i) conventional market approaches; (ii) implicit market approaches; and (iii) constructed market approaches.

OECD (1995) classified the valuation methods into four according to their appropriateness and applicability in the measurement of the different properties of environmental assets, i.e., (i) productivity (ii) health (iii) amenity and (iv) existence values.

According to Gunatilake (2003) ecosystem valuation methods are broadly of two types market based and non market based. Non market based methods may be proxy market based or constructed market based methods.

According to Birol *et al*., 2006 ecosystem valuation methods are broadly divided into revealed preference methods and stated preference method based on the behaviour in the actual or surrogate markets.

According to degroot *et al.*, 2006 the wetland valuation methods are of three types, direct valuation, indirect valuation and survey based.

2.7.2 Types of Valuation methods

The Wage Differential Method (WDM) is also known as Hedonic Wage Model Method is a special case of hedonic pricing method. It assumes that the wage rate paid for a job reflects a set of attributes, including safety. The hedonic wage is the difference between what the wage for a riskless job and the wage of a job with higher risk (Thaler and Rosen, 1976).

Cost of avoidance (COA) or Preventive Cost approach in ecosystem valuation takes into account the expenditure incurred by individual to avoid illness as the value of providing that service (Verma, 2001).

Choice Experiment (CE) approach of environmental valuation can be considered as alternative to valuation techniques based on stated preferences such as contingent valuation method (Hanley, *et al*., 2001). In Choice Experiments, respondents are provided with a number of alternative descriptions of the good with different attributes and their levels, and are asked to choose among them. Choice modeling methods are consistent with consumer theory.

Wetland services could be replaced with human-made systems; an example is natural waste treatment by marshes which can be (partly) replaced with costly artificial treatment systems (deGroot *et al*., 2002, Farber *et al*., 2002). The replacement cost approach uses the cost of available substitutes for the particular non-priced service or good to estimate the value of latter. The non-priced good can be either a consumer good (e.g. parks) or an input factor (e.g. grazing ground). In both cases, if the two substitutes provide an identical service, the value of the non-priced good is the saved cost of using the substitute.

The Travel Cost Method (TCM) is the most common indirect method used to estimate the recreational use value of natural areas. TCM is based on the assumption that total expenditures made by an individual for visiting a recreation site reflect his/her willingness to pay for this site (Ortacesme *et al*., 2002). The sole decision variable is the number of visits to a certain recreation site in a certain period of time (generally one year). Consumer surplus is estimated by relating expenditures to the number of visits. The Travel Cost Method is applied in two different ways, namely the Individual Travel Cost Method (ITCM) and the Zonal Travel Cost Method (ZTCM).

Using opportunity cost approach of valuation, the value of non-priced goods and services can be estimated by considering foregone benefits of using the same resource for other alternative objectives. In brief, this approach measures what has to be given up for the sake of conservation of the resources. It is a very useful approach to estimate the value of non-marketed goods. This is, because the benefits of certain uses such as preservation, protection of habitats, cultural or historical sites, cannot be directly estimated (Markandya *et al*., 2002).

Productivity change method of environmental valuation can be employed when environmental quality serves as an input for production. The first step is quantification of physical change in production due to quality change in environment. Then appropriate market price can be used to value the productivity change (Gunatilake, 2003). Therefore, other things being not changed, the changes in an environmental attribute may lead to changes in the output of the marketed good. To elaborate, the valuation exercise is carried out taking the value of the change in the environmental attribute as the change in the market value of production. Caution should be taken, in the use of the proper output price.

The Contingent Valuation Method (CVM) is a widely used nonmarket valuation method especially in the areas of environmental cost benefit analysis and environmental impact assessment. Its application in environmental economics includes estimation of non-use and nonmarket use values. In recent years, this method is commonly used in developing countries to elicit the individual‘s preferences (Venkatachalam, 2004). The purpose of CVM is to elicit individuals' preferences, in monetary terms, for changes in the quantity or quality of nonmarket environmental resources.

Another approach is the cost-of-illness (COI) method in which the benefits of pollution reduction are measured by estimating the possible savings in direct out-of-pocket expenses resulting from illness and opportunity costs. Two important limitations of this approach is that it does not consider the actual disutility of those who are ill, nor does it account for the defensive or averting expenditures that individuals may have taken to protect themselves (Birol, 2006).

In property valuation and housing market research, the locational value is usually analyzed by hedonic methods that use multiple regression techniques on large data sets and require a formality based on microeconomic theory in the analyses. Hedonic methodology is mainly used for market valuation of goods for their utility bearing characteristics. The goods under consideration embody varying amounts of attributes and are differentiated by the particular attribute composition that they possess. In most cases, the attributes themselves are not explicitly traded, so that one cannot observe the prices of these attributes directly. In such a case, hedonic pricing models are very essential in order to determine how the price of a unit of commodity varies with the set of attributes it possesses. If the prices of these attributes are known, or can be estimated, and the attribute composition of a particular differentiated good is also known, hedonic methodology will provide a framework for value estimation (Selim, 2008)

Market prices are a simple accounting procedure to value environmental goods and services which are traded in markets (Turner, 2010). It is the most widespread method used for evaluating marketed ecosystem services. Market prices are used to value the costs/benefits associated with changes in quality and quantity of environmental goods that are traded in perfectly functioning markets.

Mitigation or restoration cost refers to the cost of mitigating the effects caused by the loss of ecosystem services or the cost of getting those services restored (Korsgaard and Schou, 2010).

2.7.3. Case Studies on Environmental Valuation

Emerton *et al*. (1998) evaluated the indirect values of Nakivubo wetland in Uganda. Here water purification was the major indirect benefit provided by the wetland and was estimated using the replacement cost method. The net present value per hectare for the service was valued as US $ 1810 per annum.

The Consumer Surplus due to the environmental quality improvement in the Sivash area was estimated by Levchuck (2003) based on the estimated Marginal Willingness-to-Pay curve. Contingent Valuation Method (CVM) was used for estimating an economic value of the Sivash wetland ecosystem, on the institutional Willingness-to-Pay (WTP) base. The estimated institutional WTP for the Sivash conservation was estimated on $32/ha.

Rejeesh (2003) estimated the carbon sequestration benefits of mangroves in Kerala and has found that different species of mangroves fixes altogether an aggregate of 23.64 tonnes of carbon per hectare. The carbon content was considered as 50 percent of total biomass. The value of carbon sequestered was found out by attaching a value of $ 20 (Rs 917) per tonne of carbon. The total value carbon sequestration was estimated to be Rs 21677 per hectare.

A study was conducted by Anoop (2007) in Ashtamudy estuary in Kollam district of Kerala. Market valuation approach was employed to estimate the value of the direct use values. In case of recreation, the standard travel cost model was employed and the option value was estimated using a contingent valuation. The study revealed that the value of Ashtamudy estuary was Rs.77.16 million per annum.

Mamtha (2009) reported that the valuation of ecosystem service in Kolleru lake of Andhra Pradesh resulted in a TEV of 94 crores. Age, education, level of dependence on lake was the important factors that influenced the WTP and it varied among the different stake holders.

Results based on CVM studies by Binilkumar, 2010 in the Kole wetlands of Thrissur revealed that during the CVM survey almost all of the respondent households expressed their approval and willingness to participate for the better conservation of the wetland. For the sake of better conservation, they are ready to contribute a part of their annual income as WTP (97 per cent of the respondents of CVM study were willing to contribute a part of their income annually for the better conservation of the wetland.) This point, invariably, indicates that the stakeholders assign high value for the wetland resource. Gross annual WTP was estimated to be INR 13,365,400 for the all the stakeholders in Thrissur Municipal Corporation put together. The amount, indicated high perceived monetary value placed on the improved conservation of Kol wetland by the urban households.

Akwetaireho (2009) assessed the annual Total Economic Value (TEV) of Mabamba Bay wetland system and found out that the monthly mean household WTP for ecosystem services stood at US$7.2 while the mean household WTA for loss of access to wetland goods and services was US$ 196 per month

Ramachandran *et al*. (2011) assessed the economic value of Varthur, a sewage fed wetland using CVM technique. Two hundred and thirty five people from forty randomly selected households were used for analysing the value. The results revealed that the value of the Varthur wetland was Rs118.9/ha/day.

This study determined the economic value of wetland resources and their contribution to food security in the three agro ecological zones of Uganda. The values of wetland resources were estimated using primary and secondary data. Market price, Productivity, and Contingent valuation methods were used to estimate the value of wetland resources. The per capita value of fish was approximately US$ 0.49 person^{-1}. The domestic water use value was US$ 34 million year^{-1}. Flood control was valued at approximately US$ 1,702,934,880 hectare^{-1} year^{-1} and water regulation and recharge at US$ 7,056,360 hectare^{-1} year^{-1}. The annual contribution of non-use values was estimated in the range of US$ 7.1 million for water recharge and regulation and to US$ 1.7 billion for flood control. Thus, resource investment for wetlands conservation is economically justified to create incentives for continued benefits (Kakuru *et al.*, 2013).

Hema (2013) studied the mangrove ecosystems of Kerala. The study was conducted using market prices, Contingent valuation method and Choice experiments. The study revealed that the estimated TEV of the mangrove ecosystem in Kerala was 1,17,947 million for the mangrove ecosystem which was 0.14 per cent of Gross State Domestic Product.

Materials and Methods

3. MATERIALS AND METHODS

Appropriate research design is a pre-requisite to draw meaningful inferences backed by scientific framework. The present study entitled "Ecosystem valuation of wetlands: A case study of Vellayani lake" was undertaken with the overriding objective of assessing the Total Economic Value of the wetland ecosystem of Vellayani lake. This chapter is divided into three parts.

3.1 Study area

3.2 Sampling and data collection

3.3 Analytical framework

3.1 STUDY AREA

Knowledge on the socio economic and climatic background of the study area is of paramount importance to analyse the data appropriately and draw meaningful inferences.

Thiruvananthapuram, the capital of Kerala state has a geographical area of 2186 sq. km, which accounts 5.63 per cent of the total area of Kerala. It is southern most in Kerala State and is situated between North latitudes 8° 17' and 8° 54' and East longitudes 76° 41' and 77° 17'. The district stretches along the shores of the Arabian Sea for a distance of 78 kms. Thiruvananthapuram district is bordered by Kollam district on the North, Thirunelveli and Kanyakumari districts of Tamil Nadu on the East and the South respectively and the Arabian sea in the West. The wetland area of the district is estimated as 5942 ha.

Lying on the South East of the Thiruvananthapuram city, Vellayani lake (Plate 1) is one of the three major fresh water lakes of Kerala. The lake is an elongated water body, allinged in a North South direction. It lies between $8^0$24'09" - $8^0$26'30" N; 76°59'08" - 76°59'47" E. The lake is situated 11km south of Thiruvananthapuram city and 7 km from Kovalam tourist centre. Lying hardly about 3 kms away from sea, the lake is surrounded in all sides by gently sloping hillocks. The whole terrain lies 29 m above MSL, and the lake bed is 0.1 to 1.5 m below the MSL. The lake stretches from Venniyoor - Muttakadu region in the South to reservoir in the North and from Poonkulam in the West, to Kakkamoola

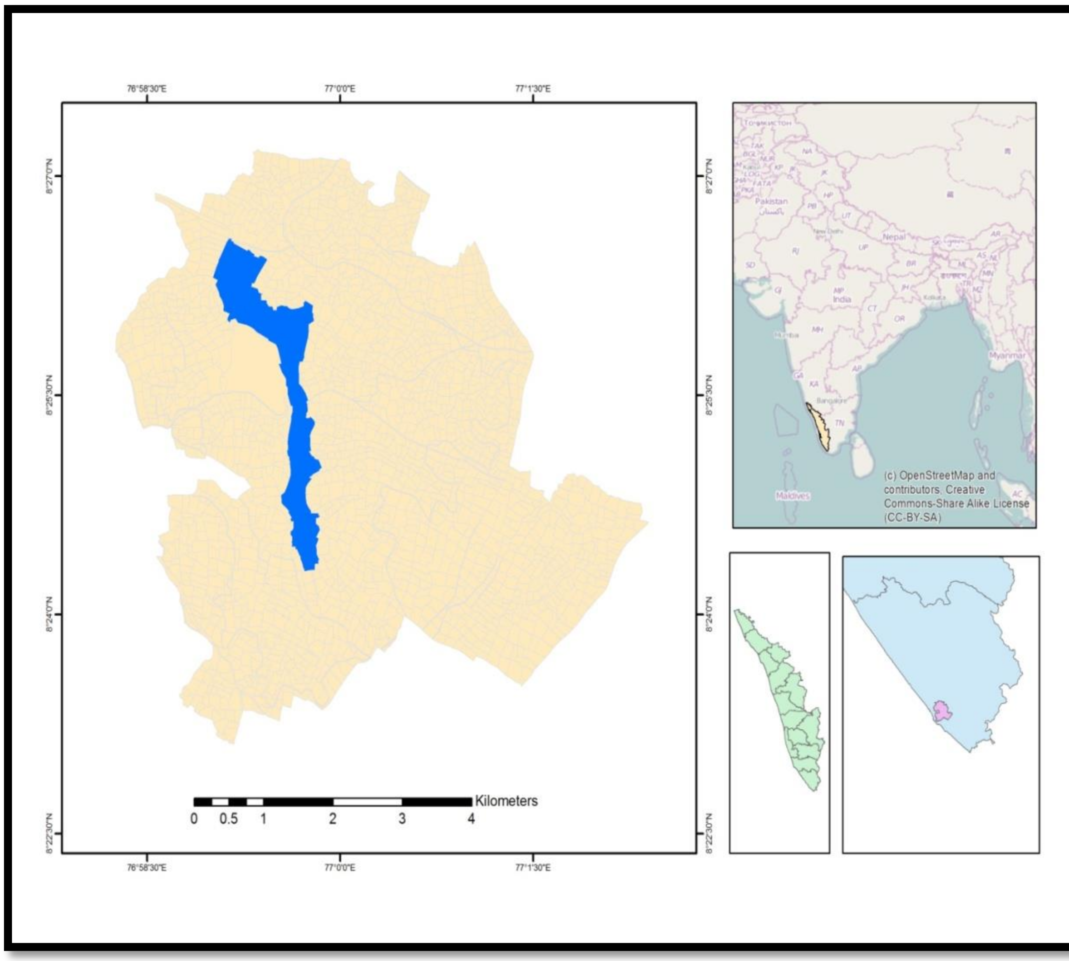


Plate 1. Map of study area

in the East. The length of the lake is 3.7 km with a maximum breadth of 2.1 km and a maximum depth of 3 meters.

With the help of satellite images of the lake prepared using Geographical Information System (GIS) and cross checking with field visits, it was revealed that, the entire water body of Vellayani lake lies in *Kalliyoor* and *Venganoor* panchayats of Nemom and Athiyanoor blocks respectively. Hence the relevant information regarding both the panchayats and the details of Vellayani lake was collected.

3.1.1 Description of Kalliyoor and Venganoor Panchayats

Kalliyoor panchayat is located about 10 km from Thiruvananthapuram city. The total area of the panchayat is 1723.50 ha, with 21 wards. It is bordered by Thiruvananthapuram Corporation on the North, and West, Pallichal Panchayat on the East and Venganoor panchayat on the South. Kalliyoor means "*Kallukalude ooru*" in Malayalam, meaning the land of rocks. It has a history of thousands of years and has its own cultural heritage and was known for its good source of diamonds in the past (KSLUB, 2010).

The census details of Kalliyoor Panchayat (Appendix I) revealed that there were 10,482 households with a total population of 40,816 in the panchayat including 34,919 literates and 5,897 illiterates. The total number of workers were 15,471, of which 4,569 were marginal workers. Majority of the population are cultivators, agricultural labourers and marginal workers (GOI, 2014a).

Venganoor panchayat lying 11 km from Thiruvanathapuram city, is the birth place of eminent social reformers Mahatma Ayyankali (KARD, 2004). The total area of the panchayat is 12.6 sq km with 20 wards. It is bordered by Thiruvananthapuram Corporation, Vellayani lake and Kalliyoor panchayat in the North, Thiruvananthapuram Corporation and Kottukal panchayat in the South, Balaramapuram-Vizhinjam road and Kottukal panchayat in the East and Thiruvananthapuram Corporation in the West.

The census data of the panchayat (Appendix II) indicated that there were 9,277 households with a total population of 35,963. Out of the total population, 30,807 were literates and 5897 illiterates. The total number of workers were 14,526 of which 3303 are marginal workers (GOI, 2014a).

3.1.2 Agriculture and Animal Husbandry

Both the Panchayats possessed almost similar cropping pattern, with coconut as the base crop. Other major crops in the area were vegetables, banana and mixed cultivation of perennials and annuals like jack, mango, arecanut, cashew, pepper, tapioca, pulses and fodder. Betel vine is cultivated in Palapoor area. Paddy cultivation is also practiced in some parts of the *Kanjirathadi, Pandarakari and Mangilikari*. Animal husbandry is prevalent in both the panchayats.

3.1.3 Education

Kalliyoor has seven lower primary schools, two upper primary schools and one High school. In addition to this Centralised Sports Hostel for Canoeing, Kayaking and Rowing (CSH) and Ayyankali Memorial Sports School offers training on sports. College of Agriculture, Vellayani, the major professional college in Kerala, that offers under graduate and post graduate courses in different subjects is also located there. In Venganoor panchayat there are seven lower primary school, three upper primary school, one high school, and one higher secondary school.

3.1.4 Watershed details

The Kalliyoor panchayat is blessed with a network of canals which empties in to the Vellayani lake. These canals serve as irrigation source and influence the water table of wells in bordering area. The major canals or *thodu* running across the panchayat are *Pallichal thodu, Kalliyoor thodu, Keezhoor thodu,* and *Nedinjil thodu*. Excess water collected in the lake during heavy rain is drained through the *Kannukalichal* in the North western side of the lake into the Karamana river.

In Venganoor Panchayat, the main inlets into the lake are *Koliyoor thodu, Muttakkad thodu, Panangodu thodu, Venniyoor thodu, Vavvamoola thodu, and Nedinjil thodu* (shared by Kalliyoor Panchayat). The watershed map of the lake is depicted in Plate 2. The drains into the lake are seasonal and they get dry up during summer period.

3.2 SAMPLING AND DATA COLLECTION

As Vellayani lake lies in Kalliyoor and Venganoor panchayats, both these panchayats were selected for study. The study was based on both primary and secondary data. The primary data pertaining to the year 2013 was collected from January 2013 to January 2014. The secondary data was collected through discussion with officials and referring various registers maintained with government and non governmental agencies. The list of organizations from where the secondary data required for the study collected is furnished in the Appendix III.

The primary data regarding the level of dependence of the stakeholders on the lake were collected based on personal interview method using structured pretested interview schedule, Participatory Rural Appraisal (PRA) and focus group discussions. Schedules were prepared separately for each class of stakeholders. In addition to this, ten scientists, ten social activists and ten technical experts were also contacted to arrive at lake management policies.

At first the geographic boundary of the lake (Plate 3) and the study area was delineated using the Satellite maps and Geographical Information System (GIS) techniques and it was cross checked by field visits. Keeping the satellite map as a guide transect walk was conducted along the banks of the lake. Transect walk helped to identify the ecosystem services provided by the lake, main land use systems, a general understanding on the resources status (vegetation, soil, water), the general socio economic conditions of the stakeholders and to locate sites for the detailed study. During the transect walk, local residents in the area who were interested to contribute their opinions were approached (Plate 4) to collect the information on their association with Vellayani lake.

In the next step, PRA was conducted across the lake in country boat (Plate 5) to identify the main ecosystem services, the aquatic plants in the lake, hot spots of pollution etc. The systematization of ecosystem services provided by the Vellayani lake was done based on the classification of ecosystem services given

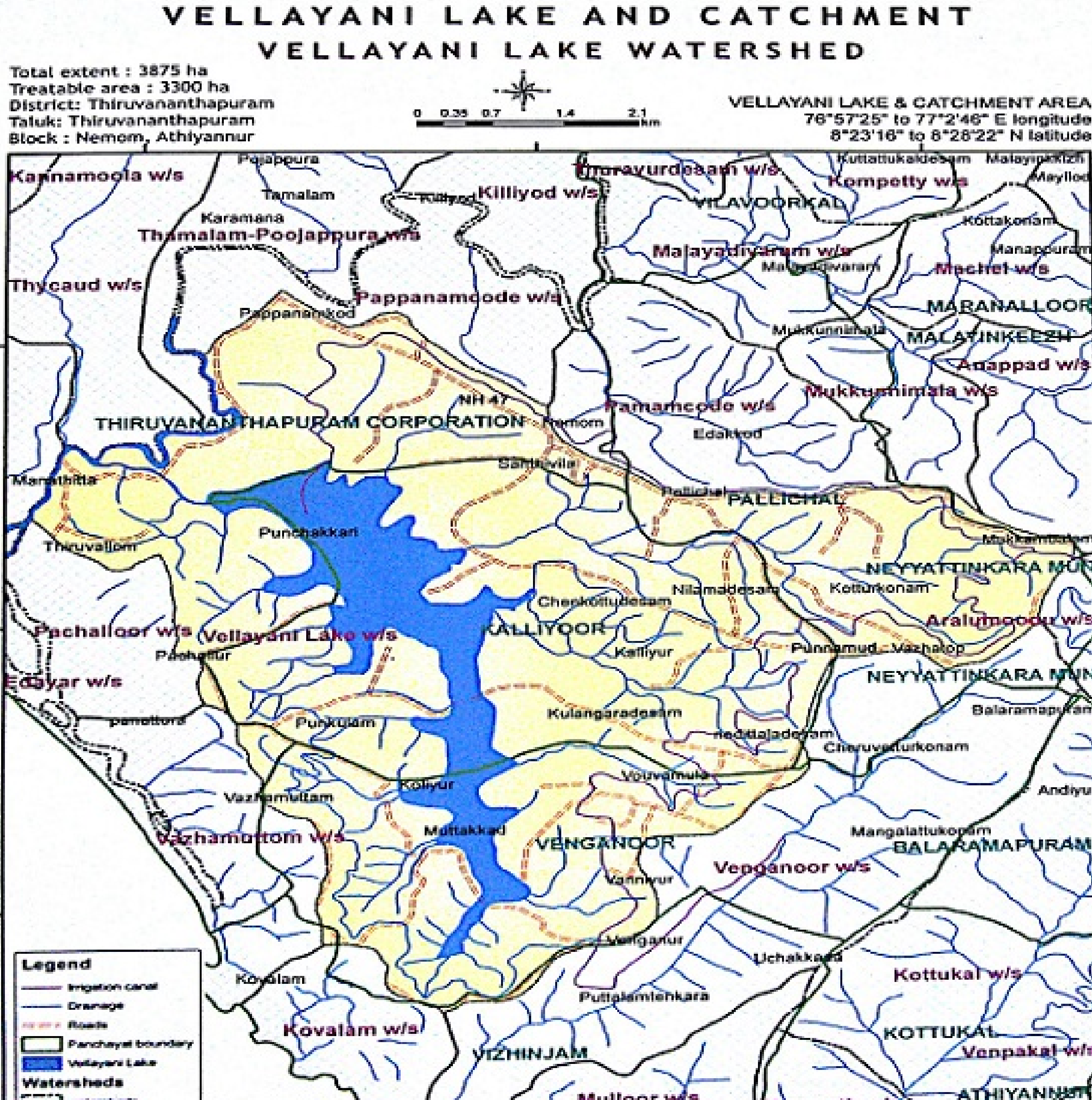
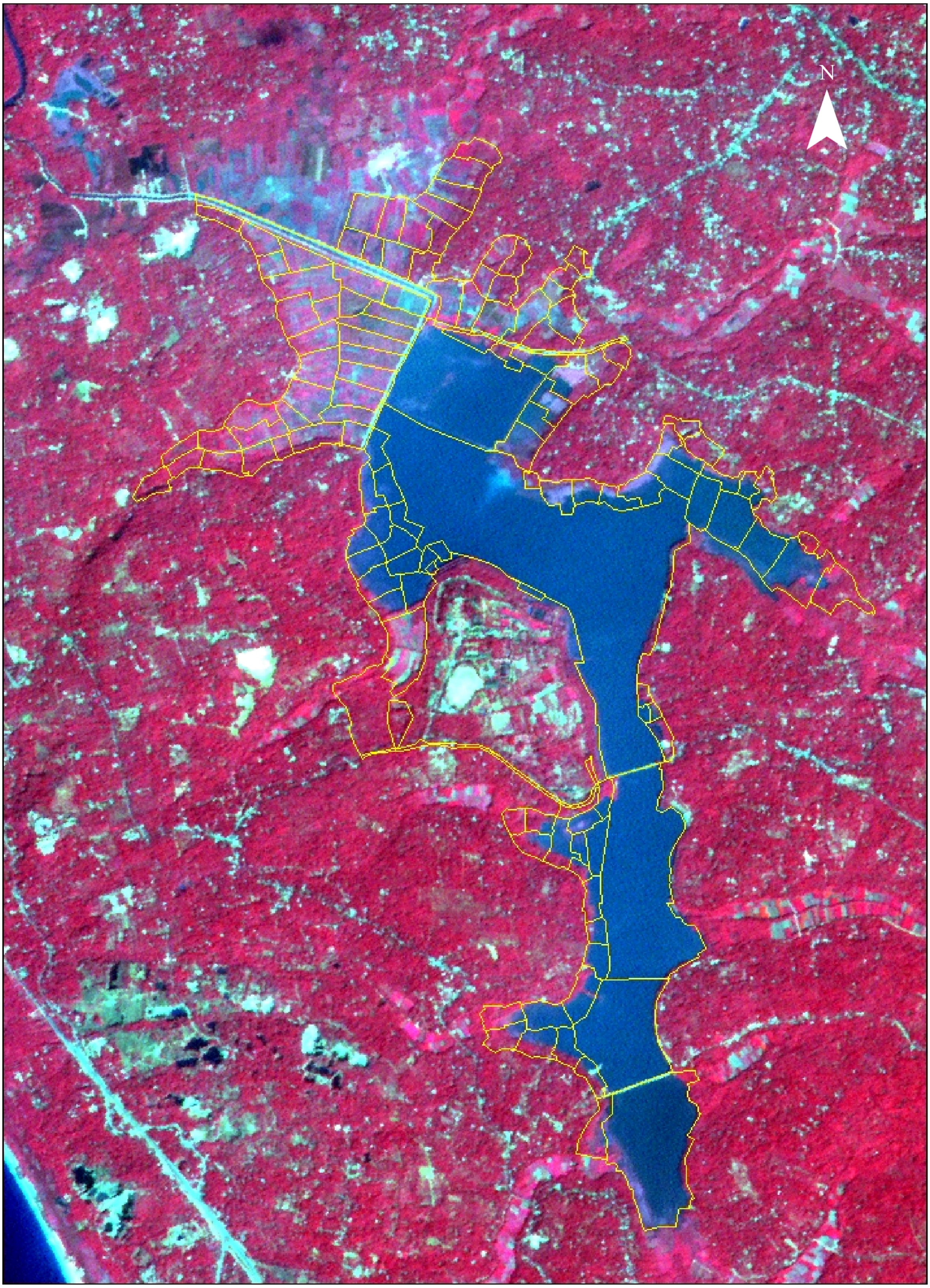


Plate 2. Vellayani lake watershed map



Courtesy KSLUB Trivandrum

Plate 3. Map of Vellayani lake

Plate 4. PRA along the lake border

Plate 5. PRA across Vellayani lake

by MA, 2005. Later focus group discussions were made with the fishermen and lotus collectors to get an idea about their views on Vellayani lake and identifying problems and appraising strategies for solving them.

Based on the identified ecosystem services, the stakeholders of Vellayani wetland ecosystem were singled out for assessing their level of dependence on the lake.

3.2.1 Sampling Procedure

The group of stakeholders identified were fishermen, lotus collectors, duck rearers, visitors and local residents. The sampling procedure for each category of stakeholders is described below.

3.2.1.1 Fishermen

The fisherfolk included the group of people, both men and women who depended on the lake for their livelihood. The sample frame for this group was prepared based on the information from the fishermen co operative society and also through local enquiry. Out of the fifty four actively participating fishermen in the lake a random sample of thirty five fishermen was drawn for the present study.

3.2.1.2 Lotus collectors

This group included those who generated their livelihood by selling the lotus leaves and flowers collected from the lake. During the study period only six persons were involved in this activity and all of them were selected for the study.

3.2.13. Duck rearers

Duck rearers are those who are depended on the lake for wading their flocks of ducks during the day time. All the five duck rearers who depended on the lake were selected for the study.

3.2.1.4. Visitors

Visitors are the group of people who visited the lake for recreation, spiritual or cultural activities. Based on the pilot study, the main recreational area identified were Kakkamoola bund road and the reservoir bund. The data collection was done during the *Karkidaka vavu bali* (religious ritual performed in the lake) and Ayyankali boat race. The visitors for bird watching and photography were surveyed during the month of October. The survey was conducted in reservoir area from 7.00 am to 5.00 pm as the opportunity for enjoying the cool serene beauty of the lake and bird watching was more in this area.

Visitors making multi destination trips were purposively avoided as it was commonly observed that the people travelling along the bund roads halt a few minutes to enjoy the beauty of the lake and the gentle breeze.

The collected data were later subjected to critical examination and only those respondents who gave reliable answers, making single destination visits and who incurred an expense in coming to the lake were selected. Thus the sample size selected was eighty five.

The total number of visitors performing *Karkkidakavavu bali* was obtained from the temples in the boundary *viz.* Thrikulangara Mahavishnu temple and Vevila Mahavishnu Temple and that for Ayyankali boat race was collected from *Ayyankali Jalolsava Samithi*. The total number of visitors for photography and bird watching was estimated by extrapolating the number of visitors during the surveyed month for the entire year.

3.2.1.5 Local Residents

A sample of local residents residing around the lake were contacted to elicit their Willingness to Pay (WTP) to conserve the lake and also to quantify the aesthetic value of the lake. A purposive multi stage stratified sampling was used for the study. Based on PRA, eight different locations were identified around the lake considering the presence of sufficient number of households for data collection and almost equal distribution around the lake. GPS co ordinates were obtained to ensure that the locations are almost equally spaced (Plate 6).The selected location were

1. Arattukadavu
2. Vazhavila
3. Kakkamoola
4. Vavvamoola
5. Venniyoor
6. Kadavinmoola
7. Agricultural College (AGC)

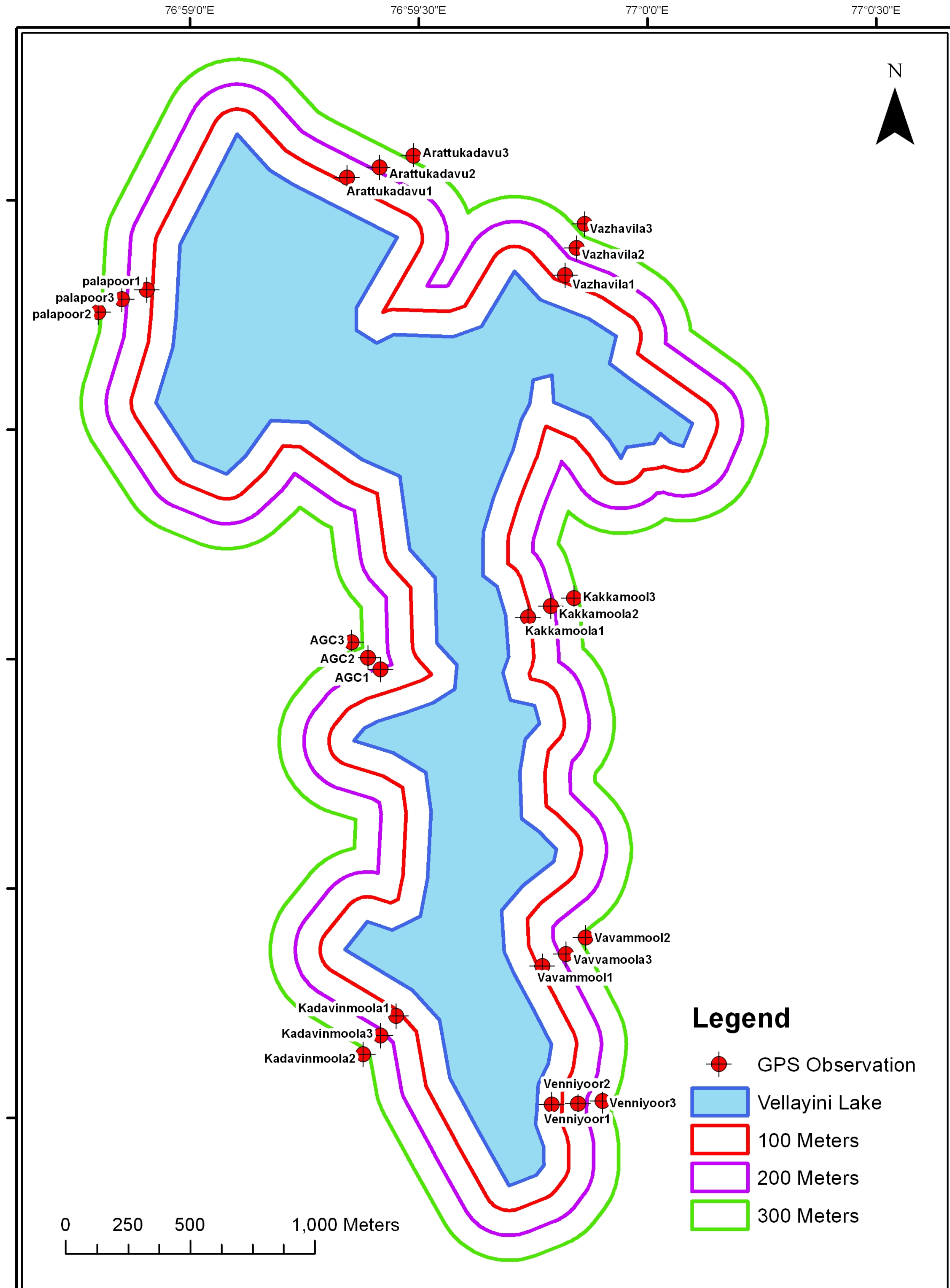


Plate 6. Vellayani Lake with Study Locations

8. Palapoor

The GPS co ordinates of the selected study locations are presented in Table 3. Eight locations (Plate 7 – Plate 14) selected were further stratified into three zones based on the distance from the lake. Zone I was at a distance of 100m, Zone II at a distance 200m and Zone III was at a distance of 300m from the lake. So total twenty four locations were identified for the study. Ten respondents were selected from each locations thus making a total sample size of two hundred and forty.

Table 3. GPS co- ordinates of study locations

Locations	Zone1		Zone2		Zone3	
Arattukadavu	8.442750°	76.989944°	8.443003°	76.991081°	8.443106°	76.992153°
Vazhavila	8.442750°	76.989944°	8.439825°	76.997389°	8.440703°	76.997700°
Kakkamoola	8.426425°	76.995561°	8.426828°	76.996383°	8.427119°	76.997233°
Vavvamoola	8.413603°	76.995686°	8.414381°	76.997406°	8.414800°	76.998236°
Venniyoor	8.408719°	76.996333°	8.408750°	76.997281°	8.408847°	76.998175°
Kadavinmoola	8.411786°	76.991383°	8.411222°	76.990700°	8.411178°	76.989850°
AGC	8.424569°	76.990178°	8.424981°	76.989717°	8.425556°	76.989111°
Palapoor	8.438286°	76.981414°	8.437828°	76.980756°	8.437219°	76.980092°

3.2.2 Summary of Sampling Technique

The Table 4 summarises the details of sample size selected for the study.

Table 4. Total sample size of the study

Sl no.	**Stakeholder communities**	**Sample size**
1.	Fishermen	35
2.	Lotus collectors (Population)	6
3.	Duck rearers (Population)	5
4.	Visitors	85
5.	Local residents	240
	Total sample size of the study	**371**

Thus the total sample size of the study was three hundred and seventy one.

Plate 7. Arattukadavu

Plate 8. Vazhavila

Plate 9. Kakkamoola

Plate 10. Vavvamoola

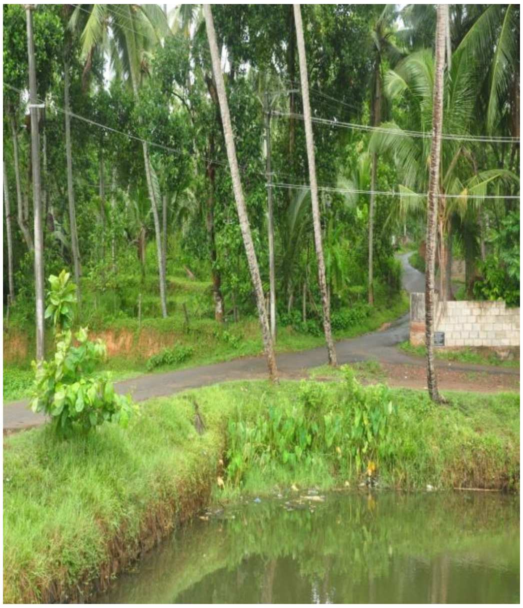


Plate 11.Venniyoor

Plate 10 Kadavinmoola

Plate 13. AGC

Plate 14.Palapoor

3.3 ANALYTICAL FRAMEWORK

The baseline wetland inventory on Vellayani lake was not available. The basic data about the lake was collected from survey and secondary data. The details of biodiversity in fisheries, entomofauna, birds, microalgae and macrophytes were collected from various published sources and discussions with experts. Biodiversity on tree species in the households of the study area at a distance 100m, 200m and 300m from the lake in eight locations around the lake such as AGC (S1), Arattukadavu (S2), Kadavinmoola (S3), Kakkamoola (S4), Palpoor (S5) Vavamoola (S6), Vazhavila (S7) and Venniyoor (S8) were collected from field survey. The tree crops were classified into plantation crops, fruits, agro forestry, medicinal tress, spices and vegetable trees. Total number of tress from each household was enumerated. A proportionate index was worked out by dividing the number of each type of trees in each household with the total number of trees in each category in the households. Mean indices for the three zones was obtained and the indices for each of the study locations are presented in tabular form.

As Vellayani lake is a drinking water source the water quality of the lake assumes importance. The water quality of the lake can be affected by pesticide residue and other parameters that affected the drinking water quality. In order to study the presence of pesticide residue water sample was drawn from *Karikuzhy* area of the lake for laboratory analysis. The statistical analysis of drinking water quality of the lake was done based on the laboratory results of water quality parameter of samples collected from six locations of the lake, by Kerala State Pollution Control Board in the year 2013. The data set was subjected to statistical analysis using Principal Component Analysis (PCA).

3.3.1 Principal Component Analysis

The central idea of PCA is to reduce the dimensionality of a data set consisting of a large number of interrelated variables, while retaining as much as possible variation present in the data set. This is achieved by transforming to a new set of variables, the Principal Components (PCs), which are uncorrelated, and which are ordered so that the first few retain most of the variation present in all of the original variables (Jolliffe, 2002).

3.3.2 Total Economic Value (TEV)

Economists classify the ecosystem goods and services according to how they are used and the main frame work used is the Total Economic Value (TEV) approach. This frame work typically disintegrates TEV into two categories use value and non use value based on benefits derived from present and future generations. Use value consists of direct use value, indirect use value and option value. Non use value is composed of bequest value and existence value. The TEV framework as given by deGroot *et al*. (2006) employed in the study is presented in Fig.1. A range of valuation techniques exists for assessing the economic value of goods and services in wetlands and those which are used in the study are given in Table 5.

Table 5. Valuation framework for TEV estimation

Sl No	**Ecosystem service**	**Valuation method**
1	Lotus collection	1.Market Price Method
2	Fishing	1. Market Price Method
3	Duck rearing	1. Market Price Method
4	Drinking water	1. Market Price Method
5	Irrigation water	1.Oppurtunity Cost Method
6	Bathing and washing	1.Oppurtunity Cost Method
7	Recreational service	1.Public pricing Method 2. Travel Cost Method
8	Aesthetic value	1.Hedonic Pricing Method
9	All other services including supporting and regulating function	1.Contingent Valuation Method

The stakeholders who were benefitted by the ecosystem service use were identified and their socioeconomic characteristics were analysed and presented in a descriptive way basically estimating the averages and percentages. The

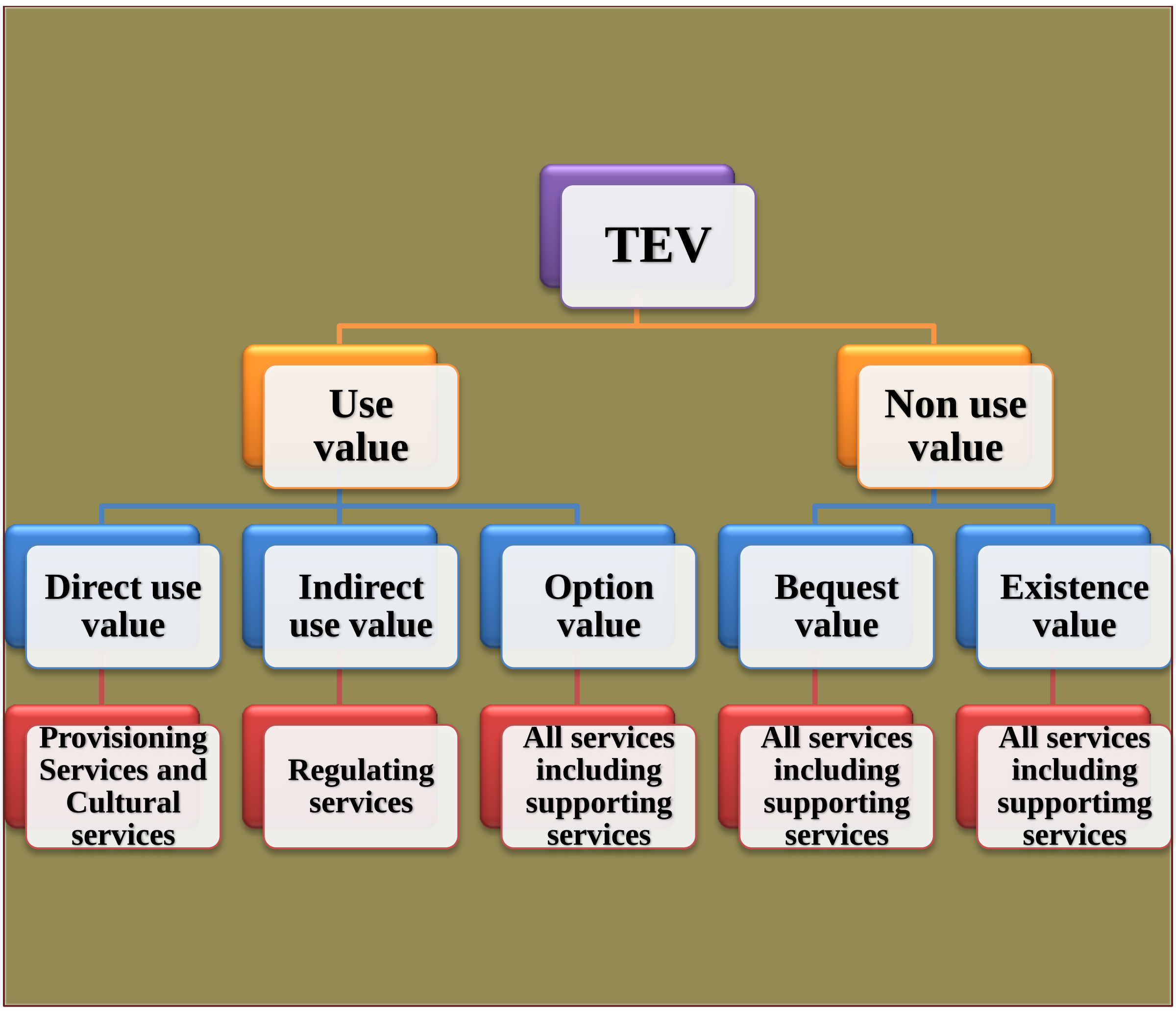


Figure 1. TEV framework

estimation of TEV was done by summating the values of Provisioning services, Cultural services, Regulating services and the Supporting services.

3.3.2.1 Valuation of Provisioning Services

Provisioning services are the products that people obtain from an ecosystem. For valuation of goods and services directly derived from the lake such as fishes, lotus, duck rearing and drinking water, market price method (de Groot *et al*., 2006) was used.

The expenditure pattern of income generating activity was also worked out. In working out capital expenditure the value of perennial assets such as buildings boats and vehicles were amortised using the formula.

$I = B \frac{i}{1-(1+i)^{(-n)}}$ where

I - Amortised annual value

i - Annual interest rate (short term lending rate 9.5% taken)

B - Purchase Price

n - Number of useful years

The gross income was worked by multiplying the prevailing market price of the good with the quantity extracted from the lake to get the economic value and it was estimated using the following formula.

a) Gross income = Income generated from using the ecosystem service.

$= \Sigma (P_i Q_i)$

P_i = Price of the i^{th} product

Q_i = Quantity of the i^{th} product or resource

The survey schedule for fishermen, lotus collectors and duck rearers are furnished in Appendix IV,V,VI.

To get the economic value of drinking water, the quantity of water extracted from the lake by the drinking water schemes of Kerala Water Authority, Central Public Works Department and College of Agriculture, Vellayani were multiplied with the market price of drinking water (Rs.3750 per Kilolitre). The water from the lake was also used for irrigating crops, bathing and washing. Opportunity cost method (Jantzen, 2006), *ie* the value of same quantity of water if it was used for drinking water purpose was used as the value of the ecosystem service use.

3.3.2.2 Valuation of Cultural Services

The MA (2005) defined cultural ecosystem services as “the non material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences”. The cultural services provided by Vellayani lake are Ayyankali boat race, *Karkidaka vavu bali,* training in water sports, provision of scenic beauty and other aesthetic services. Among the cultural services, the ecosystem service use for conducting annual Ayyakali boat race and the ecosystem service use by Centralised Sports Hostel for Canoeing, Kayaking and Rowing was valuated using public pricing method (de Groot, *et al*., 2006) by taking the investment made per year as economic value.

3.3.2.3 Valuation of Recreational and Spiritual Services

The lake is used by people for spiritual cultural and religious purpose. The Travel cost method (TCM) is a consumer oriented method commonly used for assessing environmental amenities connected to recreational areas, nature reserves and other natural areas (Bharali and Mazumdar, 2012; Centeno and Prieto, 2000; Raharjo and Gravitani, 2012; Bedamatta *et al*., 2012; Poor and Smith, 2004.; Vincent and Defrutos, 2011; Iamtrakul *et al.*, 2005). This method was employed in the present study to get the recreational value of the lake. The schedule used for the survey is attached in Appendix VII.

There are two major steps for travel cost analysis. The first is to derive a Trip Generation Function (TGF) for visits to a site based on the cost of travel. Using data on travelling costs and number of trips taken to an area, a demand curve can be derived giving number of trips taken as a function of travelling costs which can be used to value the recreational services of the area (Spaninks and Beukering, 1997).The second step is the regression of TGF.

Two major variants of the TCM are the Zonal Travel Cost Method (ZTCM) and the Individual Travel Cost Method (ITCM) (Vincent and Defruto, 2011). ITCM uses survey data from individual visitors to link the demand of public goods to its determinants. The number of trips made by an individual over a given period of time may be estimated by calculating how far the visitor must travel to get to the site, the time spent in travelling, travel and on-site expenses, their income and other socioeconomic characteristics. Two advantages of ITCM are that it follows conventional methods used by economists to estimate economic values based on market prices, and it also relies on what people actually do rather on what people say they would do in hypothetical situations (Bell and Leeworthy, 1990).

The present study employs ITCM using poisson regression for count data. Poisson regressions are one type of generalised linear model. It assumes that the response variable follows a Poisson distribution conditional on the value of the predictor variables. This can be used to model the occurrence of an event of interest as a function of predictor variables. Hellerstein and Mendelsohn (1993) have dealt in detail about the conceptual and econometric reasons for choosing a count data model. Here the number of trips is a non negative integer. Using a distribution restricted to this area will lead to increased estimation efficiency as well as avoidance of potential biases. A Poisson model can be used to model invisible goods, for which the probability distribution defined only over the non-negative is required. So a poisson regression using count data model was used to estimate the TGF.

A random variable Y is said to have a Poisson distribution with parameter μ if it takes integer values y = 0, 1, 2, . . . with probability

$$\Pr\{Y = y\} = \frac{e^{-\mu}\mu^{y}}{y!} \qquad \text{for } \mu > 0.$$

The Poisson regression model used in the present study is given below

$\mathrm{Log}(\mu) = \beta_0 + \beta_1 A_i + \beta_2 I_i + \beta_3 T_i + \beta_4 C_i + \beta_5 P_i$

Where,

μ - Number of visits per year

β_0 - Intercept

A_i – Age of respondent in number of years

β_1 - Regression coefficient of A_i

I_i - Individual income(Rs/month)

β_2 - Regression coefficient of I_i

T_i - Time spent in lake in hours

β_3 - Regression coefficient of T_i

C_i - Travel cost incurred per trip to visit the site (Rs.)

β_4 - Regression Coefficient of C_i

P_i - Purpose of visit

β_5 - Regression Coefficient of P_i

The Poisson regression model uses a log link function that relates the expected value of the response variable to the linear predictor. This ensures that the mean remains positive for all linear predictors and hence positive for all parameters and covariate combinations. The fitted values are now exponentiation of the linear predictor. The method of maximum likelihood was used to estimate the parameters of Poisson regression models. This method finds the parameter estimates that are most likely to occur in the given data. These parameters estimate maximises the likelihood function, which expresses the probability of the observed data as a function of unknown parameters.

The consumer surplus (CS), which is an approximation of compensating variation) can be found out by integrating the area under the demand curve. The consumer surplus per trip can be estimated from this model as,

$CS = -\frac{1}{\beta_4}$ Where, β_4 is the estimated coefficient of travel cost (Hanley *et al*., 2007). The CS is multiplied by the total number of visitors to get the recreational value of the site (Anoop, 2008).

3.3.2.4 Valuation of Aesthetic Services

Aesthetic value of the lake (increase in land value due to lake view) was estimated using Hedonic Pricing Method (HPM). The HPM is derived from the characteristics theory of value by Lancaster, Griliches, and Rosen, and uses market prices to estimate the marginal value associated with a particular characteristic (e.g. environmental services or quality) of a good.

According to Poor *et al*. (2007) there are two stages in HPM. The first stage involves estimating the hedonic price function, where the price of a residential property is regressed on various property characteristics to determine the value, the property has on the characteristics. Regression of hedonic price function is a way of statistically estimating the relationship between a property's characteristics and its market value, and thus a way of determining the value of the property itself. This function known as the Hedonic Price Function, explains a property price in terms of the attributes. The dependent variable of the hedonic price function is the actual sales price of houses recorded. For each property sale, there are a set of attributes associated with the property which helps to explain the sales price.

The hedonic property price model applied in the present study employs data on actual property price per cent of households during the study period along with different attributes of the location. At first a pilot study was conducted in the study locations to determine the factors that affect the property prices. The actual property price per cent of the area was collected through survey. In the study locations the property price determination is mostly done by the speculations made by real estate agents. The land mafia was keen in determining the price of land based on the inherent characteristics of the property. Structural attributes of houses were not considered for the study because in a state like Kerala where construction of houses varies drastically according to the economic status of people, it will be very difficult to estimate the variability. The schedules used to elicit the information are furnished in Appendix VIII.

Based on pilot study, the important attributes that determined the property price of the location identified were environmental, location, neighbourhood and lake view. The marginal implicit prices of individual characteristics were estimated using a multiple regression model with housing price as the dependent variable and various other characteristics as explanatory variables. Under the assumptions that the housing market is in equilibrium and that the area studied lies within a single housing market, the estimated marginal implicit prices derived from regression coefficients represent the price an individual would be willing to pay for an additional unit of a piece of land with lake view. SAS package was used to estimate the hedonic pricing model to relate property sale price to environmental, location, neighbourhood, and lake view characteristics. Economic theory does not specify which functional form is most appropriate for use in a hedonic pricing analysis; based on the attribute being valued, we can choose the econometric model. Different models such as log, semi log, quadratic and linear were tried and the best model was selected based on the R^2 value.

The premium placed on the land with lake view was determined by multiplying marginal implicit value of the lake view variable with the mean property sale price and area of the zone 1 where the view of lake is there.

3.3.2.5 Valuation of Regulating and Supporting Service

Contingent Valuation Method (CVM) is a valuation technique used to estimate the non use value (Brookshire *et al.*, 1983) and nonmarket use values (Loomis and duVair, 1993) or both (Desvousges *et al*., 1993) of environmental resources. The regulating and supporting services provided by the lake such as ground water recharge, stabilisation of micro climate and biodiversity conservation were determined using Contingent Valuation Method (CVM). In general in CVM, the individuals are asked their Willingness to Pay (WTP) or Willingness to Accept (WTA) for change in the provision of the environmental goods usually by way of questionnaire survey. The individual's maximum WTP and minimum WTA compensation for an environmental change is assumed to be the value the person attaches to such change. CVM estimates the Hicksian consumer surplus and the welfare measure in the CVM is Compensating Surplus and Equivalent surplus based on the scenario.

As given by Markandya *et al.* (2002) elicitation of the WTP using CVM employed in the study followed 3 steps

1. A scenario was described explaining the ecosystem services of the lake mainly the regulating and supporting services and the threats faced by the lake.
2. The respondents were invited to consider the proposed context where the lake is well managed under a trust.

3. The respondents were invited to supply their statement concerning their WTP from which the value attached to a change in the provision of good and service in question is inferred.

As a first step, a pilot study was conducted in all the twenty four locations in order to get an idea about the socio economic conditions of the people. Based on the pilot study the elicitation format was finalised following the steps proposed by Marakandya *et al.*, 2002 and Gunatilake, 2003. The data collection proceeded on the assumption that each individual has a maximum Willingness to Pay (WTP) and will respond “Yes” to a bid only if his or her WTP is greater than the bid amount. It was revealed from the pilot study that the information obtained about an individual’s WTP from the dichotomous choice format was limited and an alternative format, where a follow-up bid is asked was used. The follow-up bid is lower if the person answered “No” to the starting bid and higher if the person answered “Yes.” Thus the format used for elicitation of WTP was double-bounded dichotomous choice (take it or leave it with follow up). An open ended question was posed at the end of the game to confirm the maximum WTP. The questionnaire for elicitation is attached in the Appendix IX.

The intial bid fixed was Rs.100 per month based on the pilot study. At the higher end it extended to 25 per cent and at the lower end it extended to 1 per cent. The model specification and identification of the independent variables was done based on previous research (Anoop, 2007; Mamta, 2009; Hema, 2013) and the field conditions. The factors influencing the WTP of the respondents were estimated using multiple regressions with WTP as dependent variable with a set of other relevant explanatory variables. Various functional forms were tried to get the best goodness of fit. WTP of other stakeholders like fishermen, lotus collectors and duck rearers were also estimated using linear regression model

The reasons for respondent’s WTP and non willingness to pay were collected using seven statements and five statements respectievely. Each statement was assigned value according to Likert scale with a score ranging from 5- for strongly agree, 4- for agree, 3- for neutral, 2- for disagree and 1- for strongly disagree.

The TEV of the lake was arrived by summating all the above estimated values.

3.3.3 Forecast of Ecosystem Service Flow

The trends in ecosystem service flow was predicted based on the drivers of change. The per capita value of the goods and services was arrived at by dividing the values of the goods and services provided by lake evolved from the present study by the present population of the two panchayats. Assuming the same population growth rate from 2001 to 2011, the population in 2021 was predicted. The value was compounded using a rate of 10.5 per cent, which is usually used in such studies, for the year 2021. The per capita value of goods and services in 2021 was predicted by dividing this value with the predicted population of the two panchayats.

3.3.4 Other Organisations

In addition to stakeholders selected for valuation of the ecosystem of the Vellayani lake there are many institutional stakeholders who affects or are affected by the ecosystem use. The interest of these institutions are evident from their involvement in either protection of the lake or presence near the lake, even though they are not deriving any monetary benefits from the lake. Their involvement in ecosystem protection or use is presented in a descriptive manner.

3.3.5 Anthropogenic Forces on Lake System

Anthropogenic forces are human activities that change the ecosystem. Simple tabular analysis was used to analyse the frequency of visits made by the stakeholders to the lake, their opinion on extent of pollution, conservation status of the lake, wetland conservation and property right status.

The relevancy ranking was done for assessing the relative importance people attach for the ecosystem services. The respondents were asked to rate the relevancy on a five point relevancy continuum *viz.*, highly relevant, moderately relevant, less relevant, no decision and not relevant. The ranks assigned for each of the above responses were 5, 4, 3, 2 and 1 respectively. The relevancy coefficient for the i^{th} value / function was worked out using the following formula.

$$RC_i = \frac{\text{Total score of all the respondents for the } i^{th} \text{ benefit}}{\text{Maximum on the continuum x Total number of respondents}}$$

The benefits were then ranked based on the relevancy coefficient such that the benefit having the highest relevancy coefficient had first rank and so on.

Local resident's perception about threats to the sustainability of the lake were analysed by construction of an index. Here the respondents were asked to grade the threats by giving a five point continuum for each threat. The index for i^{th} threat or prospect (I_i) was calculated by using the formula given below

$$I_i = \frac{\text{Total score of all the respondents for the } i^{th} \text{ threat / prospect}}{\text{Maximum score x Total number of respondents}}$$

3.3.6 Environmental and Social Problems Faced by the Stakeholders

Environmental and social problems faced by the stake holders as perceived by them were collected and analysed and their suggestions and recommendations are presented in tabular form

3.3.7 Lake Management Policies

Based on the study, management policies were suggested to ultimately halt the degradation of the lake and to maintain its sustainability. Ten scientists, ten technical experts and ten social activists were interviewed to finalise the policy suggestions. Based on the results of the present study and suggestions by experts lake management policies were suggested.

Results and Discussion

4. RESULTS AND DISCUSSION

The results obtained from the present study are discussed under the following heads.

4.1 Vellayani lake ecosystem- An overview

4.2 Ecosystem services of the lake

4.3 Stakeholders of the lake system

4.4 Economic valuation of Vellayani lake wetland ecosystem

4.5 Total Economic value of Vellayani lake

4.6 Forecast of ecosystem service flow

4.7 Organisations associated with the lake system

4.8 Anthropogenic forces on sustainability of the lake system

4.9 Environmental and social problems of stakeholders

4.10 Lake management policies

4.1 VELLAYANI LAKE ECOSYSTEM - AN OVERVIEW

Vellayani lake is famous for its picturesque landscape and rich biodiversity. An insight in to the history gives a wholesome picture about the significance of the lake in the past.

4.1.2 History of Lake System

The Vellayani lake was a principal tourist spot during the period of erstwhile rulers of Travancore. During 1952-53 Vellayani lake basin, which was ideal for paddy cultivation, was selected for dewatering and paddy farming. The lake was drained of water and divided into blocks and the paddy cultivation was started as part of “Grow More Food” campaign. Thus the periphery of the lake was segmented and leased out to farmers for paddy cultivation. Gradually they got possession (*pattayam*), and the ownership of the lake was given to them. Every year the lake would be drained before 20th February and one time cultivation was done (Nair, S.C, n.d).

Later, during 1970s Vellayani Kayal Reclamation Project (VKRP) was introduced by the Irrigation Department. A chain of pump houses, a reservoir and a canal (*Kannukali chal*) were constructed as part of reclamation scheme to facilitate paddy cultivation by providing mechanical means of dewatering and discharging to the Karamana river. Thus the lake was dewatered to form padasekharams or paddy fields and surrounding low lying area were divided into different *karis (*paddy fields*)* called *Kanjirathadi, Mangilikari, Nilamakkari, Pandarakari, Punchakari* and *Valiavilakom* for paddy cultivation. The water from paddy fields was drained by mechanical means in to the reservoir area of the lake (plate 15) and carried through *the kannukali chal* (plate 16) to Madhupalam pump house (plate 17). From there, the water was pumped in to the Karamana river and ultimately reached the sea.

The unprecedented anthropogenic stress to the lake by dewatering and consequent spatial and temporal variability in ecosystem properties of the lake evoked widespread attention of environmentalists and social activists. Due to frequent floods and consequent loss of crop, the rice farming in the Kayal land became uneconomical as well. Dewatering also caused reduction in the water table in the nearby wells. Consequently in 1992, Government of Kerala discontinued dewatering the lake and it was declared as a drinking water source as part of the Japan Drinking Water Project of the European Economic Community (Nair,S.C, n.d).

4.1.2 Temporal Changes in the Lake Area

The lake area has been reported differently by various government agencies**.** It was mentioned in the report by Kerala Agricultural University (2009) that the extend of the lake was 750 ha. earlier. The discrepancy in the reported area of the lake was cited in the first report of environment committee by 9th Legislative Assembly in 1993 that, the area of the lake was 441.98 ha. according to revenue department and 490 ha. according to irrigation department (Noorudheen, 1993).

In this context, the study attempted to asses the temporal change in open water area of the lake. For mapping the changes in the area of the water body Landsat

Plate 15. Reservoir area

Plate 16. Kannukalichal

Plate 17. Madhupalam pumphouse

imagery of February 1973, March 1992, September 2001 and IRS imagery of March 2011 was used. Both the visual (Plate 18) and quantitative data (Table 6) indicated that the lake is shrinking over the years. The acreage transformation statistics revealed that the area of water body during 1973 was 558.93 ha. Since the image was taken during February, there is every probability that the lake was dewatered for paddy cultivation for raising the summer crop. So the actual area of water body might be much more than this. Landsat 5 satellite image with TM sensor showed that the coverage of water body has been drastically reduced by to 267.89 ha by 1992. The reduction in area by about 50 per cent shows that reclamation of the lake for paddy cultivation had resulted in all round destruction in the water spread area of the lake.

After the cessation of paddy cultivation in 1992 the diminution of area was marginal. Further reduction from 2001 to 2011 was mainly due to land filling by encroachment, constructions, reclamation and land conversion by planting coconut trees and other garden crops. The latest available data on area of water body of the lake using Indian Remote Sensing Satellite-P6 is 243.39 ha. The trend in the decline of lake area is given in Fig. 2.

Table 6. Temporal variation in lake area

Satellite	Sensor	Date of Acquisition	Area of Water body(ha)	% variation
Landsat 1	MSS	09-02-1973	558.93	-
Landsat 5	TM	11-03-1992	267.89	52.07
Landsat 7	ETM+	04-09-2001	267.14	0.28
IRS-P6	LISS III	02-03-2011	243.39	8.89

The satellite image revealed that many of the canals or inlets carrying water to the lake are unidentifiable or missing from 1992 onwards. It can be inferred that the

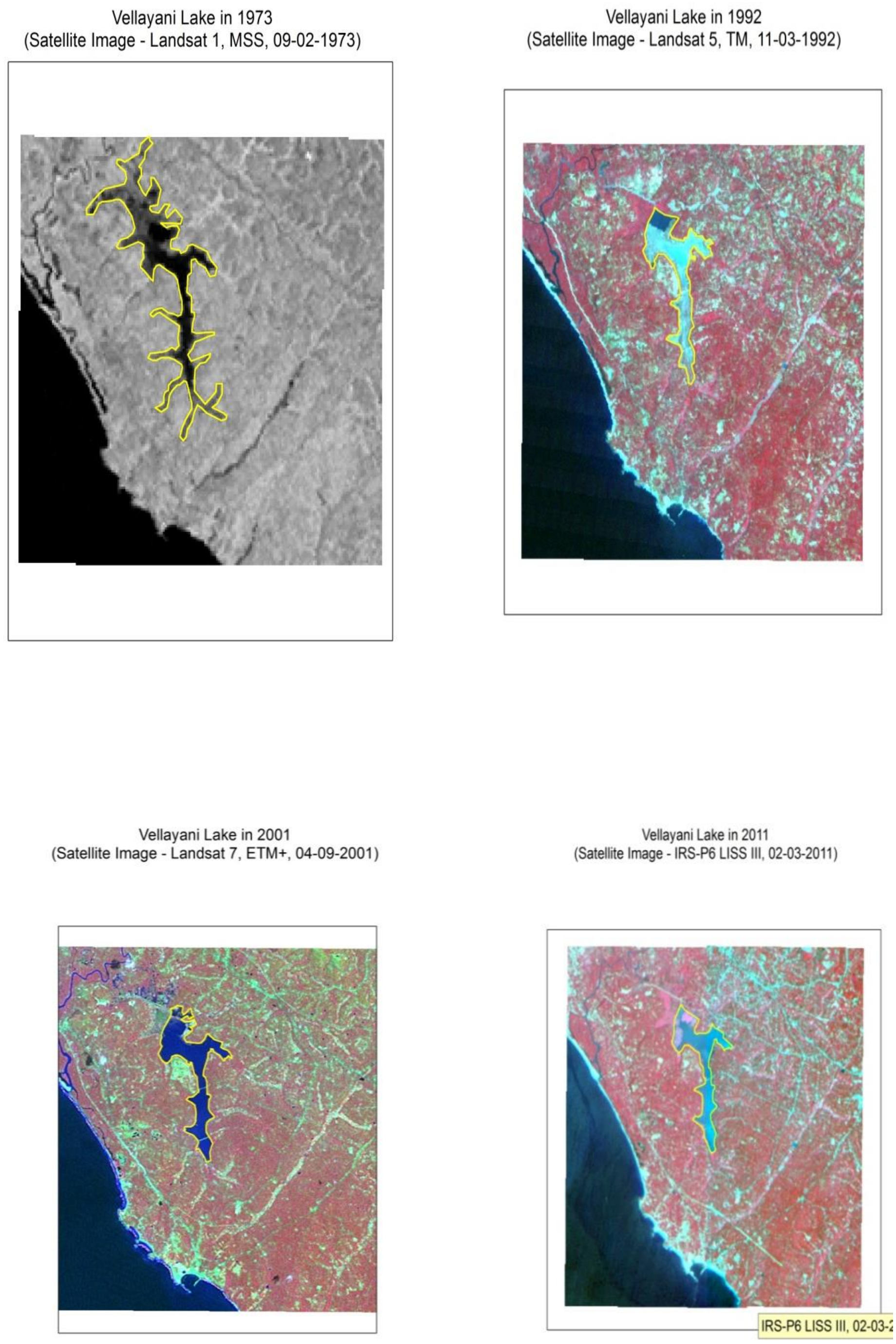


Plate 18. Temporal variation in lake area

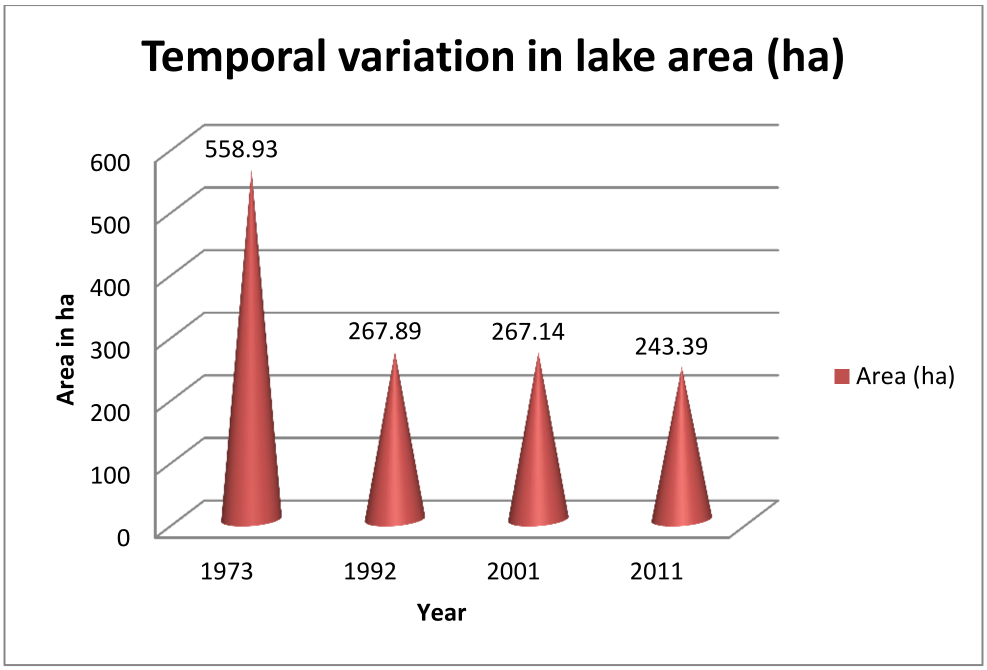


Figure 2. Temporal variation in area of lake

drastic reduction in the area of the lake is not the result of processes occurring in nature alone, but the substantial reason is irrational human activities like unsustainable exploitation of the ecosystem services due to demographic pressures.

Construction of bund roads across the lake, permanent reclamation for paddy cultivation, conversion of wetland area, encroachment of the lake for construction also considerably reduced the lake area. The surge in the property prices, increasing demographic pressure and the public property status of the lake system had resulted in the large scale destruction of the ecosystem. The lack of awareness on the significance of this valuable wetland ecosystem system among the public could be another reason for the sharp decline in the area and degradation of ecological environment.

Alarming levels of human induced environmental degradation of fresh water lakes and subsequent reduction in area was also reported by Rao *et al*. (2004) and Reddy (2014) through digital processing of the IRS-1D LISS-III image of Kolleru lake. According to them about 42 per cent of the 245 km^2 Kolleru lake area was encroached for aquaculture and 8.5 per cent more area was occupied for agriculture, while the rest of the lake is either being dried out by reclamation or is infested with weed. Similarly Singh and Moirangleima (2009) reported shrinkage in area to a tune of 50 per cent from 1989 to 2002 in open water area of Loktak and Pumlen lake of Manipur due to human pressure. This indicates that the degradation of wetlands happening all over the country is also visible in Vellayani lake system.

4.1.4 Current Status

As soon as the paddy cultivation was discontinued, the reservoir area which was used to collect the water while dewatering the lake for paddy cultivation, is kept as such and other parts of lake such as *Kanjirathadi*, *Mangilikari*, *Nilamakkari*, *Pandarakari*, *Punchakari* and *Valiavilakom* are permanently separated from the lake as agricultural fields. The mud and silt collected in the reservoir at the time of dewatering has reduced the water holding capacity. The shutters provided at the

Madhupalam to pump out the excess water from the lake carried by Kannukali chal, now also functions to prevent the back flow of water from Karamana river to the Vellayani lake so that the salt water intrusion into the lake is prevented. Many canals carrying water into the lake was degraded or disappeared. Encroachment, reclamation, sand mining and other human activities had affected the sustainability of the lake. Luxuriant growth of lotus which vanished during dewatering reappeared and now part of scenic beauty of the lake system.

Two bund roads were constructed across the lake at Kakkamoola and Vavvamoola for easy transportation to Thiruvananthapuram city. Reservoir bund road was constructed along the north western side near palapoor. Drinking water pump houses are also operational in the lake. Many local people are dependent on the lake for their livelihood by way of fishing, lotus collection and duck rearing. The lake is still part of cultural activities like boat race and also many religious functions of temples around and is a source of recreation.

The shrinkage of rice cultivation displaced agricultural labour from the farm sector to other sectors. Most of the small and marginal farmers confined their cultivation to vegetables and some others became laboures. The large scale vegetable cultivation in *Pandarakkari* in the northern side of the lake, which was once paddy field is a live example for this change. The other paddy fields in the northern side of the lake *viz. Punchakari, Nilamelkkari, Mankilikari* and *Kanjirathadi* are being kept fallow and are infested with greater club rush (*Scirpus grossus* L.F). Patches of paddy cultivation are also seen in those areas. Some parts are irrevocably converted to garden land. In many parts like Venniyoor, Vavvamoola and Agricultural College (AGC), coconut trees can be seen on the fringes of the lake which were planted with a selfish motive of permanent reclamation.

4.1.5 Topography

Topographically the lake is at mid land region. Land form is low rolling terrain. The catchment area consists of narrow valleys, moderately sloping land and low mounds. The elevation ranges from 20 to 80 m above mean sea level.

4.1.6 Soil and Geology

Major soil type of the area is red loam. The area is composed of archean gneiss and crystalline schist along with laterite and alluvial sediments. Colluvial and alluvial deposits are found in valleys and plains. According to the Department of Soil Survey and Soil Conservation, the major soil series observed in the catchment were Poovar - Kazhakkottam- Chirayinkil soil association, Karamana – Nanchalloor soil association, Amaravila- Korani- Sreekariyam soil association, Vellayani-Neyyattinkara soil association, Vilappil - Mukkunni soil association and Vizhinjam – Neyyattinkara- Pallichal soil association. The soil association map is depicted in Plate 19.

Land capability classes, which is the grouping of the soils according to their potentials and limitations indicated that the area belongs to class IIe and IVe and the soils have progressively increasing hazards and limitations and require more intensive treatments for sustained use.

4.1.7 Climatic Factors

The Vellayani lake catchment area experiences humid tropical climate with the bimodal distribution of rainfall from South West and North East monsoon. The rainfall received in the catchment area is the major source of water for the lake. The details on weather data collected from the Class B observatory at College of Agriculture, Vellayani is given in the Appendix X.

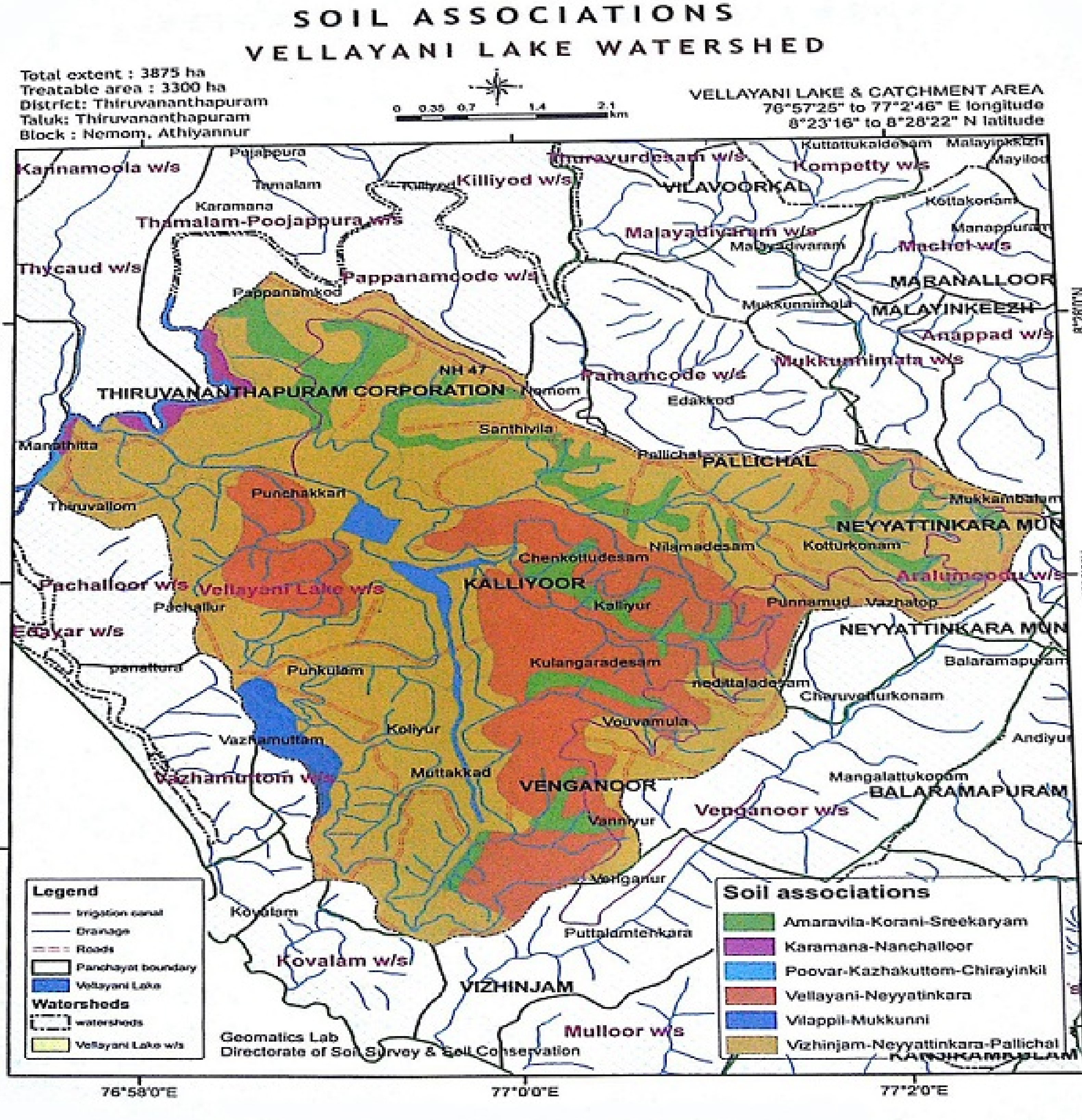


Plate 19. Soil associations in Vellayani lake watershed

4.1.8 Cropping Pattern

Cropping pattern is the proportion of area under different crops in a farm at a point of time. The cropping pattern of the study area at a distance of 100 m (zone I), 200 m (zone II) and 300 m (zone III) from the lake was collected through field survey (Table 7, Fig. 3). It was revealed that the area, once famous for the luxurious greenery of paddy fields is now almost devoid of this green bioresource and is replaced by vegetables and other perennial crops.

It was inferred that, the cropping pattern in the study area is dominated by the perennial crop, coconut irrespective of the distance from the lake.

Table 7. Cropping pattern of the study area (ha)

Crop	Zone I	Zone II	Zone III
Coconut	0.502 (77.26)	0.035 (69.46)	0.022 (66.04)
Banana	0.029 (4.50)	0.003 (6.10)	0.002 (5.98)
Vegetables	0.079 (12.12)	0.009 (17.04)	0.006 (17.19)
Tapioca	0.038 (5.80)	0.003 (5.37)	0.001 (4.65)
Others	0.002 (0.37)	0.001 (5.37)	0.002 (6.12)
Total	0.647 (100)	0.049 (100)	0.031 1(100)

Like any other typical Kerala household, the households of Vellayani lake ecosystem were also having mixed cultivation with annual and other perennial crops. In all the three zones, coconut was the major crop occupying more than 66 per cent of

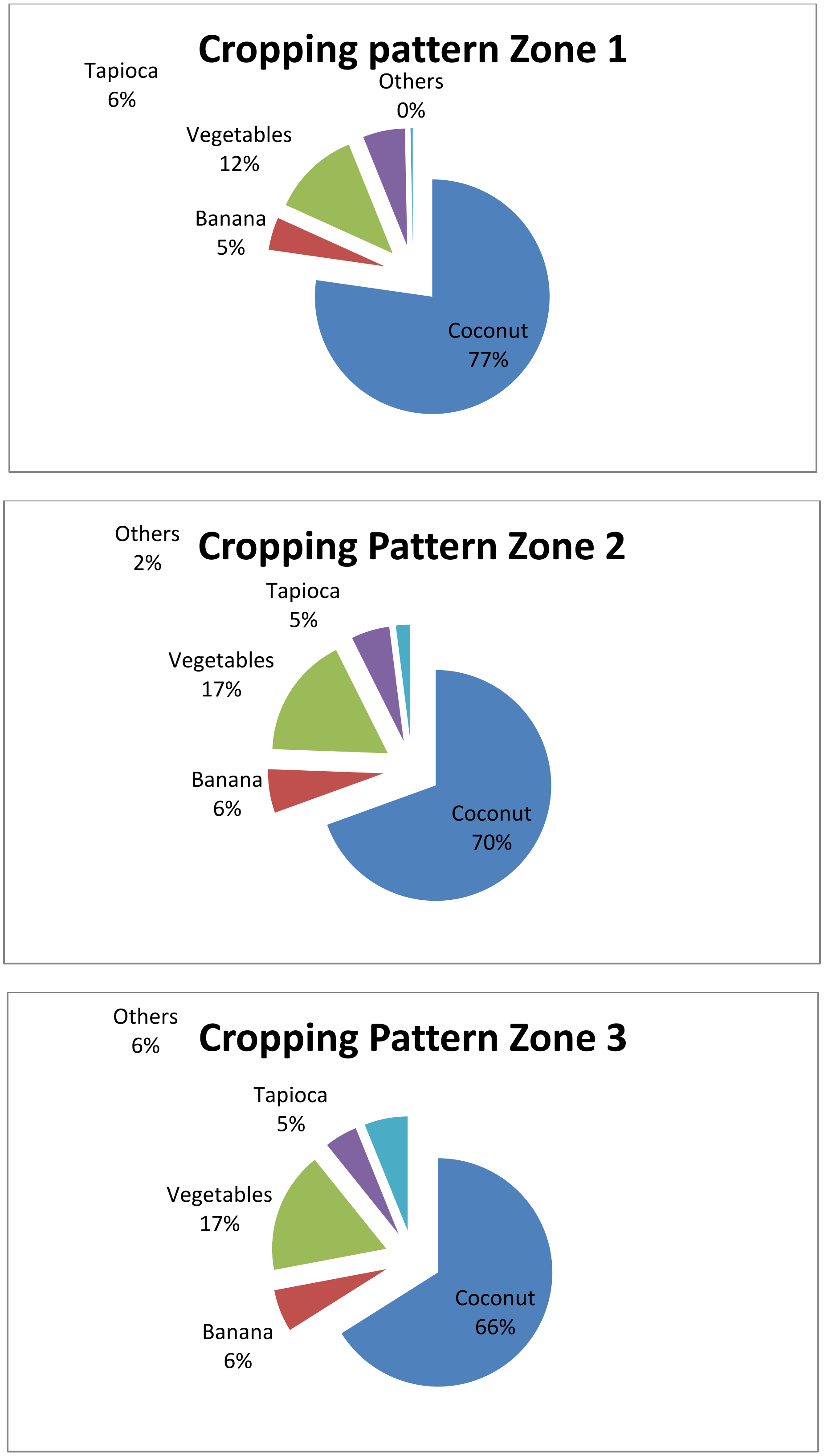


Figure 3. Cropping pattern of the study area

the area. Vegetables were next important in the households and occupied nearly 15 per cent of the total area. Banana and tapioca occupied more than 5 per cent of the total area. Others group included agro forestry trees, fruit trees, medicinal plants, spices and plantation trees other than coconut.

The labour scarcity, increased labour wage structure, conversion of wetlands to garden land for real estate purpose and the universal phenomenon of aversion of the new generation towards agriculture was generally observed in the area may be the reason for dominance of less labour intensive cash crop like coconut.

4.1.8. Biodiversity

Fresh water ecosystems, particularly in tropical regions harbour an extra ordinary concentration of the world's biodiversity. Biodiversity is the quantity, variety and distribution across biological scales ranging through genetics and life forms of populations, species, communities and ecosystems (Mace *et al.,* 2005). Biodiversity affects the capacity of living systems to respond to changes in the environment, underpins ecosystem function and provides the ecosystem goods and services that support human well-being (Costanza *et al*., 1997 and Hooper *et al*., 2005).

The lake and its ecosystem is a bio resource and harbours rich biodiversity of many plants, animals and micro organisms. The secondary data on biodiversity of the lake on fishes, birds, insects, micro algae and macrophytes collected from various sources are presented below.

4.1.8.1 Fisheries

Fresh water fishes comprise one of the most threatened vertebrate group. The lake is a source of variety of fishes both indigenous and exotic. Fishes are source of livelihood to people. Different types of fishes present in the lake (Table 8) was recorded in a scientific manner during the "Vellayani Lake Fish Census (2013)" organized by the Department of Aquatic Biology and Fisheries, (University of

Kerala) and Agency of Development of Aquaculture Kerala (ADAK). The census recorded twenty nine species of fishes in the lake.

Table 8. List of fishes recorded from Vellayani lake

Sl no	Scientific name	Common name
1	*Anguilla bicolor bicolour (*McClelland*)*	Indonesian short fin eel
2	*Dayella malabarica* (Day*)*	Days round herring
3	*Amblypharyngodon microlepis* (Bleeker)	Indian Carplet
4	*Catla catla* (Hamilton)	Catla
5	*Cirrhinus cirrhosus* (Bloch)	Mrigal carp
6	*Labeo rohita* (Hamilton)	Rohu labeo
7	*Rasbora daniconius* (Hamilton)	Slender rasbora
8	*Punitus parrah* (Day)	Parrah barb
9	*Puntius sarana subnasutus* (Valenciennes)	Olive barb
10	*Punius ticto* (Hamilton*)*	Ticto barb
11	*Puntius vittatus* (Day)	Green stripe barb
12	*Mystus oculatus* (Hamilton)	Malabar mystus
13	*Ompok bimaculatus* (Bloch)	Butter catfish
14	*Heteropneustes fossilis* (Bloch)	Stinging catfish
15	*Xenentodon cancila* (Hamilton and Buchnan)	Freshwater garfish
16	*Hyporhamphus xanthopterus* (Valenciennes*)*	Red tipped halfbeak
17	*Aplocheilus lineatus* (Valenciennes)	Striped panchax
18	*Mastacembelus armatus* (Lacepede)	Zig-zag eel
19	*Ambassis ambassis* (Lacepede)	Commerson's glassy
20	*Parambassis thomassi* (Day)	Western Ghat glassy perchlet
21	*Etroplus maculates* (Bloch)	Orange chromide

22	*Etroplus suratensis*	Pearl spot
23	*Oreochromis mossambicus* (Peters)	Mozambique tilapia
24	*Glossogobius giuris* (Hamilton and Buchnan)	Tanky goby
25	*Pseudosphromenus cupanus* (Cuvier)	Spiketail paradisefish
26	*Channa marulius* (Hamilton and Buchnan)	Great snakehead
27	*Channa striata* (Bloch)	Striped snakehead

(Source -Kumar and Kiran, 2013)

The fish census showed the absence of native fishes of lake such as Indian mottled eel (*Anguilla bengalensis*) Valenciennes calriid (*Clarias dussumieri*) and crocodile tooth pipe fish (*Microphis cunculus*) and the reduction from forty two species of earlier recorded species to twenty nine species of fishes (Kumar and Kiran, 2013).

Local residents and fishermen reported that, there is considerable reduction in *attu vala* (*Wallago attu*) and *attu konj(Macrobrachium* sp.) in the fish landings. The study identified that the major economically important fishes now present in the lake are Pearl spot(*Etroplus suratensis*), Rohu (*Labeo rohita*), Catla (*Catla catla)*, Prawns (*Macro brachium* sps)., Striped snake head (*Channa striatus)* and Stinging cat fish *(Heteropneustes fossilis)*. If this decline in fish biodiversity remains unaltered without any interventions opportunity to conserve the remaining fish will also vanish. It was observed that the environmental conditions of the lake was altered and manipulated by way of reduction in free flow of water due to construction of bund roads across the lake and other anthropogenic stressors like unregulated fishing, encroachment, pollution and weed growth. This might have affected the natural niches of different fish species which led to reduction in the diversity of fish species as well as the quantity of fishes in the lake. Similar observations were made by Nath and Deka (2012) that anthropogenic factors like festival fishing, encroachment, conversion of wetland are the reasons for reduction in the fish diversity of Chandubi tectonic lake, Assam. Reduction in fish diversity due to anthropogenically induced changes were also observed by Rojas and Rivero (2000) in Valencia basin of Venenzuela.

The fish stock enhancement with Indian carps launched for income enhancement of fishermen in Vellayani lake resulted in the increased availability of introduced fishes and adversely affected the population of indigenous fishes. This was in conformity with the findings by Alexander and Sankar (2013) that the fish fauna of Ousteri Lake, Puduchery is threatened by alien fish species, common carp.

4.1.8.2 Aquatic Entomofauna

Aquatic insects or entomofauna live some portion of their life cycle in water. These insects form a large part of the diet of most fish species. For this reason a healthy insect population is of considerable interest for productive fish population. Abhinja *et al.* (2013) studied the diversity of insect fauna and reported that there are 60 species of insects classified under 37 families and 8 orders in Vellayani lake. Similarly dominance of hemipteran and coleopteran insects was reported by Majumder *et al*. (2013) in the urban lakes of Tripura.

Table 9. Entomo fauna in Vellayani lake

Sl no	Order	Genus
1	Hemiptera	*Diplonychus* sp.
2		*Ranatra* sp.
3		*Laccotrephes* sp.
4		*Naucoris sp.*
5		*Distotrephes* sp.
6		*Helotrephes sp.*
7		*Paraplea* sp.
8		*Micronecta* sp.
9		*Anisops* sp.
10		*Gerris* sp.
11		*Mesovelia* sp.
12		*Hebrus* sp.
13		*Hydrometra* sp.
14		*Velia* sp.
15		*Microvelia* sp.
16		*Eurymetra* sp.
17	Coleoptera	*Sternolophus* sp.
18		*Amphiops* sp.
19		*Cybister* sp.
20		*Hydrovatus* sp.
21	Ephemeroptera	*Baetis* sp.
22		*Cloeon* sp.
23		*Caenis* sp.
24	Trichoptera	Polycentropus *sp.*
25		Leptocerus sp.
26		Hydropsychae sp.
27	Lepidoptera	*Paraponyx* sp.
28		*Bellura* sp.
29		*Eoophyla* sp.
30	Diptera	*Anopheles* sp.
31		*Chironomus* sp.
32		*Culex* sp.

(Source- Abhinja, 2013)

4.1.8.3 Avian/Bird Biodiversity

Avian/Bird diversity and abundance are strongly associated with productive, lush habitats, water bodies etc. The lake system supports a variety of resident and migratory birds (Plate 20). Hotspots of bird diversity in Vellayani lake are the reservoir bund area close to *Pandarakari, Punchakari* and other paddy fields. The important resident and migratory birds in the lake system based on discussions with bird watchers is presented in Table 10.

Table 10. Major migratory and resident birds in Vellayani lake ecosystem

Sl No	**Migratory birds**	**Resident**
1	Wood Sand piper	Green bee eater
2	Pintail snipe	Purple heron
3	Barn swallow	Oriental darter
4	Blue tailed bee eater	Common Kingfisher
5	Envasian Marsh Harr	White throated kingfisher
6	Booted eagle	Pied Kingfisher
7	Common stone chat	Lesser whistling teal
8	Greater spotted eagle	Cotton teal
9	Booted eagle	Black bittern
10	Black headed Bunting	Yellow bittern
11	Marsh Harrier	Brahmining kite
12	Osprey	Shikra
13	Red necked falcon	White Ibis
14	Black Capped kingfisher	Pied Crested Cuckoo
15	Common Spotted Sandpiper	Water Cocked
16		Indian Coot
17		Red bittern
18		Asian open bill
19		Painted snipe
20		Lesser Whistling Duck

Plate 20. Birds in lake system (Photo Coutesy – Dr. Abhilash Arjunan)

Rare species of migratory birds seeking stopover habitat during a critical time in their life cycle are seen in the lake system. The presence of large number of resident and migratory birds in this region attracted attention of many bird watchers. But no detailed population study on the bird population was available.

The changing scenario of wetland habitat of the lake system including construction of roads around, bund roads across the lake, human habitations, cessation of paddy cultivation, conversion of paddy land surrounding the lake especially in the *karis* of Kalliyoor panchayat, have broke up the organic continuity of the lake and the extend of wetland area. This wetland is less preferred by many birds like euarasian spoonbills, painted storks and pelicans under the changed landscape and human interference. Common stone chat, a dry species spotted recently in the lake system is suggestive of increasing temperature and overall water level reduction. Similar decline in wetland birds due to habitat loss was also observed by Gopakumar and Kaimal (2008) in Mannar, Kerala.

4.1.8.4 Microalgae

Microalgae are aquatic autotrophs that significantly contribute to carbon sequestration by utilizing nutrients in water bodies. They are important primary producers in the lake. Aneesh and Manilal (2013) studied the diversity and distribution pattern of microalgae in Vellayani lake and identified Scenedesmus, Spirulina, Microcystis and Straurastrum as major micro algae in the lake.

4.1.8.5 Macrophytes

A macrophyte is an aquatic plant that grows in or near water and is emergent, submergent, or floating. In lakes macrophytes provide cover for fish and substrate for aquatic invertebrates, produce oxygen, and act as food for some fish and wildlife (Carpenter, 1986). Table 11 illustrates the macrophytes present in Vellayani lake as given by Kamal (2011).

Table 11. Macrophytes in Vellayani lake

Sl No	Common name	*Scientific name*
1	Buffalo grass	*Brachiaria mutica*
2	Colocasia	*Colocasia esculenta*
3	Greater club rush	*Scripus grosses*
4	Jungle rice	*Echinocloa colona*
5	Kulavazha	*Eichhornea crassipes*
6	Fern	*Dryopteris erythrosora*
7	Nagapola	*Limnocharis flava*
8	Lotus	*Nelumbo nucifers*
9	Injipullu	*Panicum repens*
10	Water cabbage	*Pistia striata*
11	Aambal	*Nymphea odorata*
12	Neyyambal	*Nymphoides indicus*
13	Kuzhal pullu	*Eleocharis dulcis*
14	Water spinach	*Ipomoea aquatica*

(Kamal, 2011)

Carpenter (1980) reported that the interactions between macrophytes and littoral fauna are probably very important for ecosystem processes. Submerged macrophytes have major effects on productivity and biogeochemical cycles in fresh water.

Lotus is an economically important macrophyte, which is the source of income to people. Water lilies and lotus add beauty to the lake. But the aquatic invasive weed like Eichhornea, is posing serious threat to the lake which is to be immediately checked.

4.1.8.6 Tree Biodiversity around the Lake

Home gardens in Kerala carry a significant stock of trees which contribute towards the environmental benefits accrued through tree vegetation (Jayaraman *et al*., 2008). It ensures food, fuel, fodder and timber for the households. The biodiversity in tree crops were collected from eight study locations. The common names and scientific names of the trees and location wise are attached in the Appendix XI, XIa, XIb, and XIc. The tree crops in the households were classified as plantation crops, fruit trees, agro forestry and medicinal plants, spices and vegetable trees.

Table12. Location wise distribution of tree biodiversity (Mean)

Sl no	**Crops/ Locations**	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**S_6**	**S_7**	**S_8**	**Total**
1	**Plantation**	0.43	0.62	0.46	0.54	0.45	0.52	0.42	0.55	3.99
2	**Fruit trees**	0.47	0.27	0.37	0.26	0.44	0.38	0.36	0.31	2.86
3	**Agro forestry**	0.05	0.09	0.07	0.07	0.05	0.09	0.1	0.11	0.63
4	**Medicinal Trees**	0	0.01	0.1	0.1	0.06	0.01	0.07	0.01	0.36
5	**Tree spices**	0.05	0.01	0	0.02	0	0	0.05	0.02	0.15
6	**Vegetable Trees**	0	0.01	0	0.01	0	0	0.01	0	0.03

The data on the total diversity index of the eight study locations which is a cumulative of all the three zones as contributed by different crops (Zone I, Zone II and Zone III) is presented in Table 12. The mean of the total diversity index of different locations revealed a different trend as contributed by the different crops. It was clearly evident from the table that the mean biodiversity index of the different locations was as a result of the dominance of plantation crops followed by the minor fruit crops. The dominance of plantation crops was contributed by coconut palms. The gradation in the pattern of index for all the spots were the same with plantation crops contributing to maximum biodiversity except for the S_1 wherein maximum biodiversity was contributed by fruit tree crops.

Hence it could be inferred that the biodiversity effects were a reflection of the choice of specific multipurpose tree crops. Plantation and fruit crops contributed to more than 90 per cent of the biodiversity in the region of study. Though distinct differences were recorded among the indices, in none of the cases the result was statistically significant. However it was interesting to note that the biodiversity contribution of agro forestry crops in all the spots were distinctively less for Vellayani lake ecosystem and the results are contrary to findings reported by Jayaraman *et al*., 2008. It was also noticed in the study area that the fencing with plants and trees as seen in traditional households are vanishing which is replaced by brick walls. The number of the tree species is getting depleted because trees are cut for the construction of houses resulting in the lowering of biodiversity. In many households the courtyard is cemented leaving space for one or two trees only. Rapid urbanisation and real estate motives led to fragmentation of land for construction of houses. As houses are constructed with close proximity the leaves from trees may fall on neighbor's house which may lead to disputes and quarrels. In order to avoid such situations, practice of growing tree species in households is less prevalent now a days which may be another reason for low biodiversity in the area.

4.1.8.7 Water Quality

In Thiruvananthapuram, water scarcity is a problem for city dwellers and those in the outskirts. Most of the fresh water bodies all over the world are getting polluted, thus decreasing the potability of water. The availability of water both in terms of quality and quantity is essential for the very existence of mankind. .

The anthropogenic discharges constitute a constant polluting source, for water bodies whereas surface run off is a seasonal phenomenon largely affected by climate within the basin (Singh *et al*., 2004). These two forces pose negative externality with respect to the water quality. The lake is being utilized for daily needs of people like bathing and washing. The canals carrying water to the lake are flowing from human inhabited area and agricultural fields. So monitoring the surface water quality is important in terms of health security of the area.

a)Pesticide Residue Analysis

Kalliyoor Panchayat is a good vegetable growing belt of Thiruvananthapuram district. In the agricultural fields, indiscreet use of pesticide was noticed. The lake being the watershed of the area there is possibility of pollution by pesticide residue. Possibility of pollution by pesticide residues in lakes was reported by studies by Pandey *et al.*(2001) where the presence of pesticide residue was observed in Yamuna river.

In order to detect the presence of pesticide residue in the lake, water sample was drawn from *Karikuzhy* area, where the lake is adjoining the agricultural land. The sample was tested at the Pesticide Residue Research and Analytical Laboratory (PRRAL) at the College of Agriculture, Vellayani and the results are given in Table 13.

Table.13. Pesticide residue analysis of lake water

Sl No	Pesticides tested	Results($\mu g L^{-1}$)
1	Organo chlorines	Below limit of Quantitation
2	Organo phosphorus	Below limit of Quantitation
3	Synthetic pyrethroids	Below limit of Quantitation

The results revealed that, even though indiscriminate use of pesticide was noticed in the surrounding area, the lake is not contaminated by pesticide residue at present. One of the reasons may be, neither the agricultural fields nor the canals coming from the fields are directly entering the lake except in a few locations. Whatever residues coming from these fields might get absorbed by sediments, which may be another reason for negative result. As intensive vegetable cultivation was observed in the area, the chances of pesticide contamination is more and it cautions us to be watchful against pesticide pollution in Vellayani lake.

b) Drinking Water Parameters

Domestic sewage, waste water from polluted canals, agricultural run-off and pollution due to bathing and washing are the prominent source of surface water pollution in the lake. Monitoring the water quality as well as sources of pollution is essential for creating the efficient management plan for the wise and sustainable management of water quality of the lake.

As Vellayani Lake is a drinking water source, the quality of water in the lake is very important with respect to health aspects of the people using it. Realizing its importance as a freshwater source, the Kerala State Pollution Control Board (KSPCB) is implementing a project to analyze the water for chemical and biological parameters from 2009-10(KSPCB, 2010). In the present study, for statistical analysis of water quality the laboratory test results of KSPCB from six locations of the lake for twelve months from January 2013 to December 2013 was used. Six representative locations selected by KSPCB for monthly monitoring of water quality were, Vandithadom (Reservoir area), Agricultural College, left side and right side of Kakkamoola bund, left side and right side of Vavamoola bund. The water quality parameters selected for study is furnished in the Table 14.

Table 14. Water quality parameters studied

Water quality parameters	Unit
Temperature	
PH	
Conductivity	mhos/cm
DO	mg/L
BOD	mg/L
COD	mg/L
Turbidity	NTU
Nitrate-N	mg/L
Alkalinity (As CaCo3)	mg/L
Total Hardness As CaCo3)	mg/L
Calcium (As CaCo3)	mg/L
Magnesium (As CaCo3)	mg/L
Chloride	mg/L
Sulphate	mg/L
Phosphate	mg/L
Sodium	mg/L
Pottassium	mg/L
Iron	mg/L
Total Coliform	TC/100ml
Fecal Coliform	FC/100ml

In order to understand the most important factors that affected the water quality, the data was subjected to Principal Component Analysis (PCA). PCA was conducted with the objective to achieve parsimony and reduce dimensionality by extracting the smallest number components that account for most of the variation in the water quality. It was performed on the symmetric covariance matrix. The covariance matrix contains scaled sums of squares and cross products.

From the results of the analysis given in Appendix XI and XII it was inferred that out of the twenty factors that determined the drinking water quality of the lake two data sets PC 1 and PC 2 could explain 99 per cent of the variability in drinking water parameters. A scree plot (Fig. 4) showing the eigen values sorted from large to small as function of principal component number shows that after the second principal component a break in downward slope occurs which indicated that all other principal components except PC1and PC2 could be omitted from analysis. The biplots showing relationship relationships between PC scores and PC loadings associated with PC1 and PC2 is represented in Fig. 5.

The first component *viz.* PC1 had high positive loading in Total coliform (0.96) and Fecal coliform (0.29). In PC2 also the factor loadings were high for Total coliform and Fecal coliform. Thus it can be inferred that the most important factors that affected the drinking water quality are the Total coliform and Fecal coliform contents. Similar reports on the pollution of Vellayani lake by coliforms were also reported by TOKAU (2005) and Kamal (2011). The presence of coliform bacteria warns about the negative externality posed by the organic waste and faecal matter. Reports on pollution of lakes by coliform bacteria was also given by Hatha *et al.* (2008) and Abhirosh *et al*. (2011) in Vembandu lake in Kerala and by Usha *et al*. (2008) in Yellamallapa chetty lake in Bangalore. In a similar study conducted by Mahmood *et al.* (2011) on the ground water quality of Lahore, it was reported that that five factors, which explained 74 per cent of the total variance in water quality data set were salinization, alkalinity, temperature, domestic waste and chloride.

As the lake is rainfed, the water quality parameters showed variation in pre monsoon and post monsoon periods. The people living near the lake should be made aware of the degradation of water quality of the lake and local self government may

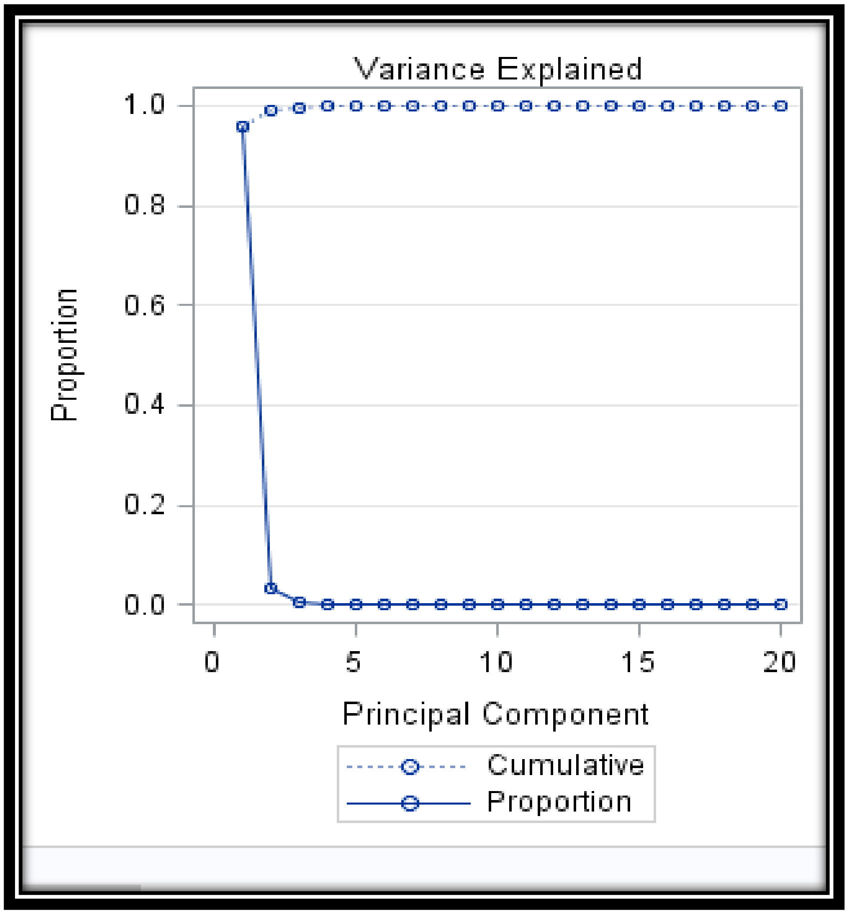


Figure 4. Scree Plot

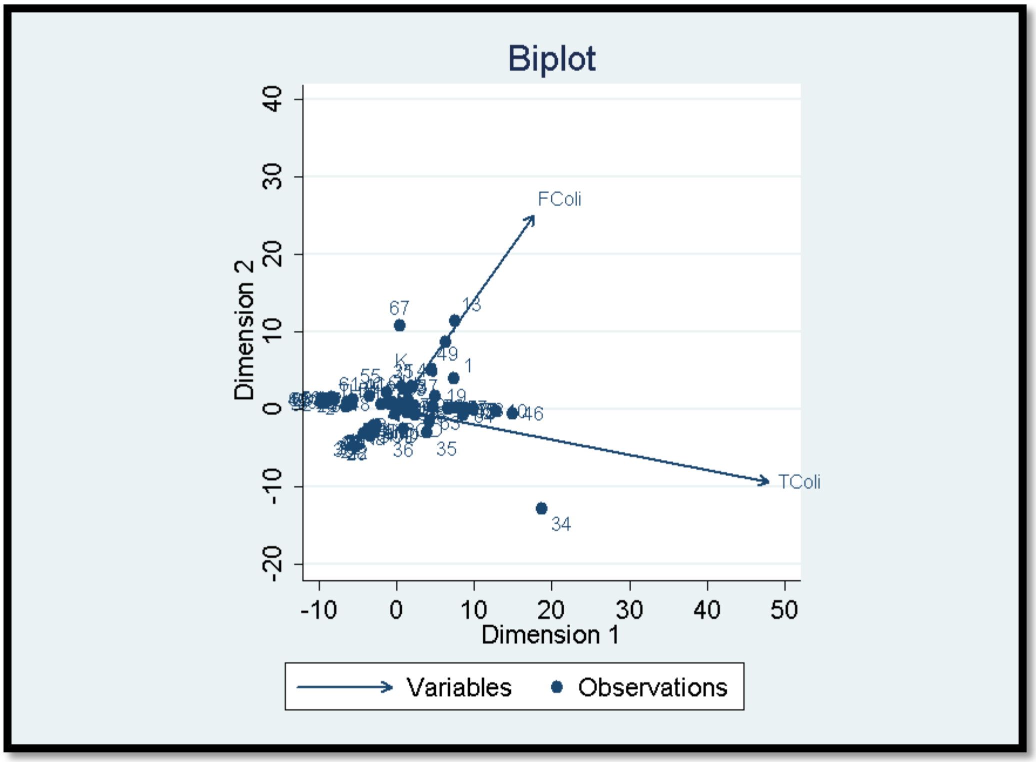


Figure 5. Biplots

take steps for arranging proper drainage facilities to the households bordering the lake to prevent further pollution.

4.2 ECOSYSTEM SERVICES OF VELLAYANI LAKE

Ecosystem services are the benefits people obtain from ecosystems. The lake provides many services to the people and they are directly or indirectly benefitted by these services. Identification of ecosystem services provided by the lake is the first step for the valuation process. In order to identify the services provided by the lake Participatory Rural Appraisal (PRA), surveys and focus group discussions of the stakeholders were conducted.

PRA is considered as one of the popular and effective approach to gather information in rural areas. It is based on village experiences where communities effectively manage their natural resources. The basic concept of PRA is to learn from rural people about rural life and conditions (Chambers, 1994). Transect walk as a tool of PRA suggested by de Zeeuw and Wilbers (2004) helps in understanding natural resources, present land use pattern, vegetation, changes in the physical features and cropping systems in villages, public resources, land use, social differentiation and mobility in communities. PRA also helps in identifying the stakeholders who are interested in a natural resource.

A list of main ecosystem services of the lake prepared based on the indicators described by MA (2005) is represented in Table 15.

Table15. Ecosystem services of Vellayani lake

Sl no	Classification	Ecosystem service
1	Provisioning service	1.Fishing
		2.Duck rearing
		3. Lotus collections
		4.Provision of drinking water
		5. Provision of Irrigation water
		6.Bathing and washing
2	Regulating services	7. Ground water recharge
		8. Stabilizing micro climate
3	Cultural services	9.Cultural heritage and identity
		10.Spiritual and religious services
		11.Scenic beauty
		12.Recreational services
		13.Educational and scientific services
		14.Aesthetic services
4	Supporting services	15.Biodiversity conservation

It was inferred that, the ecosystem services provided by the lake are provisioning services, regulating services, cultural services and supporting service. The provisioning services provided by the lake are drinking water, fishing, duck rearing, lotus collection, irrigation, bathing and washing. The regulating services are ground water recharge and stabilising micro climate. The cultural heritage and identity, spiritual and religious value, providing scenic beauty, recreational value, educational and scientific study are the main cultural services and the supporting service of the lake is biodiversity conservation.

4.3 STAKEHOLDERS OF LAKE SYSTEM

In the context of ecosystem valuation, stakeholder is defined as a group or individual who affect or is affected by the ecosystem services. The services supplied by an ecosystem determine the relevant stakeholders and the stakeholders determine the relevant ecosystem services (Hein *et al*., 2006). Identification of stakeholders enhance the applicability of ecosystem services valuation to support decision making. The value of the ecosystem depends on the views and needs of the stakeholders (Vermeulen and Koziell, 2002). The stakeholders in relation to Vellayani lake system were identified through PRA, focus group discussions and site visits. Based on the ecosystem services provided by the lake, stakeholder communities (Table 16) were identified depending on the direct or indirect services of the lake enjoyed by them.

Table 16. Stakeholders of lake system

Services	Beneficiaries/ stakeholders
I. Provisioning	
A. Income generation	1. Fishermen
	2. Lotus collectors
	3. Duck rearing farmers
B. Drinking water	4. Kerala Water Authority (KWA)
	5.Central Public Works Department(CPWD)
	6.College of Agriculture (CoA)
C.Irrigation	7.College of Agriculture (CoA)
D.Washing and Bathing	8. Local residents
II. Regulating function	
D. Ground water recharge	9. Local residents
E. Stabilising micro climate	10. Local residents
III. Cultural services	
F. Spiritual and inspirational	11.Visitors of Karkidaka vavu bali
G. Recreational	12. Visitors of Ayyankali boat race
	13. Bird watchers and photographers
H. Aesthetic	14.Local residents
I. Educational	15. Centralized Sports Hostel (CSH) for Kayaking, Canoeing and Rowing
IV Supporting Function	
J. Biodiversity conservation	16. Local residents

The stakeholders who earn their livelihood through the lake were fishermen, lotus collectors and duck rearers. KWA, CPWD and CoA were extracting water from the lake for drinking water supply. CoA uses the lake for irrigating crops in the instructional farm and research plots. Local residents utilize the lake for bathing and washing, enjoys the benefit of stabilization of microclimate, ground water recharge in wells and biodiversity conservation by the lake. Visitors participate in religious rituals like *Karkkidaka vavu bali*, in cultural activities like boat race, bird watching and photography. CSH is an organization under Kerala State Sports Council, that imparts training in Kayaking, Canoeing and Rowing in the lake.

Data was collected from the institutional stakeholders such as KWA, CoA, CPWD and CSH through discussions with officials and also referring the registers maintained by them. Individual stakeholders such as fishermen, lotus collectors, duck rearers, visitors and local residents were interviewed using pretested structured schedules. The schedule of enquiries were developed in order to elicit the socio-economic status of each stake holder community, value of ecosystem service use and the stakeholder's awareness on Vellayani lake. The TEV estimation frame work used in the study is depicted in Fig.6.

4.3.1 Socio-Economic Status of the Stakeholders

It is important to understand the socio-economic status of the each stakeholder community in order to relate its impact on quality of living standards. The important characteristics considered were age, gender, marital status, occupation, education and income.

4.3.1.1. Age

Age was operationally defined as the number of years completed by respondents at the time of study. Age wise distribution of each stakeholder community is furnished in the Table 17.

Table 17. Age wise distribution of stakeholder communities

Age	Fishermen	Lotus collectors	Duck rearers	Visitors	Local residents
Upto 40	12 (34.29)	2 (33.33)	1 (20.00)	41 (48.24)	43 (17.92)
40-60	19 (54.29)	3 (50.00)	1 (20.00)	36 (42.35)	129 (53.75)
>60	4 (11.43)	1 (16.67)	3 (60.00)	8 (9.41)	68 (28.33)
Total	35 (100.00)	6 (100.00)	5 (100.00)	85 (100.00)	240 (100.00)

(Figures in parenthesis denote per cent to total)

It was noticed that the more than 50 per cent of the fishermen, lotus collectors and local residents were middle aged belonging to the age between forty to sixty years, while 60 per cent of duck rearers were senior citizens. Hence it can be inferred that the younger generations prefer to do jobs other than their ancestral profession. Majority of the visitors (48.24 %) were in the age group of less than forty years.

4.3.1.2 Gender and Marital Status

The gender profile and marital status of the respondents are given in the Table 18. Majority of the stakeholder groups were males and married.

Table 18. Gender profile and marital status distribution of the stakeholders

Status	Fishermen	Lotus collectors	Duck rearers	Visitors	Local residents
Male	33 (94.29)	5 (83.33)	4 (80.00)	70 (82.35)	202 (84.17)
Female	2 (5.71)	1 (16.67)	1 (20.00)	15 (17.65)	38 (15.83)
Total	**35 (100.00)**	**6 (100.00)**	**5 (100.00)**	**85 (100.00)**	**240 (100.00)**
Married	31 (88.57)	6 (100.00)	5 (100.00)	69 (81.88)	238 (99.17)
Unmarried	4 (11.43)	0 (0.00)	0 (0.00)	16 (18.82)	2 (0.83)
Total	**35 (100.00)**	**6 (0.00)**	**5 (100.00)**	**85 (100.00)**	**240 (100.00)**

(Figures in parenthesis denote per cent to total)

Eventhough fishing and lotus collection was risky and requires skill in rowing the boat (which requires good physique) the participation by women in these activities need appreciation.

4.3.1.3 Holding Size

Average holding size of the stakeholder groups residing in the catchment area of the lake is illustrated in the Table 19.

Table 19. Average holding size of the stakeholders (ha)

Category	Average holding size
Fishermen	0.03
Lotus collectors	0.04
Duck reares	0.05
Local residents	0.06

It was noticed that the average size of holding was marginal with not much variation in area among the stakeholder communities. This was much lower than the state average operational holding size of 0.22 ha (GOI, 2014a).

4.3.1.4 Distance from Lake

The classification of stakeholders residing in the study area based on the distance from the lake is given in the Table 20. As most of the visitors are residing far from the catchment area of the lake they were exempted from this exercise.

Table 20. Distribution of stakeholders based on distance from the lake

Category	Fishermen	Lotus collectors	Duck rearers	Local residents
Up to100m	10 (28.57)	5 (83.33)	4 (80.00)	80 (33.33)
100m - 200m	3 (8.57)	1 (16.66)	1 (20.00)	80 (33.33)
200m - 300m	5 (14.29)	0 (0.00)	0 (0.00)	80 (33.33)
Between 300m and 500m	17 (48.57)	0 (0.00)	0 (0.00)	0 (0.00)
Total	35 (100.00)	6 (100.00)	5 (100.00)	240 (100.00)

(Figures in parenthesis denote per cent to total)

It was observed that majority of the stakeholders who earned their livelihood from the lake resides within 100 m from the lake except the fishermen who were having more staggered distribution compared to other stakeholders.

4.3.1.5 Educational Status

The educational status of the respondents presented in Table 21 revealed that majority of the stake holders were formally educated irrespective of their category. Majority of fishermen (68.57 %), lotus collectors (66.67 %) and local residents (62.92%) were high school educated while 80 per cent of duck rearers had only primary education. Among the visitors majority (44.71 %) were educated up to predegree.

. Table 21. Frequency distribution of educational status of stakeholder communities

Educational Status	Fishermen	Lotus collectors	Duck rearers	Visitors	Local residents
Illiterate	4 (11.43)	0 (0.00)	0 (0.00)	1 (1.18)	4 (1.67)
Primary	3 (8.57)	0 (0.00)	4 (80.00)	10. (11.76)	41 (17.08)
High school	24 (68.57)	4 (66.67)	1 (20.00)	22 (25.88)	151 (62.92)
Pre degree	3 (8.57)	1 (16.67)	0 (0.00)	38 (44.71)	14 (5.83)
Degree and above	1 (2.86)	1 (16.67)	0 (0.00)	4 (16.47)	30 (12.5)
Total	35 (100.00)	6 (100.00)	5 (100.00)	85 (100.00)	240 (100.00)

(Figures in parenthesis denote per cent to total)

Illiteracy was meager among the stakeholder communities. Among the fishermen majority were educated up to high school which was against the observations of Gupta (1991) and Nayik (1993) wherein low level of literacy was observed among fishermen communities. Kerala is the first state to have achieved universal literacy and it might have reflected in the literacy status of the respondents also.

4.3.1.6 Occupational Classification

Occupational classification of the visitors and local residents given in the Table 22 indicated that the majority of the local residents (37.92 %) and visitors (35.29%) were labourers. Nearly 18 per cent of the local residents were retired from some service and about 13 per cent among them were self employed. Among the visitors 14 per cent had private job while about 12 per cent each were students and retired persons.

Table 22. Occupation wise distribution of respondents

OCCUPATION	Local residents	Visitors
Labourers	91 (37.92)	30 (35.29)
Fisherman	12 (5.00)	0 (0.00)
Lotus collectors	6 (2.50)	0 (0.00)
Government job	25 (10.42)	6 (7.06)
Private job	9 (3.75)	12 (14.12)
Self employed	31 (12.92)	5 (5.88)
House wife	11 (4.58)	7 (8.24)
Students	0 (0.00)	10 (11.76)
Retired	42 (17.50)	10 (11.76)
Others	13 (5.42)	5 (5.88)
Total	240 (100.00)	85 (100.00)

(Figures in parenthesis give percentage to total)

The occupational pattern can be correlated with the educational pattern of the respondent. Majority of local residents were educated up to high school level which was also reflected in their occupational pattern. Majority were labourers. Only 28 per cent among them had government job or retired from government service. So it can be concluded that in general the respondent were mostly having lower educational and occupational status.

4.3.1.7 Monthly Income

The stakeholder communities who earn their livelihood through the lake were economically backward and coming from the lower strata of the economy.

Table 23. Distribution of monthly income of stakeholder communities

Income	Fishermen	Lotus collectors	Duck rearers	Visitors	Local residents
Up to Rs 10,000	5 (14.29)	0 (0)	0 (0)	2 (2.35)	12 (5.00)
Rs10,001 -20000	24 (68.57)	2 (33.33)	4 (80.00)	60 (70.59)	201 (83.75)
Rs.20,001-50,000	6 (17.14)	4 (66.67)	1 (20.00)	19 (22.35)	22 (9.17)
>Rs50,000	0 (0.00)	0 (0.00)	0 (0.00)	4 (4.71)	5 (2.08)
Total	35 (100.00)	6 (100.00)	5 (100.00)	85 (100.00)	240 (100.00)

(Figures in parenthesis denote per cent to total)

Monthly income varied between Rs. 10,001 to Rs 20,000 for majority of fishermen, duck rearers local residents and visitors. Monthly income more than Rs. 50000 was observed among the visitors only.

4.4 ECONOMIC VALUATION OF VELLAYANI LAKE WETLAND ECOSYSTEM

Any wetland complex has a high diversity of habitats and species and supports a wide range of economic activities. Ecosystem goods and services provided by the wetlands tend to be shared, all goods are not bought and sold and they are public in nature. Despite the growing recognition of the need to conserve wetlands, losses have continued. One main reason is that wetlands throughout the world are considered by many to be of little or no value, or even at times to be of negative value. This lack of awareness of the value of wetlands and their subsequent low priority in the decision-making process has resulted in the destruction or substantial modification of wetlands, causing an unrecognised social cost. Thus it has become obvious that quantifying and integrating these services into decision making will be crucial for sustainable development (Turner *et. al*, 2010). Since most of the development decisions are based on the economic considerations assessment of value of wetland services of the lake assumes importance. Economic valuation can provide useful information to wetland management, helping policy makers to make responsible decisions to develop policies that reflect the value of the resources and issues associated with their management and conservation. Because of the complexity and inter dependence of services and values of the lake there are conflicting interests among stakeholders. An understanding of the value of wetland is crucial while deciding the conservation and development priorities.

Peer research on ecosystem valuation of freshwater lakes in Kerala was unavailable. However, studies on valuation of wetland ecosystem such as Ashtamudi lake (Anoop, 2007) mangroves (Rejeesh, 2003; Hema, 2013) and Kole wetlands (Binilkumar, 2010) are available.

The procedure used in the estimation of TEV is illustrated in the Fig. 6. The accounting period considered was the year 2013.

TEV is worked under three major headings.

4.4.1 Valuation of Provisioning services

4.4.2 Valuation of Cultural Services

4.4.3 Valuation of Supporting and regulating functions

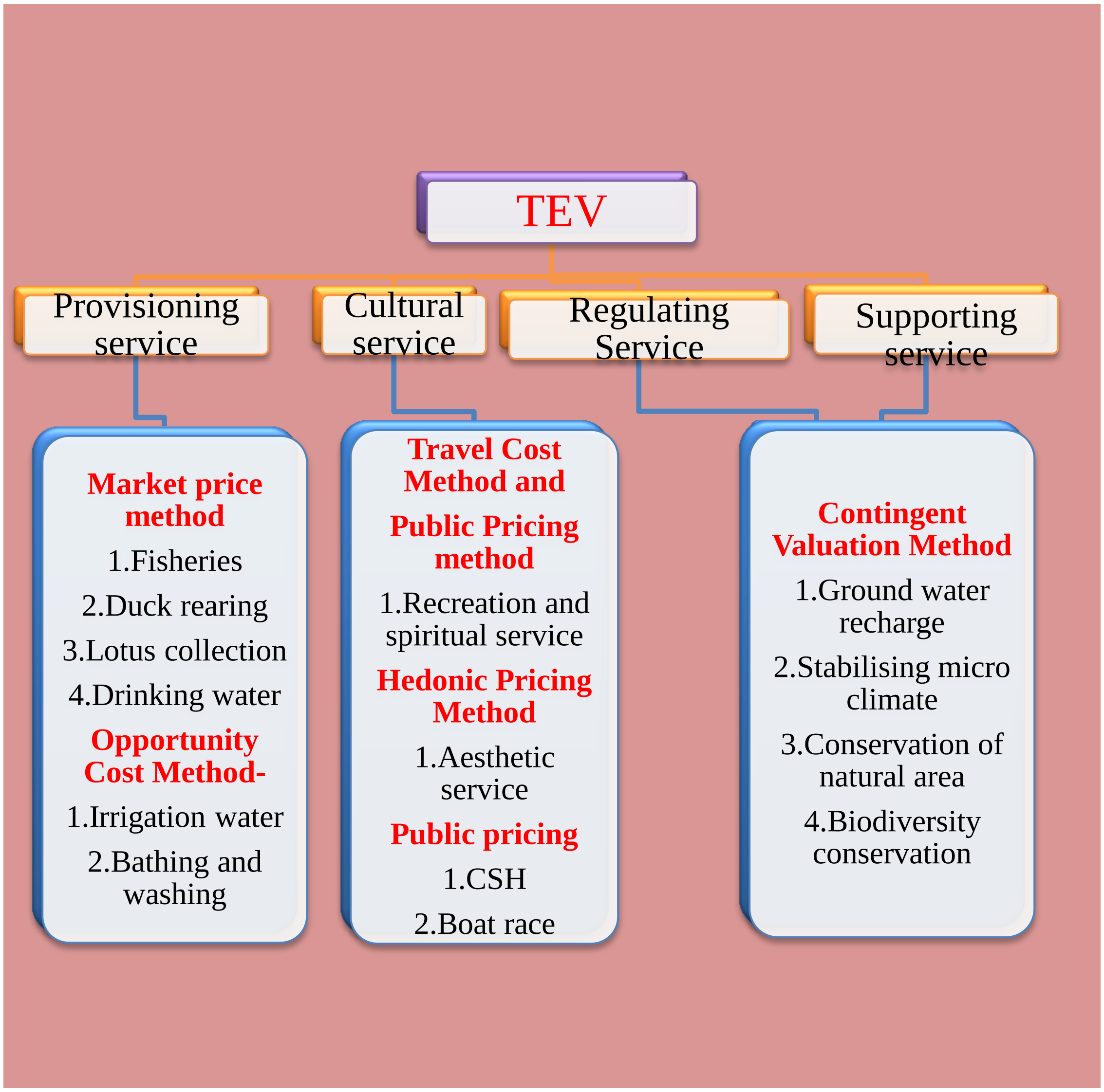


Figure 6. TEV estimation framework of the study

4.4.1 Valuation of Provisioning Services

Provisional services are the products extracted from a wetland ecosystem. The Vellayani freshwater wetland ecosystem provides diverse provisioning services that are useful in supporting livelihoods through income generation to the local population such as fishing, lotus collection and duck rearing, drinking water, it serves as irrigation source and used by people for bathing and washing. To attach monetary values to these services, the first step was to quantify the amount of each service harvested from the wetland and relating them to the existing market price.

4.4.1.1 Fisheries

Fishing is a traditional means of subsistence to local communities from Vellayani lake. The lake harbours diverse species of fishes, both indigenous and exotic. During focus group discussions (Plate 21) the fishermen opined that during paddy cultivation in the lake there were wide array of fish species in large quantities. More than 100 fishermen were solely depending on the lake for their livelihood at that time. But destruction or modification of the fish habitat due to various anthropogenic stresses caused decline in the distribution of the variety and quantity of fishes in the lake. This decline in fish population considerably reduced the income of the fishermen community and many of them migrated to other jobs for their livelihood. So at present only about 50 per cent of them are in this profession.

As it is a freshwater lake motorised boats are not allowed in the lake and fishing is not much commercialised (Plate 22). Gill nets are the typical fishing gear used in Vellayani lake. The major gears used in the lake are the following.

1. Drift gill nets (*Pattu vala/Neetu vala*)
2. Encircling gill nets (*Vanguvala*)
3. Cast nets (*Veesu vala*)
4. Bottom set gill nets (*Katta Vala)*

Hook and line and tubular fish traps are used for recreation. The distribution pattern of fishing gears of the respondent for commercial fishing is given in Table 24.

Table 24. Type of fishing gears used by respondents

Type of gillnets	Frequency
Drift gill nets	23 (65.71)
Both Encircling Gillnets and Cast nets	2 (5.71)
Cast nets	4 (11.43)
Both Drift gill nets and Cast nets	5 (14.29)
Both Bottom set gill nets and Drift gill nets	1 (2.86)
Total	**35 (100)**

. (Figures in parenthesis indicate percentage to total)

1. ***Drift Gill Nets (Neetuvala /Pattuvala)***

Drift gill nets are the most popular gear used in the lake. Among the respondents 65.71 per cent were employing this. The fishermen using drift gill nets set for the lake by evening hours. They usually spend 2-3 hours in lake from 4.00 pm to 7.00 pm and travel across the lake in country boats to fix the net vertically in the water column in a suitable location. The net will be held vertically by means of float line in the top of the net and the nets hang below it. Then the net is left there to fish passively during the night. In the early morning the nets entangled with fishes will be pulled out. Drift gill nets contributes medium sized fishes like Tilapia, Eels in addition to the Catla, Rohu etc. Sary *et al*. (2014) also have reported this practice.

2. ***Encircling Gill nets (Vangu vala)***

The encircling gill nets are operated in the lake during day time. It is operated with the help of 3-6 people. Fishermen using encircling gillnet, set for lake by around 7 am in country boats and fix the nets near the area where lotus plants are grown.

They scare away the fishes by agitating water. The scared fishes get entangled in the net. Among the respondents only 5.71 per cent were using this type of fishing net. The use of encircling gill nets in the lake was reported by Athira, 2011; Sandhya, 2003 and Kiran *et al*., 2013.

3. Cast Nets (Veesu vala)

A cast net, also called a throw net, is another type of net used for fishing. Among the respondents only11.43 per cent were using cast nets exclusively and 14.29 per cent used both drift nets and cast nets. It is a circular net with small weights distributed around its edge. The net will be cast or thrown by hand in such a manner that it spreads out in the water and sinks. This technique is called net casting or net throwing. Fishes are caught as the net is hauled back in. This is particularly effective for catching small bait or forage fish. The cast nets are mostly used in the day time. As the mesh size is small with the chances of more fingerlings to be caught, these nets are not encouraged in Vellayani lake.

4. ***Bottom Set Gill Nets (Kattavala)***

Fishing using bottom set gill net is an aggressive method which disturbs water and captures fingerlings also. So fishing using bottom set gill nets is not encouraged in the lake and around 3 per cent of the fishermen used it along the drift gill nets.

4.4.1.1.1 Institutional Support for Fisheries

In a sector dominated by poor fishermen the role of policies and institutions, assumes critical significance. Stock depletion in the lake due to various anthropogenic forces was a reason for reduction in social welfare of the fisherfolk which made many of them to leave this profession. Considering the depletion in fishery resource, the fisheries department and Agency for Development of Aquaculture (ADAK) implemented various stock enhancement programmes in the lake by introducing Indian major carps. Fish stock enhancement is a culture based technology for fisheries enhancement (Pillai and Katiha, 2004). According to Jhingran (1992) and Sugunan (1995) it could be used as strategy to increase the fish production in rivers and reservoirs in India. Consequently it was observed that at present the major fishes in fish landings are introduced fishes like major carp and indigenous fishes are decreasing in commercial catches which is a matter of concern.

For ecosystem based management and stronger enforcement of fishing regulations a co operative society named *Vellayani Kayal Malsyathozhilali Sahakarana Sangham* was formed on 30.03.2011 with the specific purpose of improving the socio- economic conditions of the fishermen. The present study was done taking thirty five fishermen as sample of which thirty one were society members. The society provides a platform for marketing the fishes through their outlet functioning near the lake (Plate 23). It also provides soft loans for the fishermen in case of any contingency. But mere membership in the society does not often lead to the welfare of the fisherfolk. Even though it is mandatory that all the members of the society should market their fish catch through the society only about 50 per cent of them were adhering to this. The reason is that the co-operative society is purchasing the fishes from the fishermen community and it is sold to the consumers through their outlet at a price greater than the purchase price. The difference in amount will be utilized for day to day and welfare activities of the society. The fishes from Vellayani lake are cherished by people, and seeing its demand the fishermen often directly sells to the consumers at the selling price existing in the society. The lack of co operation among fishermen, low educational status along with the lack of awareness on co operative principles may be the other reasons for the co operative society not getting better outreach among the fishermen. Lack of co operation among fishermen co operative society in Thiruvananthapuram district was also observed by Jinraj(1997).

4.4.1.1.1 Economic Value of Fishing

The costs involved in fisheries operations included both fixed and variable costs. Fixed costs were incurred for the purchase of the cost of country boat. The value of country boat was amortized to apportion the value to each year. As shown in

Plate 21. Focus group discussions

Plate 22. Fishing in Vellayani lake

Plate 23. Sales outlet of fishermen co operative society

Table 25 the amortized value of boat was estimated as Rs. 13.03 lakh year^{-1} which accounted to nearly 20 per cent of their total expenses.

The recurring expenses or variable cost included cost of gears, floats, rope, labour charge and repair charges of net and boat. The fishing nets get entangled in lotus and other aquatic plants and will be torn of frequently and are replaced every year which accounted more than 48 percent of their variable costs. The labour charge which is 1/3 rd of the daily income accounted to nearly 30 per cent of variable costs. Even though negligible by about 1 per cent, expenditure was incurred on repair and maintenance of gears and crafts.

Table 25. Expenditure pattern of fishing activity

Particulars	Total Expenditure (lakh Rs year^{-1})	% to total
I. Capital investment		
Amortized value of Boat	13.03	20.48
II. Recurring expenses		
Fishing gears and accessories	31.14	48.29
Labour	18.84	29.61
Repair and other charges	0.63	0.99
Total recurring expenses	50.62	79.53
Grand total	**63.65**	**100.00**

(Figures in parenthesis indicate percentage to total)

It was inferred that the total expenditure incurred by the fishermen was Rs 63.65 lakh per year.

The total returns from fishing was calculated based on the value of average catch per day of fish landings. The economically important fishes as per the data collected from the respondents were pearl spot, rohu, catla, prawn, striped snake head, stinging cat fish and tilapia. The market price prevailed during the study was collected from the co operative society. The average working days per year was 243 days. The average catch per day was multiplied by the corresponding market price to get the returns from fishing for the entire fifty four fishermen. Thus the economic value of fishing from the lake per year was worked out as 145.09 lakh per year (Table 26).

Table 26. Income from fishing from Vellayani lake

Type of fish	**Average catch per day(Kg)**	**Average market price (Rs/Kg.)**	**Market value (Rs. lakh /year)**
Pearl spot	1.19	230	35.91
Rohu	2.11	110	30.45
Catla	1.82	100	23.88
Prawn	0.36	330	15.58
Striped snake head	1.29	120	20.31
Stinging Cat Fish	0.125	60	0.98
Tilapia	1.71	80	17.95
Grand total			**145.09**

In a similar attempt Hema (2013) estimated the annual income from fishing from mangroves in Ernakulam region was Rs 20,59,94/- and in Kannur it was Rs.14,83,34.

4.4.1.2 Lotus Collection

The lotus, *Nelumbo nucifera Gaertn*., under the family Nelumbonaceae is the national flower of India. It is regarded as sacred and treated as a symbol of purity and sanctity because of the unique beauty (Mandal and Bar, 2013). Lotus is a perennial plant and is a spiritual symbol for Hindu religion. Culturally, lotus was considered auspicious in society, with evidence of its use in many spheres. The flowers are used for worships in temple, to make garlands and the leaves are used for wrapping flowers and to serve rice. It has therapeutic value also.

The presence of lotus plant in Vellayani lake was mentioned in the history and it has an association with tradition and culture of the region. The lake was mainly used to grow lotus flower for the Lord Sree Padmanabha. Later, when paddy cultivation was started the lotus plants were destructed due to dewatering. After the cessation of paddy cultivation the lotus plants have grown luxuriously and now it covers a considerable area of the lake. In course of time people started collecting (Plate 24) and selling the leaves and flowers in local markets for their livelihood.

The lotus plants are naturally grown in the lake and not commercially cultivated. The lotus collectors formed a group of 2-3 and they use country boats to traverse across the lake during early morning by around 6 am. Among them one person rowed the boat and others collected the leaves and flowers. Harvesting was done by cutting the base of the leaves without stem, and the flowers are cut with stem. On an average, five hours are spend in the lake in the morning and evening to collect the leaves and flowers. In the evening also the same process was continued. The leaves are wrapped in bundles of hundred and flowers were sold single and are marketed next day only. Leaves were more economically important and flowers were not available throughout the year especially during the cold months as the growth of lotus is through two distinct periods, active and dormant (Mandal and Bar, 2013). The collected leaves are marketed either directly or through intermediaries.

4.4.1.2.1 Economic Value of Lotus

The expenditure on lotus collection (Table 27) included investment cost, recurring cost and marketing cost. Out of the total cost of Rs 12.08 lakh per year nearly 2 per cent was incurred by the investment expenditure for country boat and vehicle.

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Plate 24. Lotus collection in Vellayani lake.

Table 27. Expenditure pattern of lotus collection (lakhRs/ year)

Sl no	Particulars	Value	% to total
I	**Investment Cost**		
1	Amortized value of country boat	0.14	1.19
2	Amortized value of Vehicle for transportation	0.1	0.79
	Total Amortized value of capital investment	**0.24**	**1.99**
II.	**Recurring cost**		
1	Knife	0.04	0.31
2	Coir	0.49	4.08
3	Boat rent	0.6	4.97
4	Labor charge	6.79	56.21
	Total recurring expenses	**7.92**	**65.56**
III.	**Marketing cost**		
1	Transportation charge	3.47	28.73
2	Loading and unloading unloading	0.45	3.71
	Total marketing cost	**3.92**	**32.43**
IV	**Total Cost(I+ II+ III)**	**12.08**	**100.00**

The recurring expenses of 65.66 per cent included the cost of knife (often lost in the lake during collection and frequently purchased), coir for making bundles of leaves, rent for the boat (for those who did not own a boat) and labour charges. The average labour cost prevailed was Rs 175 per day and it accounted to more than 56 per cent of the total cost. The high labour cost is typical in any income generating activity in Kerala and was confirmed by Kannan (1998) and Devi (2012). Thus the total recurring expenses incurred by them was estimated as Rs 7.92 lakh per year.

The marketing cost included transportation charge and loading and unloading charges which also accounted to one third of the total cost. Thus it can be inferred that the total expenses incurred for lotus collection in the lake was Rs 12.08 lakh per year.

The lotus collectors are getting income by the sale of leaves and flowers (Table 28). The flowers are not available throughout the year but the lotus leaves are abundant in the lake and it is the main source of income to them. Leaves are sold in bundles of hundred. Fifty per cent of them sell the produce directly in the flower market and others are selling it through the intermediaries. The leaves and flowers marketed directly fetched a price of Rs.25 per bundle and Rs.1 per flower while the intermediaries are purchasing flowers at a rate of Rs 20 per bundle and 50 paisa per flower only.

Table 28. Returns from lotus collection

Sl no	**Particulars**	**Quantity collected per year**	**Value (lakh Rs /year)**
1	Leaves (bundles)	1,41,270	29.12
2	Flowers(number)	4,53,600	4.5
	Total		33.63

The total value of lotus collection was obtained by multiplying the number of leaf bundles and flowers collected with their respective selling price and their average working days per year. The economic value of lotus collection from the lake was Rs.33.63 lakh per year.

In a similar attempt Jain *et al.* (2004) reported that an income of Rs. 57000 per year was generated through lotus collection in Sanepat lake of Manipur.

4.4.1.3 Duck Rearing

Ducks are very common domesticated bird for eggs in Vellayani area (Plate 25). Duck rearing is a subsidiary source of income for the stakeholders. The farmers usually keep the adult ducks under a scavenging or free-range rearing system in

Plate 25. Ducks wading in Vellayani lake

which the ducks are released to the lake in the morning and are driven back to the housing or sheds in the evening.

4.4.1.3.1 Economics of Duck Rearing

Since duck rearing is not practiced as a commercial enterprise and it did not demand high fixed cost. Artificial feed were not used for rearing ducks and they are fed with about 200gm of wheat /rice per day.

The expenditure pattern of duck rearing of the sample represented in Table 29 revealed that investment on housing and cost of ducks accounted to nearly 4 per cent of total expenses per year. The recurring expenses included cost of feed and medicines and it accounted to about 96 per cent of the total expenditure. Thus the duck rearing in the lake demanded Rs. 2.50 lakh per year.

Table 29. Expenditure pattern in duck rearing

Sl no	**Particulars**	**Value in lakh Rs/ year**	**% to total**
I	**Investment cost**		
1	Amortised value of Shed	0.06	2.6
2	Cost of Ducks	0.02	1.1
	Total investment cost	0.08	3.7
II.	**Recurring Cost**		
	Feed and Medicine	2.42	96.23
III	**Total Cost(I+II)**	**2.50**	**100.00**

The returns from duck rearing (Table 30) included primarily the income from sale of eggs as the ducks were raised mainly for table egg production. Ramachandran and Ramakrishnan (1982) and Ravindram (1983) also reported that the primary purpose of duck rearing in Kerala is table egg production. The demand for fresh duck eggs is very high in Vellayani area and outskirts and an egg fetched a price of Rs 10.

The birds were sold on demand from the consumers or else used for family consumption and they are sold at the rate of Rs.200 per bird (weighing 1 to 1.25 kg).

Table 30. Returns from duck rearing

Sl no	**Income**	**Quantity (Number per year)**	**ValueRs lakhs/year**
1.	Eggs	33900	3.39
2.	Birds	50	0.40
	Total		3.79

The economic value of duck rearing was derived by multiplying the total number of eggs and birds sold per year with the average market price. Thus the contribution of duck rearing to the total value of Vellayani lake was Rs 3.79 lakhs per year. The economic importance of duck rearing is less with respect to the TEV of the lake system but it is worth to watch the birds wading in the lake and it add to the richness in biodiversity. The number of duck rearers in the Vellayani lake system is decreasing owing to theft of birds, attack by dogs and also economic loss as the birds lay eggs anywhere in the lake since they are kept in free range system.

4.4.1.3.2 Comparative Analysis of Provision of Income Generation from the Lake

The Table 31 illustrates the gross income derived from livelihood generation from the lake system. More than 80 per cent of the income generation from the lake was from fishing followed by lotus collection (18.23%) and duck rearing (Fig.7). Thus the existence of Vellayani lake, creates an economic earning worth Rs 1.83 crore per year for the people inhabited in and around the lake.

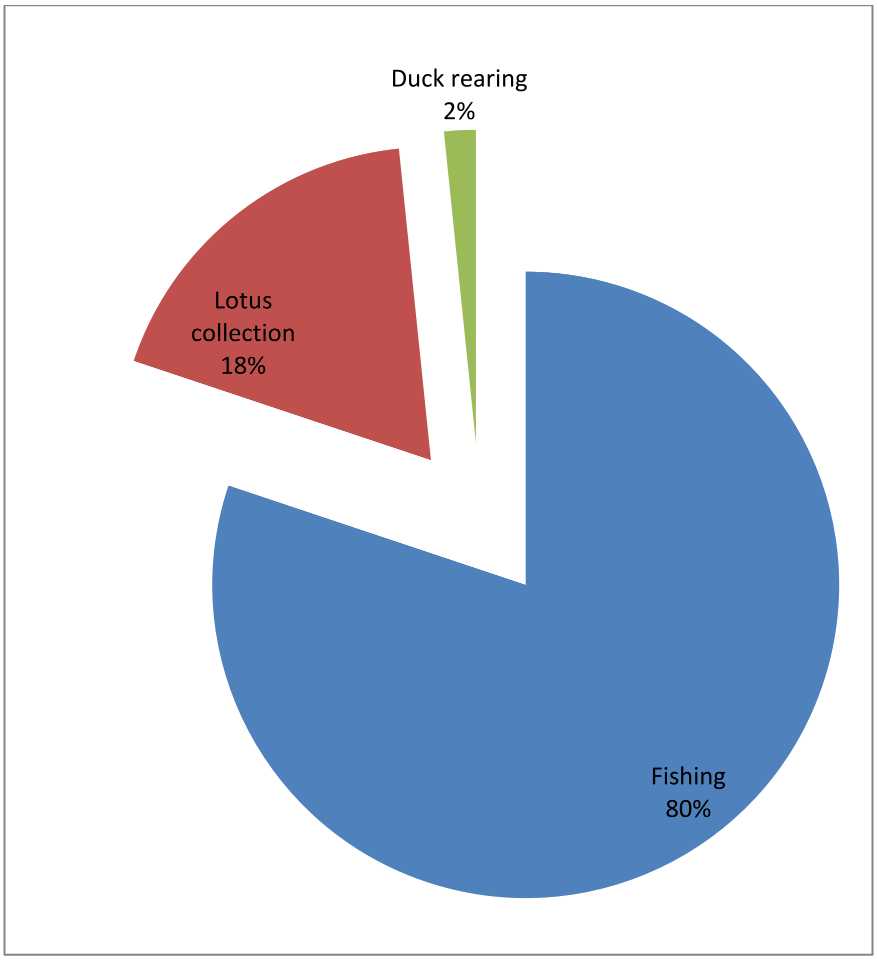


Figure 7. Income generation from the lake - A comparison

Table 31. Income generation from the lake- A comparison (Crore Rs /year)

Sl No	Category	Gross income	% to total
1	Fishing	1.45	80.11
2	Lotus collection	0.34	18.23
3	Duck rearing	0.04	1.63
	Total	1.83	100.00

Thus it can be inferred that in spite of providing the basic life support system the lake is livelihood provider for the stakeholder communities which indicated its role in determining the socioeconomic status of the people around the lake. So it become apparent that these stakeholder communities be addressed while implementing the conservation strategies to provide equitable access to all the groups in income generation activities.

4.4.1.4 Drinking Water Provision

Water is crucial for all life on earth. It plays an essential role in our health, economy, food production, and environment. Safe drinking water is imperative for public health, economic development and economic welfare. The value of water and the importance of having the public recognize the true value of water are of great relevance to the goals of achieving sustainability and efficiency in water supply systems.

Thiruvananthapuram, the capital city of Kerala is facing severe shortage of drinking water due to lack of enough fresh water sources. Vellayani lake, assumes importance as it is the only fresh water lake in the district. At present the lake serves as an important source of drinking water for the outskirts of the Thiruvananthapuram city. The water supply schemes established in the lake are by Kerala Water Authority (KWA), Central Public Works Department (CPWD) and College of Agriculture (CoA), Vellayani.

In addition to this, the construction of a major water supply scheme by KWA is progressing in the lake near Agricultural College which has immense potential to serve the water scarce areas of Kovalam and Vizhinjam.

In Kerala the public water supply is done through KWA. KWA was established on April 1st 1984 as an autonomous body of the Government of Kerala (GOK, 2008). The major water supply schemes established by KWA at Vellayani lake are explained below.

Kalliyoor-Thiruvallom-Muttacadu (KTM) Scheme supplies water to Ward no 1, 15 and 16 of Kalliyoor and ward 2 of Venganoor panchayat. The pump house is situated at Reservoir Bund (Plate 26). The scheme comes under the jurisdiction of Assistant Engineer's Office at Thiruvallam. Two pumps, one of 75 HP centrifugal pump and another of 60 HP submersible pump extracts water from the lake, 24 hours a day. The water is carried through cast iron pipe with a diameter of 200 mm to reach the filter plant at Vandithadam. The capacity of the water treatment plant is 2 MLD. The discussions with the officials revealed that the plant is not functioning to its full capacity due to the natural wear and tear over the years and nearly 1.6 MLD of water is pumped from the lake daily.

Another scheme Water Supply Scheme to Vizhinjam Transhipment Terminal was commissioned on April 2013 (Plate 27). The well cum pump house in the lake is located at Vavvamoola. Two 75 HP pumps extract water which is delivered to the treatment plant site at Vizhinjam through 200 mm DIK9 raw water pumping main. The water treatment plant is having a 3.3MLD capacity.

Water Supply Scheme to Kovalam Tourism Area and Vizhinjam Portion (Plate 28) is an ongoing project yet to be commissioned. Kovalam international tourist destination is the hot spot to the tourists from around the world. The comprehensive area of the scheme comprises of the entire Kalliyoor, twenty wards of Venganoor Panchayats and seventeen wards of Thiruvananthapuram corporation. The intake well is under construction at the Vellayani lake and the Treatment plant at the Agricultural College campus. The ultimate demand for the whole scheme expected is 21.9 MLD (WASCON, 2012). The work is being executed through the Kerala Water Authority and monitored by Department of Tourism.

In addition to this the Central Government Office complex had also installed a drinking water pumping station and is maintained by Central Public Works Department (CPWD) which is meant exclusively for Central government office complex and its quarters located at *Poonkulam*. The pump house is located near the KWA pump house in the reservoir (Plate 29). The discussions with the officials revealed that about 1,40,000 litres of water is pumped from the lake daily. The filtering of water is done at the filter plant in *Poonkulam.*

There are two drinking water pump houses in CoA, Palapoor pump house and college pump house for meeting water requirements of college, hostels, quarters, all the department and sports school situated inside the college. The drinking water is pumped from the well near the lake. On an average 95,000 litres of water is pumped from lake per day to cater the needs of the college.

4.4.1.4.1 Valuation of Drinking Water Provision

In this study drinking water is valuated using market price method. For this quantity of water extracted per year is multiplied by corresponding market price to get the economic value. In Kerala, drinking water supply is highly underpriced and subsidized to cater the needs of all sectors of the economy. So the use of domestic water rates fixed by Kerala Water Authority will not reflect the true value or to at least recover the full cost of producing and distributing water. Verma (2001) also reported the same while valuing the drinking water provision of Bhoj wetlands. During the study it was observed that many tanker lorries are supplying drinking water to water scarce areas in the catchment area. They are charging a price of Rs. 3750 per Kilo litres. This price was employed in calculating the economic value of drinking water extracted from the lake.

Plate 26. KTM Scheme

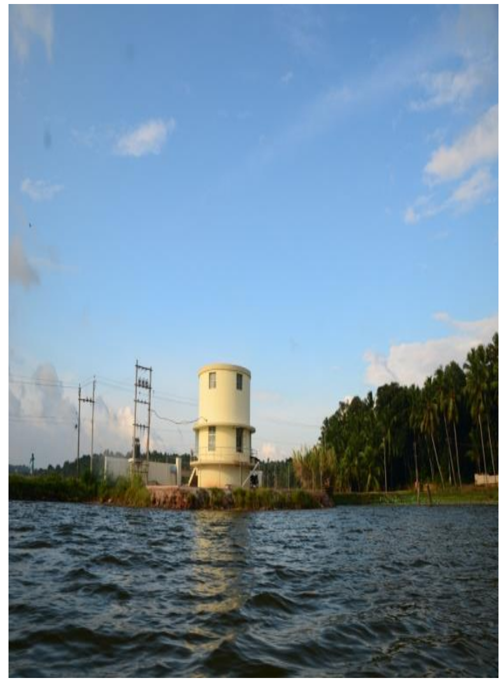


Plate 27.WSS to Vizhinjam

Plate 28. WSS to Kovalam (Under construction)

Plate 29. CPWD pumping station

A new scheme WSS to Kovalam and Vizhinjam has an ultimate potential of 21.9MLD. At present there is a lacunae of quality water supply with fully treated water to this area. If safe and acceptable water supply is ensured in adequate quantities, there is scope for flourishing tourism. These areas which are the main attraction of international tourists to India are source of foreign exchange to the country. The drinking water supplied from the lake after the completion of the project will definitely boost the tourism industry and will increase the foreign exchange earnings. So the project has got relevance in the national level also. The water extraction from this project was also considered for valuation.

Table 32. Economic value of drinking water provision

Sl No.	**Scheme**	**Quantity of water extracted (lakh litres per year)**	**Value in Rs Crore / year**
I	**KWA scheme**		
1	KTM scheme	5840	21.9
2	WSS to Vizhinjam	12045	45.17
3	WSS to Kovalam and Vizhinjam	79935	299.76
	Sub total(Total1+2+3)	**97820**	**366.83**
II	CPWD	511	1.92
III	CoA	346.75	1.3
	Total	**98677.75**	**370.05**

It was inferred that nearly 98677.75 lakh litres of water was extracted from the lake for various water supply schemes (Table 32). The economic value of drinking water provision was multiplicative of total water extracted to the market price of drinking water. The total value of drinking water provision by the lake worked out was Rs.370.05 crore year^{-1}.

The role of Vellayani lake is important in terms of water security of the region providing access to safe drinking water to the people. Access to safe drinking water is very much essential for human health. So the presence of a valuable fresh water source averts health risk of the people due to the consumption of the contaminated water. Thus the contribution of the lake in terms of water and health security of the people assumes importance.

Valuation of drinking water supply from wetlands was also done by Verma (2001) in the Upper lake of Bhoj wetland using supply cost method and estimated the value as Rs.9.54 crore per year. In a similar attempt, Pour and Kalashami, 2012 used Contingent Valuation Method for determining economic value of drinking water in Kohkiloye & Boyerahmad province of Iran and the results indicated that economic value of drinking water is 6877 Rial per cubic meter.

4.4.1.5 Provision of Irrigation Water

Vellayani lake is a potential source of irrigation in the area. But the practice of irrigating the crops using water from the lake was not observed in the area. The farmers are using the water from the canals flowing through their fields for irrigation.

Table 33. Cropping pattern of instructional farm,Vellayani

Block	**Area (ha)**	**Cultivated area (ha)**	**Irrigated crops**	**Rainfed crop**
A	6.30	6.30	Vegetables, banana	Coconut,nutmeg
B	20	16.00	Vegetables, Rice	Coconut
C	14.70	12.50	Banana	Tuber crops
D	18.00	16.65	Vegetables, banana	Tuber crops, coconut
E+F	6.00(E)	5.00(E)	Potting shed, Progeny orchard, Fodder, College Garden	Coconut
	10.(F)	7.8(F)		

(Instructional Farm, 2013)

The College of Agriculture, located on the banks of Vellayani lake is using the lake for irrigation, which is having research plots and instructional farm for imparting agriculture education.

The college has well maintained instructional farm. Cropping pattern of the farm is coconut based intercropped with vegetables, banana and tuber crops (Table 33). Coconut and tuber crops are rainfed crops while all other crops are irrigated. The irrigation water is pumped directly from the lake to irrigate the crops in the instructional farm. The details on the quantity of irrigation water pumped from the Vellayani lake is given in the Table 34. Three pumps are directly pumping 15.12 lakh litres of water per day for irrigation and others are augmentation pumps.

Table 34. Quantity of water pumped for irrigation

Sl No	Name of pump House	Type of pump	Source	Working Hours	Discharge (litres /sec)	Volume of water pumped from lake(lakh litre per day)
1	Irrigation pump 1	KDT 2070	Lake	9	30	8.64
2	Irrigation pump2	KDS1050 KDT 1050	Sump	6	15	----
3	Mannamvarambu (NARP)	KDT1050	Lake	6	15	3.24
4	Colony nada	KDT850	Lake	6	10	3.24
5	NARP Palappoor	10HP	Infiltration pond	6	15	-
6	Diesel pump	5Hp	Water pit	3	10	-
	Total quantity extracted directly from lake					15.12

(Source-Instructional farm, 2014)

4.4.1.5.1 Economic Value of Irrigation Water

Valuation of irrigation water in the context of ecosystem valuation is complex. The direct valuation method using existing market price will not reflect the actual value of irrigation water as the irrigation water is underpriced in the state. Vijayan

(2004) in her study on Neyyar irrigation project also reported that in Kerala the irrigation water is underpriced.

According to Jantzen (2006) the opportunity costs of a resource, is the value of the next highest valued alternative use of that resource and the total revenue for next best alternative is the welfare measure. The drinking water is the next best alternative use of lake water when compared to its use as irrigation water. Thus the total revenue that could have been earned if it were used for drinking water purpose is the economic value of irrigation water. The total value of water extracted for irrigation was estimated by multiplying the actual quantity of water extracted per year from the lake for irrigation with market price of drinking water (Rs. 3750 per kilolitre) and the amount was estimated as Rs.20.69 crores per year.

4.4.7 Bathing and Washing

Vellayani lake is used by people for bathing, washing and to wash the livestock. People are using the lake due to water scarcity in houses and to enjoy the opportunity to swim and bath in the lake. On an average about fourteen persons are bathing and five cows are washed per day in the lake. Based on the discussions with the respondents the per capita use of water for bathing and washing was 20 litres and for washing cows it was 100 litres. This was evaluated using opportunity cost method *ie*. multiplicative of price drinking water and price of equal quantity of water used for bathing and washing. Total value for bathing and washing was Rs 0.009 crores per year. But bathing and washing poses problem of pollution of water.

4.4.1.7 Summary of Provisioning Service

The provisioning ecosystem services of the lake used by the stakeholders were fishing, lotus collection, duck rearing, drinking water, irrigation water and bathing, which together contributed Rs.392.58 crore per year to the TEV of the lake. The value of provisioning services is given in the Table 35 and is presented in Fig. 8.

It was observed that the drinking water contributed nearly 95 per cent of total provisioning service. There is growing importance of the Vellayani lake in providing

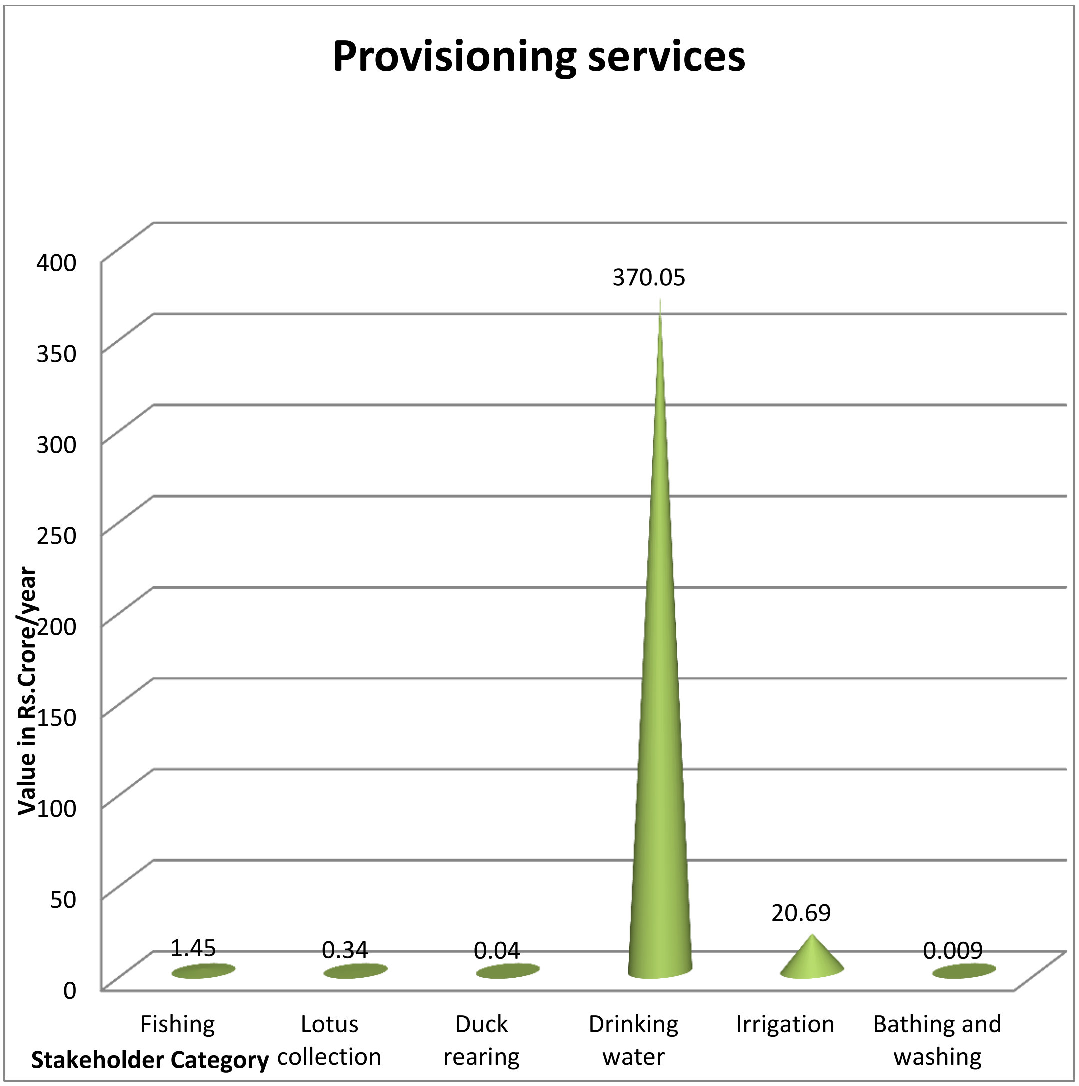


Figure 8. Provisioning services of the lake - A comparison

life sustaining materials like drinking water even to the people outside the two panchayats. In the current scenario of global warming and climate change, water scarcity is creating crisis to the city dwellers as well as those living in the outskirts of Thiruvananthapuram district, drinking water provision by the lake assumes paramount importance.

Table 35. Value of provisioning service by the lake-A comparison

Sl No	Provisioning service	Method	Economic value(crore per year)	% to total
1	Fishing	Market price	1.45	0.37
2	Lotus collection	Market price	0.34	0.09
3	Duck rearing	Market price	0.04	0.01
4	Drinking water	Market price	370.05	94.27
5	Irrigation	Opportunity Cost	20.69	5.27
6.	Bathing and washing	Opportunity Cost	0.009	0.00
		Total	**392.58**	**100.00**

The lake is providing livelihood through fishing, lotus collection, duck rearing, used for irrigation, bathing and washing which accounted to about 6 percent of total provisioning services Thus the conservation of the lake is highly important as it is a drinking water source, provides livelihood, enhances agriculture research and food security through provision of irrigation.

4.4.2 Cultural Services

Traditionally, the Vellayani lake provided many and varied important social, ecological and economical functions at different periods of societal development. It is a place for rituals conducted in the nearby temples. The important cultural service provided by the lake are

1. Recreational and spiritual services

2. Cultural services
3. Aesthetic services
4. Opportunity for formal education and training

4.4.2.1 Recreational and Spiritual Services

The recreational value of the lake is important while calculating the TEV of the lake. Photography, bird watching, boat race, and *Karikidaka vavubali* are the recreational and spiritual activities of the lake. The recreational area is dispersed over two locations one in Kakkamoola bund road and the other at reservoir bund.

Karkidaka Vavu Bali, the Hindu ritual performed in memory of the departed souls of ancestors, is conducted every year in Vellayani lake. It coincides with the no moon day of Malayalam month *Karkkidakam.* People believe that the departed souls attain liberation if the ritualistic homage is performed on *Karkidaka vavu* (Plate 30). Thousands of people throng the lake on that day for offering rituals so that their ancestors could attain peace in heaven. Priests from *Vevila* temple and *Thrikulangara* temple on the banks of Vellayani lake help people to perform the ritual.

Travel Cost Method (TCM) is a standard procedure for estimating the recreational value of natural resource. TCM is considered the oldest method for assessing environmental amenities, developed by Harold Hotelling in 1947. Hotelings model consisted of estimating the visit rate based on the distance tourists had to travel. His model was extended by Clawson and Knetch who employed the price of substitutes and quality of evaluated destinations (Spacek and Antouskova, 2013). TCM estimates the Marshallian consumer surplus, which approximates, and is bounded by, the compensating variation (CV) and equivalent variation (EV) welfare measures (Brander *et al.*, 2006)

TCM methodology is a surrogate market approach where by expenditure in an associated market, (in this case the market for travel) is used to estimate the benefits measured as consumer surplus, of the recreation service provided by natural areas. The travel cost incurred by individuals when visiting a recreation site is an implicit price for the services of that site. Exploiting the empirical relationship between increased travel distances and associated declining visitation rates would allow for the estimation of the demand relationship. In this way, the Marshallian demand curve for the recreation service can be estimated and appropriate consumer surplus measures calculated thus provides a basis for comparing them with the cost of their supply (Driml, 2002). In TCM, if a consumer visits a recreational site, the benefits he receives should be less than or equal to the cost incurred, although he does not pay a market-determined price. As such, this method uses the travel cost as a proxy for the price of recreation assuming rational behavior on the part of the consumer. In this exercise Individual Travel Cost Method (ITCM) was employed. For conducting ITCM study a sample of 85 respondents were selected for eliciting the information.

The total number of visits made to the lake by each visitor per year for various purposes was expressed as a function of socio economic characteristics and the travel cost per visit to generate the Trip Generating Function (TGF).

Poisson regression for count data was used to estimate the TGF. Use of Poisson regression for count data model for estimation of TGF analysis had been confirmed by Fonseca and Rebelo (2010). The method of maximum likelihood was used to estimate the parameters of TGF. This method isolates the parameter estimates that are most likely to occur in the given data. These parameter estimates maximize the likelihood function which expresses the probability of the observed data as a function of unknown parameters (SAS Institute, 2008). The data was analyzed using SAS package with Poisson regression for count data model.

The functional form fitted is given below.

$$\text{Log}(\mu) = \beta_0 + \beta_1 A_i + \beta_2 I_i + \beta_3 T_i + \beta_4 C_i + \beta_5 P_i$$

or

$$\mu = \exp(\beta_0 + \beta_1 A_i + \beta_2 I_i + \beta_3 T_i + \beta_4 C_i + \beta_5 P_i)$$

Where,

μ - Number of visits made per year

A_i - Age of respondent in number of years

β_1 - Regression coefficient of A_i

I_i - Individual income (Rs/month)

β_2 - Regression coefficient of I_i

T_i - Time spent in lake in hours

β_3 - Regression coefficient of T_i

C_i - Travel cost incurred per trip to visit the site (Rs.)

β_4 - Regression Coefficient of C_i

P_i - Purpose of visit

β_5 - Regression Coefficient of P_i

The selected parameters are explained below. Regarding the age (A_i) of the respondents, more than 48 per cent of the respondents belonged to the age group of 40 and above. Nearly 10 per cent among them were senior citizens. The individual income (I_i) per month of more than 70 per cent of the visitors ranged between Rs 10001/- and Rs.20,000/- .The average monthly income of the visitors was Rs 18094/-. Individuals visit the lake for photography, enjoying scenic beauty, cultural activities and spiritual activities. The time spent (T_i) varied according to the purpose. It was observed that those coming for photography spend nearly five hours in lake while others spend nearly one to two hours per visit. Travel cost (C_i) per visit included total cost incurred in travelling to the lake and back. The cost of food and water if incurred was also included. The average travel cost incurred was Rs 94.24 per visit. Purpose of visit (P_i) was included as dummy variable with the value of 1 if the purpose was spiritual activity, 2 if the purpose was cultural activity and 3 if the purpose was photography or site seeing.

The criteria for assessing the goodness of fit are provided in Appendix. XIV. The measures are the deviance and the Pearsons Chi square statistic. The values of these statistics divided by the squared scale parameter (that is dispersion parameter) are called the scaled deviance and scaled Pearsons Chisquare. Because the scale parameter by definition is 1 for Poisson regression, the statistics (original and scaled) are equal.

The value /DF (Degrees of freedom) values are computed by dividing the goodness of fit statistics by degrees of freedom. These values for the scaled deviance or the scaled Pearsons chi square are useful for assessing the goodness of fit of the model. Values close to 1 indicate good model fit. The value/ DF column was 2.6057 for scaled deviance and 2.6079 for scaled Pearson chi square. They are not close to one. This might indicate over dispersed data which occurs frequently in Poisson regression. But over dispersion does not affect parameter estimates (SAS Institute, 2008).

Other fit statistics included the Akaike Information Crieteria(AIC), the Corrected Akaike Information Criteria (AICC) and Beyesian Information Criteria (BIC). Each statistics is a measure of the goodness of the model fit. Smaller value represents better fit. Different models were estimated taking into account various combinations of the explanatory variables. The model with the smallest AIC (532.12), AICC (533.57) and BIC (549.22) values was selected for the study. The parameter estimates are given in the Table 36.

Table 36. Parameter estimates of TGF

Parameter	**DF**	**Estimate**	**Standard Error**	**Pr > ChiSq**
Intercept	1	2.1766**	0.253	<.0001
Age(A_i)	1	-0.0041	0.0033	0.2173
Individual income(I_i)	1	0.000	0.000	<.0001
Time spent (T_i)	1	0.0769*	0.0382	0.0443
Travel cost (C_i)	1	-0.0018**	0.0007	0.0085
Purpose of visit (1)	1	-0.2702*	0.1338	0.0435
Purpose of visit(2)	1	-0.3155**	0.1075	0.0033
Scale	0	1	0	

** Significant at 1 per cent level of significance

*Significant at 5 per cent level of significance.

The overall signs and significance of estimated co efficient were consistent with both the economic theory and existing literature. The negative sign and significance of travel cost variable (-0.0018) indicates a demand schedule which is consistent with recreation demand studies of Shrestha *et al.* (2002) and Marawila *et al.* (2010). It also indicates that the visitation rate decreases as travel cost increases. Other significant variables were income, time spend in the lake, and purpose of visits.

Consumer surplus is widely accepted measure of net social benefit (Zawacki *et al*., 2000). Based on the estimated model consumer surplus per trip was estimated using the formula

$$CS = | 1 / \beta_4 |$$

Where β_4 is the estimated coefficient of travel cost (Hanley *et al*, 2004). Thus by finding the absolute value of reciprocal of travel cost coefficient consumer surplus per visit was estimated as Rs. 555.55. The estimated total recreational value of the lake obtained by multiplying the total number of vistors by the consumer surplus per visit was Rs. 55.83 lakh per year (Table 37).

Table 37. Recreational value of Vellayani lake

Particulars	**Value**
Consumer surplus per visit	Rs 555.55
No of visitors per year	10050
Total Consumer surplus	Rs 5583278
Recreational value in lakh Rs year $^{-1}$	55.83

Similar studies were very few in Kerala. In an attempt to determine the recreational value of the Periyar Tiger Reserve of Kerala, Bulov and Lundgren (2007) used TCM to determine the consumer surplus as 15 billion USD. Similarly recreational value of Ashtamudi estuary employing TCM by Anoop (2007) was Rs 0.15 crores which is less than the estimated value of Vellayani lake. Recreational value of Kaziranga national park estimated by Bharali and Mazumdar (2012) using TCM was Rs 773.45 Million. Dehalavi and Adil (2011) also applied TCM to Keenjhar lake and estimated the recreational value of the lake as 42.2 million USD.

4.4.2.2 Cultural Service

Kerala is famous for its boat races conducted in different water bodies in many districts. In Thiruvananthapuram the most famous boat race is the Ayyankali Trophy boat race conducted annually in Vellayani lake. It is conducted every year under the joint auspices of Government of Kerala and Mahatma Ayyankali Jalolsava Samithi trust on the *Avittam* day of Malayalam month Chingam.

In the cultural feast conducted in September 17, 2013 big rowing boats (*Chundan vallam*) and small rowing boats participated in the regatta which created a festive mood in the two panchayats (Plate 31).

Plate 30. *Karkidaka Vavubali*-The spiritual offering in lake

Plate 31. Ayyankali Boat race

Table 38. Public Investment for Ayyankali Boat Race, Lakh Rs /year

Sl No.	Particulars	Expenditure
1	*Chundan vallam*	2.46
2	Sounds	0.70
3	Arch stage pavilion	0.57
4	Nadan pattu	0.39
5	Motor boat	0.11
6	Procession	0.08
7	Printing	0.30
8	Photo	0.14
9	Flex	0.29
10	Trophy polishing	0.04
11	Announcement	0.00
12	Trophy	0.06
13	Badge	0.03
14	Rent	0.02
15	Price –first	0.65
16	Second	0.32
17	Third	0.22
18	Vanitha	0.12
19	Kayaking	0.06
20	Swimming	0.05
21	DTP	0.03
22	Press meeting	0.01
23	Car rent	0.16
24	Travel	0.08
25	Miscellaneous	0.08
26	Electricity	0.01
	Total	6.9

(Ayyankali Jalolsava Samithi Trust, 2014)

As explained by deGroot *et al.* (2006) public investment made for ecosystem service use was employed for assessing economic value. The pattern of investment made for the event in the year 2013 is given in the Table 38. It was revealed that the total investment made for the ecosystem service use was Rs 6.9 lakhs which indicates the economic value of the ecosystem service use for boat race per year.

4.4.2.3 Aesthetic Services

Lakefront property is preferred for residence by people to enjoy the scenic beauty and cool breeze. Such property with aesthetic value usually fetches a premium price when compared to properties without it. This study employed Hedonic Pricing Method to examine the components that determine the property price of land around the lake and the contribution of aesthetic value in determining the property price. Hedonic Pricing Method (HPM) is a revealed preference method of valuation. It uses surrogate markets for placing a value on environmental quality. The real estate market is the most commonly used surrogate in hedonic pricing of environmental values. The HPM is based on the idea that properties are not homogenous and can differ with respect to a variety of characteristics. Property prices can be affected by location specific environmental, structural, and neighborhood characteristics. It relies on observable market transactions to obtain values of various characteristics of heterogeneous products (Boxall *et al*., 2005). It also assumes that the housing market is in equilibrium, individuals had made their utility maximizing choices given the prices of alternative housings locations and these prices just clear the market.

In the present study, eight locations around the lake were selected for study with a sample size of two hundred and forty. The primary data set for analysis was actual property price per cent of households in the year 2013. Selection of variables was based on the discussions with realtors and local residents. The details of variables selected for study is given in Appendix VIII. The variables selected were environmental, neighbourhood, location and lake view. To describe the lake view characteristic dummy variables were included with a value of 1, if lake view is there and 0 if there is no lake view.

The data set were subjected to step wise regressions using linear, semilog, log and quadratic model. The most appropriate fit was selected based on the statistical significance and theoretical corrections. When the results were compared the linear functional form had the best fit it was retained for study. The linear hedonic price function selected is expressed below.

$$P_i = \beta o + \beta_1 E_i + \beta_2 L_i + \beta_3 N_i + \beta_4 V_i + \beta_5 V_i + e_i$$

Where

βo- Intercept

P_i - price per cent of the property at the time of data collection

β_{1-} Regression coefficient of P_i

E_i - Vector of environmental attributes of that property

β_{2-} Regression coefficient of E_i

L_i -Vector of location attributes

β_{3-} Regression coefficient of L_i

N_i -vector of neighbourhood characteristics

β_{4-} Regression coefficient of N_i

V_i - Lake view variable (dummy y=1,n-0)

β_{5-} Regression coefficient of V_i

e_{i-} Error term

The linear model selected with nine variables could explain the variability in land price around the lake. The variables found statistically significant with the prior expected signs are represented in the Table 39.

Table 39. Explanatory variables and their expected effect

Sl No	Particulars	Expected effects
	Location attributes(in meters)	
1	Distance to market(in meters)	-
2	Distance to school/college (in meters)	-
3	Distance to nearest hospital (in meters)	-
4	Distance to closest road with good transportation facility (in meters)	-
5	Distance to nearest shopping centre (in meters)	-
6	Distance to nearest bus stop (in meters)	-
	Neighbourhood attributes	
7	Availability of Pucca road to the plot(yes=1/no=0)	+
8	Noise exposure(scale of 1-3)	-
	Lake view variable	
9	Lake view(y=1/n=0)	+

+ Increasing effect on property price

-decreasing effect on property price

All the location attributes were expected with a negative sign. Among the neighborhood attributes the availability of pucca road was expected with positive sign while noise exposure was expected with negative sign and the lake view variable with positive sign. Availability of view to the beauty of the lake will add to property price so it was expected with a positive sign. The regression results represented in Table 40 revealed that none of the environmental attributes were significant in determining the property price.

Table 40. Parameter estimates of Hedonic Price Function

R^2 = 0.75

Variable	Parameter Estimate	Standard Error	F Value	Pr > F
Intercept	1.55859**	0.18159	73.67	<.0001
Distance to market	0.0008724**	0.00017934	23.67	<.0001
Distance to school/college	-0.00102**	0.0001812	31.56	<.0001
Distance to nearest hospital	0.0002636**	0.00007346	12.88	0.0004
Distance to closest road	-0.00365**	0.00049457	54.51	<.0001
Distance to nearest shopping centre	0.00108**	0.0001145	88.2	<.0001
Distance to nearest bus stop	-0.00171**	0.00012543	185.52	<.0001
Availability of Pucca road to the plot	1.01709**	0.07934	164.35	<.0001
Noise exposure	-0.12039*	0.05174	5.41	0.0208
Lake view(y=1/n=0)	0.32414**	0.07941	16.66	<.0001

*Significant at 5 per cent level

**Significant at 1 per cent level

Out of the location attributes distance to market, distance to school/college, distance to nearest hospital, distance to closest road with good transportation facility and distance to nearest shopping centre were found to affect the property price. Out of the neighborhood characteristics only availability of pucca road and noise exposure had an impact on property price.

As against the expectation, the property price was found to increase with the distance to market. This may be due to the difficulty in getting fruits, vegetables, fish etc. in the absence of accessibility to market. The reason may be the odour and pollution from the markets and resultant health problems. Same trend was observed with respect to the distance from the hospital also. This may be because the people are health conscious and proximity to hospital may cause health problems due to contagious diseases and hospital waste. Another reason may be the accessibility of doctors in their residence. Regarding the shopping centers in all the eight locations selected there were enough shops in the area. But most of the respondents preferred margins free markets, where commodities are available in cheap rate and they are located away in the main junctions only. This may be the reason why people are not giving importance to such shops, and the coefficient was found positive as against the expectation.

The results of the analysis revealed that the most significant factor that contributed to the property price is the availability of the pucca road to the plot. The next important factor that influence the land price was view of Vellayani lake. This is in consistence with the studies by Chaudhry *et al.* (2013) that a firm and positive link between market rates of residential plots and environmental attributes like good water quality lake proximity was noticed in Chandigarh, India. The significant regression coefficient of the lake view variable indicated that the lake view influenced property price of property around the lake. The land with lake view was of two types in the study area. In the locations like Vavvamoola, Venniyoor, Kadavinmoola and some areas of Palapoor and Kakkamoola the lake is bordered by a tarred road and the properties located near the road commands fairly high prices. The second type included the land on the banks of the lake as in Arattukadavu, Vazhavila, AGC and some parts of Kakkamoola and Palapoor. Most of the residential property lying close to the banks of the lake was reclaimed land from the lake. Large scale conversion of wetlands and construction of buildings in the banks was prevalent earlier. At present the enforcement of stringent laws against reclamation and constructions and actions taken by social activists such as filing suits against the encroachers and builders decreased the demand for such properties. Naturally the property price of such reclaimed land is low even though lake view is there. But the locations which are situated after a Pucca road definitely had premium price due to lake view. The R^2 value of 0.75 shows that 75 per cent of the change in value of property price could be explained by the selected explanatory variables.

Hedonic approaches had been used to determine implicit prices for numerous housing attributes, including location (Doss and Taff, 1996; Sander and Polasky, 2009; Irwin, 2002; Loomis and Feldman, 2003; Mahan *et al*., 2000; Jim and Chen, 2006). Tapuswan *et al.* (2007) also estimated the total premium in sales price in Western Australia due to wetland proximity using hedonic pricing method.

Under the assumptions that the housing market is in equilibrium and that the area studied lies within a single housing market, the estimated marginal implicit prices derived from regression coefficients represent the price an individual would be willing to pay for an additional unit of a particular characteristic keeping all other characteristics constant.

It was inferred from the study that the marginal implicit price of getting one cent of land with lake view evaluated at mean property price of Rs. 2,44250/- was Rs 79171/-. This illustrates the preference given by individuals for land with lake view. The total area of zone 1 was determined with the help of remote sensing data as 141.01 ha. So the total aesthetic value of land with scenic beauty of the lake is Rs.275.92 Crores.

Urbanisation is getting intensified in many parts of Thiruvananthapuram district. So many nature lovers and senior citizens are now shifting from the urban areas to cool and beautiful places as in Vellayani. In a state like Kerala property price is neither determined by the market forces of demand and supply nor by government but by the speculations by real estate agents. Hence prices are always held high when compared to other states. This may be the reason for higher aesthetic value. In a similar way Verma (2001) employed this method to determine the influence of Bhoj wetland in property price and estimated that the there is fifty per cent increase in property price in such properties when compared to others. Kruse and Ahman, (2009) estimated the impact of lake adjacency of Klamath river in California using hedonic price method and estimated that a property on the lake will be sold for 108 percent more per acre than a property that is not on a lake, all else being equal.

The present study provided the quantitative estimate for the preference existed for living near lake. People are willing to pay more for increased proximity to lake. The high aesthetic value demands conservation of such area.

4.4.2.4 Opportunity for Formal Education and Training

Kerala State Sports Council (KSSC) established in 1974 is a grant-in-aid institution for promoting sports in Kerala. Twenty three centralized sports hostels by KSSC nurture talented sports persons to international level and gives specialized training in various disciplines of sports across the state.

In the banks of Vellayani Lake, KSSC runs a centralized sports hostel extending residential training on Canoeing, Kayaking and Rowing for school students. Training is being given to 25 boys and 15 girls from morning 6.00am to 7.30 am and evening 4.30 pm to 6.00pm (Plate 32) in the lake.

Valuation of an institution using an ecosystem service is very difficult. No standard methods could be traced. Public pricing method as given by Degroot *et al.* (2006) proposed the public investment for ecosystem use as its value. So the investment made in the year 2013 in running the sports hostel was used as the economic value of the ecosystem service use. The expenditure pattern of CSH, Vellayani for the year 2013 collected from KSSC, Thiruvananthapuram is presented in the Table 41.

Plate 32. Training in water sports by CSH, Vellayani

Table 41. Expenditure on CSH, Vellayani, lakh Rs/ year

Month	Expenditure
January 2013	9.90
February 2013	1.10
March 2013	0.00
April 2013	0.97
May 2013	0.66
June 2013	1.71
July 2013	1.88
August 2013	1.86
September 2013	1.39
October 2013	1.84
November 2013	1.64
December 2013	0.83
Grand total	23.78

(KSSC, 2014)

Since in this exercise, the ecosystem services used by the institution in a particular year was only taken into consideration, the capital charges can be ignored, as the inclusion of capital charges may over estimate the value of ecosystem service use. Monthly expenditure summated for the year 2013 is taken as public investment. Thus the total value of the ecosystem use by CSH, Vellayani was Rs 23.78 lakhs per year.

4.4.2.5 Comparative Analysis of Cultural Services

In the present study the main cultural services considered for estimating the value of Vellayani lake were the services by CSH, Ayyankali boat race, recreational and spiritual services and the aesthetic value of the lake. The values of the respective parameters estimated is illustrated in Table 42.

Table 42. Cultural Services –A Comparative Analysis

Sl No	Service	Value (Crore Rs per year)	% to total
1	Ecosystem service use by CSH,Vellayani	0.24	0.089
2	Ecosystem service use by Ayyankali boat race	0.07	0.03
3	Recreational and spiritual services	0.56	0.20
4	Aesthetic services	275.92	99.69
5.	**Total**	**276.79**	**100.000**

When the contribution of different components (Fig. 9) of the cultural value of the lake was analysed, it was inferred that the aesthetic value owing to the increased land value contributed to maximum. Ecosystem service use by CSH, Ayyankali boat race and recreational value is comparatively less. Thus the total cultural value of the lake was Rs. 276.79 crore per year.

4.4.3 Valuation of Regulating and Supporting Services

In addition to the provisioning and cultural services, the lake system provides regulating services such as ground water recharge, stabilization of micro climate provision of cool breeze, reduction in atmospheric temperature and supporting functions such as biodiversity conservation. These services are important while calculating the TEV.

The present study employed Contingent Valuation Method (CVM) for estimating the regulating and supporting. In CVM study questions were asked that help to reveal the monetary trade offs, each person would make concerning the value

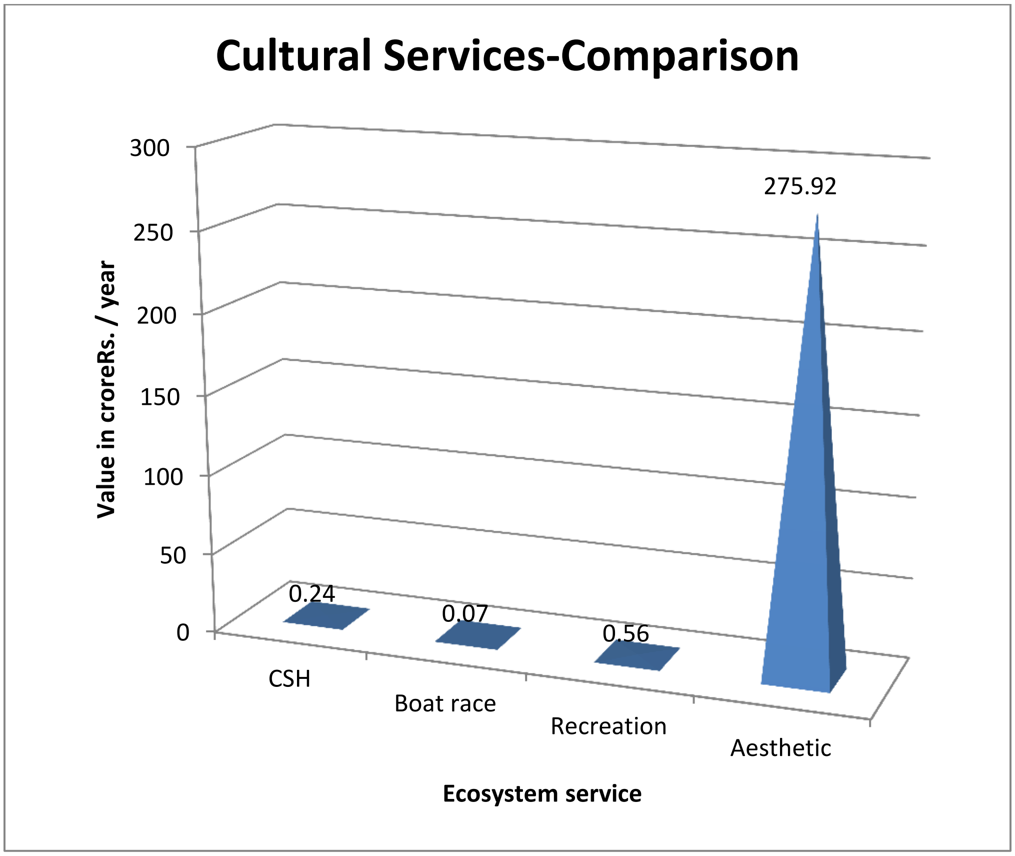


Plate 9. Cultural services – A comparison

of goods and services (Carson, 2012). In other words it involves eliciting the Willingness to Pay (WTP) of the respondents for a defined change in goods or service (Loomis *et al*., 2000 and Spash, 2000). The WTP in question is a dependent variable elicited from the respondents and is made a function of many socioeconomic and individual characteristics. In the present study, for conducting CVM data were collected from two hundred and forty respondents from three zones at a distance of 100 m, 200 m and 300 m from the lake.

The respondents in each zone were interviewed to elicit their WTP per year for the conservation of lake contingent upon the hypothetical scenario that, in order to conserve the lake which provided the regulating and supporting services, whether they are willing to pay or not. A double bounded dichotomous choice format was used for elicitation of the WTP. The effectiveness of the double bounded dichotomous choice format method in CVM studies were confirmed by Blomquist and Whitehead, 1998; Mamat *et al*., 2003; Venkatachalam, 2004; Ramlan *et al.*, 2011 and Ikeuchi *et al*., 2012. The number of respondents willing to pay to conserve the lake and their mean stated value of WTP in each zone is furnished in the Table 43 and Fig. 10.

Table 43. Mean stated WTP of respondents

Zone	No of respondents with the WTP	No of respondents not willing to pay	Total number of respondents	Mean stated WTP (Rs/Year)
Zone I	52 (65)	28 (35)	80 (100)	354.25
Zone II	36 (45)	44 (55)	80 (100)	237.12
Zone III	28 (35)	52 (65)	80 (100)	174.37
Total	116 (48.33)	124 (51.67)	240 (100)	225.22

(Figures in parenthesis give percentage to total)

The study revealed that only about 48 per cent of the respondents were willing to pay for the conservation of lake. The mean WTP for the local residents was Rs

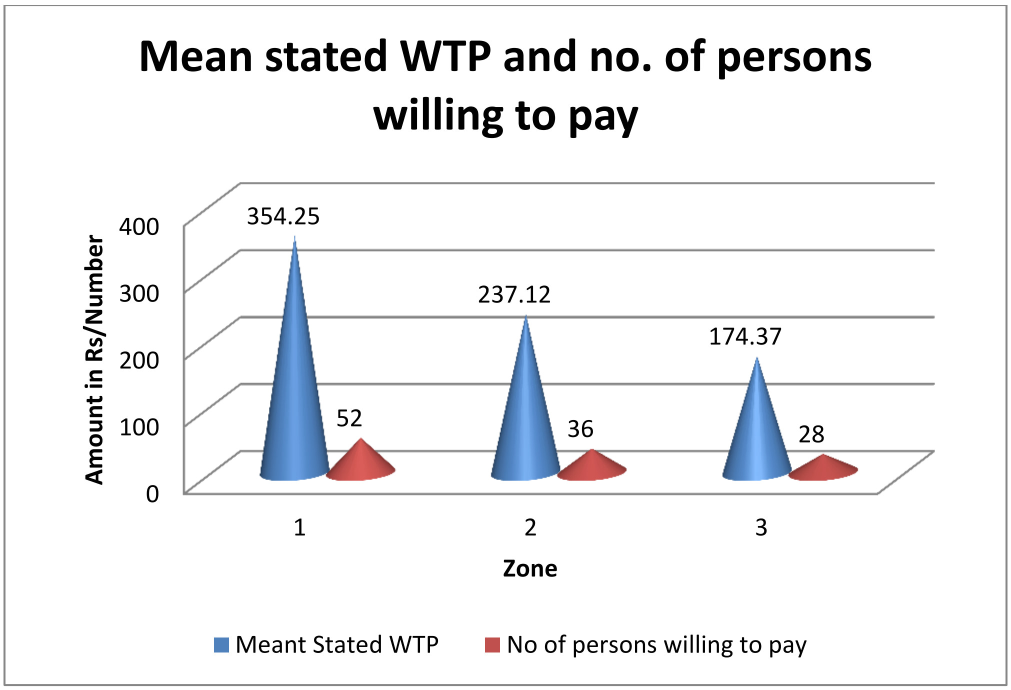


Figure 10. Mean WTP of Local Residents

225.22 per year which was between Rs. 354.25 per year in zone I and Rs. 174.37 per year for zone III. The amount was much lower than average annual willingness to pay of Rs. 500 to Rs. 1200 for aesthetic and recreational purpose of Powai lake in India (Gupta and Mythili, 2009).

When location wise analysis was done in zone I, the higher WTP can be attributed to the acceptance of higher bids by respondents of Kakkamoola followed by Kadavinmoola and AGC. The frequency distribution of respondents with WTP and average WTP in each of the study location is furnished in Appendix XV and Appendix XVI respectively. Kakkamoola is more urbanized when compared to other locations and respondents had higher income which might get translated to higher willingness to pay. The income distribution of respondents given in appendix XVII shows that the respondents in Kakkamoola had the highest average monthly income when compared to other zones. The number of respondents willing to pay was also high in Kakkamoola followed by AGC. Arattukadavu in Zone I had least number of respondents willing to pay and least mean stated WTP (Rs.73/year). General backwardness with low educational status, low transportation facilities and rural atmosphere existed in the area. Except for livelihood generation such as lotus collection and fishing they are dependent on Pallichal canal as water source. This may be the reason for low WTP of the region.

In zone II the mean stated WTP was Rs 237.12 per annum with 45 per cent of the respondents willing to pay. The mean stated WTP was maximum for AGC. The zone III had still lower mean stated WTP (Rs 174.37 per year) and the number of respondents willing to pay was least (35 %).

Thus it is clear that, the WTP varies inversely with the distance from the lake. As the distance from the lake is increased naturally the direct dependence on the lake is decreased. Those who are living near the lake are using it for bathing, washing or to enjoy the scenic beauty of the lake. The hilly terrain of zone II and III of Vavvamoola, Kakkamoola, Venniyoor and Kadavinmoola makes the people in zone I alone to reap the benefits of ground water recharge which may be the reason for higher WTP of zone I.

Descriptive statistics of WTP was worked out and presented in the Table 44. It was inferred that the WTP was towards the lower side in the study area. The maximum WTP was Rs. 2400 per year and minimum was Rs. 100 per year. This may be due to the inherent characteristics of the area. The occupational and educational profile of the respondents revealed that most of them were labourers with low educational status and were earning their livelihood toiling all the day. Payment in kind was not considered for the study in order to avoid overstating of WTP. This lower WTP indicated the lack of awareness among people and throws light to the need for creating awareness on people on the importance of conserving this unique resource in their locality.

Table 44. Descriptive Statistics of WTP

Statistics	Value
Mean	528.1
Standard Error	44.61
Median	325
Mode	600
Standard Deviation	480.51
Sample Variance	230892.02
Minimum	100
Maximum	2400
Sum	61260
Count	116

The econometric model of CVM encompasses all the variables, the economic theory indicates would have an influence on WTP. CVM studies aim to find out the significant causal relationship between the selected socio economic and other characteristics, with WTP. Starting with this analytical basis an initial estimation was done using all the available characteristics which might influence the WTP. Various functional forms like linear, semilog, quadratic etc. were tried using SAS package. The best model selected using forward selection method was linear with nine explanatory variables.

The model used for analysis is as follows.

$Y = a+b_{1i}X_1i-b_{2i}X_{2i}+b_{3i}X_{3i}+b_{4i}X_{4i}+b_{5i}X_{5i}+b_{6i}X_{6i}-b_{7i}X_{7i}-b_{8i}X_{8i}+b_{9i}X_{9i}+e_i$

. Where,

Y	Willingness to pay to conserve the lake(Rs/year)
a	Intercept
X_{1i}	Area owned in Cents
b_{1i}	Regression co efficient of X_1
X_{2i}	Distance from lake in meters
b_{2i}	Regression co efficient of X_2
X_{3i}	Monthly income in thousand Rs.
b_{3i}	Regression co efficient of X_3
X_{4i}	Gender (1-male,2-Female)
b_{4i}	Regression co efficient of X_4
X_{5i}	Marital status(1-married, 2-unmarried)
b_{5i}	Regression co efficient of X_5
X_{6i}	Education(values ranging from 1 to 5)
b_{6i}	Regression co efficient of X_6
X_{7i}	Source of water(1-well, 2-tap water from Vellayani lake, 3-both)
b_{7i}	Regression co efficient of X_7
X_{8i}	Submerged property in lake in cents
b_{8i}	Regression co efficient of X_8
X_{9i}	Dependent on lake (1-no,2-yes)

b_{9i} Regression co efficient of X_9

e_i Error term

The selected variables are explained as the following. The average holding size or area (X_1) of the respondents was 18.48 cents. All the holdings were marginal in size. The actual distance of the residence (X_2) of the respondents from lake was recorded in meters. The monthly income(X_3) of the respondents was presented in thousand rupees. The average monthly income was Rs 12350/- per month. Zone I recorded maximum income of Rs 13,710 per month and the average monthly income was minimum for Zone II. Dummy variable of 1 was given if male and 2 was given if female(X_4). Marital status(X_5) was given a dummy value of 1 if married and 2 if unmarried. Education (X_6) was also dummy variable with a value of 1 if illiterate, 2 if educated up to secondary, 3 if educated up to high school, 4 if maximum education is pre degree and 5 if educational status is degree and above. WTP of the respondents depends on source of water(X_7) because the Vellayani lake is the source of water in public distribution. A dummy variable of 1 was given if their water source was well, 2 if the source was tap water and 3 if they had both. Many local residents had their property submerged (X_8) in the lake which was earlier paddy field. The average size of their land holdings in the lake was 5.38 cents. The dependence of the respondents on the lake (X_9). Value of 1 was given if they are not dependent and value of 2 was given if they are dependent for income generation bathing, washing or any other purpose. The variables selected after regression with the prior expected sign are given in Table 45. All the important variables except distance from the lake was expected with a positive sign.

Table 45. Explanatory variables of WTP with expected sign

Variable name	**Explanatory variables**	**Expected sign**
Y	Willingness to pay to conserve the lake (Rs/year)	
X_1	Area owned in Cents	+
X_2	Distance from lake in meters	-
X_3	Monthly income in thousand Rs.	+
X_4	Gender (1-male, 2-Female)	+
X_5	Marital status (1-married, 2-unmarried)	+
X_6	Education (values ranging from 1 to 5)	+
X_7	Source of water (1-well, 2-tap water from Vellayani lake, 3-both)	+
X_8	Submerged property in lake in cents	+
X_9	Dependent on lake (1-no, 2-yes)	+

Table 46 illustrates the multiple linear regression results of the model. The R^2 value of 0.1971 indicated that nearly 20 per cent of the variation in WTP could be explained by the selected variables. Explanatory power was low, but it is more than similar studies by Imandoust and Gadam (2007), where R^2 was 0.161. Coefficients of the regression model was statistically significant and consistent with economic theory.

Table 46. Model parameters of WTP

Variable	Parameter Estimate	Standard Error	F Value	Pr > F
R^2	0.1971			
Intercept(a)	-1269.79673**	437.34226	8.43	0.0041
Area owned(X1)	1.21852	1.00378	1.47	0.226
Distance from lake(x2)	-0.21317	0.3057	0.49	0.4863
Monthly income(X3)	6.38484**	2.24397	8.1	0.0048
Gender(X4)	105.65303	72.63438	2.12	0.1471
Marital status (x5)	847.23656*	391.8677	4.67	0.0316
Education(X6)	88.24074*	40.10837	4.84	0.0288
Source of water (x7)	-40.46607	29.29923	1.91	0.1686
Submerged property in lake (x8)	-1.41391	0.88116	2.57	0.11
Dependent on lake (x9)	249.2667**	75.51623	10.9	0.0011

* Significant at 5 % level of significance

** Significant at 1 % level of significance

The variables which significantly influenced the WTP by the respondents were the monthly income, marital status and education. The significance of income and education in determining the WTP of stakeholders is consistent with the study by Qureshi *et al*., 2013. It was reported by Dasgupta and Dasgupta, 2004 and Yang *et al*., 2008 also that higher the education and income of the people higher will be the WTP. Halkos and Matsiori (2013) also reported high association between individual WTP towards river protection and characteristics like education and income. It is noteworthy that even though the distance from the lake was not found to be significant parameter the negative sign of the variable indicated that as distance from the lake increases the WTP decreases. This observation was in conformity with studies by Kantogianni *et al*., 2001. A study by Mamat *et al*., 2013 indicated that age, education and gross income are the important factors that affected the WTP.

The respondents were asked to give the reasons for their willingness to pay and non willingness to pay in a Likert scale ranging from 5 to 1. Seven statements were given as the reasons for WTP and 5 statements as the reasons for not willing to pay.

Table 47. Reasons for WTP of respondents

Sl No	Reasons for WTP	Score	Rank
1	I feel this is a reasonable amount I can afford to pay	0.89	1
2	I want to contribute to preserve the lake for my future generations(bequest value)	0.89	1
3	I am concerned about the degradation of the lake	0.87	2
4	I think conservation of lake is good for me and the society	0.82	3
5	I take personal pleasure in knowing that the lake will continue to exist(existence value)	0.81	4
6	I feel it is my moral duty to conserve the lake for future generation	0.68	5
7	I do not use the lake now but I am willing to contribute to have the option of using it in future(option value)	0.53	6

A perusal of Table 47 showed that, among the reasons stated by the respondents for expressing their willingness to pay to conserve the lake, the reason that it is a reasonable amount and the bequest value received first rank with highest score of 0.89 followed by the statement that they are concerned about the degradation of the lake(score 0.87). The least priority was given for option value with a score of 0.53. This shows that the respondents are concerned about the lake mainly because of the possibility of extracting various direct and indirect benefits from the lake by future generations also and the amount is reasonable for them.

The scores of reasons for not willing to pay presented in Table 48 revealed that the first rank was received by the statement that it is the government's responsibility to conserve the lake with a score of 0.96 followed by the statement that the limited income restricted their ability to pay (score 0.86).The least rank was received by the statement that citizens are not concerned about the conservation of the lake with a score of 0.54.

Table 48. Reasons for not willing to pay of respondents

Sl No	Reasons for not willing to pay	Score	Rank
1	It is the government's responsibility to conserve the lake	0.96	1
2	Limited income restricts my ability to pay	0.86	2
3	Those who are using lake should pay	0.78	3
4	Don't think that the lake are to be conserved	0.73	4
5	Citizens are not concerned about conservation activity	0.54	5

It was cited by some respondents that as the Vizhinjam transshipment area is drawing water from the lake for drinking water purpose, the conservation activity is their responsibility and not the responsibility of the public. In general the respondents had difficulty in conceiving the concept of willingness to pay as they think that they should not take the responsibility of the duty to be performed by the government.

The willingness to pay for other stake holders *ie*. fishermen, lotus collectors and duck rearers were collected and presented in the Table 49.

Table 49. Mean stated WTP of other stakeholder communities

Sl No	Category	No. of respondents with WTP	No. of respondents with no WTP	Total	Mean stated WTP (Rs per year)
1	Fishermen	21 (60)	14 (40)	35 (100)	623.42
2	Lotus collectors	1 (16.67)	5 (83.33)	6 (100)	60
3	Duck rearers	2 (40)	3 (60)	5 (100)	72

(Figures in parenthesis indicate percentage to total sample in each group)

It was noticed that share of persons with WTP was comparatively high among fishermen(60 %) when compared to lotus collectors(16.67 %) and duck rearers (40%) with mean stated WTP of Rs 623.42 per year, Rs.60 per year and Rs.72 per year respectievly.

Different combinations of econometric models were worked out to estimate the WTP. The best combination selected using forward selection procedure the best model was linear with R^2 value of 0.2915. The variable which were found relevant were area, age, marital status and education. The regression results are given in Table 50.

The linear functional form is presented below.

$$Y= a+b_{1i}X_{1i}+b_{2i}X_{2i}+b_{3i}X_{3i}+b_{4i}X_{4i} +e_i$$

where,

Y	Willingness to Pay(Rs/year)
a	Intercept
X_{1i}	Area owned in cents
b_{1i}	Regression Co-efficient of X_{1i}

X_{2i} Age in Years

b_{2i} Regression Co-efficient of X_{2i}

X_{3i} Marital Status

b_{3i} Regression Co-efficient of X_{3i}

X_{4i} Education

b_{4i} Regression Co-efficient of X_{4i}

e_i Error term

Table 50. Model parameters of WTP of other stakeholders

Variable	Parameter Estimates	Standard Error	F Value	Pr > F
R^2	0.2915			
Intercept	-1668.8211	1794.1896	0.87	0.3578
Area	87.30645	36.1496	5.83	0.0203
Age	24.19835	21.62274	1.25	0.2696
Marital	1099.9792	820.99653	1.8	0.1877
Education	-280.91815	300.88106	0.87	0.3559

The aggregate value of the lake system was obtained by extrapolating the WTP estimates and is presented in Table 51.

Table 51. WTP of Vellayani Lake

Category	Estimated WTP per household (Rs)	No of House holds	Total WTP (Crore Rs/Year)
Residents	1481.54	19694	2.91
Other stake holders	488.56	65	0.003
TOTAL			2.91

The total WTP of local residents is multiplicative of their estimated WTP and the number of households of the two panchayats. The total number of households was obtained from census data (GOI, 2014a).

Being the largest group the local residents had highest estimated willingness to pay of Rs. 2.91 crore per year and the other stakeholders had an estimated WTP of 0.003 crore per year. Thus the total WTP for conserving the regulating and supporting services of Vellayani lake estimated was Rs 2.91 crores per year. The main reason for low WTP is the lack of awareness among the people. Significant effect of people's awareness on WTP was reported by Mayur (2014).

Similar studies were done by Anoop (2007) to determine the option value of Ashtamudi estuary using CVM. The estimated WTP was Rs 0.39 crore per year which is much lower than the value obtained for Vellayani lake. Mamat *et a*l. (2013) used the dichotomous-choice contingent valuation method for estimating the WTP to protect natural environments in Pulau Redang Marine Park, Malaysia and reported that average WTP ranged between RM 10.86 and RM28.69 that could contribute between RM 1.65 million and RM 4.36 million in aggregate. Hema (2013) estimated used CVM to estimate the TEV of mangrove ecosystems and estimated the value as Rs. 1, 17,947 million per year.

4.5 TOTAL ECONOMIC VALUE (TEV) OF VELLAYANI LAKE

The TEV encompasses measure of the economic value of any environmental asset. It is the value derived by the people from a natural resource. The TEV is equivalent to the sum of its use values and non-use values (Yang *et al*., 2008). A failure of information and lack of understanding of values associated with them is the major reason for the degradation of this valuable freshwater source. To develop sustainable and welfare optimizing wetland management policy understanding the value of the ecosystem services is crucial. The TEV of Vellayani lake estimated by the summation of economic value of various services was Rs.672.28 crore per year. The TEV of Vellayani lake derived from the present study along with the level of dependence is given in the Table 52 and presented in Fig.11.

The perusal of the table revealed that drinking water contributes to nearly 55 per cent of the value of ecosystem services provided by the lake. In Thiruvananthapuram district, with high density of population and water requirement, the importance of conserving this fresh water resource is a matter of urgent attention. Besides this, the drinking water projects have international relevance as this is source of water for upcoming Vizhinjam transshipment container terminal and Kovalam Tourism area.

Next important factor contributing to the TEV of the lake is aesthetic value. In Kerala where property prices are skyrocketing every day, with booming real estate market and property transactions, presence of a picturesque lake definitely catches higher price. The tremendous hike in housing and land prices due to the presence of the lake captured using hedonic property pricing method revealed an aesthetic value of 275.92 crores which contributes to nearly 41 per cent of the TEV. Even though other sectors like fishing, lotus collection and duck rearing were meagre, it is still important as they are source of income for economically backward and downtrodden sections of the society. In a country where “inclusive growth” is a key element of the

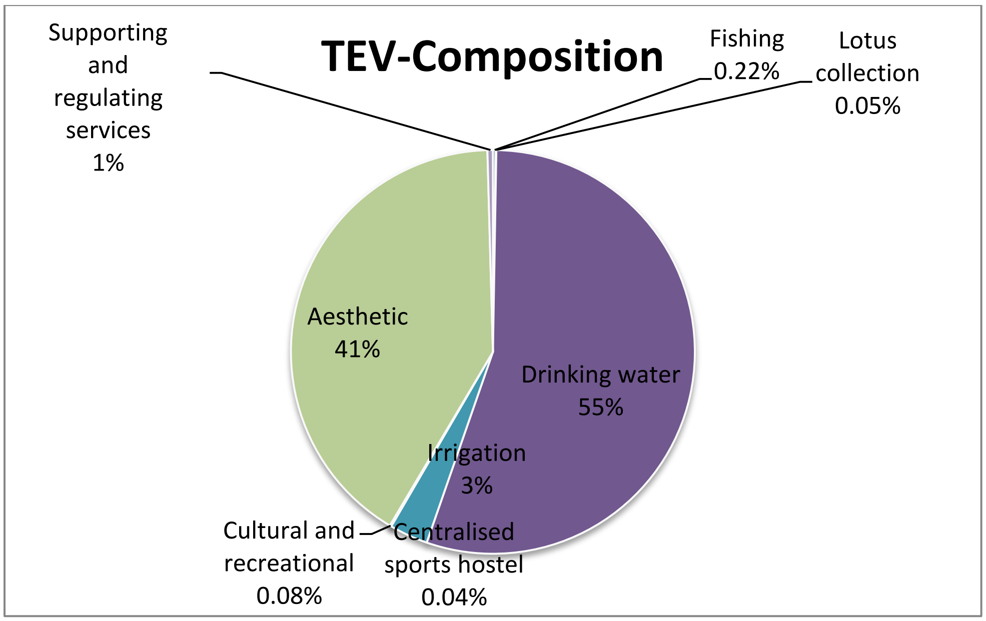


Figure 11. Composition of TEV of Vellayani lake

policy platform the sustainable development of these economically backward sectors assumes importance.

Table 52. TEV of Vellayani lake

Components of TEV	Value in crore Rs/year	Level of dependence (%)
Fishing	1.45	0.22
Lotus collection	0.34	0.05
Duck Rearers	0.04	0.00
Drinking water	370.05	55.04
Irrigation	20.69	3.08
Bathing and washing	0.009	0.00
Centralised sports hostel	0.24	0.04
Ayyankali Boat race	0.07	0.01
Recreation	0.56	0.08
Aesthetic	275.92	41.04
Regulating and supporting function	2.91	0.43
TEV	**672.28**	**100.00**

The cultural services including recreational, spiritual and educational and aesthetic services also significantly contribute to the TEV of the lake. The low value for supporting and regulating functions estimated using WTP indicates lack of awareness of people about services contributed by the lake.

The socio-economic conditions also influence the value of wetland services by the lake because the economic conditions had an effect on the Willingness to Pay (WTP). The low WTP of 2.91 crore per year of the people for the conservation of the lake revealed the low value attached and lack of awareness of the people and it demands a sense of urgency for greater public awareness on conserving the lake. This low awareness about its importance may be main the reason for degradation of the lake.

The contribution by various components of TEV given in Table 53 indicated that the provisioning services are the major component that contribute to the TEV of the lake (Fig.12).

Table 53. Components of TEV

Sl no	Component of TEV	Value (Rs. crore year^{-1})	% to total
1.	Provisioning service	392.58	58.40
2.	Cultural services	276.79	41.17
3.	Regulating and supporting function	2.91	0.43
	TEV	672.28	100.00

The value of ecosystem services expressed in the present study is an estimate of the benefits to the society. So these values can serve as communication tools for balanced decision making with respect to resource use and conservation activities. The TEV of Vellayani lake ecosystem estimated from the present study which was 0.002 per cent of the Gross State Domestic Product (GSDP) of Kerala. Being a lake confined to small area this value assumes importance and highlights the importance of the lake system in our economy.

Recognizing the environmental and economic importance of the lake system conservation of this resource rich ecosystem assumes greater relevance. In a similar attempt Anoop (2007) estimated the TEV Ashtamudi Lake, one of the Ramsar sites of Kerala by aggregating economic contribution of different stakeholders. The study revealed that the TEV of Ashtamudi lake was Rs. 205.11crore per year which was less than the present study. Studies conducted by Mamtha (2008) on Kolleru lake in Andhra Pradesh and Babu and Kumar (2011) in Yamuna river flood plains observed

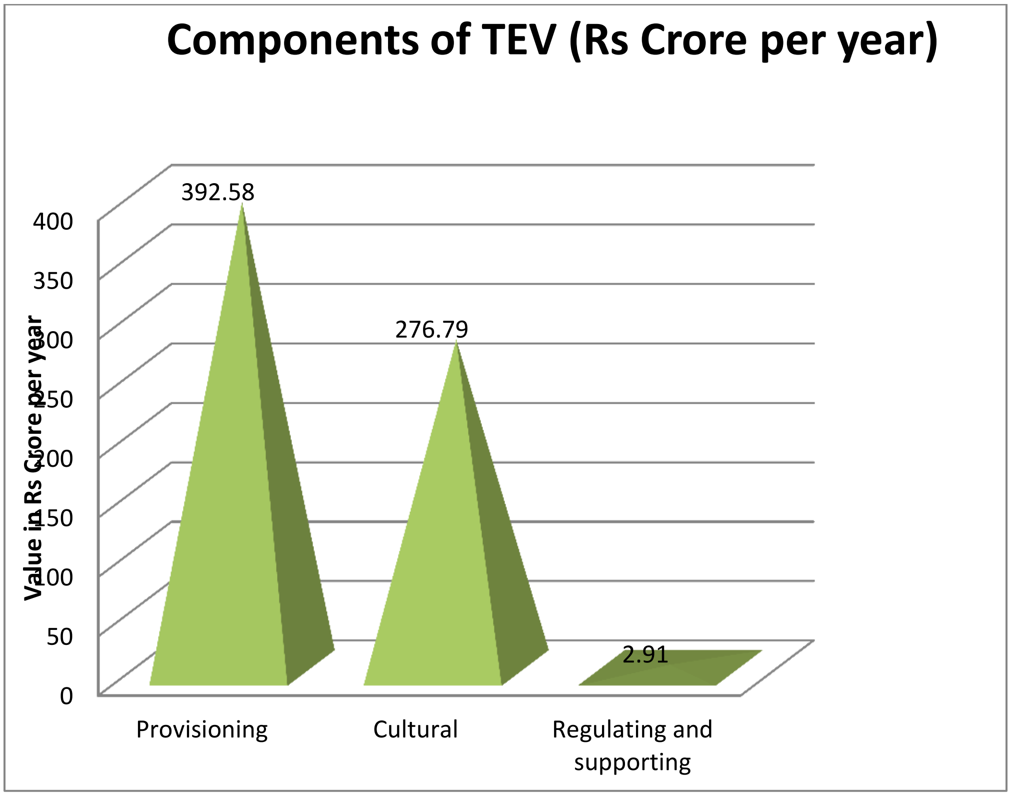


Figure 12. Components of TEV

that the TEV of the ecosystems were Rs. 94192.2 lakhs per year and Rs. 216.78 lakh per annum.

4.6. FORECAST OF ECOSYSTEM SERVICE FLOW

The study attempts to forecast the demand for goods and services based on the current trend in provision of ecosystem services. In the light of study, based on drivers of change, discussions with the respondents and general conditions in the area it was inferred that due to over exploitation many services are declining, some increasing and others remaining the same.

The important goods and services delivered by the lake along with their trend and scale of beneficiaries are presented in Table 54. With the growing population, the need for drinking water, bathing washing, cultural, spiritual, recreational and educational value has an increasing trend. Drinking water pumped from the lake will likely be used by more people with the increase in the population. It was observed that those coming for *Karkidaka vavu bali* and enjoying the boat race are increasing every year. So this trend is expected to continue.

Lotus collection is an age old practice but there had been no conspiquous increase in the number of persons earning their livelihood through this. So the chances for increase in number of lotus collectors are less and thus it shows a trend to remain the same.

According to fishermen, the variety and quantity of fishery resource of the lake had decreased over years. Many indigenous fish had vanished from the lake. So there is a likely trend of decline in fishery resource. If the loss and degradation of the lake due to exploitation of the lake continues in the same trend the fishing, duck rearing, provision of irrigation, ground water recharge provision of scenic beauty and biodiversity conservation by the lake is likely to decline over years.

Table 54. Trends in Ecosystem Service Flow

Ecosystem service	Trend	Scale of beneficiaries
Provisioning Service		
Drinking water	↑	Local
Fishing	↓	Local, Regional
Duck Rearers	↓	Local
Lotus collection	→	Local
Bathing and washing	↑	Local
Irrigation	↓	Local
Regulating Function		
Ground water recharge	↓	Local
Cultural Services		
Cultural heritage and identity	↑	Local, Regional
Spiritual and religious value	↑	Local, Regional
Providing scenic beauty	↓	Local, Regional, Global
Recreational value	↑	Local, Regional, Global
Educational and scientific study	↑	Local, Regional, Global
Supporting function		
Biodiversity conservation	↓	Local

↑ Increasing

→ Remaining same

↓ Decreasing

In a similar attempt Palomo *et al*., (2013) revealed that in Sierra Nevada protected area in Spain, climatic regulation, erosion control and aesthetic values were perceived with a diminishing trend.

4.6.1 Forecast of Goods and Services

The per capita value of TEV based on the present population of the Kalliyoor and Venganoor panchayats was calculated by dividing the value of TEV components derived from the study by the population of the two panchayats (Table 55).

Table 55. Forecasted value of goods and service in 2021.

Components of TEV	Per capita value in 2013	Forecasted Per capita value in 2021 (Rs/Year)
Fishing	188.85	447.26
Lotus collection	44.28	104.87
Duck Rearing	3.91	9.25
Drinking water	48196.77	114144.04
Bathing and washing	1.14	2.83
Irrigation	2694.75	6381.95
Centralised sports hostel	31.26	74.03
Ayyankali Boat race	9.12	21.59
Cultural and recreational value	72.94	172.74
Aesthetic value	35936.91	85109.10
Other services and nonuse value	380.31	900.69
TEV	87559.10	207368.36

The population of the two panchayats as per 2011 census is 76,779. According to GOI (2014a) the decadal population growth from 2001 to 2011 in Kalliyoor and Venganoor is 10.80 per cent and 7.76 per cent respectively. Assuming the same decadal growth from 2011 to 2021, the population of the two panchayats in 2021 was worked out as 84,089. The per capita value of goods and service for 2021 is worked out by assuming a inflation rate of 10.5 per cent. Thus the forecasted per capita TEV in 2021 is Rs 207368.36 year^{-1}

4.7 ORGANIZATIONS ASSOCIATED WITH THE LAKE SYSTEM

In addition to stakeholders selected for valuation of the ecosystem of the Vellayani lake there are many institutional stakeholders who affects or are affected by the ecosystem use. The interest of these institutions is evident from their involvement in either protection of the lake or presence near the lake even though they are not deriving any monetary benefits from the lake. So their involvement in ecosystem protection or use is separately discussed here. The main institutions associated with Vellayani lake are

- Government Departments
- Kanthari International
- Daksha Seth Dance Company
- Save Vellayani lake campaign

Government agencies at different levels are involved in managing ecosystems, and in regulating the access to ecosystem services. Local self government department of the Kalliyoor and Venganoor panchayat are very keen in implementing schemes for Vellayani lake conservation. Considering the importance of Vellayani lake as a fresh water source, the Department of Environment and Climate Change implemented a programme for Rs 50 lakhs under the scheme “Eco restoration of Wetland Scheme for Conservation of Vellayani lake”. Various other departments interested in the conservation of Vellayani lake are Revenue department, College of Agriculture, Fisheries department, Agency for Development of Aquaculture, Kerala (ADAK), Centre for Water Resources Development and Management (CWRDM), Suchitwa mission, Irrigation department and Soil Survey and Soil Conservation department. Kerala State Pollution Control Board is implementing a scheme for monthly monitoring the water quality of the lake.

The Daksha Sheth Dance Company located on the banks of Vellayani lake is a group of internationally famous performing artists from diverse backgrounds who seek to bridge contemporary dance and traditional movement arts. They highly value the scenic beauty and refreshing experience of the gentle breeze from the lake.

Kanthari International is an educational and training institute situated on the banks of Vellayani lake. It was co-founded by Sabriye Tenberken and Paul Kronenberg in 2009 as an extension of their pioneering project Braille without borders. The not-for-profit institute aims to identify and train persons who have had to face adverse social conditions including physical disabilities, poverty and war strife. Its original official name was "International Institute for Social Entrepreneurship". The participants highly cherish the beauty of the lake and they forget their disabilities when they were taken for a boat ride in the lake.

`Save Vellayani Lake' campaign, is a participatory movement formed to conserve Vellayani lake and its ecosystem. The thrust of the campaign under the joint aegis of the Rajiv Gandhi Centre, a voluntary organisation based at Venganoor, the Athyianoor Block Pachayath, Literacy Mission, Thiruvananthapuram and the Karunya Social Circle Unit, Peringamala, is to protect the lake as a fresh water source. Several programmes had been spearheaded by them for creating awareness among people to conserve the lake and also prevention of encroachment and sand mining. They were regularly conducting programmes involving local people and various organizations to create awareness regarding the conservation.

4.8 ANTHROPOGENIC FORCES ON THE LAKE ECOSYSTEM

It is the immense value of lake that draws people towards it for various activities. Despite the enormous ecosystem services and its socioeconomic importance the Vellayani lake is threatened by many sustainability issues. The physico-chemical and biological characteristics of the lake system are greatly influenced by both natural and anthropogenic inputs. Anthropogenic forces are human activities that affect the sustainability of lake ecosystem. These anthropogenic inputs directly affects the lake or originates from catchment areas to find their way through the streams, and eventually enter the lake.

The changes in population and land use inevitably lead to stresses that impact the lake, thereby reducing the benefits the people drew. Multiple stresses through anthropogenic forces like pollution, encroachment, reclamation and sand mining are driving forces behind the temporal and spatial changes in the lake ecosystem rather than the natural forces. These stresses are introduced mainly due to the lack of awareness on the ecological services rendered by the lake and also the property rights issues.

Perception is the judgment of people about some good or service and it is an outcome of a process of evaluating the received information about that good or service. It has got an important role in peoples' decision making in a particular situation and is a crucial element in determining their preferences regarding conservation of wetlands. It is essential to study the perceptions of the people who have some stake over the environmental resources in order to make appropriate policies for their conservation (Binilkumar, 2010). Stakeholder's perceptions will be influenced by their dependency level on the resources, the conservation, awareness and their own socio-economic features.

The frequency of visits made by stakeholders to the lake and their perceptions on extend of pollution in lake, conservation status of the lake, wetland conservation, ecosystem services and the threats faced by lake were analysed to study the views of stakeholders that affect the sustainability of the lake system. As the visitors to the lake from other regions do not have good insight about the lake, they were not included in this exercise.

4.8.1 Frequency of Visit to Lake

People visit the lake for various reasons such as livelihood generation, enjoying the scenic beauty and for religious and cultural activities. As the frequency of visits to the lake increases, the natural environment of the lake is affected. The frequency of visits to lake by the stakeholders is given in the Table 56. All the stakeholders who derive their livelihood from the lake such as fishermen, lotus collectors and duck rearers visit the lake daily. In the case of local residents majority (52.5%) visits the lake daily. They may make deliberate visits for washing or bathing or may spend some time near the lake while travelling through the roads constructed across the lake.

Table 56. Frequency of visits by the stakeholders to lake

Stakeholder Category	Daily	Once in 2 days	Fortnightly	Monthly	Occasionally	Total
Fishermen	35 (100)	0 (0)	0 (0)	0 (0)	0 (0)	35 (100)
Lotus collectors	6 (100)	0 (0)	0 (0)	0 (0)	0 (0)	6 (100)
Duck rearers	5 (100)	0 (0)	0 (0)	0 (0)	0 (0)	5 (100)
Local Residents	126 (52.5)	34 (14.16)	11 (4.58)	15 (6.25)	54 (22.5)	240 (100)
Total	172 (60.13)	34 (11.89)	11 (3.85)	15 (5.24)	54 (18.88)	286 (100)

(Figures in parenthesis give percentage to total)

With respect to the local inhabitants, those who are living close to lake always have vicinity towards the lake. Palapoor one of the study locations had connectivity to Punchakari area through the reservoir bund road (Plate 33) along the North Western side of the lake. Locations such as AGC-Kakkamoola and Vavvamoola – Kadavinmoola are connected through the Kakkamoola bund road (plate 34) and Vavvamoola bund road (Plate 35) respectively across the lake. These three bund roads offered good connectivity to Thiruvananthapuram. People in these locations are frequently using these roads for transportation. Such bund roads were not available for other locations such as Arattukadavu, Vazhavila and Venniyoor which may be the reason for the low visitation rate.

Plate 33.Reservoir Bund Road

Plate 34. Kakkamoola bund road

Plate 35. Vavvamoola Bund Road

4.8.2 Opinion on Extent of Pollution in Lake

Pollution of the lake due to anthropogenic forces and demographic growth was reported from across the globe (Das *et al*., 2008; Musamba *et al*., 2011; Naganawa, 2012; Zarrineh and Abad, 2014). To assess the perception of the respondents on the extend of pollution in the lake a four point continuum was used and the results are given in Table 57. Nearly 72 per cent perceived that the lake is moderately to highly polluted. Except the lotus collectors majority of the stakeholder community classes (> 40%) believed that the lake is moderately polluted with an average of 52.08 per cent.

This was presumably because the respondents think that the main reason for pollution of the lake is the rain water carried from the human inhabitations through canals or through runoff. The decay of debris of aquatic vegetation like lotus plants, water lilies and Eichhornea was cited as another reason. Some of them reported the itching due to contact with lake water.

Table 57. Distribution pattern of stakeholders perception on extend of pollution

Stakeholder Category	Not at all	Marginally	Moderately	Highly	Total
Fishermen	4 (11.43)	7 (20.00)	18 (54.29)	5 (14.29)	35 (100.00)
Lotus collectors	2 (33.33)	2 (33.33)	1 (16.67)	1 (16.67)	6 (100.00)
Duck rearers	1 (20.00)	2 (40.00)	2 (40.00)	0 (0.00)	5 (100.00)
Local Residents	52 (21.67)	42 (17.5)	104 (43.31)	43 (17.91)	240 (100)
Total	59 (20.63)	53 (18.53)	125 (52.08)	49 (20.41)	286 (100)

(Figures in parenthesis give percentage to total)

Unscrupulous dumping of untreated household waste, bathing by humans and animals, open canals that carry polluted water, instances of dumping chicken waste in sacs are the other sources of pollution. Some of the respondents of Kakkamoola opined that the open defecation in early morning hours had certainly affected the water quality.

4.8.3. Opinion on Conservation Status of the Lake

The perception of the respondents on the conservation of the lake given in Table 58 revealed that, the majority of the fishermen (85.71%), lotus collectors (83.33%) and duck rearers (80 %) and local residents believed that the lake is moderately conserved and the average for the total sample observed was 50.69 per cent. It can be observed that 31.81 per cent were of the opinion that the lake was less conserved and the major category who raised this problem were the local residents (38.83%).

Table 58. Distribution pattern of respondent’s opinion on conservation status of the lake

Stakeholder Category	Very well conserved	Moderately conserved	Less conserved	No opinion	Not at all conserved	Total
Fishermen	1 (2.86)	30 (85.71)	4 (11.43)	0 (0)	0 (0)	35 (100)
Lotus collectors	0 (0)	5 (83.33)	1 (16.67)	0 (0)	0 (0)	6 (100)
Duck rearers	1 (20)	4 (80)	0 (0)	0 (0)	0 (0)	5 (100)
Local residents	28 (11.67)	106 (44.16)	86 (35.83)	2 (0.83)	18 (7.5)	240 (100)
Total	30 (10.48)	145 (50.69)	91 (31.81)	2 (0.7)	18 (6.3)	286 (100)

(Figures in parenthesis give percentage to total)

As such no planned and serious pollution abatement programmes were enforced in the lake. But restrictions were imposed by the local self government on illegal activities like sand mining, construction of buildings and implementation of drinking water projects. NGOs like ‘Save Vellayani lake Campaign’ conduct demonstrations and protests against degradation of the lake which may be reason for the majority opinion that the lake was moderately conserved.

Those who opined that the lake is not at all preserved are not satisfied by the current efforts made by any of the organizations in protecting the lake. They emphasized the need for developing a strategic plan for lake management, with proper institutional backing to protect the Vellayani lake from becoming a vanishing lake. They also opined that those who have political power and money power can influence the authorities in doing illegal activities like encroachment and sand mining and this should be prevented.

4.8.4 Stakeholders Support for Wetland Conservation

In order to elicit responses of the stakeholders on wetland conservation mainly two questions were asked and the results are given in Table 59. Majority of the respondents from all stakeholder communities were willing to support the conservation of wetlands only if it affected them.

Table 59. Distribution pattern of opinion of the stakeholders on wetland conservation.

Stakeholder Category	Conditional support	Un conditional support	Total
Fishermen	32 (91.43)	3 (8.57)	35 (100.00)
Lotus collectors	6 (100.00)	0 (0.00)	6 (0.00)
Duck rearers	4 (80.00)	1 (20.00)	5 (100)
Local residents	185 (77.08)	55 (22.91)	240 (100)

(Figures in parenthesis give percentage to total)

Further discussions with them revealed that most of them offered moral support or they were willing to extend support for some institutional efforts without any involvement in the form of cash or kind. Few of them were ready for spending a part of their income in supporting conservation activities.

4.8.5 Property Rights Status

One of the several ways through which people are connected with any natural resource is through the system of property rights. The issue of property rights raises fundamental questions like who claims rights to what resources, who has access to natural resources, and who has the responsibility for managing it. In property rights regime, Vellayani lake can be considered as a public property, as major portion of the lake is under government possession *ie*. CoA, Vellayani. Discussions with farm officials revealed that out of 173.50 ha of wetland under their possession, 165 ha is completely submerged in water and remaining 8.5 ha are fringe area, where reclamation was done for coconut cultivation. CoA has got possession of lake in fringes of lake at Kulangara, Vavamoola, Panangode, Reservoir, Kadavinmoola and Colony nada. Individuals who had paddy cultivation in the lake also possessed fragments of submerged land in the lake.

The exact area of submerged private property in the lake was not determined by government authorities. However the process has been initiated by the revenue department and the delineation of area and owners of the lake is expected to be published in the near future. Using Geographical Information System (GIS) it was attempted to reveal the ownership details of the lake based on cadastral maps. The plate 36 indicated the survey numbers of private properties which is presently in submerged condition. The yellow borders indicates Venganoor panchayat and the red border shows Kalliyoor panchayat. It is evident that in both panchayats land fragments of individual owners were lying in the lake.

Market failures occur because markets for environmental goods and services do not exist or when the markets do exist, the market prices underestimate their social scarcity values. Markets can exist and function efficiently only when property rights on goods and services exchanged are well defined (Sankar, n.d). The negative externalities due to pollution, encroachment, sand mining and reclamation which cause the degradation of natural environment of the lake arise due to the non enforcement of property rights. The access to lake is free and open to all as there is no clear definition of the boundaries of individual properties submerged. The authorized users are not defined and turned the use of the lake in an open access

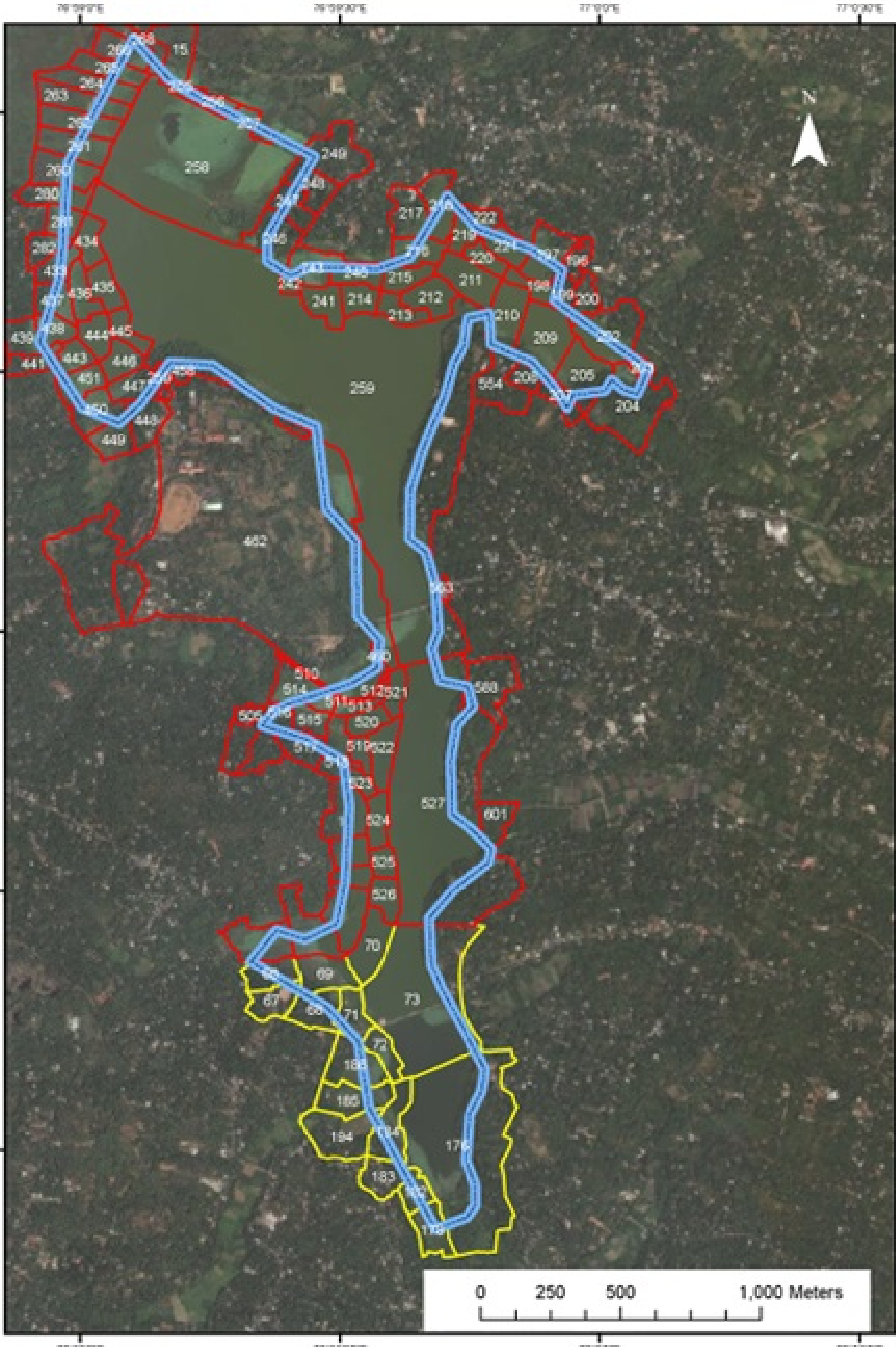


Plate 36. Vellayani lake with land parcels

regime which led to the degradation of the lake. Environmental problems such as pollution and depletion and degradation of natural resources arise because of market failures.

A perusal of Table 59 revealed that among the stakeholders communities studied 50 per cent of lotus collectors 6 per cent of fishermen and 9 per cent of local residents have their property submerged in the lake with an average holding size of 0.06 ha, 0.003 ha and 0.02 ha respectively.

Table 60. Details of submerged land in the lake and the average size of holdings

Category	**Lotus Collectors**	**Fishermen**	**Local residents**
Persons with submerged land (frequency distribution)	3 (50)	2 (5.7)	22 (9.16)
Average holding size in ha	0.06	0.003	0.02

(Figures in parenthesis indicate percentage to total)

These submerged properties are kept idle with them due to the restrictions in reclaiming the wetlands. The stakeholders have different views regarding the management of this property. Those who had paddy cultivation earlier in the lake wanted to get the lake reclaimed for cultivation and others wanted to keep it as such. This difference in opinion and conflicting idea among the stakeholders is a major issue to be addressed before implementing any management action plan. However they are willing to sell the property to government if properly compensated.

The property of individuals were also submerged as part of Vellayani lake, and objections were raised by many individuals on the interventions made on their property in the lake. Management action plan to conserve the lake excluding the private property is not possible, which is a threat for extensive conservation activities including the entire lake area.

4.8.6 Stakeholder’s Perception towards the Ecosystem Services

Vellayani lake provides many services to the people. The respondents may have varying levels of perception to the services received from the lake based on factors such as experience, familiarity, residency and knowledge. A check list of these services were prepared based on the pilot study and the discussions with the respondents. The local residents were asked to rank them according to the relevance they attach to the service in a five point Likerts scale. A relevancy rank was worked out for the eighteen major ecosystem services and the ranking based on the index is presented in the Table 61.

According to the respondents, the most important ecosystem service provided by Vellayani lake is drinking water provision which was ranked 1 with a relevancy coefficient of 0.99. People residing in both the panchayats were utilizing the drinking water from the lake through water supply schemes of KWA. The provision of scenic beauty by the lake was given a score of 0.94. The biodiversity conservation, recreational value, cultural heritage and identity and employment to fisherman followed this. Functioning of College of Agriculture, Vellayani and the spiritual and religious value of lake was given an index of 0.83 followed by lotus leaf and flower collection, washing and bathing, microclimate stabilization, conservation of natural area, ground water recharge, functioning of CSH, increase in land value and duck rearing. The practice of irrigating the crops using the water from the lake was not observed among people except for CoA, Vellayani. Farmers around the lake are using the water from the canals flowing into the lake. So irrigation as an ecosystem service from the lake got the least rank.

Table 61. Relevancy Ranking of Ecosystem Services

Rank	Service	Relevancy Coefficient
1	Drinking water	0.99
2	Providing scenic beauty	0.94
3	Biodiversity conservation	0.92
3	Recreational value	0.92
4	Cultural heritage and identity	0.90
4	Employment to fisherman	0.90
5	Educational and scientific study	0.86
6	College of Agriculture, Vellayani	0.83
6	Spiritual and religious value	0.83
7	Lotus leaf & flower collection	0.82
7	Washing and bathing	0.82
7	Stabilising micro climate	0.82
8	Conservation of natural areas as such.	0.80
9	Ground water recharge	0.73
10	Centralised sports hostel(Kayaking,Canoeing, rowing)	0.69
11	Increase in land value	0.64
12	Duck Rearing	0.57
13	Irrigation water	0.47

In a similar attempt in ranking the use value of Ashtamudi estuary Anoop (2007) revealed that fisheries ranked first among use value with a score of 0.838.

4.8.7 Stakeholder's Perception on Threats Faced by the Lake.

In spite of its fundamental importance to society, Vellayani lake freshwater system have been severely affected by a multitude of anthropogenic and natural disturbances, which have led to serious negative effects on the structure and functions of the lake. Mounting pressures for development due to demographic growth clubbed with other natural and manmade disturbances are the major reasons for these threats. An externality exists whenever the welfare of some agent, or household, depends not only on his or her activities, but also on activities under the control of some other agent. The important threats faced by the lake were listed based on the pilot study and the discussions with the respondents and an index on threats faced by the lake was prepared (Table 62).

Table 62. Index of threats on sustainability of lake

Rank	Threat	Index
1	Pollution	0.94
2	Encroachment	0.93
3	Non demarcation of borders	0.92
4	Demographic pressure	0.91
4	Sewage	0.91
5	Weeds and eutrophication	0.87
6	No management action plan	0.85
7	Agricultural waste	0.84
8	Sand mining	0.83
9	Lotus plants grown in lake	0.77
10	Two bund roads across the lake	0.57
11	Reclamation	0.55

The ranks obtained by arranging the index on the threats faced by the lake revealed that pollution was the most important threat to the lake sustainability with an index of 0.94. As it is a fresh water lake with drinking water schemes installed the respondents were concerned about various sources of pollution that poses threat to its sustainability. The encroachment of the lake by individuals, non demarcation of boundaries of the lake are the other threats faced by the lake. It was followed by threats such as demographic pressure, channelization of sewage into the lake, presence of weeds and eutrophication. Other important threats were absence of management action plan for lake, channelization of agricultural waste into the lake, sand mining, and the growth of lotus plants that prevented easy movement of country boats, entangling of fishing net and decay of organic debris. The construction of bund roads even though improved the road transportation, country boats used by fishermen and lotus collectors had to be carried across the bund road to reach the other side. Easy flow of water was also prevented. Reclamation for paddy cultivation was not prevalent now and it received the least index of 0.55.

This result is in consistence with the results revealed by Anoop (2007) that pollution is the major issue faced by Ashtamudi lake with a score of 0.823 and rank of 1.

4.8.8 Anthropogenic Stressors on the Lake

The Vellayani lake system is subjected to much human induced environmental change. Anthropogenic pressure is most often related to human population increase. An attempt has been made to compile the manifold anthropogenic stressors of the lake and is described below.

4.8.8.1 Agricultural /Fishing Activities

1) The reclamation of the lake for paddy cultivation during 1950s seriously affected the ecological balance of the lake and the catchment area. Inspite of the ecological imbalance it led to encroachment and sand mining.

2) The intensive use chemical fertilizers and indiscriminate use of pesticides was observed in the fields in catchment area. The Kalliyoor Panchayat is one of the good vegetable growing belt of the Thiruvananthapuram district and indiscreet pesticide use is prevalent in that area. The study revealed that, eventhough the lake is not polluted by pesticide residue, the pesticide use pattern of the area warrants constant monitoring in this matter. The canals bringing water to the lake contains of loads of nutrients from the fertilizers applied in the fields which may lead to eutrophication. This is evident from the growth of weeds in the reservoir area (Plate 37).

3) Cultivation of coconut by making heaps of soil in the borders of the lake reduced the area of the lake (Plate 38)

4) Unregulated fishing such as using small mesh sized nets caused the small fingerlings be trapped which reduced the fish population.

4.8.8.2 Watershed Impact.

1) Vellayani lake is rainfed with canals and rain water as main source of water. Diversion, degradation and destruction of these streams/ waterlets due to demographic pressures has reduced the quantity of water flowing into the lake.
2) These water lets are now sources of untreated domestic waste and pollutes the lake (Plate 39). They also carry the residues of chemicals which are applied in the surrounding fields. The runoff received by the lake from the surrounding area carried contaminants from human habitations and nearby roads.
3) Laterite mining and flattening of Thiruvallam hill and Kalliyoor hill is posing serious threat to ecosystem. The denudation of hills and mining not only reduces the water carried to the lake but may cause pollution. Studies by Krishnakumar (1998) on the hydrogeochemistry of Vellayani lake also cautions about this.
4) Sediment loads in reservoir reduced the water holding capacity as well as made it shallow. The siltation in reservoir was mainly contributed during the lake dewatering for paddy cultivation.

Plate 37. Siltation and weed growth in reservoir area

Plate 38. Coconut cultivation in borders of Vellayani lake

Plate 39. Polluted canals carrying water to Vellayani lake

4.8.8.3 Demographic Pressure

1) The rapid population growth and urbanization in the surrounding panchayats are degrading the lake. Illegal constructions and encroachment are the results of demographic growth and urbanization.

2) Many people who are living close to the lake are viewing the lake as source for dumping their household waste. They are directly disposing the waste to the lake. In many houses it was seen that the waste water from bathrooms are channelized in to the lake (Plate 40). Visitors and even locals throw plastic and other bottles after use in to lake. Many canals to lake like *Pallichal thode, Kalliyoor thode, Palappor thodu, Muttakadu thodu* etc. are polluted with household waste and drained into the lake there by polluting the lake.

3) Houses were constructed close to the lake. This may cause the leaching of sewage waste to the lake and prevents easy flow of run off water in to the lake.

4) Sand mining is a major problem in Vellayani lake that affected the functioning and persistence of ecological systems. Due to intervention by panchayat authorities and surveillance by police the sand mining is reduced considerably. The respondents reported that illegal sand mining still continue in *Palapoor* area during night time. The alert groups in Venganoor Panchayat did good job in preventing sand mining from Kadavinmoola and Vavvamoola.

5) Tourism is slowly growing in Vellayani lake owing to its proximity to Kovalam, the world famous tourist destination. The growth in tourism may pollute the lake unless the visitors are properly monitored and managed.

6) In order to facilitate easy transportation two bund roads were constructed across the lake one at Kakkamoola and another at Vavvamoola which prevented the free flow of water and divided the lake into three separate lake.

7) Extraction of water in tanker lorries for distribution in urban area is also prevalent (Plate 41).
8) The new drinking water project with an ultimate demand of 21.9MLD will cause mass extraction of water and so proper water budgeting studies is needed before implementation.

4.8.8.4. Habitat Modification

1) Many fishes like Mushi, attu vala, attu konj, varal which were once prevalent declined in population due to change in the ecosystem.
2) Due to climatic and ecosystem variation the type of migratory birds coming to the lake is altered. The reason for decline of water birds at the Punchakkari Vellayani wetlands is habitat loss due to the absence of paddy cultivation which earlier provided vast areas of mudflat for feeding. Local poachers are catching birds for selling them as pets which is a major threat to the biodiversity.

It was inferred that the sustainability of the lake is largely affected by the anthropogenic stressors rather than the natural forces. The degradation of lake due to anthropogenic stressors were also observed by Qadri and Yosuf (2008) in Dal lake of Kashmir, Verma *et al*. (2011) in Phutak lake in Nagpur and Dhar and Slathia (2014) Himalayan lake, Mansar.

So in order to save the Vellayani lake, the pristine water body ecologically efficient conservation efforts encompassing all the natural and manmade factors is needed. The remedial measures for the anthropogenic stresses mentioned are immediately demanded so that further depletion and degradation is prevented.

4.9. ENVIRONMENTAL AND SOCIAL PROBLEMS FACED BY THE STAKE HOLDERS AND THEIR SUGGESTIONS AND RECOMMENDATIONS

The removal, destruction or impairment of natural ecosystem of the lake system due to both natural and anthropogenic factors are among the greatest causes of critical impacts on the sustainability of Vellayani fresh water ecosystem. The

Plate 40. Household waste channelized into the lake

Plate 41. Extraction of water in tanker lorries

conflicting interests of various stakeholders group is the main hurdle in ecosystem management. The environmental and social problems as perceived by the stakeholders and their suggestions for improving the situations according to them is given in the Table 63.

Table 63. Problems faced and suggestions by stakeholders

Problems	**Suggestions and recommendations by stakeholders**
1.KWA 1. Deterioration in water quality	1. Clean the waterlets coming to the lake 2. Constantly monitor the water quality and check pollution
II. Fishermen 1. Reduction in indigenous species of fishes 2. Unregulated fishing like use of small mesh sized nets by certain fishermen 3. Bund road across the lake prevented the easy transportation of country boats across the lake	1. Regular fish stock enhancement 2. Revitalise the co operative society for fishermen and monitor the fishing practice. 3. Bridges should be constructed in the place of bund roads
III. Lotus collectors 1. Bund road across the lake prevented the easy transportation of country boats across the lake	1. Bridges should be constructed in the place of bund roads
IV .Duck rearers 1. Loss of eggs because ducks may lay eggs in lake	Nil
V. Visitors 1. No facilities available to sit and enjoy the beauty of the lake 2. Street lamps are not provided on all the sides of the lake 3. Absence of roads all around the lake	1. Benches may be provided on the banks 2. Street lamps should be fixed in all sides of the lake 3. Roads may be constructed all around the lake
VI. Local residents 1. Non demarcation of borders of lake.	1. Resurveying and demarcate the borders and

2. Submerged property in lake 3. Muddy water in wells in households close to lake in Arattukadavu and Vavvamoola 4. Certain residents wanted to restart paddy cultivation in the lake which was opposed by others 6.Illegal activities like encroachment, sand mining, pollution and constructions 7. Bund roads across the lake will submerge during rainy season which made transportation difficult.	private property 2.Strict surveillance by government department to prevent illegal activities 3.Panchayat authorities should make arrangement for waste disposal for the households bordering the lake 4.A bridge with good transportation facility should replace the bund roads

4.10 LAKE MANAGEMENT POLICIES

The lake provides enormous value of the ecosystem services, but it is not conceived by many people. This led to degradation and overexploitation of this resource. As a result of demographic pressure and consequent intensified use of the ecosystem services, the lake is increasingly being threatened. Different lake users may conflict with one another for ecosystem use. So an attempt is made to formulate a comprehensive lake management plan based on reliable scientific data, known facts and opinion from technical experts, scientists and social activists.

4.10.1 Institutional Responsibilities

1. Optimum management of the natural resource is important for maintaining sustainability. For this the critically important factor is the assignment of proper property rights. Right to control a property can be derived only by assigning fully defined and enforceable ownership, otherwise market failures are often noticed which affects the sustainability. The enforcement of proper property rights by bringing the lake under a single management may be a prime policy towards the conservation of the lake. The study suggests the formation of Vellayani Lake Management Authority with statutory powers with members from line departments and stakeholders. All the negative externalities affecting the lake should be taken

care of by the trust. Effective co-ordination between all the line departments and stake holders is a key factor in lake management. All the ecosystem users should get a license from the Authority.

2. The study revealed the WTP to conserve the lake by the respondents was low to the extent of Rs 2.91 crore per year. So it is obvious that any management action plan for conserving the lake with the contribution from the local people alone is not practical. They may be made aware of the services provided by the lake and the need to protect the lake. Further it was indicated that the drinking water is the most important provisioning services by the lake. So the economic intervention for the conservation of the lake may be done by introducing a cess along with the water tariffs realized from the individuals using it. Government of India had laid down minimal per capita water supply norms of 70 lpcd (liters per capita per day) in the rural areas. So at least one rupee per 70 litres may be fixed as cess to realize a minimum of 13.97 crores per year for the lake conservation. This amount is meager when compared to the TEV of the lake per year.

3. The pioneering activities by the trust may be the delineation of the borders and boundaries of the lake and construction of retaining walls with eco friendly materials like geo textiles to prevent any encroachment. In all the boundaries fencing may be provided to prevent dumping of the waste. Boat landing centres may be fixed according to the requirement of the stakeholders at certain points. Only licensed boats may be allowed in the lake to prevent sand mining.

4. Proper water budgeting studies may be made before implementing water supply schemes to prevent large scale water extraction. The Pallichal canal is carrying the water from Neyyar Irrigation Project (NIP) to Vellayani lake which contributes to major share of water source in to the lake. In the present context, when contribution of water from NIP to Tamil Nadu and Kerala is much debated, it is important to ensure that the water from NIP reaches the lake through the Pallichal canal.

4.10.2 Stakeholder Management

1. The study revealed that provision of drinking water occupies about 95 per cent of provisioning service. So the lake may be conserved as a fresh water source for assuring the water security for the future.
2. Fishing being the major income generating activity (80%) of the lake the income augmentation of fishermen may be done through regular stock enhancement with fishes like pearl spot, rohu, catla etc. Fishermen should be given license and should be made aware of ecosystem approach in fishing.
3. As majority of fishermen were literate a fishing guide in the form of a book explaining the sustainable and scientific practices to be followed in fishing like size of gillnet mesh and other site specific fishing regulations may be issued. Valid fishing licenses may be issued to all the fisher folk.
4. The existing co operative society may be revitalized and it should be made mandatory that all the fish landings should be recorded in the co operative society whether it is marketed through the society or not. This will help in getting proper record of the fish caught from the lake for future reference.
5. Lotus collectors and duck rearers, even though low in number, are depending on the lake for their livelihood and they are never been addressed. So any action plan formulated for the lake should take care of improving their economic conditions also.
6. The recreational and spiritual value of the lake is gaining importance. The picturesque beauty of the lake and the opportunity to watch rare species of birds attracts many visitors to the lake. It should not be at the expense of natural quality of this fresh water resource.
7. The local residents are deriving many direct and indirect benefits from the lake. To make them aware of the importance of the lake and voluntarily join to conserve the lake, campaigns may be conducted.

4.10.3. General Recommendations.

1. All the existing water lets which is bringing water to the lake may be cleaned opened as the lake is rainfed.
2. The practice of draining household waste into the lake or canals should be prohibited.
3. The two bund roads at Kakkamoola and Vavvamoola may be replaced by bridges.
4. Desilting is needed in the reservoir area in order to increase the water holding capacity.
5. Profuse weed growth in the region where *Pallichal thodu* joins the lake may be removed. Easy flow of water to *Kannukali chal* is prevented due to this.
6. Necessary action may be taken up by authorities to stop flattening of surrounding hillocks.
7. Map of the lake with hot spots of pollution and biodiversity and the practices to be followed while using the lake may be displayed properly.
8. At least 100m from the lake may be considered as buffer zone of the lake and may be sustainably conserved.
9. Constant monitoring of the quality of water in lake should be there.
10. Biodiversity of lake including the macrophytes, insects, fishes, birds etc. should be protected.

The critical need of the day is to recognize the inter-linkages and benefits that could be obtained if Vellayani lake is managed in an integrated and sustainable manner. If not properly managed, the degradation and loss will continue in an accelerated manner leading to the death of the invaluable services provided by the lake which cannot be replaced by any means. More than the economic value of the services of the Vellayani lake estimated, the very existence of a fresh water body for the present and future generation is a matter of significance. Management of lake is a very challenging task and requires actions at many levels and involvement of stakeholders. The economic value of the ecosystem services derived from the study may be considered in economic decision making process to develop economically, environmentally, ecologically and socially acceptable strategies for sustainable management of this unique freshwater source.

Summary

5. SUMMARY

The study entitled "Ecosystem Valuation of Wetlands: A Case Study of Vellayani Lake" was conducted during the year 2013- 2014 at College of Agriculture, Vellayani. The major objective of the study was to assess the Total Economic Value (TEV) of the Vellayani lake, the only fresh water resource in Thiruvananthapuram.

The satellite image of the lake prepared using Geographical Information System revealed that the entire water body of the lake lies in Kalliyoor and Venganoor panchayats. Analysis of temporal variation in area of the water body indicated a drastic reduction in area from 558.73 ha in 1973 to 243.39 ha in 2011. The reduction in area was not the result of natural geological process alone, but the major reason is irrational human activities like unsustainable exploitation of the ecosystem services (benefits the people receive from the lake) due to demographic pressures. Being the only fresh water source in the capital city of Kerala, the area loss in such an alarming rate is a matter of concern. The failure to understand the economic value of the ecosystem services provided by the lake is the major reason for over exploitation of the lake leading to degradation. Under this background, it is imperative that the value of the lake is to be estimated and the importance of this unique ecosystem be understood, so that it better reflects in the decisions which affect the maintenance and service provision by the lake.

The lake and its ecosystem is a bioresource and harbours rich biodiversity of plants and animals. A study of the cropping pattern in the catchment area of the lake revealed that the area, once famous for paddy cultivation, is now almost devoid of paddy and is replaced by vegetables and other perennial crops. The study area had mixed cultivation, with coconut as the major crop occupying more than 66 per cent. Vegetables occupied nearly 15 per cent, and 5 per cent each was occupied by banana and tapioca. The lake system also supports a variety of birds and fishes.

As Vellayani lake is a potential source of drinking water, monitoring its water quality is important. Vegetable cultivation with indiscreet use of pesticide was noticed in the surrounding panchayats and so water sample was drawn from the lake and tested for pesticide residue. Even though pesticide residue was not observed in the sample constant monitoring is needed in this regard. For assessing the drinking water quality of the lake the study adopted the laboratory test result of water samples drawn from six locations of the lake by the Kerala State Pollution Control Board for the year 2013. Principal Component Analysis of the data revealed that Faecal Coliform and Total Coliform are the most important factors that affected the drinking water quality of the lake. This warns about the possible pollution of the lake by sewage.

Participatory Rural Appraisal (PRA), field surveys and focus group discussions were conducted to identify the ecosystem services and stakeholders of the lake system. The main ecosystem services provided by the lake are provisioning services such as drinking water, fishing, duck rearing, lotus collection, irrigation, bathing and washing; regulatory services such as ground water recharge, stabilising microclimate; cultural services such as bird watching photography, boat race, religious rituals, training centres in water sports and finally supporting function such as biodiversity conservation.

Identification of stakeholders enhances the applicability of valuation of ecosystem services to support decision making. The value of the ecosystem depends on the views and needs of the stakeholders. The main stakeholders of the lake system were fisherfolk, lotus collectors, duck rearers, Kerala Water Authority (KWA), Central Public Works Department (CPWD), College of Agriculture, Centralized Sports Hostel foe canoeing Kayaking and rowing, visitors and local residents. The fisherfolk included the group of people, both men and women who depended on the lake for their livelihood. A random sample of 35 fishermen was drawn for the present study. There were six lotus collectors who earned their livelihood by selling the lotus leaves and flowers collected from the lake and all of them were selected for the study. All the five duck rearers who depended on the lake for wading their flocks of ducks were also contacted for collecting the data on ecosystem service use. From among the visitors who visits the lake for recreation, spiritual or cultural activities a sample of eighty five visitors were selected for the study. Two hundred and forty local residents were selected for eliciting their Willingness to Pay to conserve the lake and also to quantify the aesthetic value of the lake. The local residents were selected based on PRA from eight different locations (Arattukadavu, Vazhavila, Kakkamoola, Vavamoola, Venniyoor, Kadavinmoola, Agricultural College and Palapoor) identified around the lake. These locations were divided into three zones at a distance of 100 m, 200 m, and 300 m from the lake. A purposive stratified random sampling was used select a sample size of two hundred and forty respondents in such a way that ten sample respondent were selected from each location. Thus the total sample size for the study was three hundred and seventy one.

The socio economic characteristics of the stakeholders were collected to correlate its impact on the quality of living standard. The important characteristics considered were age, gender, marital status, occupation status, education and income.

The stakeholders who were depending on the lake for livelihood generation such as fishermen, lotus collectors and duck rearers were valuated using market price method. The use value estimated for fishing was Rs. 1.45 crores year $^{-1}$, lotus collection Rs. 0.34 crore year^{-1}, and duck rearing Rs. 0.04 crore year $^{-1}$.

The lake is a source of drinking water for outskirts of the Thiruvananthapuram city. The main drinking water schemes installed in the lake are the Kalliyoor-Thiruvallam-Muttacadu scheme, Water Supply Scheme to Vizhinjam transshipment area by the KWA, CPWD pumping station for the central government office complex at Poonkulam; and the pump house of College of Agriculture, Vellayani. A new Water Supply Scheme to Kovalam and Vizhinjam area is also under construction. All the schemes together extracted nearly 98,677 lakh litres of water per year from the lake. Market price method was used to valuate the drinking water provision and the total value of drinking water provision by the lake was Rs. 370.05 crores year^{-1}.

The instructional farm of College of Agriculture, Vellayani draws 15.12 lakh litres of water per day from the Vellayani lake to irrigate crops. As irrigation water is under priced in Kerala opportunity cost method was used for valuation. The total value of irrigation service was obtained by multiplying the actual quantity of water extracted from the lake for irrigation with the market price of drinking water, and the amount was estimated as Rs. 20.69 crore year^{-1}. The lake was used for bathing and washing and monetary value associated with this valuated using opportunity cost method was Rs 0.87 lakh year $^{-1}$.

Thus provisioning ecosystem services of the lake contributed Rs. 392.58 crores year^{-1} to the TEV of the lake. It is imperative to note the growing importance of the Vellayani lake in providing life sustaining materials and livelihood for people in the two panchayats. In the current scenario of global warming and climate change, water scarcity is creating looming crisis to the city dwellers as well as those living in the outskirts of Thiruvananthapuram district. Thus, the provision of safe drinking water by the lake is important in terms of health security of people also. It contributes to nearly 95 per cent of the total provisioning service. This indicates the need of conserving the lake for life sustaining functions for present and future generations.

Vellayani lake also provides cultural services to the people. Traditionally, the lake provided many and varied important social, ecological and economical functions at different periods of societal development. It was a part of rituals conducted in the nearby temples. The important cultural service provided by the lake are opportunity for formal education and training by Centralised Sports Hostel for Canoeing, Kayaking and Rowing (CSH), photography, bird watching, site seeing, boat race and religious rituals like *karkkidaka vavubali*. Aesthetic value *ie.* increase in the price of property of local households due to lake view is also important.

In the banks of Vellayani Lake, Kerala State Sports Council runs centralized sports hostel for Canoeing, Kayaking and Rowing where training is given for three water sports Canoeing, Kayaking and Rowing. The ecosystem service use by CSH valuated using public pricing method was Rs. 0.24 crore per year.

The Ayyankali trophy boat race conducted annually in Vellayani lake attracts many people from all over the district. It is conducted every year under the joint auspices of Government of Kerala and Mahatma Ayyankali Jalolsava Samithi trust. In the cultural feast conducted in September 17, 2013 big rowing boats (*Chundan vallam*) and small rowing boats participated in the regatta which created a festive mood in the two panchayats. Public investment made for ecosystem service was the economic value of ecosystem use which accounted to Rs.0.07 crore year^{-1}.

The recreational and spiritual activities of the lake were opportunity for photography, bird watching and enjoying the serene beauty of the lake and *Karikidaka vavubali.* Travel Cost Method (TCM), the standard procedure for estimating the recreational value of natural resource was used to estimate the recreational value. Poisson regression for count data model using maximum likelihood estimation method was employed to estimate the Trip Generating Function. The total consumer surplus per visit was estimated as Rs 555.55 per visit and the total recreational value of the lake was estimated as Rs 0.56 crore year^{-1}.

The aesthetic value of the lake was estimated using the Hedonic Pricing Method. For estimation of the marginal implicit price for getting one cent of land with lake view, regression was done with actual property price per cent of the local households as the dependent variable and the environmental attribute, location attributes, neighborhood characteristics and lake view variable as independent variables. The best model selected was linear with R^2 value of 0.75. The regression results revealed that the most important factors that determined the price of land around the lake was the presence of a pucca road followed by lake view of the property. The marginal implicit price of getting one cent of land with lake view was Rs. 79171/- when valuated at mean property price per cent of Rs. 2,44,250/-. So the total aesthetic value of the lake was estimated as Rs 275.92 crores year^{-1}.

Supporting and regulating functions such as ground water recharge, stabilization of microclimate and biodiversity conservation were valuated using a Contingent Valuation Method (CVM). For this double bounded dichotomous choice method was used to elicit the Willingness to Pay (WTP). The mean stated WTP by local households was Rs.225.22 per year. For other stakeholders such as fishermen, lotus collectors and duck rearers the mean stated WTP was Rs 623.42 per year, Rs. 60 per year, Rs. 72 per year respectively. The WTP was estimated using ordinary least squares regression. The results revealed that the major factors that affected the WTP of the local households were area, distance from the lake, monthly income, gender, marital status, education, source of water and presence of submerged property in lake. Thus the value of regulating function and supporting function estimated using CVM was Rs.2.91 crore year^{-1}.

The Total Economic Value (TEV) encompasses measure of the economic value of any environmental asset. It is the value derived by the people from a natural resource. To develop sustainable and welfare optimizing wetland management policy understanding the value of the ecosystem services is crucial. The TEV, the sum of all the goods and services offered by the lake is estimated as Rs 672.28 crore per year. The drinking water contributed to nearly 55 per cent of the TEV of ecosystem services. In a district like Thiruvananthapuram, with high demand for drinking water the importance of conserving this fresh water resource is a matter of urgent attention. Besides this, the lake provides drinking water to projects of international relevance such as Vizhinjam Transhipment Container Terminal and Kovalam tourism area. Next important factor contributing to the TEV of the lake is aesthetic value. In a state where property prices are skyrocketing every day, with booming real estate market and property transactions, presence of a picturesque lake definitely catches higher price. The hike in land prices, due to the view of the lake, captured using hedonic property pricing method revealed an aesthetic value of Rs. 275.92 crores year^{-1} which contributed to nearly 41 per cent of the TEV. Even though contribution of sectors like fishing, lotus collection and duck rearing were meager they assumes importance as they are source of income for economically backward and downtrodden sections of the society. The low WTP (2.91 crore year^{-1}) of the people regarding the conservation of the lake revealed that people underestimate the ecological and economic importance of this precious resource due to lack of awareness. The trends in flow of goods and service were predicted based on drivers of change. The per capita value of demand for goods and services was forecasted for 2021 as Rs. 0.20 crore per year.

In addition to stakeholders selected for valuation of the ecosystem there are many institutional stakeholders who affects or are affected by the ecosystem use. The government institutions are interested in implementing conservation programmes. Institutions like kanthari international, Daksha Seth Dance Company situated in the banks of the lake are interested in enjoying the lake beauty. Organisations like ‘Save Vellayani Lake Campaign’ are regularly conducting programmes involving local people and various organizations to create awareness regarding the conservation. The interest of these institutions is evident from their involvement in either protection of the lake or presence near the lake even though they are not deriving any monetary benefits from the lake.

Anthropogenic forces are human activities that affect the sustainability of lake ecosystem. The physico-chemical and biological characteristics of the lake basin is greatly influenced by both natural and anthropogenic inputs. These anthropogenic inputs directly affects the lake or originates from catchment areas to find their way through the streams, and eventually enter the lake. The major anthropogenic stressors of the lake were encroachment, sand mining, diversion, degradation and destruction of the canals bringing water to the lake, laterite mining in surrounding hillocks, reclamation, pollution and unregulated fishing. The analysis of frequency of visits made by the stakeholders revealed the majority (>60%) of the stakeholders visited the lake daily and believed that the lake is moderately polluted. More than 50 per cent of the respondents had the opinion that the lake is only moderately conserved and demanded more conservation activities.

Vellayani lake can be considered as a public property as major portion of the lake is under government possession with College of Agriculture, Vellayani. But several individual owners have fragments of property in the lake in submerged condition. Among the stakeholders communities studied 50 per cent of lotus collectors 6 per cent of fishermen and 9 per cent of local residents have their property submerged in the lake with an average holding size of 0.06 ha, 0.003 ha and 0.02 ha respectively. These properties are submerged in the lake and kept idle. Clear definition of the boundaries of individual properties is not done and consequently no authorized users are defined. At present access and use of the lake is free and open to all, and therefore anyone can exploit the lake without limit which led to the overexploitation and degradation of the lake. As property of individuals were also submerged as part of Vellayani lake objections were raised by many individuals on the interventions made on their property in the lake. Management action plan to conserve the lake excluding the private property is not possible, which is a threat for extensive conservation activities including the entire lake area.

The relevancy ranking by the respondents about the ecosystem services provided by the lake revealed that the most important ecosystem service by the lake is provision of drinking water followed by provision of scenic beauty. Ranking of the threat to the lake revealed that most important one faced by the lake was pollution followed by encroachment.

The important environmental and social problem faced by the stakeholders as perceived by them were deterioration of water quality, reduction in indigenous fishes in the lake and non demarcation of the boundaries of the submerged property in the lake.

In the light of the present study management action plan was developed. It was suggested that the enforcement of proper property rights by bringing the lake under a single management should be a prime policy towards the conservation of the lake. The low WTP by the people reveals that the management of the lake using people's contribution alone is not feasible. The study suggests the formation of Vellayani Lake Management Authority with statutory power having members from line departments and stakeholders. The authority may take steps to prevent encroachment, sand mining and reclamation which are major threats of lake. All the activities regarding the lake may come under this authority so that further degradation of the lake is prevented The pioneering activities by the trust may be the delineation of the borders and boundaries of the lake and construction of retaining walls with eco friendly materials like geo textiles to prevent any encroachment. In all the boundaries fencing may be provided to prevent dumping of the waste. Boat landing centres may be fixed according to the requirement of the stakeholders at certain points. Only licensed boats may be allowed in the lake to prevent sand mining.

The critical need of the day is to recognize the inter linkages and benefits that could be obtained if Vellayani lake is managed in an integrated and sustainable manner. If not properly managed, the degradation and loss will continue in an accelerated manner leading to the death of the invaluable services provided by the lake which cannot be replaced by any means. More than the economic value of the services of the Vellayani lake estimated, the very existence of a fresh water body for the present and future generation is a matter of great significance. Management of lake is a very challenging task and requires actions at many levels and involvement of stakeholders. The economic value of the ecosystem services derived from the study may be considered in economic decision making process to develop strategies for conservation and sustainable management of this unique freshwater source.

References

6. REFERENCES

Abhinja,U.G., Ratheesh,R., and Kumar,A.K.B. 2013. Distribution and diversity of aquatic insects of Vellayani lake in Kerala. *J.Environ. Biol.*34 : 605-611

Abhirosh , C., Sherin, V., Thomas, A.P., Hatha, A.A.M., and Mazumder,A. 2011. Potential public health significance of faecal contamination and multidrug-resistant Escherichia coli and Salmonella serotypes in a lake in India. *Public Health*. 125 : 377 -379

Abila, R. 2005. *Biodiversity and Sustainable Management of a Tropical Wetland Lake Ecosystem : A Case Study of Lake Kanyaboli, Kenya* [online]. DAAD Alumni Summer School 2005 - Topics of Integrated Watershed Management. Available: http://www.uni-siegen.de/zew/publikationen/volume0305/abila.pdf [18 April 2014]

Adger, N., Brown,K., Cervigni,R., and Moran, D. 1994. *Towards Estimating Total Economic Value of Forests in Mexico.* CSERGE Working Paper GEC 94-21, Centre for Social and Economic Research on the Global Environment, University of East Anglia and University College London. 37p. http://www.cserge.ac.uk/sites/default/files/gec_1994_21.pdf [20 May 2014]

Akwetaireho, S. 2009. Economic Valuation of Mabamba Bay Wetland System of International Importance, Wakiso District, Uganda. M.Sc. Thesis. Alps-Adriatic University of Klagenfurt, Klagenfurt, Austria,135p.

Alexander, R. and Kumar, R.S. 2013. Diversity of Fish Fauna and Their Threats in Ousteri Lake, Puducherry, India. *World J. Zool*. 8 (2): 154-158

Aneesh, C. and Manilal, V.B. 2013. Continuous Presence of Colony Forming Microcystis and Scenedesmus in Fresh Water Lake and Ponds. *Bot. Res. Int.* 6 (1): 7-12

Anilkumar, R. 1999. *Ecological Appraisal and analysis of land use changes in Vellayani lake basin-A study towards sustainable development*. Project Report,Kerala Research project on Local leval development,Centre for developmental studies ,Trivandrum, 63p.

Anoop, P. 2007. Economic valuation of Ashtamudi estuary in Kerala. M.Sc (Ag) Thesis, University of Agricultural Sciences, Bangalore, 73p.

Anoop, P., Suryaprakash, S., Umesh, K. B. and Babu, A. T. S. 2008. *Conservation of lakes and wetlands for future.* In:Sengupta,M. and Dalwani,R. (eds.), Economic valuation of use benefits of Ashtamudi estuary in South India. Proceedings of Taal 2007, Jaipur, India.Ministry of Environment and forest, Government of India, International Lake Environment Committee Foundation, Jaipur, pp. 1822-1826.

Athira, S. 2011. Present status of fish stock enhancement and its impact o fisherman in Vellayani lake of Kerala, M.Sc thesis, Department of Aquatic Biology and Fisheries, University of Kerala, Kariyavattom, Thiruvananthapuram, p.38

Aziz, P.K.A. 1989. *The Vellayani Fresh Water Lake Trivandrum Kerala: A Status Report.* Kerala State Committee on Environment,Trivandrum, 85p.

Babu,C.R., Kumar,P., and Praad,L., and Agarwal., R. 2002. *Valuation of Ecological functions and Benefits: A Case Study of Wetland Ecosystems along the Yamuna River Corridors of Delhi Region*[online]. EERC Working Paper Series: WB-6, New Delhi. Available: http://coe.mse.ac.in/eercrep/fullrep/wetbio/WB_FR_LallanPrasad.pdf [11 Feb 2012] .

Bagstad, K.J., Johnson, G.W., Voigt, B., and Villa, F., 2013. Spatial dynamics of ecosystem service flow: a comprehensive approach to quantifying actual services. *Ecosyst.Serv*. 4: 117–125

Barbier, B.E. 1989. *The Economic Value of Ecosystem.2- Tropical Wetlands*. Gate Keeper Series, No LEEC 89-02, 18p. Available : http://www.mekonginfo.org/assets/midocs/0001747-economy-the-economic-value-of-ecosystems-2-tropical-forests.pdf [2 May 2014]

Barbier, B. E. 1993. Sustainable use of wetlands valuing tropical wetland benefits: economic methodologies and applications. *The Geol. J*. 159(1): 22-32.

Barbier, E.B. 2013. Valuing Ecosystem Services for Coastal Wetland Protection and Restoration: Progress and Challenges. *Resources*. *2*(3) : 213-230

Barbier, E.B., Acreman M.C., and Knowler, D. 1997. *Economic valuation of wetlands: a guide for policy makers and planners.* Ramsar Convention Bureau, Gland, Switzerland,125p.

Bedametta, S., Jyotishi,A., and Mahapatra,S.K. 2012. *Wetland Valuation : A review of Theoretical and Empirical Issues.* Working Paper No.116, Amrita School of Business, Coimbatore. 31p.

Bell, F.W. and Leeworthy, V.R. 1990. Recreational Demand by Tourists for Salt water Beach Days. *J. of Environ. Econ. Mgmt*. 18:189-205.

Bharali, A. and Mazumdar,R. 2012. Application of travel cost method to assess the pricing policy of public parks: The case of Kaziranga national park. *J. Regi. Dev.Plan.1 (1):* 41-50

Bhattacharya, S., Ganguli, A., Bose, S., and Mukhopadhyay, A. 2012. Biodiversity, traditional practices and sustainability issues of East Kolkata Wetlands: A significance Ramsar site of West Bengal, (India), Res. *Rev. BioSc*. 6(11) : 340-347

Binilkumar, A.S. 2010. Economic valuation of wetland attributes: A case study of Kol wetlands in Kerala .Ph.d thesis, Indian Institute of Technology, Mumbai, 257 p.

Birol, E., Karousakis, K., and Kandour, P. 2006. Using economic valuation techniques to inform water resources management: A survey and critical appraisal of available techniques and an application. *Sci Tot. Environ*. 365 : 105-122.

Blomquist, G. C., and Whitehead, J. C., 1998. Resource Quality information and Validity of Willingness to Pay in Contingent Valuation. *Resour. Energy Econ.* 20(2): 179-196

Boxall,P.C., Chan,W.H., and Mc Millan, L. 2005. The impact of oil and natural gas facilities on rural residential values : A spatial hedonic Analysis. *Resour. Ener. Econ*. 27(4): 248-269

Boyd, J. and Banzhaf, S. 2006. What Are Ecosystem Services? The Need for Standardized Environmental Accounting Units [online]. *Discussion paper, Resources for the future.* Available: http://www.rff.org/Documents/RFF-DP-06-02.pdf [2 Jan.2014]

Brander, L.M., Raymand, J., Florax, G.M., and Vermaat , J.E. 2006. The empirics of wetland valuation: A comprehensive summary and a meta analysis of the literature. *Environ. Resour. Econ*. 33: 223-250

Brinson and Malvarez. 2002. Temperate freshwater wetlands: types, status, and threats. *Environ. Conserv.* 29 (2): 115–133

Brookshire, D., Eubanks, L., and Randall, A. 1983. Estimating option price and existence values for wildlife resources. *Land Econ.* 59:1–15.

Brown, T.C., Bergstrom, J. C., and Loomis, J.B. 2006. *Ecosystem Goods and Services: Definition, Valuation and Provision* [online]. Discussion Paper. http://www.fs.fed.us/rm/value/docs/ecosystem_goods_services.pdf [2 Feb. 2014]

Bulov, S. and Lundgren, T. 2007. An Economic Valuation of Periyar National park A Travel Cost Approach.[on line].Lulea University of Technology. Available: http://epubl.ltu.se/1402-1773/2007/070/LTU-CUPP-07070-SE.pdf [24 April 2012]

Carpenter, S.R. and Lodge, D.M., 1986. Effects of submersed macrophytes on ecosystem processes. *Aquat. Bot*., 26: 341-370.

Carpenter, S.R., 1980. Enrichment of Lake Wingra, Wisconsin, by submersed macrophyte decay. *Ecol.* 61: 1145-1155

Carson, R.T. 2012. Contingent valuation: A practical alternative when prices aren't available. *J. Econ. Persp.* 26(4): 27-42

CED (Centre for Environment and Development). 2003. *Survey and Inventory of Wetlands of Kerala for Conservation and Sustainable Management of Resources*. Centre for Environment and Development, Trivandrum. 216p.

Centeno, A.B. and Prieto, L.C.H. 2000. The travel cost method applied to the valuation of historic and cultural heritage of the Castile Leon region of SPAIN. *Proceedings of fortieth congress of the European Regional Science Association*.2000, Barcelona Available: http://core.kmi.open.ac.uk/download/pdf/7051452.pdf [12 May 2013]

Chambers, R. 1994. The origin and practice of PRA. *Wld Dev*. 22(7): 953-969

Chaudhry , P.,Sharma,M.P., and Singh, G. 2013. Significance of Environmental Amenities in a Planned City: An Evidence from Chandigarh, India, *J. Environ. Sci. Toxic. Food Tech.*4(6):60-66

Costanza, R., d'Arge, R., de Groot, R., Farberk, S., Grasso, M., Hannon, B., Limburg, K., Naeem,S., O'Neill,R.V., Paruelo,J., Raskin,R.G., Suttonkk, P., van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. *Nature*.387:253-260

Costanza, R., D'Arge, R., DeGroot R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J, Raskin, R., Sutton, P., Belt, M. 1997. The Value of the World's Ecosystem Services and Natural Capital. *Nature*. 387: 253–260.

Das, B., Narwani, A., Matthews, B., Nordin, R., and Mazumd, A. 2008. Anthropogenic disturbance history influences the temporal coherence of paleoproductivity in two lakes. *J Paleolimnol* .Available: http://snre.umich.edu/cardinale/wp-content/uploads/2012/04/Das-et-al-J-Paleolim-2008.pdf[12 Jan.2013]

Dasgupta, P. and Dasgupta, R. 2004. Economic value of safe water for the infrastructurally disadvantaged urban household: A case study in Delhi, India. *Water Resour. Res.* 40: 1-10. Available : http://onlinelibrary.wiley.com/doi/10.1029/2003WR002461/pdf [14 Sept. 2014]

DEFRA. 2007. *An Introductory Guide to Valuing Ecosystem Services*. Department of Environment Food and Rural Affairs, London, 65p. Available: http://archive.defra.gov.uk/environment/policy/natural-environ/documents/eco-valuing.pdf [22 April 2012].

deGroot, R. D., Stuip, M., Finlayson, M. and Davidson, N. 2006. *Valuing wetlands-guidance for valuing the benefits derived from wetland ecosystem services.* Ramsar Technical Report No. 3, CBD Technical Series No. 27, Ramsar Convention Secretariat, Gland, Switzerland and Secretariat of the Convention on Biological Diversity, Montreal, Canada, 45p.

deGroot, R. D., Stuip, M., Finlayson, M. and Davidson, N. 2006. V*aluing wetlands-guidance for valuing the benefits derived from wetland ecosystem services*. Ramsar Technical

Report No. 3, CBD Technical Series No. 27, Ramsar Convention Secretariat, Gland, Switzerland and Secretariat of the Convention on Biological Diversity, Montreal, Canada . 45p.

deGroot, R.S., Wilson, M.A., and. Boumans,R.M.J. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecol.Econ.*41 : 393-408.

Dehlavi, A. and Adil, I.H. 2011. *Valuing the Recreational Uses of Pakistan's Wetlands: An Application of the Travel Cost Method.* SANDEE, Nepal, 28p. Available: http://www.sandeeonline.org/uploads/documents/publication/932_PUB_Working_Paper_58_Ali_Dehlavi.pdf [12 May 2012]

Deka, J., Tripathi, O.P., and Khan, M. L. 2011. A multi-temporal remote sensing approach for monitoring changes in spatial extent of freshwater lake of Deepor Beel Ramsar Site, a major wetland of Assam. *J. Wet. Eco.* (5): 40-47

Desvousges,W.H., Johnson, F.R., Dunford, R.W., Boyle, K. J., Hudson,S.P., and Wilson, N. 1993. Measuring natural resource damages with contingent valuation: tests of validity and reliability. In: Hausman, J. A, (ed.), *Contingent Valuation: A Critical Assessment*. North Holland, pp. 91– 159.

Devi, P. 2012. Dynamics of Farm Labour Use — An Empirical Analysis. Agric.Econ. Res. Rev. 25(2): 317-326

Dewanta, A.S. 2010. Valuation of Mount Merapi National Park: A Travel Cost Analysis. *Econ. J. Ener. Mkt*. 2(1): 77-86

Dhar, S and Slathia, D. 2014. A Freshwater Ramsar Site under Pressure :Assessing Threats and Identifying Conservation Needs for Lower HimalayanLake, Mansar (India). Int. *J. Innov.Res. Sci. Engg. Tech.* 3(6): 13:13747-13753

Dixon, J.A. 2008. Environmental Valuation: Challenges and Practices A Personal View. In: *Economics and Conservation in the Tropics: A Strategic Dialogue,* January 31 – February 1, 2008 [Online]. Available: http://www.rff.org/Documents/08_Tropics_Conference/Tropics_Conference_Papers/Tropics_Conference_Dixon_Environmenal_Valuation.pdf [12 Mar 2013].

Doss, C.R., Taff, S.J., 1996. The influence of wetland type and wetland proximity on residential property values. *J. Agric. Resou. Econ.* 21(1): 120–129.

Driml, S. 2002. Travel cost analysis of recreational value in the wet tropics of world heritage area. *Econ. Anal. Pol*. 32 (2): 11-26

Emerton, L., Iyango, L.,Luwum,L., and Malinga,A. 1998. The present economic value of Nakivubo urban wetland, Uganda. IUCN, Kampala, 30p. Available : https://portals.iucn.org/library/efiles/documents/1999-047.pdf [12 Mar. 2014]

Eppink,G., Brander,L.M., and Wagtendonk, A.J. 2014. An intial assessment of economic value of coastal and freshwater wetlands in West Asia. *Land.* 393: 557-573

Farber, S.C., Costanza, R., and Wilson, M.A. 2002. Economic and ecological concepts for valuing ecosystem services. *Ecol. Econ.*41: 375-392

Fisher, B., Turner., R. K., and Morling. P. 2009. Defining and classifying ecosystem services for decision making. *Ecol. Econ*.68 : 643 – 653

Fonseca, S. and Rebelo, J. 2010. Economic Valuation of Cultural Heritage: Application to a museum located in the Alto Douro Wine Region– World Heritage Site. *Pasos.* 8: 339-350.Available : http://www.redalyc.org/pdf/881/88112768007.pdf [14 May 2014]

Gawler, M. 1998. What are best practices? Lessons in participatory management of inland and coastal wetlands. In: Gawler, M. (ed.*), Proceedings of a Workshop held at the 2nd International Conference on Wetlands and Development*, Dakar, Senegal Wetlands International IUCN, WWF Publication No. 56, Wageningen, The Netherlands, pp 1-12

Global Nature Fund.2004 . *Reviving Wetlands – Sustainable Management of Wetlands and Shallow Lakes* [online]. Global Nature Fund (GNF), Germany, Available : http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=Manual_Broschure_Englisch.pdf [20 April 2014]

GOI [Government of India]. 2007. *Conservation of wetlands in India:A profile(Approaches and guidelines).* Ministry of Environment and Forests, New Delhi, 40p.

GOI [Government of India]. 2014. *Agriculture Census 2010-11*[on-line]. Available: http://agcensus.nic.in/document/agcensus2010/completereport.pdf [2 Jan.2014]

GOI (Government of India). 2014a. *Panchayat PCA*. CD-ROM, Directorate of Census Operations, Poonkulam.

GOK (Government of Kerala). 2008. *Water Policy 2008*. Water Resources Department. Government of Kerala, 30p.

Gopakumar, P.S. and Kaimal, P.P. 2008. *Conservation of lakes and wetlands for future.* In:Sengupta, M. and Dalwani, R. (eds.), Loss of wetland breeding habitats and population decline of white breasted water hen, Anourornis phoenicurus phoenicurus (pennent)- A case study. Proceedings of Taal 2007, Jaipur, India.Ministry of Environment and forest, Government of India, International Lake Environment Committee Foundation, Jaipur, pp. 592-536

Gopal, L. 2010. Suitability of small aquatic ecosystem for fish stock enhancement programme: a case study of Vellayani lake. M.Sc thesis, Department of Aquatic Biology and Fisheries, University of Kerala, Kariyavattom, Thiruvananthapuram, p.26

Government of Alberta. 2011. Ecosystem Services Approach Pilot on Wetlands [online]. Government of Alberta. Available: http://environment.gov.ab.ca/info/library/8493.pdf [12 June 2014]

Gunatilake, H. M. 2003. *Environmental Valuation : Theory and Applications*. Post graduate Institute of Agriculture, Srilanka, 373p.

Gupta, J. 1991. Factors influencing aspiration of marine fishermen *Ind J.Extn.Edn*.17: 36-45

Gupta, V and Mythili, G. 2009. Willingness to Pay for Water Quality Improvement: A Study of Powai Lake in India. *Asian J. Water, Environ. Pollution*, 8(1) : 15-21.

Halkos,G and Matsiori, S. 2013. The relationship between people's attitude and willingness to pay for river conservation. MPRA Paper No 50560. Available: http://mpra.ub.uni-muenchen.de/50560/ [12 Aug. 2014]

Hanley,N.S., Mourato, and Wright, R.E. 2001. Choice modeling approaches:A superior alternative for environmental valuation.J. Econ Surveys15(3): 435-462

Hanley, N., Shogren, J.F., and White,B. 2007. *Environmental Economics*. Second Edition. Palgrave Macmillan, New York, 459p.

Hanley, N., Wright, R.E. and Adamowicz, W.L. 1998. "Using Choice Experiments to Value the Environment". *Environ. Resour. Econ*. 11: 413- 428.

Hatha, M., Chandra,C., and Varghese,S. 2008. *Conservation of lakes and wetlands for future*. In:Sengupta, M. and Dalwani, R. (eds), Increased prevalence of indicator and pathogenic bacteria in the Kumarakom lake: A function of salt water regulator A function of salt water regulator in Vembandu lake a Ramsar site,along west coast India. Proceedings of Taal 2007, Jaipur, India.Ministry of Environment and forest, Government of India, International Lake Environment Committee Foundation, Jaipur, pp. 250-255

Hein, L., Koppen,K.V., de Groot, R. S., and Ierland, E. C .V. 2006. Spatial scales, stakeholders and the valuation of ecosystem services. *Ecol. Econ*. 57 : 209 – 228

Hellerstein, D. and Mendelsohn, R. 1993. Theoretical foundations for count data models. *Am. J. Agric. Econ*. 75 (3): 604-611.

Hema, M. 2013. Economic valuation of mangrove ecosystems in Kerala. Ph.D Thesis, Kerala Agricultural University, Thrissur, 196p.

Holland, R.A., Eigenbrod, F., Armsworth, P.R. Anderson, B,J..Thomas, C D., and Gaston, K. H. 2011. The influence of temporal variation on relationships between ecosystem services. *Biodiver. Conserv*. 20: 3285–3294

Hooper, D.U., Chapin F. S ., Ewel, J. J., Hector, A., Inchausti, P., Lavorel, S., Lawton, J. H., Lodge, D. M., Loreau, M., Naeem, S., Schmid, B., Setala, H., Symstad, A. J., Vandermeer, J., and Wardle, D.A. 2005. Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. *Ecol. Mono*.75:3–35

Iamtrakul,P., Hotato,K., and Tekenomo,K. 2005. Public Park valuation using travel cost method. Eastern Asia Society for Transportation studies , 5 -1244-1264

Ikeuchi,A., Keita Tsuji, K.,Yoshikane.,F and Ikeuchi,U. 2012. Double-bounded Dichotomous Choice CVM for Public Library Services in Japan. *Procedia Soc.*

Behav. Sci.Available : http://slis.sakura.ne.jp/IC-ININFO_Atsushi_Ikeuchi_et_al.pdf [12 Mar.2014*]*

Imandoust, S.B. and Gadam, S.N. 2007. Are people willing to pay for river water quality, contingent valuation, *Int. J. Environ. Sci. Tech.,* 4 (3): 401-408

Irwin, E.G., 2002. The effects of open space on residential property values. *Land Econ.* 78 (4): 465–480.

ISRO (Indian Space Research Organization). 2011. *Information Brochure National Wetland Inventory and Assessment*, Space Application Centre, Indian Space Research Organization, Ahamedabad, 24p.

ISRO (Indian Space Research Organization). 2010. *National Wetland Atlas : Kerala*, Space Application Centre, Indian Space Research Organization, Ahamedabad, 130p.

IUCN [International Union for Conservation of Nature] . 2004. *The Conservation and Sustainable Use of Freshwater Resources in West Asia, Central Asia and North Africa* [online] . Available : http://cmsdata.iucn.org/downloads/the_conservation_and_sustainable_use_of_freshwater_ressources_in_west_asia_central_as.pdf [20 April 2014]

Jain, A., Singh, R.S and Singh, B. 2004. Economic evaluation of Lotus (*Nelumbo nucifera Gaertn*) cultivation in Sonapet lake,Manipur valley. *Nat. prod.Radi.*36:418-421

Jantzen, J. 2006. *The Economic Value of Natural and Environmental Resource.* Institute of Applied Environmental Economics, The Netherlands, 79p. Available: http://www.itme.nl/pdf/assessment%20of%20econ%20value%20of%20environment%20final.pdf [12 Jan.2012]

Jayaraman, K., Krishnankutty, C.N. Menon, A.R.R., Anitha, V., Nair, P. V., Sivaram, M. Jayson, E.A. and Rugmini, P. 2008. *Information Compendium on Kerala Forestry Sector.* KFRI Research Report No. 31, Kerala Forest Research Institute, Peechi, 56p.

Jenkins,W.A., Murray ,B.C. Kramer, R.A., and Faulkner, S.P. 2010. Valuing ecosystem services from wetlands restoration in the Mississippi Alluvial Valley, *Ecol. Econ.* 69 : 1051–1061

Jhingran,V.G. 1992. *Fish and Fisheries in India*, Hindustan Publishing Corporation, Delhi, India, 750 p.

Jim, C.Y and Chen, W.Y. 2006. Impacts of urban environmental elements on residential housing prices in Guangzhou (China). *Landscape Urban Plan.* 78 (4) :422–434.

Jinraj,P.V. 1997. Socioeconomic status of traditional fisherfolk in Kerala-A study in Thiruvananthapuram district, M.Sc(Ag) Thesis, Kerala Agricultural University, Thiruvananthapuram, 77p.

Jolliffe, I, T. 2002. *Principal component Analysis* [book on –line]. Springer. Available : http://wpage.unina.it/cafiero/books/pc.pdf. [30 Mar.2014]

Kakuru, W., Turyahabwe, N., and Mugisha, J. 2013. Total economic value of wetlands products and services in Uganda. *Sci. World J.* [e-journal]. Available: http://www.hindawi.com/journals/tswj/2013/192656/.[21 Mar.2013]

Kamal, K. 2011. Evaluation of aquatic pollution and identification of Phyto remediators in Vellayani lake. M.Sc (Ag) Thesis, Kerala Agricultural University, Thiruvananthapuram, p.129

Kang , A. 2010. *Protection and Management of Urban Lakes in India* [on line]. Centre for Science and Environment. Available : http://www.cseindia.org/userfiles/Lake%20Protection%20and%20Management%20of%20Urban%20Lakes%20in%20India.pdf [20 May 2014]

Kang, A. 2013. *Briefing Paper: Legal, Institutional and Technical Framework for Lake/Wetland Protection* . Centre for Science and Environment, Tughlakabad Institutional Area , New Delhi.14p.

Kannan, K.P. 1998. Political Economy of Labour and Development in Kerala — Some Reflections on the Dilemmas of a Socially Transforming Labour force in a Slow

Growing Economy. Working Paper. The London School of Economics and Politics, London, 62p.

KARD (Kerala Association for Rural Development and Peace). 2004. *Vibhavabhoopada Nirmana Report.* Kerala Association for Rural Development and Peace,Thiruvananthapuram, 25p.

KAU (Kerala Agricultural University). 2009. *Sustainable Management of Vellayani Wetland Ecosystem: An Intervention Strategy*. College of Agriculture, Vellayani. 51p.

Kiran, P.R.B., Sary, P.S., Sajid, A,. and Madhu, V.R. 2013. Use of encircling gill net, *vaanguvala*, for catching Indian major carps (*Catla catla* and *Labeo rohita*) in the Vellayani Lake, Trivandrum. *In: Proceedings of the 25th Kerala Science Congress,* 29 January to 1st February, 2013, Technopark, Trivandrum, pp. 147-149

Kontogianni, A., Skourtos,M.S., Langford, I.H., Bateman,I.J., Georgiou,S. 2001. Integrating stakeholder analysis in non-market valuation of environmental assets. *Ecol. Econ*. 37 : 123–138

Korsgaard,L., and Schou, J.S. 2010. Economic valuation of aquatic ecosystem services in developing countries. *Wat. Policy*. (12) : 20-31

Kreuter, U. P., Harris, H.G., Matlock, M.D., and Lacey, R.E. 2001. Change in ecosystem service values in the San Antonio area, Texas. *Ecol Econ* 39: 333–346.

Krishnakumar, A. 2002. Environment degradation of river basin of South Kerala, Ph.D Thesis, University of Kerala, Thiruvanathapuram, 363p.

Kruse, S.A and Ahmann,J. 2009. The Value of Lake Adjacency: A Hedonic Pricing Analysis on the Klamath River, California, Ecotrust Working Paper, Portland, 12p. Available : http :// archive. ecotrust.org/ workingpapers/ WPS5_Value_of_Lake_Adjacency.pdf [12 May2013]

KSLUB (Kerala State Land Use Board). 2011. *Neerthadishtitha karma padhidhi kalliyoor grama panchayat.* Vikasbhavan, Trivandrum. 98p.

KSPCB (Kerala State Pollution control Board). 2010. *Vellayani lake.* Kerala State Pollution Control Board,Thiruvananthapuran, 44p.

Kumar, A.B. and Kiran, P.K.B. 2013. Vellayani Fish Census Field Guide and Report. Department of Aquatic Biology and Fisheries, University of Kerala,Thiruvananthapuram, 64p.

Kumar, M.M. 2011. Studies on plankton population and Benthic communities in Vellayani lake, Kerala, M.Sc thesis, Department of Aquatic Biology and Fisheries, University of Kerala, Kariyavattom, Thiruvananthapuram, p.46

Kumar, P and Sukdev, P. 2009. *The Economics of Ecosystems and Biodiversity for National and International Policy makers –Summary: responding to the value of nature 2009.* Wesseling, Germany, p.39.

Lekshmi, M.S. 2012. Diversity of free living freshwater protozoa in Vellayani lake in Kerala. M.Sc Thesis, Department of Aquatic Biology and Fisheries, University of Kerala, Kariyavattom, Thiruvananthapuram, p.26

Levchuck, S. 2003. Economic valuation of the Sivash wetlands (Crimea, southern Ukraine). M.Sc Thesis, Department of Environmental Sciences, Wageningen University, The Netherlands , 149p.

Loomis, J. B, and duVair, P.H. 1993. Evaluating the effects of alternative risk communication devices on willingness to pay: results from a dichotomous choice contingent valuation experiments. *Land Econ*. 69: 287– 98.

Loomis, J., Kent, P., Strange, L., Fausch, K., and Covich, A. 2000. Measuring the total economic value of restoring ecosystem services in an impaired river basin: results from a contingent valuation survey. *Ecol. Econ*. 33 : 103–117

Loomis, J and Feldman, M. 2003. Estimating the benefits of maintaining adequate lake levels to homeowners using the hedonic property method. *Water Resou. Res.* 39 (9): 1259.

Loomis, J., Kent,B., Strange,l., Fausch,K., and Covich,A. 2000. Maesuring the TEV of restoring ecosystem service in an impaired river basin: Results from Contingemt Valuation survey. *Ecol. Econ.*33:109-117

MA (Millennium Ecosystem Assessment). 2003. Ecosystems and Human Well-being: A Framework for Assessment, Island Press, United states. 235p.

MA (Millennium Ecosystem Assessment Report). 2005. *Ecosystems and Human well-being: Wetlands and Water Synthesis,* World Resources Institute, Washington DC, 68p.

Mace,G., Masundire, H., and Baillie, J. 2005. Biodiversity[online]. Ecosystems and Human Well-being: Current State and Trends. Available : http://www.unep.org/maweb/documents/document.273.aspx.pdf [2 Mar. 2014]

Mafumbo, J., Jordahl, M., Nabulumbi, J., Mwesigye , J., Madanda,S., Malinga,J., Arinaitwe,B and Bagyenda, R. 2010. *A Socio-Economic Baseline Survey of Communities.Adjacent to Lake Bisina/Opeta and Lake Mburo/Nakivali Wetland Systems*. Available: http://natureuganda.org/downloads/Socio-Economic%20Baseline%20Survey%20of%20COBWEB%20Project%20Implementation%20Areas.pdf [20 April 2014]

Mahan, B.L., Polasky, S., Adams, R.M. 2000. Valuing urban wetlands: a property price approach. *Land Econ.* 76 (1): 100–113.

Mahmood, A., Muqbool, W., Mumtaz, M.W., and Ahmad, F. 2011. Application of multivariate statistical techniques for the characterization of GroundWater Quality of Lahore, Gujranwala and Sialkot (Pakistan). *Pak. J. Anal. Environ. Chem*. 12(1): 102-112

Majumder, J., Das, R.K., Majumder, P., Ghosh, D. and Agarwal, B.K. 2013. Aquatic insect fauna and diversity in urban fresh water lakes of Tripura, Northeast India. *Middle East J. Sci. Res. 13* (1): 25-32

Maltby, E. 2003. Wetland management goals: Wise use and conservation. *Landsc. Urban Plan.* 20: 9–18.

Mamat, M.P., Yacob,M.R., Radam,A., Ghani,A.N.A., and Fui, L.H. 2013. Willingness to pay for protecting natural environments in Pulau Redang Marine Park, Malaysia. *African J. Environ. Econ. Manag.* 1 (5) : 120-125.Available: www.internationalscholarsjournals.org [12 Dec.2014]

Mamtha, E. 2009. Valuation of ecosystem service –A case study of Kolleru lake in Andhra Pradesh. MSc (Ag) thesis, Kerala Agricultural University, Thrissur, 63p.

Mandal, R.N., and Bar, N. 2013. The sacred lotus the incredible wealth of wetlands *Resonance* :732-737

Marawila, T.D. and Thibottuwawa, M. 2010. *To Develop or Conserve? The case of the Diyawanna Oya Wetlands in Srilanka,* SANDEE,Nepal,37p.

Markandya, A., Harou, P., Bellou ,G. L. and Cistulli, V. 2002. *Environmental Economics for Sustainable Growth: A Handbook for Practitioners*. Elgar Publications, Northampton, 567p.

Mayur, M. 2014. Economic valuation using contingent valuation technique: an empirical analysis. *Indian J. Research Manag., Business Social Sci.* 2 :85-88.

Mezgebe, A.H. and Raju, S. 2011. *Towards sustainable Utilization of Lake Chamo Biodiversity Resources: Geospatial analysis of lake level Changes, Challenges and Opportunities, Ethiopia*[online]. International Conference on Sustainable Development of Natural Resources in Africa 2011.Available: http://i.unu.edu/media/unu.edu/page/24842/icsdnra_2011-poster-alemayehu-hailemicael-ghana-unu-poster1.pdf [12 April 2014]

Munasinghe, M. 1993. *Environmental Economics and Sustainable Development. World Bank Publications*, Washington, DC. 112p.

Musamba, E.B., Ngaga, Y.M., Boon,E.K., and Giliba, R.A. 2011. Impact of Socio-economic Activities around Lake Victoria: Land Use and Land Use Changes in Musoma Municipality, Tanzania. *J Hum Ecol.* 35(3): 143-154

Naganawa, H. 2012. Lake gusinoe to baikal via selenga delta: protection-destruction spiral. *Lakes Reserv. Ponds*. 6(1): 9-19

Nair , S .C. nd. *Report on conservation of Vellayani Fresh Water Lake Furnished by the Dean College of Agriculture Vellayani,* College of Agriculture, Trivandrum, 7p.

Nath, B. and Deka, C. 2012. A study on fish diversity, conservation status and anthropogenic stress of Chandubi tectonic lake, Assam, India. *J.Bio.Innov*. 1(6): 148-155

National Academy of Sciences. 2004. *Valuing Ecosystem Services: Toward Better Environmental Decision-Making* [online]. National Research Council based on the committee's report. Available http://www.nap.edu [13 May 2012].

Nayik, N.1993. *A Study of Artisanal Fishing Community on the South West Coast of India Following Motorisation of Traditional Craft*. Research Report, Programme for Community Organisation,Trivandrum ,75p.

Noorudheen, K.P. 1993. *Paristhithi Samithi(1992-94)*, Ninth Kerala Legislature,Thiruvananthapuram, 35p.

OECD (Organization for Economic Co-operation and Development). 1995. The Economic Appraisal of Environmental Projects and Policies: A Practical Guide. Organization for Economic Co-operation and Development, Paris, 171p.

Ortacesme, V., Ozkan, B., and Karuguzel, O. 2002. An estimation of recreational value of Kursunlu Waterfall Nature Park by the individual travel cost method. *Turkey J. Agric. Fores*. 26: 57-62.

Palomo, I., lopez, B.M., Potschin, M., Young, R.H., and Montes, C. 2013. National Parks, buffer zones and surrounding lands: Mapping ecosystem services flows.I*ndian J. Environ. Prot.* 2: 511-524

Pascual,U. And Muradian, R. 2010. The economics of valuing ecosystem services and biodiversity [online]. Available : http://www.teebweb.org/wp-content/uploads/2013/04/D0-Chapter-5-The-economics-of-valuing-ecosystem-services-and-biodiversity.pdf [12 May 2014]

Pattanaik,C and Reddy, C.S. 2007. Need for conservation of wetland ecosystems: A case study of Ansupa lake(Orissa), India using remote sensing based data. *Natl. Acad. Sci.Lett*. 30(5): 161-164

Pearce, D. W. and Turner, R. K. 1989. *Economics of Natural Resources and the Environment.* Johns Hopkins University Press, Baltimore, 392p.

Pillai, N.G.K and Katiha, P.K. 2004. *Evolution of Fisheries and Aquaculture in India*. CMFRI, Kochi, 240p.

Plottu, E., Plottu, B. 2007. The concept of Total Economic Value of environment: A reconsideration within a hierarchical rationality, *Ecol. Econ.* 61 (1): 52‑61

Poor, P.J. and Smith, J.M. 2004. Travel cost Analysis of a cultural Heritage site: The case of historic St. Marys city of Maryland, *J of Cult. Econ*. 28: 217-229

Poor, P.J., Pessagno, K.L., and Paul, R.W. 2007. Exploring the hedonic value of ambient water quality: A local watershed-based study. *Ecol.Econ.* 60 (4): 797-806

Pour,M.T and Kalashami,M.K. 2012. Applying CVM for Economic Valuation of Drinking Water in Iran. International Journal of Agricultural Management & Development, 2(3): 209-214

Qadri, H. and Yosuf, A.R. 2008. *Conservation of lakes and wetlands for future.* In:Sengupta, M. and Dalwani, R. (eds), Dal lake ecosystem conservation strategies and problems. Proceedings of Taal 2007, Jaipur, India.Ministry of Environment and forest, Government of India, International Lake Environment Committee Foundation, Jaipur, pp. 1453-1457

Qureshi, N.W., Krishnan, C. M., Sundaramoorthy,C., Vasisht, A.K. Baba, S.H., Kumar, N.R., and Sharma,R. 2013. Truncated growth and compromised sustainability: the case of lake fisheries in Kashmir, *Agric.Econ.Res.Rev.* 27:57-66

Radhika,C, G., Mini, I., and Gangadevi, T. 2004. Studies on abiotic parameters of a tropical freshwater lake Vellayani lake,Thiruvanathapuram district, Kerala.*Poll. Res.* 23 (1): 49-63

Raghunandan, L. 1995. At The Turn Of The Tide: The Life and Times Of Maharani Setu Lakshmi Bayi, The Last Queen Of Travancore. Eastern Press Bangalore Private Ltd, Bangalore, 466p.

Raharjo, M and Gravitani, E. 2012. The economic value of Sangiran museum Central Java, Indonesia: Application of travel cost method, *Int. J. Scl. Sci. Econ. Art*. 2(2) : 39-43

Rajeela, A. 2011. Studies of water quality of Vellayani lake in Kerala in relation to stock enhancement with Indian major carps. M.Sc thesis, Department of Aquatic Biology and Fisheries, University of Kerala, Kariyavattom, Thiruvananthapuram, p.38

Ramachandra , T. V., Alakananda, B, Rani , A., and Khan, M. A. 2011. Ecological and socio-economic assessment of Varthur wetland, Bengaluru (India). *J. Environ.Sci.Eng.* 53: 101-108

Ramachandran, C.K. and Ramakrishnan, A. 1982. A survey on the status of duck farming in suburbs in Trichur Town. *Poult. Guide.* 9(9): 65-68.

Ramlan, M.A., Radam ,A., Yacob,M,R., and Yahya, N.M. 2011. Willingness to pay towards the sustainability of Forest Research Institute Malaysia's (FRIM's) canopy walkway. *Int. J. Busi. Manag. Social Sci.* 2(3) : 85-92

Randall, A. 1988. What mainstream economists have to say about the value of biodiversity. In :Wilson, E.O. (ed.), *Biodiversity*, National Academic Press, Washington DC, pp. 217-226.

Rao, K.N., and Krishna, G.M., and Malini B.H. 2004. Kolleru lake is vanishing a revelation through digital processing of IRS-ID LISS –III sensor data. *Current Sci.* 86(9):1312-1316

Ravindram, T.K. 1983. A survey on the status of duck farming in Kerala state. M.V.Sc. Thesis, Kerala Agricultural University, Mannuthy. 112p.

Reddy, P.R. 2014.Freshwater ecosystems and biodiversity : A Case Study of Kolleru Lake, India: A Review . *J. Ind. Geophys.* 18(2): 277-288

Rejeesh, E., 2003, *Economic evaluation of mangrove resources of Kerala*. M.Sc(Ag) Thesis, University of Agricultural Sciences, Bangalore, 135p.

Rojas, H.L. and Rivero, A.L.B. 2000. Anthropogenically induced fish diversity reduction in lake Valencia Basin Venezula. *Biodiversity Conserv*. 9: 757-765.

Sabeena N.S. 2012. Impact of limnological parameters o fish stock enhancement programme in Vellayani lake, Trivadrum, M.Sc thesis, Department of Aquatic Biology and fisheries, University of Kerala, Kariyavattom, Thiruvananthapuram, p.55

Sajid, A. 2012. Growth performance of Catla catla as a candidate species for fish stock enhancement programme in Vellayani lake, Thiruvananthapuram, M.phil thesis, Department of Aquatic Biology and Fisheries, University of Kerala, Kariyavattom, Thiruvananthapuram, p.36

Sander, H, A. and Polasky, S. 2009. The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota, USA. *Land Use Pol*. 26 : 837–845

Sandhya, G. 2003. Structure and diversity of fish assemblages and their dynamics in VeIlayani lake. Ph.D thesis, Kerala University, Trivandrum,145p.

Sankar, U. n.d. Environmental Externalities(online). Madras School of Economics, Chennai. Available: http://Coe.Mse.Ac.In/Dp/Envt-Ext-Sankar.Pdf [12Dec. 2014]

Sary, P.S., Kiran, P. R.B., Sandhya, R., Anitha, R., and Madhu, V.R. 2014. Comparative analysis of operational parameters and catch composition of 'pattuvala' and 'vaanguvala' operated in the culture based fisheries in Vellayani lake, Thiruvananthapuram, *J. Aqua. Biol. Fish*. 2(1) : 229-232

SAS Institute. 2010. *Statistics 2: ANOVA and Regression*. SAS Institute Inc,USA, 325p.

Schuyt, K and Brander,L. 2004. *Living Waters Conserving the Source of Life.* WWF, Amsterdam, 29 p. Available: http://www.unwater.org/downloads/wetlandsbrochurefinal.pdf [02 Jul. 2014]

Selim, S. 2008. Determinants of house prices in Turkey: A hedonic regression model. *Dogus Univ Dergisi*. 9(1):65-76

Serna-Chavez, H.M., Schulp, C.J.E., van Bodegom, P.M., Bouten, W., Verburg , P.H., and Davidson, M.D. 2014. A quantitative framework for assessing spatial flows of ecosystem services. *Ecol. Indi.* 39: 24–33

Shrestha, R.K., Seidl, A,F. and Moraesc, A.S. 2002. Value of recreational fishing in the Brazilian Pantanal: a travel cost analysis using count data models. 42 : 289–299

Singh, A, L., and Moirangleima, K. 2009. Shrinking water area in the wetlands of the Central Valley of Manipur. *Open Ren. Ener. J. 2*, 1-5

Singh, A, L., and Moirangleima, K. 2012. Dying Wetlands: A Threat to Livelihoods of Loktak Lake Dwellers. *Greener J. Phys. Sci*. 2 (4), 107-116

Singh, K.P., Malik. A., Mohan, D. and Sinha,S. 2004. Multivariate statistical techniques for evaluation of spatial and temporal variation in water quality of Gomti River(India) : A case study, *Wat.Res*.38: 3980-3992

Sobha ,V., Hashin, K.A., Santosh, S and Ganga, G. 2011. Qualitative analysis of Water samples of Vellayani fresh water lake in South Kerala. *Indian j. Environ. Ecoplan*,18(10:1 71-176

Soman, K. and Chattopadhyay, M. 2004. Catchment Conservation Plan for the fresh water lakes of south Kerala. Western Ghat Cell, Planning and Economic Affairs Department. Thiruvanathapuram, p.243.

Spacek, J and Antouskova, M. 2013. Individual single-site travel cost model for Czech paradise geopark. *Acta Univer. Agric. Silvi. Mendel. Brune*. 7: 2851–2858

Spaninks, F. and Beukering, P. V. 1997. *Economic Valuation of Mangrove Ecosystem Potential and Limitations*, CREED Working Paper No. 14, Institute of Environmental Studies, The Netherlands. 62p.

Spash, C.L. 2000. Ecosystems, contingent valuation and ethics: the case of wetland recreation. *Ecol. Econ*. 34: 195-215

Sugunan,V.V. 1995. *Reservoir fisheries of India*, Food and Agriculture Organisation, Fish Technology Paper No.345,Rome. 432p.

Tapsuwan,S., Ingram,G., and Brennan,D. 2007. A Hedonic Property Price Approach in Western Australia.Available http :// www.clw.csiro.au /publications/ waterforahealthycountry /2007/wfhc_valueurbanwetlands. Pdf [12 May.2014]

Thaler, R.H. and Rosen, S. 1976. The Value of Saving a Life: Evidence from the Labor Market. Household Production and Consumption, In: Terleckyj,N.E (ed.), *Studies in Income and Wealth .University press*, Columbia, pp. 34-54.

TOKAU (Teachers Organization of Kerala Agricultural University). 2005. *Conservation of Vellayani lake -A Comprehensive Project.* Teachers Organization of Kerala Agricultural University, Thrissur,24p.

Turner ,R.K. and Georgiou, S. 2003. Wetland Valuation: state of the art and opportunities for further development. Ledoux,L.(ed.), *Valuing environmental assets*, Proceedings of a workshop organized for the Environment Agency by Environmental Futures Ltd and CSERGE, Norwich, UK, University of Eat Anglia,Norwich, pp 6-20.

Turner, R. K., Jones, M. S. and Fisher, B. 2010. Ecosystem valuation: a sequential decision support system and quality assessment issues. Ann. N. Y. Acad. Sci. 1185: 79-101.

Turpie.J, Lannas,K ., Scovronick,N., and Louw,A. 2010. *Wetland Ecosystem Services and Their Valuation: A Review Of Current Understanding And Practice*. WRC Report No. TT 440/09, Gezina.115p. Available: www.efdinitiative.org/...and.../Wetlands%20Vol%20I.pdf [1 May 2012]

Usha,C., Nandini,B., Jumbe, A.S., Anupama, B.S and Goud,S. 2008. *Conservation of lakes and wetlands for future.* In:Sengupta, M. and Dalwani, R. (eds.), Intestinal pathogens and microbial population of urban lakes-A case study of Yellamappa Chetty lake,Bangalore,India. Proceedings of Taal 2007, Jaipur, India.Ministry of Environment and forest, Government of India, International Lake Environment Committee Foundation, Jaipur, pp. 1742-1752

Venkatachalam, L. 2004. The contingent valuation method: A review. *Environ.Impact Asses*. (24) : 89-124.

Verma, M. 2001. Economic Valuation of Bhoj Wetlands for Sustainable Use. Environmental Economics Research Committee Working Paper Series WB9, Indian Institute of Forest Management, Bhopal. 184p.

Verma, S.R., Chaudhari, P.R Singh,R.K., and Wate, S.R.2011. Studies on the ecology and trophic status of an urban lake at Nagpur city, India. *Rasayan J.Chem*.4(3): 652-659

Vermeulen, S. and Koziell, I. 2002. *Integrating Global and Local Values. A Review of Biodiversity Assessment*. International Institute for Environment and Development, London, 104p. Available : http://pubs.iied.org/pdfs/9100IIED.pdf [12 May2013]

Vijayan, A. 2004. Impact of Command Area Development Authority(CADA) : Economic Analysis of Neyyar Irrigation Project. M.Sc(Ag) thesis, Kerala Agricultural University, Thrissur, 89p.

Vincente, E and Defrutos. 2011. Application of the travel cost method to estimate the economic value of cultural goods: Blockbuster art exhibition. *Revista de Economica Publica* 196(1) : 37-63

Viswanathan, S. 2010. Growth performance of *Catla catla* in fish stock enhancement programme: A case study of Vellayani lake. M.Sc thesis, Department of Aquatic Biology and Fisheries, University of Kerala, Kariyavattom, Thiruvananthapuram, p.26

Walls, M. and Riddle, A. 2012. *Biodiversity, Ecosystem Services, and Land Use: Comparing Three Federal Policies*, Discussion paper, Resources for future, Washington D C, 17 p. Available : http://www.rff.org/RFF/Documents/RFF-DP-12-08.pdf [12 May 2014]

WASCON. 2012. *WSS to Kovalam Tourism area and Vizhinjam Portion-Funding by Tourism Department Government of Kerala and Corporation of Thiruvananthapuram*.Wascon, Kerala Water Authority,Thiruvananthapuram, 245p.

Yang, W., Chang, J., Xu, B., Peng, C., and Ge,Y. 2008. Ecosystem service value assessment for constructed wetlands: A case study of Hangzhou, *China.Ecol. Econ* (68): 116-125

Young, R. H. and Potschin, M. 2011. *Common International Classification of Ecosystem Services (CICES): 2011 Update.* European Environment Agency, Centre for

Environmental Management, University of Nottingham, UK, 14p. Available: http://unstats.un.org/unsd/envaccounting/seeaLES/egm/Issue8a.pdf [11 Jan.2013]

Zarrineh, N. and Abad, M. A. N. 2014. Integrated water resources management in Iran: Environmental, socio-economic and political review of drought in Lake Urmia. *Int. J. Water Res. Environ. Eng.* 6(1): 40-48 .

Zawacki, W. T., A. Marsinko and J. M. Bowker (2000), ‘A travel cost analysis of non consumptive wildlife-associated recreation in the United States’, *Forest Sci*.46: 496-505

Zeeuw, H., and Wilbers, J. 2004. *PRA Tools for Studying Urban Agriculture and Gender* [online]. Resource Centre on Urban Agriculture and Forestry (RUAF). Avaliable: http://www.ruaf.org/ruafpublications/gender_tools.pdf [28 May. 2014]

Appendices

Appendix I

Census Details of Kalliyoor Panchayat

Sl No	Particulars	Number
1	Number of Households	10482
2	Total Population	40816
3	Total Males	20078
4	Total Females	20738
5	Population in the Age group 0-6	3497
6	Male Population in the Age group 0-6	1829
7	Female Population in the Age group 0-6	1668
8	Population Scheduled Caste	6689
9	Male Population Scheduled Caste	3300
10	Female Population Scheduled Caste	3389
11	Population Scheduled Tribe	144
12	Male Population Scheduled Tribe	77
13	Female Population Scheduled Tribe	67
14	Literates	34919
15	Male literates	17400
16	Female literates	17519
17	Illiterates	5897
18	Male Illiterates	2678
19	Female Illiterates	3219
20	Total Workers	15471
21	Total Male Workers	11317
22	Total Female Workers	4154
23	Main Workers	10902
24	Male Main Workers	8514
25	Female Main Workers	2388

Sl No	Particulars	Number
26	Main Cultivators	117
27	Male Main Cultivators	99
28	Female Main Cultivators	18
29	Main Agricultural Labourers	390
30	Male Main Agricultural Labourers	331
31	Female Main Agricultural Labourers	59
32	Main Workers in Household Industries	202
33	Male Main Workers in Household Industries	128
34	Female Main Workers in Household Industries	74
35	Main Other Workers	10193
36	Male Main Other Workers	7956
37	Female Main Other Workers	2237
38	Marginal Workers	4569
39	Male Marginal Workers	2803
40	Female Marginal Workers	1766
41	Marginal Cultivators	41
42	Male Marginal Cultivators	30
43	Female Marginal Cultivators	11
44	Marginal Agricultural Labourers	399
45	Male Marginal Agricultural Labourers	329
46	Female Marginal Agricultural Labourers	70
47	Marginal Workers in Household Industries	141
48	Male Marginal Workers in Household Industries	56
49	Female Marginal Workers in Household Industries	85
50	Marginal Other Workers	3988

Sl No	Particulars	Number
51	Male Marginal Other Workers	2388
52	Female Marginal Other Workers	1600
53	Marginal Workers- worked for 3 months or more but less than 6 months	3799
54	Male Marginal Workers- worked for 3 months or more but less than 6 months	2482
55	Female Marginal Workers- worked for 3 months or more but less than 6 months	1317
56	Marginal Cultivators- worked for 3 months or more but less than 6 months	37
57	Male Marginal Cultivators- worked for 3 months or more but less than 6 months	26
58	Female Marginal Cultivators- worked for 3 months or more but less than 6 months	11
59	Marginal Agricultural Labourers- worked for 3 months or more but less than 6 months	363
60	Male Marginal Agricultural Labourers- worked for 3 months or more but less than 6 months	305
61	Female Marginal Agricultural Labourers- worked for 3 months or more but less than 6 months	58
62	Marginal Workers in Household Industries- worked for 3 months or more but less than 6 months	107
63	Male Marginal Workers in Household Industries- worked for 3 months or more but less than 6 months	43
64	Female Marginal Workers in Household Industries- worked for 3 months or more but less than 6 months	64
65	Marginal Other Workers- worked for 3 months or more but less than 6 months	3292
66	Male Marginal Other Workers- worked for 3 months or more but less than 6 months	2108
67	Female Marginal Other Workers- worked for 3 months or more but less than 6 months	1184
68	Marginal Workers- worked for less than 3 months	770
69	Male Marginal Workers- worked for less than 3 months	321
70	Female Marginal Workers- worked for less than 3 months	449

Sl No	Particulars	Number
71	Marginal Cultivators- worked for less than 3 months	4
72	Male Marginal Cultivators- worked for less than 3 months	4
73	Female Marginal Cultivators- worked for less than 3 months	0
74	Marginal Agricultural Labourers- worked for less than 3 months	36
75	Male Marginal Agricultural Labourers- worked for less than 3 months	24
76	Female Marginal Agricultural Labourers- worked for less than 3 months	12
77	Marginal Workers in Household Industries- worked for less than 3 months	34
78	Male Marginal Workers in Household Industries- worked for less than 3 months	13
79	Female Marginal Workers in Household Industries- worked for less than 3 months	21
80	Marginal Other Workers	696
81	Male Marginal Other Workers	280
82	Female Marginal Other Workers	416
83	Non-Workers	25345
84	Male Non-Workers	8761
85	Female Non-Workers	16584

Appendix II

Census Details of Venganoor panchayat

Sl No.	Particulars	Number
1	Number of Households	9277
2	Total Population	35963
3	Total Males	17728
4	Total Females	18235
5	Population in the Age group 0-6	3160
6	Male Population in the Age group 0-6	1646
7	Female Population in the Age group 0-6	1514
8	Population Scheduled Caste	6356
9	Male Population Scheduled Caste	3136
10	Female Population Scheduled Caste	3220
11	Population Scheduled Tribe	70
12	Male Population Scheduled Tribe	37
13	Female Population Scheduled Tribe	33
14	Literates	30807
15	Male literates	15377
16	Female literates	15430
17	Illiterates	5156
18	Male Illiterates	2351
19	Female Illiterates	2805
20	Total Workers	14526
21	Total Male Workers	10185
22	Total Female Workers	4341
23	Main Workers	11223
24	Male Main Workers	8670
25	Female Main Workers	2553

Sl No.	Particulars	Number
26	Main Cultivators	161
27	Male Main Cultivators	152
28	Female Main Cultivators	9
29	Main Agricultural Labourers	448
30	Male Main Agricultural Labourers	374
31	Female Main Agricultural Labourers	74
32	Main Workers in Household Industries	243
33	Male Main Workers in Household Industries	156
34	Female Main Workers in Household Industries	87
35	Main Other Workers	10371
36	Male Main Other Workers	7988
37	Female Main Other Workers	2383
38	Marginal Workers	3303
39	Male Marginal Workers	1515
40	Female Marginal Workers	1788
41	Marginal Cultivators	31
42	Male Marginal Cultivators	20
43	Female Marginal Cultivators	11
44	Marginal Agricultural Labourers	323
45	Male Marginal Agricultural Labourers	205
46	Female Marginal Agricultural Labourers	118
47	Marginal Workers in Household Industries	57
48	Male Marginal Workers in Household Industries	23
49	Female Marginal Workers in Household Industries	34
50	Marginal Other Workers	2892

Sl no	Particulars	Number
51	Male Marginal Other Workers	1267
52	Female Marginal Other Workers	1625
53	Marginal Workers- worked for 3 months or more but less than 6 months	2561
54	Male Marginal Workers- worked for 3 months or more but less than 6 months	1291
55	Female Marginal Workers- worked for 3 months or more but less than 6 months	1270
56	Marginal Cultivators- worked for 3 months or more but less than 6 months	30
57	Male Marginal Cultivators- worked for 3 months or more but less than 6 months	19
58	Female Marginal Cultivators- worked for 3 months or more but less than 6 months	11
59	Marginal Agricultural Labourers- worked for 3 months or more but less than 6 months	235
60	Male Marginal Agricultural Labourers- worked for 3 months or more but less than 6 months	163
61	Female Marginal Agricultural Labourers- worked for 3 months or more but less than 6 months	72
62	Marginal Workers in Household Industries- worked for 3 months or more but less than 6 months	40
63	Male Marginal Workers in Household Industries- worked for 3 months or more but less than 6 months	19
64	Female Marginal Workers in Household Industries- worked for 3 months or more but less than 6 months	21
65	Marginal Other Workers- worked for 3 months or more but less than 6 months	2256
66	Male Marginal Other Workers- worked for 3 months or more but less than 6 months	1090
67	Female Marginal Other Workers- worked for 3 months or more but less than 6 months	1166
68	Marginal Workers- worked for less than 3 months	742
69	Male Marginal Workers- worked for less than 3 months	224
70	Female Marginal Workers- worked for less than 3 months	518
71	Marginal Cultivators- worked for less than 3 months	1
72	Male Marginal Cultivators- worked for less than 3 months	1

Sl no	Particulars	Number
73	Female Marginal Cultivators- worked for less than 3 months	0
74	Marginal Agricultural Labourers- worked for less than 3 months	88
75	Male Marginal Agricultural Labourers- worked for less than 3 months	42
76	Female Marginal Agricultural Labourers- worked for less than 3 months	46
77	Marginal Workers in Household Industries- worked for less than 3 months	17
78	Male Marginal Workers in Household Industries- worked for less than 3 months	4
79	Female Marginal Workers in Household Industries- worked for less than 3 months	13
80	Marginal Other Workers	636
81	Male Marginal Other Workers	177
82	Female Marginal Other Workers	459
83	Non-Workers	21437
84	Male Non-Workers	7543
85	Female Non-Workers	13894

APPENDIX III

Secondary data source for the study

Sl no	Name of the Organization
1	Kerala State Land Use Board, Vikas Bhavan, T rivandrum
2	Kerala State Remote Sensing and Environment Centre, Vikas Bhavan, Trivandrum
3	National Centre for Earth Science Studies (NCESS), Trivandrum
4	The Agency for Development of Aquaculture,ADAK , Trivandrum
5	Vellayani Kayal Matsyathozhilali Vikasanakshema Sahakarana Sangham , Vellayani, Trivandrum
6	Office of A.E Neyyar Irrigation project, Pallichal, Trivandrum
7	Office of the Irrigation Executive Engineer, Ambalamukku, Trivandrum
8	Central Ground Water Development Board, kesavadasapuram, Trivandrum
9	Ground Water Department, Ambalamuku, Trivandrum
10	Department Of Environment And Climate Change, Pettah, Trivandrum
11	Department of Aquatic Biology, Karyavattom
12	Suchitwa Mission, Panavila, Trivandrum
13	Village Office, Kalliyoor
14	Village Office, Venganoor
15	Panchayat Office, Kalliyoor
16	Panchayat office, Venganoor
17	Krishi Bhavan, Kalliyoor
18	Krishi Bhavan, Venganoor
19	Ayyankali Jalolsava Samithi, Vellayani
20	Kerala state Sports Council, statue, trivandrum
21	Centralised Sports Hostel, Vellayani
22	Vevila Maha Vishnu temple
23	Thrikulangara Maha Vishnu Temple
24	Instructional Farm ,Vellayani
25	Archives Department, Nalanda, Trivandrum

26	Kerala Water Authority, Thiruvallam
27	Kerala Water Authority, Kanjiramkulam
28	CPWD Office, Poonkulam
29	Kerala Water Authority, Planning Divison, Vellayambalam
30	Directorate Of Census Operations, Vellayani
31	Kerala State Pollution Control Board
32	Directorate of Soil Survey and Soil Conservation, Vazhuthacadu, Trivandrum
33	Kerala State Pollution Control Board , Trivandrum

APPENDIX IV

Ecosystem valuation of wetlands: A case study of Vellayani Lake.
Ph. D Research
Dept of Agricultural Economics
College of Agriculture, Vellayani

Category of the stake holder FISHERMAN

I. Respondent's Profile

1. Name of the respondent -: Mr. / Ms ----------------------------
2. Address:

3. Age (Years) : ----------------
4. Sex : ---------------- (M/F)
5. Religion :
6. Education of the Respondent :

Upto 7th	
Upto 10th	
Predegree	
Degree and above	

7. Marital status _
8. Monthly incomr
9. Are you a fulltime or part time fisherman :
10. Are you member of any social organisation related to Vellayani lake?
11. Your place of residence

12. Distance from the lake
13. Total land area owned (acres) :------- leased in(acres):------

    leased out (acres):----
14. Ownership of the House : tenanted /owned / relatives
15. Do you have your landed property submerged by the lake?
16. If yes area-
17. Do you have title deeds of the property?

II. Awareness on lake

1. Do you think that the lake is polluted? Yes/ No
2. To what extend the lake is polluted according to you

   Not at all/ Marginally/Moderately/ highly
3. Wetlands require special conservation measures “Yes/ No
4. What is your opinion regarding the present status of Vellayani lake?
   a. Very well preserved
   b. Moderately well preserved
   c. Less preserved
   d. No opinion
   e. Not at all preserved
5. Are you aware of the activities of ADAK-

III. Details regarding fishing

Are you a member of the fisherman society	
Do you have license for fishing	
No of days going for fishing in month	
Distance travelled along lake for fishing	
Do You hire labour for fishing	
Give the labour charge	
Type of gear used	
Average daily income	

II. No of hours spend in lake

1. Drift net (pattu vala) and Bottom set gill net (Katta vala)

Starting time to lake	
Activities Done	
Time at which bank is reached	
Time of start to take the net	
Activities done	
Time at which bank is reached	
Total hours spend	

2. Cast net (Veesu vala)

Time of start	
Time of end	

III. Capital Investment:

S.NO	Item	Purchase price	Year of Purchase	Econom ic life
1.	Boat			
2.				
3.	Lamp			

IV Recurring expenses

S.NO	Item	Rate	Quantity	Total
1.	Labour			
2.	Gill net			
3.	Coconut cake			

IV. Types of fishes caught from the lake.

Sl no	Type	Season

V. Average quantity retained for family consumption?

VI. Participation in the activities of the society?

Active
Passive

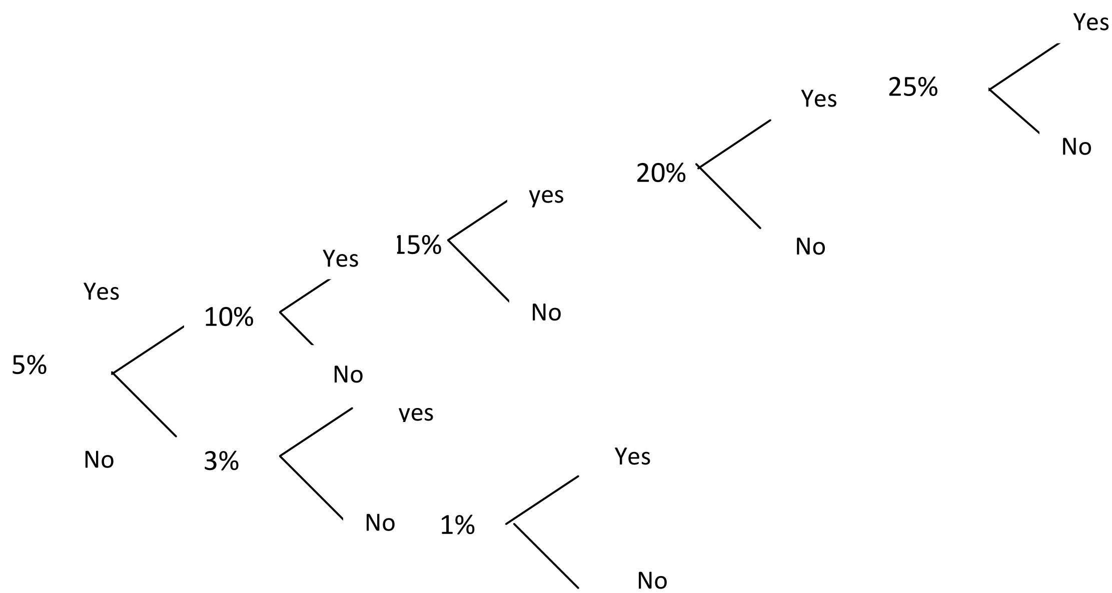
VII. What are the services provided by the society?

IX. Willingness to pay for conserving the Vellayani lake

Background information about the lake

Vellayani lake is providing many direct and indirect benefits to the society in terms of fishing, lotus leaves trading, recreation and other ecological functions. It supports about many commercially important species of fish. The lake is not properly maintained and there has been considerable depletion in quality and quantity. The situation warrants urgent intervention for conservation of Vellayani Lake.

1. Suppose the government makes a request for a voluntary contribution from all the citizens for the better management and conservation of Vellayani lake and its ecosystem with the assurance that the fund will be properly utilized for the same, are you willing to contribute for the same to get the services uninterrupted? Yes/ No



2a. If yes, would you like to effect payment

a. one time
b. Installments, specify

APPENDIX V

Ecosystem valuation of wetlands: A case study of Vellayani Lake.
Ph. D Research
Dept of Agricultural Economics
College of Agriculture, Vellayani

Category of the stake holder Lotus Collector

I. **Socioeconomic status of the respondent**

18. Name of the respondent -: Mr. / Ms -----------------------------

19. Address:

20. Age (Years) : ----------------

21. Sex : ---------------- (M/F)

22. Religion :

23. Education of the Respondent :

Upto 7th	
Upto 10th	
Predegree	
Degree and above	

24. Marital status

25. House hold size

26. Are you working fulltime or part time :

27. Are you member of any social organisation related to Vellayani lake?

28. Your place of residence

29. Distance from the lake

30. Total land area owned (acres) :------- leased in(acres):------
leased out (acres):----

31. Ownership of the House : tenanted /owned / relatives

32. Do you have your landed property submerged by the lake?

33. If yes area-

34. Do you have title deeds of the property?

II. **Awareness on lake**

6. Do you think that the lake is polluted? Yes/ No

7. To what extend the lake is polluted according to you

Not at all/ Marginally/Moderately/ highly

8. Wetlands require special conservation measures"Yes/ No

9. What is your opinion regarding the present status of Vellayani lake?
   a. Very well preserved
   b. Moderately well preserved
   c. Less preserved
   d. No opinion
   e. Not at all preserved

10. Are you willing to pay for the conservation of lake

III. **Details regarding Lotus leaf collection**

   a. Which part of the lake do you prefer for collection
   b. Give the approximate time you spend on the lake

Sl no	Particulars	
1	Start time at the morning	
2	End time in the morning	
3	Time spend	
4	Start time at the evening	
5	End time in the evening	
6	Time spend	

   c. How do you come to lake-
   d. Cost of journey

Sl no	**Capital investment**	
1.	Country Boat	
2.	Auto	
3	Others	
	Recurring Expenses per month	

1.	Knife	
2.	Coir@ Rs 100 per packet	
3.	No of labourers employed	
4.	Labour charge per day	

1. Do you market it directly or to intermediaries-

2. If directly what are costs you incur till you reach the market?

Sl No	**Particulars**	**Value**
1	Auto charge	
2	Union charge	
3	Other expenses	

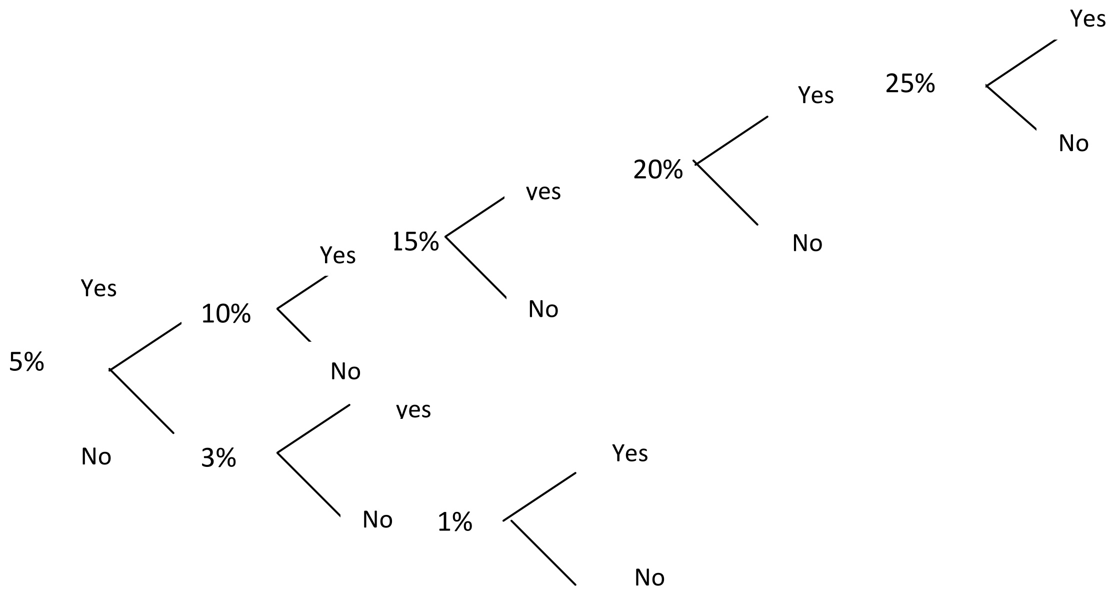
IV Income

Sl no	Activity	Value in Rs
	No of leaves plucked in day	
	Market value per 100 leaves	
	No of flowers plucked in day	
	Market value of flowers	
	No of days you work in a month	
	Do you work in all months in a year	

V. Willingness to Pay (WTP) for the management and conservation of biodiversity of Vellayani lake

Vellayani lake is one of the three fresh water lakes in Kerala. Even though the lake provides many ecosystems services like fresh water, fishing etc the lake is not properly maintained and there has been considerable depletion in quality and quantity. The situation warrants urgent intervention for conservation of Vellayani Lake.

2. Suppose the government makes a request for a voluntary contribution from all the citizens for the better management and conservation of Vellayani lake and its ecosystem with the assurance that the fund will be properly utilized for the same, are you willing to contribute for the same? Yes/ No



2a. If yes, would you like to effect payment

c. one time
d. Instalments, specify

3. Give the reason s for WTP/ or not Willing to pay

Appendix VI
Ecosystem valuation of wetlands: A case study of Vellayani Lake.
Ph. D Research
Dept of Agricultural Economics
College of Agriculture, Vellayani

Category of the stake holder Duck rearer

I. Socioeconomic status of the respondent

35. Name of the respondent -: Mr. / Ms ----------------------------
36. Address:

37. Age (Years) : ----------------
38. Sex : ---------------- (M/F)
39. Religion :
40. Education of the Respondent :

Upto 7^{th}	
Upto 10^{th}	
Predegree	
Degree and above	

41. Marital status
42. House hold size
43. Are you working fulltime or part time :
44. Are you member of any social organisation related to Vellayani lake?
45. Your place of residence
46. Distance from the lake
47. Total land area owned (acres) :------- leased in(acres):------
    leased out (acres):----
48. Ownership of the House : tenanted /owned / relatives
49. Do you have your landed property submerged by the lake?

50. If yes area-

51. Do you have title deeds of the property?

II. Awareness on lake

11. Do you think that the lake is polluted? Yes/ No

12. To what extend the lake is polluted according to you

Not at all/ Marginally/Moderately/ highly

13. Wetlands require special conservation measures Yes/ No

14. What is your opinion regarding the present status of Vellayani lake?
    a. Very well preserved
    b. Moderately well preserved
    c. Less preserved
    d. No opinion
    e. Not at all preserved

15. How many numbers of ducks you have?

16. Capital expenditure

Purchase price	Year of Purchase	Repair Charges/Yr

17. O&M Cost

Sl no	Particulars	Rate	Total
1	Rent on land		
2	Feed for ducks		
3.	Medicines		
4	Labour charge		
5	Others		

18. Income per month

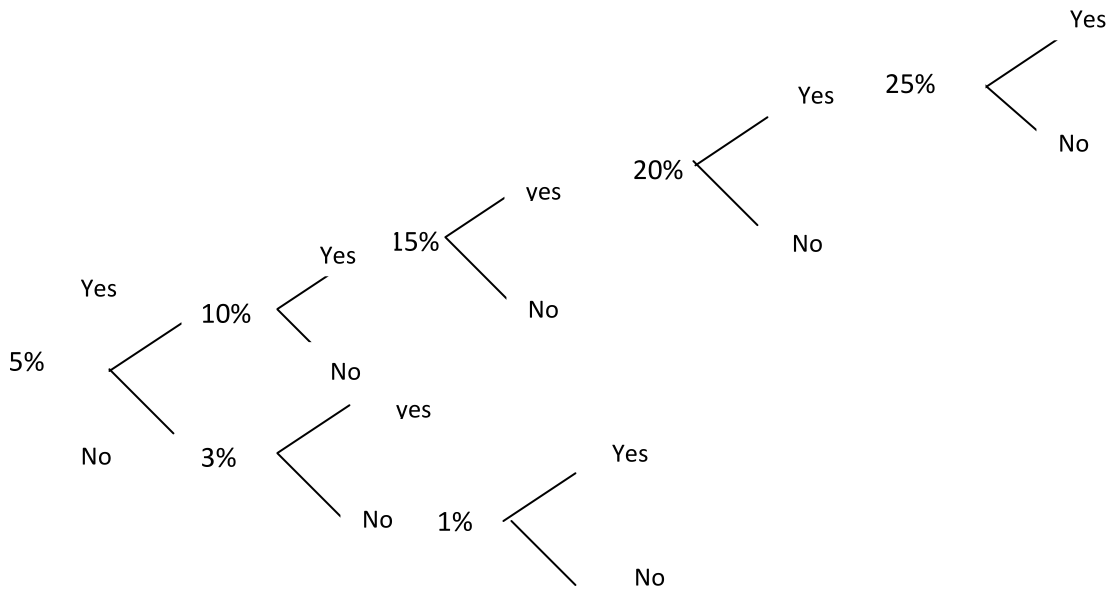
Sl no	Particulars	Rate	Total
1	Egg		
2	Meat		
3	Dung		
4	Others		

III. WTP

Vellayani lake is one of the three fresh water lakes in Kerala. Even though the lake provides many ecosystems services like fresh water, fishing etc the lake is not properly maintained and there has been considerable depletion in quality and quantity. The situation warrants urgent intervention for conservation of Vellayani Lake.

3. Suppose the government makes a request for a voluntary contribution from all the citizens for the better management and conservation of Vellayani lake and its ecosystem with the assurance that the fund will be

properly utilized for the same, are you willing to contribute for the same?
Yes/ No



2a. If yes, would you like to effect payment

e. one time
f. Instalments, specify

3. Give the reason s for WTP/ or not Willing to pay

APPENDIX VII

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF AGRICULTURAL ECONOMICS

College of Agriculture, Vellayani

Ecosystem valuation of wetlands: A case study of Vellayani lake

<u>TRAVEL COST METHOD</u>

TO BE FILLED OUT BY THE INTERVIEWER-Aswathy Vijayan

1. General information about the visitor

1. Name of the visitor

2. Address:

3. Age ------

4. GENDER	Male
	Female
5. Marital status	Married
	Unmarried
6. Education	None
	Upto 5th
	Upto 10
	Degree/diploma
	PG and above
7. Employment	Labourer
	Govt Employee
	Pvt employee
	Student
	Self employed/Business

	Non working spouse
	Other

8. Household size--------------------

9. What is your Profession?

10. Income of respondent-----------------------Rs monthly or-----------------------Rs daily

B-Visitors Recreational behaviour

1. How many times did you visit Vellayani lake within the last 12 months for recreational purpose? ------------------------------

2. If you were not in this trip, what would you most likely be doing?

    Working

    Watching TV

    House work,

    Others

3. Do you know any other recreational site that you would like to visit instead of Vellayani Lake? Yes specify-----------------

    No

4. How many hours were you at the lake today?

5. What is your purpose of coming to lake today?

Religious
Boat race
Recreational fishing
Scenic beauty
Jogging fresh air

6. Your method of conveyance is-----------------

7. Give a estimate of the following expense?

Travelling expensed from home including return charge	
Food, snacks	
Accommodation	
Others if any	

8. Please estimate the time and distance it takes you to get to this lake?

Time

Distance

9. How would you describe the quality of recreational benefits at Vellayani lake

a.V poor

b.Poor

c.Fair

d.Good

e.Excellent

f.Don’t know

10. Are you satisfied with the recreational benefits of the lake

Yes

No

11. Is a visit to Vellayani lake the sole purpose for your trip?

Yes 1

No 2

12. Please give your estimated loss in income since you are not going to job today…………………………………….

APPENDIX VIII

HEDONIC PROPERTY PRICING METHOD QUESTIONNAIRE
Ecosystem valuation of wetlands: A case study of Vellayani Lake.
Ph. D Research
Dept of Agricultural Economics
College of Agriculture, Vellayani

Category of the respondent/ stake holder	Proximal /Middle/Distant

1. Name and Address

2. Total area owned: ……………………….cents

3. Land price /cent (in Rs) : ………….

1.Environmental attributes	
1.Proximity to lake in km	
2.Type of land	
Paddy field	
Garden land	
Other water logged area	
3.Topography	
Plane	
Undulating	
Hilly	
II. Location attributes	
1. Distance to market	
2. Distance to school/college	
3. Distance to nearest hospital	
4. Distance to closest road with good transportation facility	
5. Distance to nearest shopping centre	
6. Distance to place of workship	

7. Distance to nearest bus stop	
8. Distance to nearest railway station	
9. Distance to Thiruvanthapuram city (East fort)	
10. Distance to nearest business centre	
III. Neighbourhood attributes	
1. Type of neighbourhood	
Villa	4
Agricultural area	3
Business Centre	2
Residential area	1
2. Safety and Peace in the location	
High	3
Medium	2
Low	1
3. Availability of Pucca road to the plot	
Available	2
Unavailable	1
4. Noise exposure	
Silent	
Moderate Noise pollution	
High Noise pollution	
5. Greenery	
No Physical access to greenery	
Medium Physical access to greenery	
High Physical access to greenery	

6. Availability of water	
1.Amble	
2.Scarce	
3.Scarce during peak summer	
7. Position	
1.Close to water frond	
2.After the road	
8. Shape of the plot	
Regular	
Irregular	
9. Lake view	Y / N

APPENDIX -IX

CONTINGENT VALUATION SCHEDULE
Ecosystem valuation of wetlands: A case study of Vellayani Lake.
Ph. D Research
Dept of Agricultural Economics
College of Agriculture, Vellayani

Category of the respondent/ stake holder

1. INTRODUCTION AND BACK GROUND INFORMATION

Wetlands are very important ecosystems, providing human societies with essential and highly valuable life supporting functions. People use wetlands for various purposes like agriculture, fishing, timber and fuel wood collection, recreation etc. It has become obvious that quantifying and integrating these services into decision making will be crucial for sustainable development.

Kerala is bestowed with a vast network of backwaters, lagoons, natural lakes, rivers and canals. Vellayani lake lying on the south east of the Thiruvananthapuram city is one of the three unique fresh water lakes of Kerala. This lake lying in Kalliyoor and Venganoor Panchayats has got an important role in socio economic conditions of people. It was reported by Kerala Agricultural University (2009) that the lifestyle and culture of people is dependent largely on this freshwater source. The lake serves as a source of income for majority of people in the surroundings and is maintained as drinking water source.

The main objective of the study is to identify the services provided by the Vellayani Lake as perceived by the stakeholders and to assess the willingness to pay (WTP) for ecosystem services considering various aspects like resource utilization, socio-economic and living conditions of the area, so that the Total Economic Value(TEV) of the lake could be quantified.

Your perception towards the conservation of the lake is very important. It is expected that the outcome of the research will be useful for planners and policy makers to develop a socially acceptable, environmentally sound and economically feasible strategy for interventions in wetland management. So kindly share your views and opinion by sparing some of your valuable time.

II. Respondent's Profile

1. Name of the respondent -: Mr. / Ms -----------------------------
2. Address:

Telephone:
3. Age (Years) : ----------------

4. Sex : ---------------- (M/F)

5. Education of the Respondent :

Upto 7th	
Upto 10th	
Predegree	
Degree and above	

6. House hold size_

7. Occupation :

8. Organisation you are attached to:

9. Are you a member of any Social Organisations?

10. If yes give the name of the organisation and nature of service?

11. Is there any activities associated with Vellayani lake?

12. Constraints faced by the organisation?

13. Monthly income:

14. Source of drinking water :

15. Is there any impact of lake in water in well

15. Total land area owned (acres) :------- leased in (acres):------

leased out (acres):----

16. Ownership of the House : tenanted /owned / relatives

17. What is the main activity for which your household uses Vellayani lake?

18. Distance of your house from lake : km

19. Do you have your landed property submerged by the lake?

20. If yes area-

21. Do you have title deeds of the property?

22. Do you use the lake for bathing or washing cows?

If yes, give details

1II.Awareness on wetlands especially Vellayani lake

1. Have you visited the Vellayani lake?

Yes / No

2. How often do you visit the lake? Tick the appropriate column

Sl No	Frequency	Remarks
1	Daily	
2	Once in 2 days	

3	Once in a fortnight	
4	Once in month	
5	Once in a while	

3. Do you think that the lake is polluted? Yes/ No

4. To what extend the lake is polluted according to you

Not at all/ Marginally/Moderately/ highly

5. Wetlands require special conservation measures"

Yes/ No

6. What is your opinion regarding the present status of Vellayani lake?
    1. Very well preserved
    2. Moderately well preserved
    3. Less preserved
    4. No opinion
    5. Not at all preserved

7. Would you support any environmental programme that seeks to restore and preserve natural resources?
    If it affects you
    If it does not affect you

8. You may be aware that the Vellayani lake provides a number of services to the people. A few of them are listed below. Please tick the appropriate column.

	Services	very important	Important	somewhat important	Least important	Not important
A	**Provisioning Function**					
1	Drinking water					

2.	Irrigation water					
3	Income to fisherman					
4	Income to Duck Rearers					
5	Income to Lotus leaf & flower collectors					
6	Washing cloths and vehicles, bathing					
B.	**Regulating Function**					
7.	Ground water recharge					
8.	Stabilising micro climate					
C.	Conservation of natural areas as such.					
9	**Cultural and amenity**					
10	Cultural heritage and identity					
11	Spiritual and religious value					
12	Providing scenic beauty					
13	Recreational value					
14	Educational and scientific study					
15	Functioning of College of Agriculture, Vellayani					
16	Centralised sports hostel (kayaking, Canoeing)					
D.	**Supporting function**					
17	Biodiversity conservation					
18	Increase in land value					

	Others specify					

9. You may be aware that the Vellayani lake is facing a number of threats. A few of them are listed below. Please tick the appropriate column.

	Problem	very important	important	somewhat important	Least important	Not Important
A	Encroachment					
B	No management action plan					
C	Non demarcation of borders due to private property surrounding the lake					
D	Lotus plants grown in lake					
E	Two bund roads across the lake					
F	Increasing population					
G	Agricultural waste					
H	Pollution by Bathing and washing					
I	Weeds and eutrophication					
J	Sewage					
K	Sand mining					
L	Reclamation					

M	Others specify					

10 Are you using the bund roads at Reservoir, Kakkamoola and Vavvamoola?

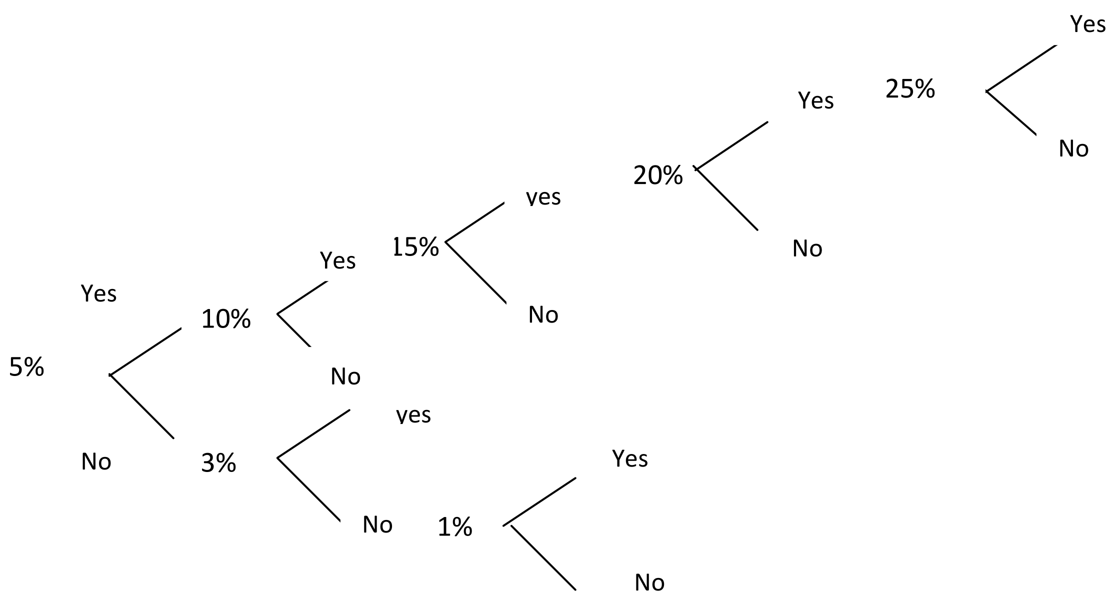
IV. Opinion questions

V. Willingness to Pay (WTP) for the management and conservation of biodiversity of Vellayani lake

Vellayani lake is one of the three fresh water lakes in Kerala. Even though the lake provides many ecosystems services like fresh water, fishing etc the lake is not properly maintained and there has been considerable depletion in quality and quantity. The situation warrants urgent intervention for conservation of Vellayani Lake.

4. Suppose the government makes a request for a voluntary contribution from all the citizens for the better management and conservation of Vellayani lake and its ecosystem with the assurance that the fund will be properly utilized for the same, are you willing to contribute for the same? Yes/ No

5. If yes how much you are willing to pay?



2a. If yes, would you like to effect payment

g. one time
h. Instalments

2b. If instalments

a. Regular payments for 1 year
b. Lifelong payment
c. others, specify

3. Reasons for willingness to pay

Sl No.	Particulars	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	I think conservation of lake is good for me and the society					
2	I feel it is my moral duty to conserve the lake for future generation					
3	I feel this is a reasonable amount I can afford to pay					
4	I am concerned about the degradation of the lake					
5.	I want to preserve the lake because I use the lake					
6	I want to contribute to preserve the lake for my future generations(bequest value)					
7	I take personal pleasure in knowing that the lake will					

	continue to exist(existence value)					
8	I do not use the lake now but I am willing to contribute to have the option of using it in future					
9	Others					

4. Reasons for not willing to pay

Sl No.	Particulars	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	Don't think that the lake are to be conserved					
2	It is the government's responsibility to conserve the lake					
3	Citizens are not concerned about conservation activities					
4	Those who are using lake should pay					
5	Limited income restricts my ability to pay (Not for scientists, TE)					
6	Others if any (Please specify)					

4. Do you think that the lake should be maintained as such or any changes needed?

5. Suggest any management action plan for the lake?

6. Crop biodiversity

Sl. No.	Crop/ Species	No of species/ Area

APPENDIX – X

Weather parameters during the study period

Month and year	Temperature (^{o}C)		RH (%)	Sunshine hours	Rainfall (mm)	Number of rainy days	Evaporation (mm)
	Max.	Min.					
Feb-12	31.20	22.48	97.34	9.22	0.00	0	3.36
Mar-12	31.70	23.30	93.66	9.33	22.00	7	3.23
Apr-12	32.10	25.08	90.03	8.90	116.40	12	3.41
May-12	31.22	25.78	90.82	9.60	48.50	5	3.58
Jun-12	30.48	24.56	91.28	9.40	72.00	16	2.95
Jul-12	29.75	24.25	92.68	9.58	114.00	15	3.36
Aug-12	29.78	23.84	92.06	9.20	182.50	14	3.44
Sep-12	30.23	24.10	89.83	9.54	57.50	10	3.48
Oct-12	30.38	23.64	92.23	8.50	110.00	13	3.03
Nov-12	30.26	23.06	97.38	8.62	11.10	9	3.26
Dec-12	30.68	22.75	97.90	8.43	40.50	4	2.63
Jan-13	30.30	22.02	95.90	9.05	262.00	3	3.45
Feb-13	31.25	22.13	92.48	9.28	38.00	5	3.72
Mar-13	32.26	23.72	92.70	9.56	86.00	5	4.50
Apr-13	33.05	25.43	89.40	9.85	42.10	3	4.15
May-13	32.32	25.45	91.72	9.33	61.30	11	3.80
Jun-13	29.32	22.82	93.53	8.18	507.50	24	2.45

Jul-13	28.88	22.95	92.30	8.63	228.80	24	2.50
Aug-13	29.28	23.52	92.48	9.25	109.10	11	2.82
Sep-13	29.13	23.85	96.40	8.75	216.20	19	3.32
Oct-13	30.64	23.24	93.13	9.20	153.00	13	3.82
Nov-13	30.65	23.45	96.64	8.18	292.70	14	2.68
Dec-13	30.85	21.83	97.40	8.65	74.4	3	2.11

Appendix XI

Common names of trees in the households

Sl no	Common / Malayalam names)	Scientific names
1	Coconut	*Cocos nucifera*
2	Arecanut	*Areca catechu*
3	Rubber	*Hevea brasiliensis*
4	Cashew	*Anacardium occidentale*
5	Jackfruit	*Artocarpus heterophyllus*
6	Mango	*Mangifera indica*
7	Lovi lovi	*Flacourtia inermis*
8	Bread fruit	*Artocarpus altilis*
9	Banana	*Musa sps*
10	Guava	*Psidium guajava*
11	Bilimbi	*Averrhoa bilimbi*
12	Papaya	*Carica papaya*
13	Sapota	*Manilkara achras*
14	Karonda	*Carissa carandas*
15	Egg fruit	*Lucuma campechiana*
16	Cocoa	*Theobroma cacao*
17	Jamun	*Syzygium cumini*
18	Anona(Anamunthiri)	*Annona muricata*
19	Vacciniium(Kara)	*Vaccinium uliginosum*
20	Gooseberry	*Ribes uva-crispa*
21	Anona sps	*Annona reticulata*
22	Bamblimas	*Citrus maxima*
23	W.I cherry	*Malpighia punicifolia*
24	Pomegranate	*Punicum granatum*
25	Teak	*Tectona grandis*
26	Thespesia	*Thespesia populnea*
27	Sandal	*Santalum album*
28	Manjium	*Acacia mangium*
29	Venga	*Pterocarpus marsupium*
30	Mahagony	*Swietenia spp.*

Sl No	Common name / Malayalam name	Scientific name
31	Ayani	*Artocarpus hirsutus*
32	Neem	*Azadiracta indica*
33	Asokam	*Saraca asoca*
34	Padimukham	*Caesalpania sappan*
35	Kanjiram	*Strychnos nux-vomica*
36	Betelvine	*Piper betle*
37	Curry leaf	*Murraya koenigii*
38	Vattayila	*Calamus vattayila*
39	Vayana	*Cinnamomum verum*
40	Tamarind	*Tamarindus indica*
41	Pepper	*Piper nigrum*
42	Agathy	*Sesbania grandiflora*
43	Moringa	*Moringa oleifera*
44	Cassia	*Cassia fistula*
45	Kattukonna	*Senna polyphylla*
46	Elavu	*Bombax ceiba*
47	Bamboo	*Phyllostachys bambusoides*

Appendix-XI a

Index of Biodiversity of Zone 1

Group	Trees	S1	S2	S3	S4	S5	S6	S7	S8
Plantation Crops	Coconut	0.35	0.71	0.51	0.46	0.32	0.33	0.44	0.59
	Arecanut	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.00
	Rubber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cashew	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.00
	Total	**0.35**	**0.71**	**0.51**	**0.53**	**0.32**	**0.36**	**0.44**	**0.59**
Fruit Trees	Jackfruit	0.14	0.00	0.10	0.06	0.11	0.02	0.04	0.05
	Mango	0.06	0.04	0.04	0.08	0.05	0.00	0.00	0.07
	Lovi	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.03
	Bread fruit	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Banana	0.29	0.00	0.15	0.00	0.41	0.48	0.21	0.00
	Guava	0.00	0.00	0.02	0.01	0.00	0.00	0.20	0.03
	Bilimbi	0.00	0.07	0.00	0.00	0.00	0.01	0.03	0.00
	Papaya	0.00	0.00	0.01	0.06	0.04	0.00	0.03	0.00
	Sapota	0.00	0.00	0.04	0.02	0.00	0.00	0.00	0.00
	Karonda	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Muttapazham	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cocoa	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
	Jamba	0.10	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Anamunthiri	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kara	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Gooseberry	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
	Athi chakka	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Bamblimas	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
	W I cherry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
	Pomegranate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
	Total	**0.62**	**0.11**	**0.39**	**0.24**	**0.64**	**0.52**	**0.55**	**0.24**

Agroforestry trees	Teak	0.00	0.00	0.02	0.05	0.00	0.01	0.00	0.08
	Cheelanthy	0.00	0.19	0.01	0.00	0.00	0.00	0.00	0.00
	Sandal	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	Manjium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Venga	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mahagony	0.01	0.00	0.00	0.03	0.01	0.05	0.00	0.09
	Ayani	0.01	0.00	0.05	0.02	0.01	0.05	0.00	0.00
	Cassia	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	Kattukonna	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Elavu	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	Bamboo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	0.02	0.19	0.09	0.10	0.03	0.12	0.00	0.17
Medicinal plants	Neem	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00
	Asokam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Padimukham	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
	Kanjiram	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Betelvine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.00**	**0.01**	**0.04**	**0.00**	**0.00**	**0.00**	**0.00**
Spice trees	Curry leaf	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Vattayila	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Vayana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Tamarind	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Pepper	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00
	Total	**0.01**	**0.00**	**0.01**	**0.07**	**0.00**	**0.00**	**0.00**	**0.00**
Vegetables	Agathy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Moringa	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.00
	Total	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**	**0.01**	**0.00**

Appendix-XI b

Index of Biodiversity of Zone 2

Group	Trees	S1	S2	S3	S4	S5	S6	S7	S8
Plantation Crops	Coconut	0.35	0.75	0.37	0.50	0.48	0.50	0.46	0.53
	Arecanut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Rubber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cashew	0.00	0.00	0.00	0.08	0.00	0.12	0.00	0.00
	Total	**0.35**	**0.75**	**0.37**	**0.58**	**0.48**	**0.62**	**0.46**	**0.53**
Fruit Trees	Jackfruit	0.09	0.15	0.06	0.19	0.26	0.06	0.02	0.18
	Mango	0.11	0.10	0.06	0.05	0.06	0.01	0.11	0.10
	Lovi lovi	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Bread fruit	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
	Banana	0.13	0.00	0.29	0.12	0.10	0.16	0.04	0.00
	Guava	0.05	0.00	0.04	0.00	0.00	0.02	0.01	0.00
	Bilimbi	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Papaya	0.03	0.00	0.01	0.00	0.00	0.01	0.00	0.00
	Sapota	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Karonda	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Muttapazham	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Cocoa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Jamba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Anamunthiri	0.00	0.00	0.06	0.00	0.10	0.03	0.02	0.00
	Kara	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00
	Gooseberry	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	Athi chakka	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Bamblinas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	W I cherry	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	Pomegranate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.46**	**0.25**	**0.55**	**0.37**	**0.51**	**0.30**	**0.21**	**0.28**

Agroforestry trees	Teak	0.00	0.00	0.01	0.00	0.00	0.00	0.08	0.03
	Cheelanthy	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.05
	Sandal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Manjium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Venga	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mahagony	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
	Ayani	0.07	0.00	0.05	0.04	0.00	0.03	0.00	0.01
	Cassia	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kattukonna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Elavu	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	Bamboo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.07**	**0.00**	**0.06**	**0.04**	**0.00**	**0.05**	**0.11**	**0.10**
Medicinal plants	Neem	0.00	0.00	0.01	0.00	0.00	0.00	0.04	0.00
	Asokam	0.00	0.00	0.02	0.00	0.00	0.03	0.15	0.03
	Padimukham	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kanjiram	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	Betelvine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.00**	**0.00**	**0.03**	**0.01**	**0.00**	**0.03**	**0.20**	**0.03**
Spice trees	Curry leaf	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Vattayila	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	Vayana	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Tamarind	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
	Pepper	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.12**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.07**
Vegetables	Agathy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Moringa	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**

Appendix-XI b

Index of Biodiversity of Zone 2

Group	Trees	S1	S2	S3	S4	S5	S6	S7	S8
Plantation crops	Coconut	0.60	0.41	0.47	0.47	0.54	0.59	0.35	0.48
	Arecanut	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.04
	Rubber	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
	Cashew	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.60**	**0.41**	**0.50**	**0.50**	**0.55**	**0.59**	**0.35**	**0.52**
Fruit trees	Jackfruit	0.06	0.11	0.07	0.07	0.03	0.12	0.01	0.20
	Mango	0.03	0.11	0.03	0.03	0.01	0.10	0.02	0.00
	Lovi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Bread fruit	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00
	Banana	0.13	0.16	0.06	0.06	0.01	0.04	0.24	0.22
	Guava	0.01	0.02	0.00	0.00	0.07	0.05	0.03	0.00
	Bilimbi	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Papaya	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sapota	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	Karonda	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Muttapazham	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	Cocoa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Jamba	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00
	Anamunthiri	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kara	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Gooseberry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Athi chakka	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Bamblinas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	W i cherry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pomegranate	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.34**	**0.46**	**0.17**	**0.17**	**0.19**	**0.31**	**0.31**	**0.42**

Agroforestry trees	Teak	0.02	0.02	0.00	0.00	0.05	0.00	0.16	0.03
	Cheelanthy	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00
	Sandal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Manjium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Venga	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mahagony	0.02	0.02	0.00	0.00	0.04	0.00	0.01	0.01
	Ayani	0.00	0.03	0.06	0.06	0.01	0.07	0.02	0.01
	Cassia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kattukonna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Elavu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Bamboo	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
	Total	0.04	0.07	0.06	0.06	0.10	0.09	0.18	0.06
Medicinal plants	Neem	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.00
	Asokam	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	Padimukham	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	Kanjiram	0.00	0.00	0.09	0.09	0.00	0.00	0.00	0.00
	Betelvine	0.00	0.00	0.18	0.18	0.16	0.00	0.00	0.00
	Total	**0.00**	**0.02**	**0.26**	**0.26**	**0.16**	**0.00**	**0.02**	**0.01**
Spice trees	Curry leaf	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Vattayila	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Vayana	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.00
	Tamarind	0.01	0.00	0.00	0.00	0.00	0.00	0.13	0.00
	Pepper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	**0.02**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	**0.14**	**0.00**
Vegetables	Agathy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Moringa	0.00	0.02	0.01	0.01	0.00	0.01	0.00	0.00
	Total	**0.00**	**0.02**	**0.01**	**0.01**	**0.00**	**0.01**	**0.00**	**0.00**

APPENDIX XII

Eigen values of PCA

PC	Eigenvalue	Difference	Proportion	Cumulative
1	105255.29	101709.09	0.9586	0.96
2	3546.19	2956.20	0.0320	0.99
3	590.00	290.34	0.0054	1.00
4	299.66	260.97	0.0027	1.00
5	38.69	11.70	0.0004	1.00
6	26.99	5.07	0.0020	1.00
7	21.92	13.22	0.0001	1.00
8	8.70	1.27	0.0001	1.00
9	7.44	2.67	0.0000	1.00
10	4.76	2.96	0.0000	1.00
11	1.81	0.69	0.0000	1.00
12	1.12	0.49	0.0000	1.00
13	0.63	0.27	0.0000	1.00
14	0.35	0.22	0.0000	1.00
15	0.14	0.08	0.0000	1.00
16	0.06	0.02	0.0000	1.00
17	0.04	0.03	0.0000	1.00
18	0.01	0.00	0.0000	1.00
19	0.01	0.00	0.0000	1.00
20	0.00	0.00	0.0000	1.00

Appendix XIII

Selected Principal Components

Particulars	PC1	PC2
Temperature	0.00	-0.01
PH	0.00	0.00
Conductivity	-0.01	-0.04
DO	0.00	0.00
BOD	0.00	0.00
COD	0.01	0.00
Turbidity	0.00	0.00
Nitrate-N	0.00	0.00
Alkalinity (As CaCo3)	0.01	0.04
Total Hardness As CaCo3)	0.00	-0.01
Calcium (As CaCo3)	0.00	-0.01
Magnesium (As CaCo3)	0.00	-0.01
Chloride	0.00	-0.03
Sulphate	0.00	0.00
Phosphate	0.00	0.00
Sodium	-0.01	-0.19
Pottassium	0.00	-0.04
Iron	0.00	0.00
Total Coliform	**0.96**	-0.29
Fecal Coliform	**0.29**	0.93

APPENDIX- XIV

Criteria for goodness of fit of Poisson regression

Criteria For Assessing Goodness Of Fit			
Criterion	**DF**	**Value**	**Value/DF**
Deviance	78	203.2462	2.6057
Scaled Deviance	78	203.2462	2.6057
Pearson Chi-Square	78	203.4124	2.6079
Scaled Pearson X2	78	203.4124	2.6079
Log Likelihood		806.6812	
Full Log Likelihood		-259.0617	
AIC (smaller is better)		532.1233	
AICC (smaller is better)		533.5779	
BIC (smaller is better)		549.2219	

Appendix XV

Frequency distribution of WTP in different Study locations

Zone	Location	No of respondents willing to pay	Total no respondents willing to pay per zone	% to total
Zone1	Arattukadavu	4	52	65
	Vazhavila	7		
	Kakkamoola	9		
	Vavamoola	6		
	Venniyoor	5		
	Kadavinmoola	6		
	AGC	8		
	Palapoor	7		
Zone2	Arattukadavu	2	36	45
	Vazhavila	4		
	Kakkamoola	4		
	Vavamoola	5		
	Venniyoor	4		
	Kadavinmoola	8		
	AGC	5		
	Palapoor	4		
Zone3	Arattukadavu	1	28	35
	Vazhavila	4		
	Kakkamoola	4		
	Vavamoola	4		
	Venniyoor	2		
	Kadavinmoola	6		
	AGC	3		
	Palapoor	4		
Total No of respondents willing to pay			**116**	**48.33**

APPENDIX –XVI

Average Willingness to Pay in different zones (Rs/Year)

Zone	Location	Average WTP	Average WTP
Zone1	Arattukadavu	73	**354.25**
	Vazhavila	300	
	Kakkamoola	675	
	Vavamoola	415	
	Venniyoor	340	
	Kadavinmoola	446	
	AGC	415	
	Palapoor	170	
Zone2	Arattukadavu	36	**237.12**
	Vazhavila	114	
	Kakkamoola	306	
	Vavamoola	76	
	Venniyoor	75	
	Kadavinmoola	320	
	AGC	510	
	Palapoor	460	
Zone3	Arattukadavu	12	**174.37**
	Vazhavila	210	
	Kakkamoola	265	
	Vavamoola	57	
	Venniyoor	240	
	Kadavinmoola	159	
	AGC	222	
	Palapoor	230	
Average willingness to pay of the local residents			**255.25**

APPENDIX- XVII

Average monthly income per household of local residents

Zone	Location	Average income in thousand Rs per month	Average income in thousand Rs per month
Zone1	Arattukadavu	10.25	13.71
	Vazhavila	11.80	
	Kakkamoola	28.42	
	Vavamoola	10.77	
	Venniyoor	8.10	
	Kadavinmoola	20.67	
	AGC	10.51	
	Palapoor	9.19	
Zone2	Arattukadavu	6.78	11.45
	Vazhavila	10.30	
	Kakkamoola	8.35	
	Vavamoola	11.32	
	Venniyoor	7.39	
	Kadavinmoola	24.60	
	AGC	14.20	
	Palapoor	8.69	
Zone3	Arattukadavu	9.92	11.89
	Vazhavila	14.60	
	Kakkamoola	13.84	
	Vavamoola	8.06	
	Venniyoor	6.61	
	Kadavinmoola	13.12	
	AGC	16.73	
	Palapoor	12.23	
Average income of all zones			12.35

ECOSYSTEM VALUATION OF WETLANDS: A CASE STUDY OF VELLAYANI LAKE

by

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Abstract of the

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ABSTRACT

The study entitled “Ecosystem Valuation of Wetlands: A Case Study of Vellayani Lake” was conducted during the year 2013- 2014 at College of Agriculture, Vellayani. The major objective of the study was to assess the Total Economic Value (TEV) of the Vellayani lake.

The main ecosystem services provided by the lake system were provisioning services such as drinking water, fishing, duck rearing, lotus collection, irrigation, bathing and washing; regulatory services such as ground water recharge, stabilising microclimate; cultural services such as bird watching, photography, boat race, religious rituals and training centres in water sports and finally supporting function such as biodiversity conservation. Based on the ecosystem services, relevant stakeholders were identified and valuated using suitable techniques.

The income generation activities of the lake such as fishing, lotus collection and duck rearing were valuated using the market price method and it accounted to Rs.1.83 crores year^{-1}. The drinking water supply schemes installed by Kerala Water Authority, Central Public Works Department and College of Agriculture, Vellayani draws nearly 98,677 lakh litres of water from the lake per year, the value of which is Rs. 370.05 crores year^{-1}. Provision of irrigation water by the lake valuated using opportunity cost method accounted to Rs. 20.69 crores year^{-1}. The economic value of bathing and washing in the lake estimated using opportunity cost method was Rs. 0.009 crore year^{-1}.

The lake is also a part of religious activities, cultural activities, and recreational activities. The ecosystem service use by Centralized Sports Hostel for Canoeing, Kayaking and Rowing and Ayyankali Boat Race, valuated using public pricing method accounted to Rs.0.24 crore year^{-1} and Rs.0.07 crore year^{-1} respectively. People visit the lake for bird watching, photography, enjoying the scenic beauty, enjoy annual boat race and to attend religious ritual, *Karkidaka vavubali.* The value of recreational and spiritual services valuated using Travel Cost Method was

Rs.0.56 crore year^{-1}. The estimation of aesthetic value of the lake employing Hedonic Pricing Method revealed that, the marginal implicit price of getting one cent of land with lake view evaluated at mean property price of Rs. 2,44250/- was Rs. 79171/- and the aesthetic value of the lake was Rs.275.92 crores year-^{1}. This illustrates the preference given by individuals for land with lake view.

The monetary valuation of supporting and regulating functions of the lake was done using a double bounded dichotomous choice contingent valuation method. The mean stated Willingness to Pay (WTP) was Rs.225.22 year^{-1} for local residents. The economic value of the lake estimated using Contingent Valuation Method was Rs.2.91 crores year^{-1}. Thus the Total Economic Value, which is the total value of ecosystem service use of the Vellayani lake estimated by summating the value of goods and services provided by the lake was Rs. 672.28 crore year^{-1}.

Analysis of temporal variation in area of the water body indicated a drastic reduction in area from 558.73 ha in 1973 to 243.39 ha in 2011. The reduction in area was not the result of natural geological process alone, but the major reason is irrational human activities due to demographic pressures.

Based on the study it was concluded that the major reason for degradation and loss of wetland services provided by Vellayani lake is the lack of awareness on the value of its ecosystem services, non enforcement of property rights and lack of lake management policies. The major anthropogenic stressors on lake are unsustainable agricultural and fishing activities, watershed impact due degradation and destruction of canals carrying water to the lake and habitat modification.

Vellayani lake management policy was formulated based on the study suggests the proper enforcement of property rights by bringing the lake under single management authority with statutory powers including members from line department and stakeholders. The authority may address the present threats on the sustainability of the lake and also chalk out action plan for prevention of further degradation. The low WTP by people indicated that conserving the lake with contribution of stakeholders alone is not practical and so at least one rupee per 70 litres may be fixed as cess to realize a minimum of 13.97 crores per year for the lake conservation. This amount is meager when compared to the TEV of the lake per year.

Today's critical need is to recognize the benefits that could be obtained if the lake is managed in an integrated manner. If not properly managed and degradation and loss continue in the same manner, we are going to lose the invaluable services provided by the lake which cannot be replaced by any other means. Management of lake is a very challenging task and requires actions at many levels and involvement of many stakeholders. The recommendations of the study, along with the values of the ecosystem services of the lake, if properly taken care of, may help in developing sustainable strategies for conservation of this unique freshwater source.