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SPECIES DIVERSITY, THE ECOLOGY OF WATTLED IBIS (*BOSTRYCHIA CARUNCULATA*) AND LAND USE/COVER CHANGE OF CHELEKLEKA LAKE, BISHOFTU

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Species diversity, the ecology of Wattled ibis (*Bostrychia carunculata*) and land use/cover change of Chelekleka Lake, Bishoftu

A Thesis presented to the school of graduate studies of Addis Ababa University in partial fulfillments for the degree of Doctor of Philosophy in Biology (Ecological and Systematic Zoology Stream)

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Acronyms

BLI: BirdLife International

CSA: Central Statistical Agency

DEAT: Department of Environmental Affairs and Tourism

DBH: Diameter at Breast Height

EFAP: Ethiopian Forestry Action Programme

EPA: Environmental Protection Authority

EWNHS: Ethiopian Wildlife and Natural History Society

FAO: Food and Agriculture Organization

GIS: Geographic Information System

IBAs: Important Bird Areas

IPCC: Intergovernmental Panel on Climate Change

LULCC: Land Use and Land Cover Change

RS: Remote Sensing

SPSS: Statistical Package for Social Sciences

WCMC: World Conservation Monitoring Centre

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Abstract

Chelekleka Lake supports different bird species including endemic birds like Wattled ibis (Bostrychia carunculata). The present study aimed to examine species diversity, ecology of Wattled ibis and land use/ cover change of Chelekleka Lake. In order to assess the population of Wattled ibis and other bird species, total count method was used. The census was done by classifying the study area into four habitats as forest, farmland, grassland and settlement area. The foraging behavior of Wattled ibis was sampled using 2 minutes focal observations of foraging individuals during wet and dry seasons. The activity pattern of Wattled ibis was recorded using scan sampling method. Observation was made on nest location, their construction, clutch size and hatching success of Wattled ibis. The length, breadth and weight of the egg found in the nest were measured using vernier caliper and a Pesola spring balance, respectively. Intensive nest searching in the study area was carried out using a spotting scope and binoculars. Nests found in different macro-habitats were measured. A total of 54 species of birds categorized under 17 families, were observed during wet and dry seasons. The total individuals of Wattled ibis was 170 and 191 during dry and wet seasons, respectively. Worms accounted (74.3 ± SD 12.9%, range=54-90%) of the annual diet of Wattled ibis. Insects were the second most dominant food items, which contributed to (18.3 ± SD 11.6 %, range = 3.5-36.5%) of the overall diet. Wattled ibis also consumed other food items, such as frogs, (2.4 ± SD 2.2 %, range =0-5 %) and small mammals (rodents 0.6 ± SD 1.0 %, range=0-3 %), which made a very small contribution to the annual diet. Wattled ibises were actively engaged in foraging during early morning (81%) and late afternoon to early evening (19%). 340 breeding pairs were observed in eight nesting site of the study area. The nest comprised of mainly sticks, a mixture of weed stems, their roots and grass clumps. In some nests, artificial items such as nylon ropes and cable wires were found. Fledgling and entirely feathered chicks were able to fly approximately at 20 days old. In the forest, egg laying started at the beginning of October. Mean clutch size at the forest and farmland were ($x^2 = 1.82$; $p > 0.05$). *In the forest, the mean number of hatchlings per nest with eggs was 1.7 and the average number of hatchlings per nest with was 2.3* ($x^2 = 3.30$; $p > 0.05$); *hatching success was 66 %. There were usually a single egg of the Wattled ibis and 2-3 eggs of the cattle egret in those mixed clutches. Nestlings were weighted to the nearest 0.1 gm. After hatching, the chicks weighed 40 g with culmen (16 mm in length), skull (38 mm), forearm (20 mm) and tarsometatarsus (18 mm). During the first three weeks of life, the chick's weight increased exponentially, although marked differences among the chicks were recorded. The extent of the land use/cover change and its effects seen on Chelekleka Lake and its swamp areas were very dramatic. The majority of the forest use/cover during the (1973-2010) in Chelekleka Lake water shades and its surroundings were converted to crop land, settlement, degraded bare lands and grasslands. Deforestation and soil degradation in the Chelekleka Lake watersheds and its surroundings were very severe. Horticulture expansion, poorly planned infrastructure developments, lack of awareness, poor attention from governments and climate change/variability exacerbate the drying of the lake. Undertaking appropriate resource conservation and management approaches, creating awareness among the local communities and sustainable agricultural activities should be practiced. The surrounding degraded land should be rehabilitated by afforestation. The socio-economic status of the local community should be improved. The stakeholders shoul give special attention to maintain the lake.*

Key Words: Chelekleka Lake, Ecology, Land use/cover change, Wattled ibis

1. Introduction

Ethiopia is a home to various wildlife ranging from alpine moorlands to lowland savannas, arid lands and extensive wetlands (Yalden, 1983). This makes it one of the few countries in the world that possesses a unique and characteristic fauna with a high level of endemism. There are 16 bird species restricted to the geographical region of Ethiopian highlands but shared with Eritrea (Vivero Pol, 2001).

Ethiopia, with its different geological formations and climatic conditions, is endowed with considerable water resources and wetland ecosystems. It includes 12 river basins, 8 major lakes, many swamps, flood plains and man-made reservoirs. According to Ethiopian Forestry Action Programme (EFAP) (1989), 110 billion $m^3$of water runs off annually from the above sources. Major river and lake systems, together with their associated wetlands, are fundamental parts of life and natural ecosystems. Wetlands are productive ecosystems that can play an important role in socio-economic development if they are effectively utilized on a sustainable basis. The extent to which water and wetland resources can potentially contribute to Ethiopia's development has barely been assessed.

Tesfaye Hundesa (1990) listed 58 major lakes and marshes in Ethiopia and Eritrea. Hillman (1993) listed a total of 77 wetlands in Ethiopia and Eritrea. He estimated that Ethiopian wetlands covered an area of 13,699 km^2 or 1.14 % of the country's land surface. Wetlands can be classified according to biomes. At the local and more specific level, wetlands can be grouped according to their habitat type, physical and biological characteristics.

A wetland is the collective term for an ecosystem whose formation is dominated by water and whose processes and characteristics are largely controlled by water. The complex interactions between biotic (fauna and flora) and abiotic (soil, water and topography)

components of wetland systems make them amongst the earth's most productive ecosystems. Wetlands are very important for the diverse values that they freely provide. They constitute a resource of great economic, cultural, scientific and recreational values. They are described both as 'the kidneys of the landscape' because of the functions they perform in the hydrological and chemical cycles, and as 'biological supermarkets' because of the extensive food webs and rich biodiversity that they support (Mitsch and Gosselink, 1993).

In Ethiopia, a total of 76 hotspots have been identified as Important Bird Areas (IBAs). Thirty of these sites (41% of the total) comprise wetlands, while the rest are representative of other types of ecosystems, indicating the importance of wetlands as bird habitats.

Wetlands shelter countless species of fauna and flora, including birds (Carp, 1980). Many wetlands are prominent because of their birdlife. Indeed, around 12% of all African bird species are found in and around wetlands (Mafabi, 1995). In Ethiopia, 204 (around 25%) of bird species are wetland-dependent (EWNHS, 1996). Although many of these birds are known, their habitats remain uninvestigated.

There are two categories of water birds: wetland specialists and generalists. Specialists are those that nest, feed and roost in wetlands. Wetland specialists are dependent on aquatic habitats and cannot survive without them (Airinatwe, 1999). Some of these are ducks, gulls, herons, waders, crakes, and the Black-crowned crane. Generalists are those birds that are frequently found in wetlands, but are sometimes seen in other habitats as well. These are ibises, herons, some weavers, warblers, plovers and other crane species (EWNHS, 1996). (Cranes, herons and ibises also depend on wetlands at least major part of their life cycle. They cannot survive without wetlands)

Wetlands have direct values that include both production and consumption of goods. These are the raw materials and physical products that are used directly for production, consumption and sale including those that provide energy, shelter, food, agricultural production, water supply, transportation and recreation. Wetland ecosystems provide ecological functions which maintain and protect nature and human systems through services such as the maintenance of water quality, flow and storage, flood control, sand storm protection, nutrient retention and microclimate stabilization, along with the production and consumption activities that they support (Tesfaye Hundesa, 1990).

Ethiopian wetlands are currently being lost or altered by many factors. Some of the factors are water diversion for agricultural intensification, urbanization, dam construction, pollution and other anthropogenic interventions. Human impacts have been substantially responsible for the increased rate of extinction in the recent decades (Wilson, 1992). The most comprehensive list, compiled by World Conservation Monitoring Centre (WCMC) revealed 117 bird species that probably have become extinct since 1600 (Jenkins, 1992).

Birds are taken as good indicators of biodiversity and monitors of environmental changes, like the level of contamination and environmental impacts (Chapman and Hall, 1993). Although defined by its avian fauna, the conservation of important bird areas would ensure the survival of a correspondingly large number of other taxa.

Chelekleka Lake and its surroundings is one of the lakes in the country with diverse flora and home to different species of birds, including endemic ones. One of the endemic birds that is found in the area is Wattled ibis (*Bostrychia carunculata)*. Due to its very limited ranges, Wattled ibis requires special attention (Hancock *et al.,* 1992). Except the

population status, there are no substantial studies regarding the ecology of the species. Because the quality of the lake is deteriorating from time to time, information about adaptive responses of the species is very important. Therefore, the purpose of the present study is to examine the ecology of Wattled ibis (*Bostrychia carunculata)* and land use/cover change of Chelekleka Lake, Bishoftu/Debrezeit.

2. Literature Review

Wattled ibis (*Bostrychia carunculata)* consists of dark and white shoulder patches, white eye and thin wattle hanging from the broad bill base. These features distinguish the Wattled ibis from its close relative, the Hadada ibis (*Bostrychia hagedash*). The average length and weight of Wattled ibis is 75 cm and 1.5 kg, respectively. The average bill and wing length are 134 mm and 353 mm, respectively (Hughes, 2006). The naked head, neck and legs are black. The bill is thick and curved use to probe into shallow water, mud and grass when foraging. Both sexes are similar but, juveniles have whiter necks and duller plumage (Plate 1).

Plate 1**.** Wattled ibis **(***Bostrychia carunculata)* (Photo:Kalkidan Esayas, 2015)

Because of Wattled ibis loud, raucous "kowrrr...kowrrr...kowrrr.." or "harrr...harrr" call, they are easily recognized even from some distance away. A flock of these ibises flying overhead becomes noisy. In flight, white patch shows on the upper surface of the ibis' wing and at close range, the wattle is visible (Brown *et al.,* 1982, del Hoyo *et al.,* 1992).

2.1. Taxonomy

Wattled ibis, *Bostrychia carunculata* is grouped in the under Order Ciconiiformes: and Family Threskiornithidae. The order Ciconiiformes constitutes 28 extant species of ibis (Table 1).

Table 1. Taxonomy of ibises

Genus Name	**Local Name**	**Scientific Name**
Threskiornis	African wattled ibis	*Threskiornis aethiopicus*
	Malagasy wattled ibis	*Threskiornis bernieri*
	Black-headed ibis	*Threskiornis melanocephalus*
	Australian white ibis	*Threskiornis moluccus*
	Straw-necked ibis	*Threskiornis spinicollis*
Pseudibis	Red-naped ibis	*Pseudibis papillosa*
	White-shouldered ibis	*Pseudibis davisoni*
	Giant ibis	*Pseudibis gigantea*
Geronticus	Northern bald ibis	*Geronticus eremita*
	Southern bald ibis	*Geronticus calvus*
Nipponia	Crested ibis	*Nipponia nippon*
Bostrychia	Olive ibis	*Bostrychia olivacea*
	São Tomé ibis	*Bostrychia bocagei*
	Spot-breasted ibis	*Bostrychia rara*
	Hadada ibis	*Bostrychia hagedash*
	Wattled ibis	*Bostrychia carunculata*
Theristicus	Plumbeous ibis	*Theristicus caerulescens*
	Buff-necked ibis	*Theristicus caudatus*
	Black-faced ibis	*Theristicus melanopis*
Cercibis	Sharp-tailed ibis	*Cercibis oxycerca*
Mesembrinibis	Green ibis	*Mesembrinibis cayennensis*
Phimosus	Bare-faced ibis	*Phimosus infuscatus*

Eudocimus	American white ibis	*Eudocimus albus*
	Scarlet ibis	*Eudocimus ruber*
Plegadis	Glossy ibis	*Plegadis falcinellus*
	White-faced ibis	*Plegadis chihi*
	Puna ibis	*Plegadis ridgwayi*
Lophotibis	Madagascar ibis	*Lophotibis cristata*

Threskiornithidae includes large terrestrial and wading birds which include the Wattled ibises. They have long and broad wings with 11 primary and about 20 secondary feathers. They are strong fliers and despite their size and weight, are very capable soarers. Worldwide, there are 36 species in the family Threskiornithidae. Out of these, seven species occur in Ethiopia. These are Wattled ibis (*Bostrychia carunculata*), African wattled ibis (*Threskiornis aethiopicus*), Waldrapp (*Geronticus eremite*), Hadada ibis (*Bostrychia hagedash*), Glossy ibis (*Plegadis falcinellus*), Eurasian spoonbill (*Platalea leucorodia*) and African spoonbill (*Platalea alba)* (Hughes, 2006).

Wattled ibises occur all over Ethiopia at altitudes ranging from 1500 m to the highest moorlands at 4,100 m asl (Hughes, 2006). It has also been recorded in Eritrea. It prefers meadows and highland river courses. It is often found in rocky places and cliffs (where it roosts and breeds). They are also found in open area, cultivated land, city parks and in mixed forests. It has also become well adapted to anthropogenic landscapes and conditions. Wattled ibis is common to abundant depending upon the habitat. Seasonal distribution of birds in any region is affected by the immigration patterns. Migratory movement is caused by climatic conditions such as food supply and length of day light (Lincolin *et al*., 1998). Wattled ibis is

sedentary but may make local altitudinal movements within its Ethiopian range (del Hoyo *et al.,* 1992).

Ibises are gregarious, often flocking in groups of 50 to 100. It rarely occurs alone. The birds normally roost on cliff edges. Ibises fly with necks outstretched and often in V-formation. This formation decreases wind resistance for trailing birds. When the leader of the pack becomes tired, it comes behind the formation and another ibis takes its place at the front.

2.2. Foraging Behavior

Foraging behavior of birds can be distinguished by their diets and the associated bill morphology. The diets comprise either herbivores or carnivores (Frank, 2007). Some of the differences among birds are seen in their bill adaptations for feeding. Certain aspects of gross bill morphology and micro-anatomy are known to be adaptive to specific modes of foraging. Some of the foraging behaviors of bird are probing, jabbing, and fossicking. Fossicking is using bill and walk to search unsystematically on the surface for food. Jabbing is penetrating to the substrates up to half bill length. Pecking is using tip of bill to peck at the surface (No penetration). Probing is inserting the bill into the sediment, allowing the capture of invertebrates that live below the sediment surface. Probing is observed more frequently in species with long and curved bills than in species with short and straight bills (Ferns and Siman, 1994; Barbosa and Moreno, 1999). A probing curved bill is able to inspect a greater volume of sediment than a straight bill of equal length. Wattled ibis consists of long and curved bill modified for probing.

The diet of Wattled ibis consists of worms and insects, frogs and small mammals (young mice) (Brown *et al.,* 1982, del Hoyo *et al.,* 1992). Wattled ibis forages in different habitats

like forest, shrubland and grassland.

Foraging behavior can reflect variation in food availability relative to demand. This means, birds adjust their foraging behavior to overcome different problems (Dobbs *et al.,* 2007). It measures prey attack rate (number of attacks on prey per unit time) and search effort (locomotory movements per attack) that are likely influenced by patch size through food availability and predation risk (Butler *et al.,* 2005). Risk is a factor that all foraging organisms must deal with. Time must be split between eating and watching for predators. Successful foraging of birds is extremely important, especially during cold weather. When predation risk is high, animals increase the proportion of time spent vigilant, negatively affecting foraging efficiency (Elgar, 1989).

2.3. Diurnal Activity Pattern

Vigilance behavior plays an important role in ensuring the fitness of animals and their offspring (Treves, 2000; Beauchamp, 2001). When animals monitor their surroundings and detect threats earlier, they may have a better chance to survive. However, high-level vigilance is often at the expense of other activities crucial for their maintenance (Inger *et al.,* 2006). Due to the risk of predation, birds usually try to forage in areas near dense vegetation that can provide safety (Suhonen, 1993).

Many factors affect vigilance pattern and how animals balance the trade-off (Li and Jiang, 2008). Vigilance behavior is affected by many factors such as foraging mode and group pattern. Investigation of the effects of foraging posture (or body posture) has received the attention of a number of researchers (Makowska and Kramer, 2007).

Flocking allows an increase in overall vigilance thus, enabling birds to devote more time to other activities and to achieve a higher feeding rate. Wattled ibises are known in their group behavior. They feed in flocks of varying magnitudes, sometimes reaching sizes of up to 50 to 100 individuals (del Hoyo *et al.,* 1992). Flock geometry has vigilance influencing factor. Individual position and distance-to-neighbor have been found to affect vigilance behavior (Öst *et al.,* 2007). In addition, group pattern (or group shape) is also a potential factor of concern. Birds with linear foraging group are more vigilant since they change their heads and body positions more than those foraging in a circular group (Bahr and Bekoff, 1999).

Most birds feed in large flocks during early morning, roost and resume feeding during late afternoon. In addition, resting, scanning, preening, aggression and cooperative interactions are among day time activities of birds. The non-foraging behaviors of ibises are drinking, fighting, handling, looking-up, pausing, preening and walking. Drinking water is usually performed with bill parallel to water surface. Fighting is confrontation with another ibis. Looking up is being alert, non-feeding posture with head held high. During pausing, the head is not held high. Walking is greater than one step per second with no foraging. Preening is attending the feathers.

Unlike cattle egrets (*Bubulcusibis coromandus)* which follow livestock animals (Jenni, 1969), Wattled ibises do not forage in association with livestock animals. But they forage in association with cattle egrets.

2.4. Nesting behavior

Wattled ibises usually nest in small to large colonies on rocky cliffs, over bushes and hanging on the walls. It has also been reported to nest singly on top of trees or ledges of buildings (del

Hoyo *et al.,* 1992). Few colonies are known above 3000 m asl, and those on trees at lower elevations (1800-2000 m). In the Bale Mountains, nesting colonies of 500 or more were recorded. The nest is a platform of branches and sticks, lined with grass and strips of bark. At high and cold altitudes, they are located to the east for maximum exposure to morning sun. Both male and female ibis take turns in guarding the nest site until the chicks are large enough to defend themselves. In addition, both parents are reported to help to feed the chicks (del Hoyo *et al.,* 1992).

2.5. Breeding Ecology

Wattled ibis breeds from March to July; and occasionally in December, during the dry season (del Hoyo *et al.,* 1992). Most breeding activities are observed after the rainy season, when plenty of food is available. The species usually breeds colonial, although it may also nest in solitary pairs or smaller groups of two to three pairs (del Hoyo *et al.,* 1992). In highlands, breeding colonial nests of Wattled ibis are placed on the eastern slopes of rocky cliffs (Hancock *et al.,* 1992), or on bushes protruding from cliff-faces, often up to 3,000 m in altitude (Brown *et al.,* 1982; del Hoyo *et al.,*1992). When breeding in solitary pairs or small groups, nests are more likely to be placed on the top of trees or on ledges of buildings at lower elevations (1,800 to 2,000 m). In both cases, the nest is a platform of branches and sticks (Brown *et al.,* 1982; del Hoyo *et al.,* 1992). The nest is made of sticks and lined with grass stems, mosses and strips of bark.

Breeding success of birds is determined using hatching success, fledgling success, reproductive success and nest success (Hughes, 2006). Hatching success is percentage of chicks hatched in relation to the number of eggs laid. Fledging success is percentage of fledglings in relation to the number of hatchlings. Reproductive success is percentage of

fledglings in relation to the number of eggs laid. Nest success is percentage of nests with fledglings in relation to the number of nests with eggs.

Wattled ibis normally lays two to three dirty-white, rough-shelled eggs. The birds seem typically to nest in colonies in bushes growing out from cliffs, but few of their nesting sites have been reported on plateau (Hughes, 2006).. The young, covered in black feathers when still at the colony, are fed away from the colonial site once they fly. The life span of the species is approximately 10-12 years (Hughes, 2006).

2.6. Population

Wattled ibises are evaluated as Least Concern (Hughes, 2006 and BirdLife International, 2015).

2.7. Effects of Land Use / Land Cover Changes (LULCCs) of Chelekleka lakes on birds

Land use and land cover is a primary ingredient of ecological structure and function, with changes affecting species habitat and distribution. It can also affect farmer livelihoods and strategies. The change involves the interaction of biophysical, social, ecological and human behavioral attributes over time, space and complex process that arises from modifications in land cover to land conversion process (Turner *et al.*, 1994).

Land use change is driven by the interaction in space and time between biophysical and human dimension. Moreover, there are also the potential impacts on physical and social dimensions (Veldkamp and Verburg, 2004). According to Lambin *et al*. (2003), land-use change is also driven by synergetic factor combinations of resource scarcity. This leads an increase in the pressure of production on resources, changing opportunities created by

markets, outside policy intervention, loss of adaptive capacity, changes in social organization and attitudes.

Due to this synergetic factor, LULCCs results in land fragmentation, biodiversity loss, degradation of agricultural productivity, decline in economic well- being, or changes in human population. For instance, the people who live in similar land use type may have differing socio-economic characteristics because their connections with places, institutions, and available resources. LULCC is one of the most important drivers of global change (Gyawali *et al*., 2004 cited in Turner *et al*., 1994; Lambin *et al*., 1999). Changes in the condition and composition of the land cover affects climate, changes in biogeochemical cycles and energy fluxes and affecting thereby livelihoods (Vitousek *et al*., 1997).

LULCCs are accelerated due to significant processes driven by human actions. It also produces changes that impact humans (Agarwal, 2001). These dynamics alter the availability of different biophysical resources including soil, vegetation, water, animal feed and others. Consequently, land use/cover changes could lead to a decreased availability of different products and services for human, livestock, agricultural production and damage to the environment as well. Daily rural livelihood practices affect LULCC and conversely, it affects rural livelihoods well being. Some of the effects are deforestation, soil erosion and associated problems like decline in soil fertility and loss of biodiversity. These have resulted in making livelihood improvement a very challenging task in countries like Ethiopia that are highly dependent on agricultural and natural resources products.

Changes in land cover can influence climate and climate in turn, can influence land use and land cover. These land cover changes affect weather and climate variability by altering

biophysical, biogeochemical and energy exchange processes at local, regional and global scales. The effect of LULCCs on the hydrological processes is mainly contributed by the changes in vegetation interception, soil evaporation, plant transpiration, infiltration and soil water content. LULCCs can have specific and cumulative effects on air, water quality, watershed function, generation of waste, extent and quality of wildlife habitat, climate and human health.

Birds are excellent indicators of environmental degradation (Furness and Greenwood, 1993). The distribution of bird species is determined by climate, availability of suitable resources, barriers of dispersal and inter-specific interaction with those organisms sharing the same area. On the other hand, home range, territories and microhabitats are indicators of the distribution of individuals within an area of convenient habitats. These are governed by access to important resources. Furthermore, the range of bird species fluctuates depending on habitat change, competition, predation and climatic change (MacArthur and MacArthur, 1961). Some bird species have limited range because of narrow habitat or specifity of food requirement. Small geographical range is associated with habitat specialization. Species occupying disturbed or strongly seasonal habitat types may also have large area of distribution.

Birds can exploit seasonal feeding and nesting opportunities. They respond to annual changes, which influence habitat and food availability by using different sets of habitats at different seasons. The migratory movement in response to seasonal climatic changes can result in short or long distance movement. For birds, rainfall regimes and associated environmental changes are of major importance in determining breeding seasons and annual cycles (Wiens, 1976).

Birds have short breeding seasons at high latitudes and long at low latitudes. The seasonality of climatic variables must impose a long-term seasonal pattern on primary production and in turn there is a restricted period of the year during which most birds breed (MacArthur *et al*., 1962). Birds generally produce young when and where there is ample food (MacArthur and MacArthur, 1961). Bird species that face seasonal irregularity in the availability of food resources shift to feeding on other resources or move to another area where preferred food resource is available. Where there is no seasonal irregularity in food availability and other factors are held constant, species can maintain itself throughout the year. Therefore, in order to sustain the livelihood of birds, their habitats should be managed and protected.

3. Significance of the study

Wetlands and their value remain little understood. But, their loss is increasingly becoming an environmental issue. Hence, the current research will help to:

- Create awareness and appreciation of wetlands
- Develop a knowledge and understanding of wetland birds and its habitat.
- Understand ecological processes of wetlands
- Develop a knowledge and understanding of the socio-economic uses of wetlands
- Reinforce wetlands policy, legislation and wise use criteria and incorporate wetland issues in other laws and policies

4. Objectives of the study

4.1. General Objective

The general objective of this study is to assess the diversity of bird species, ecology of Wattled ibis and land use/cover change at Chelekleka Lake, Bishoftu.

4.2. Specific objectives

- To determine the population status of Wattled ibis
- To determine the population status of other bird species in the study area
- To study the foraging behavior of Wattled ibis in the area
- To study habitat association of Wattled ibis;
- To assess activity patterns of Wattled ibis
- To determine the fledging and hatching success of chicks
- To collect data on the features of nests and eggs of the breeding species.
- To understand the land use/cover change of Chelekleka Lake in relation to Wattled ibis habitat degradation and conservation.

Research Questions

1. Does Chelekleka Lake support considerable number of Wattled ibis and other bird species?
2. Does Chelekleka Lake and surrounding habitat provide suitable feeding and ground to Wattled ibis?
3. Does the anthropogenic effect have an impact on the abundance, feeding, breeding and nesting success and in turn on the survival of Wattled ibises?

5. The Study Area

Bishoftu is a town lying southeast of Addis Ababa. It was formerly known as Debre Zeyit. The town is located in the 'Misraq Shewa' zone of the Oromia region and has an elevation of 1,920 m above sea level. It is a resort town, known for five crater lakes: Lake Bishoftu, Lake Hora, Lake Bishoftu Guda, Lake Kuriftu and the Lake Babogaya. Other lakes existing at the periphery of the town includes Cuban made lake, Hora Kilole Lake, Green Lake, Ziquala Lake and Lake Chelekleka.

Chelekleka Lake is a seasonally inundated pan in Debre Zeit/Bishoftu town. It attracts large numbers of water birds following the Palaearctic migration during the months from September to February. During this time, migrant birds augment resident birds. This enriches the site with diversity of Ethiopian and northern hemisphere birds. The size of the wetland varies depending on the amount of precipitation received from the surrounding highlands from year to year.

Lake Chelekleka occupies a shallow depression surrounded by a plain which used to be seen as one drives on the Bishoftu-Addis Ababa highway (Fig. 1). In recent years, due to the expansion of settlement between the road and the lake, the beautiful site of the lake is overshadowed. The size of the lake varies from season to season. During the dry season, it forms interrupted swampy small areas and there are periods where it completely dries out (March and May). The smaller Chelekleka area is found north of Babogaya Lake, Bishoftu (Yeshimebet Mamo, 2006).

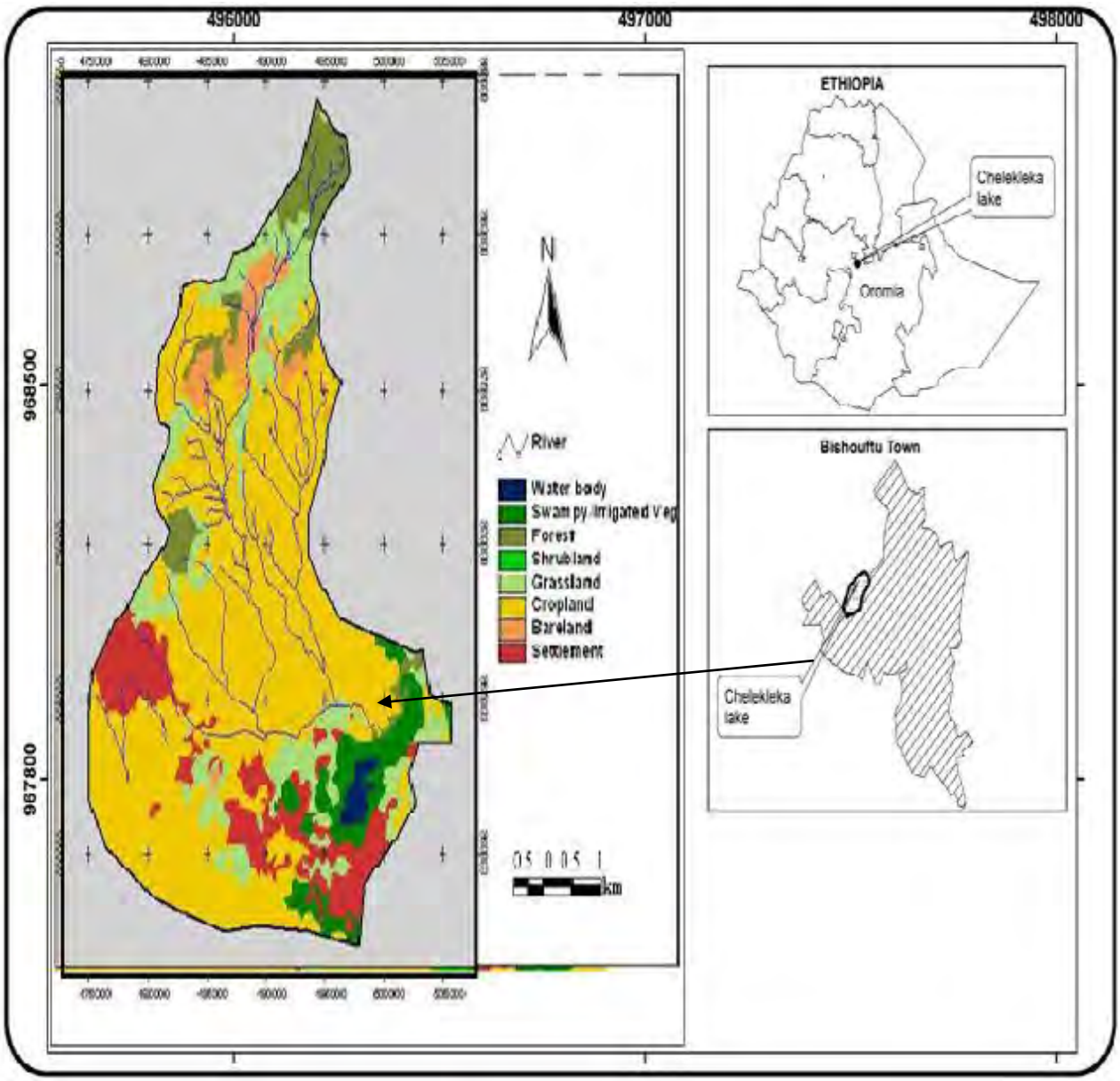

Figure 1. Map of the study area

Bishoftu crater lakes were formed as a series of volcanic explosion craters in the vicinity of the town of Bishoftu. The depressions are surrounded by rims of ejected beds and are considered as explosion craters or mars. Circular shape and steep crater rims characterize these lakes. The diameter of the explosion circular craters ranges from 0.5 to 1 km^2 (Lamb, 2001). The rim of some of the craters is slumped and triangular notches are common. The

level of the lakes is generally below the surrounding plains. The main source of water comes from precipitation and surface runoff from their small catchments. Groundwater is likely to contribute a lot to some of them (Lamb, 2001) (Fig. 2).

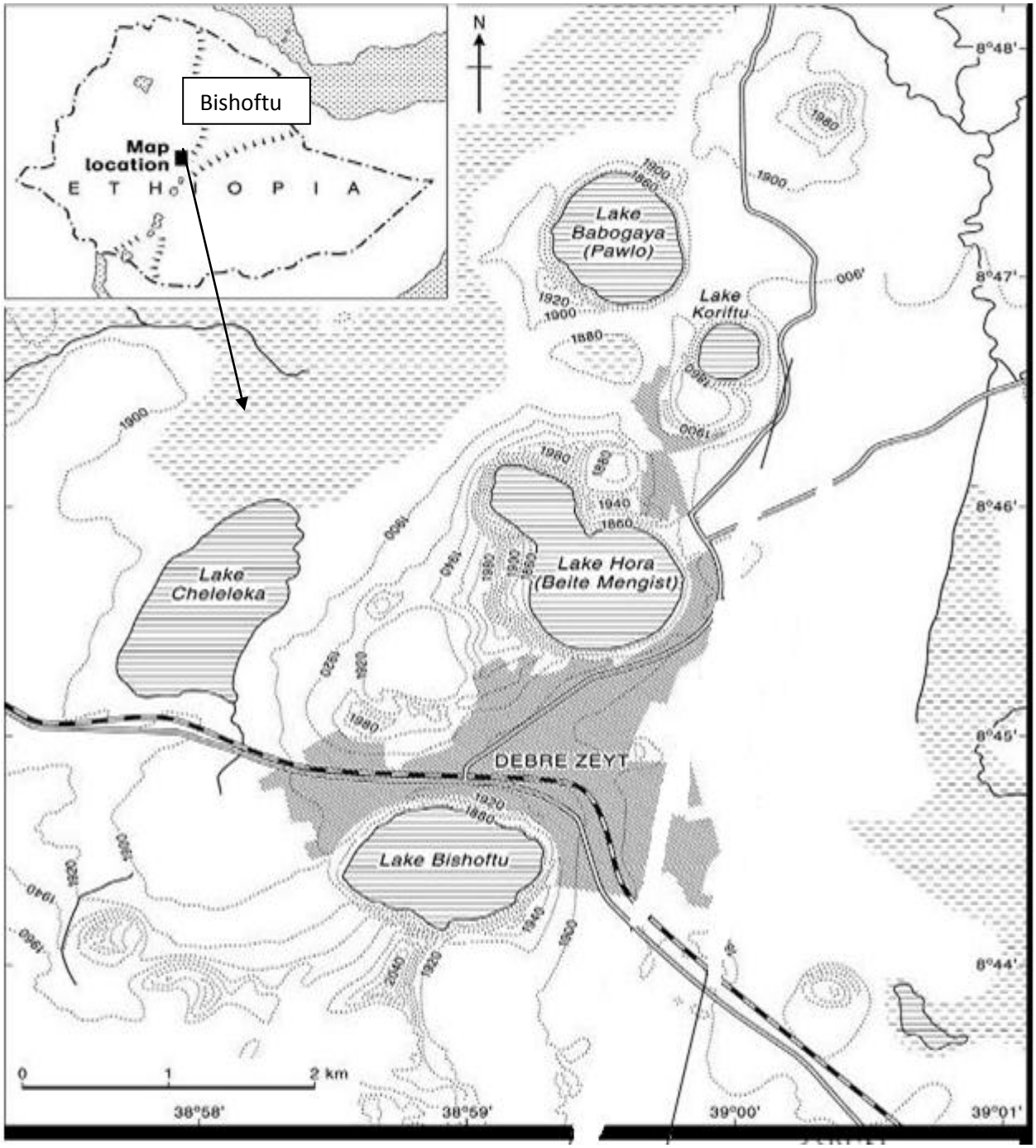

Figure 2. Location of Lake Chelekleka in relation to the other Bishoftu crater lakes (Lamb, 2001).

Topography

The topographic feature of the study area is made up of rolling terrain (a rugged topography) with the average altitude 1920 m asl. The common soil type in the study area includes luvisols, lepthosols, nithosols, vertisols and cambisols (Daniel Assefa, 2015).

Temperature/Rainfall

The climate is generally warm and temperate. Mean monthly minimum air temperature is 8.5 recorded in February. December has the lowest average temperature. The maximum mean monthly temperature is 28.3 ^{0}C in December. Precipitation is the lowest in December (5 mm) and the highest rainfall recorded in July (232 mm) (Fig.3).

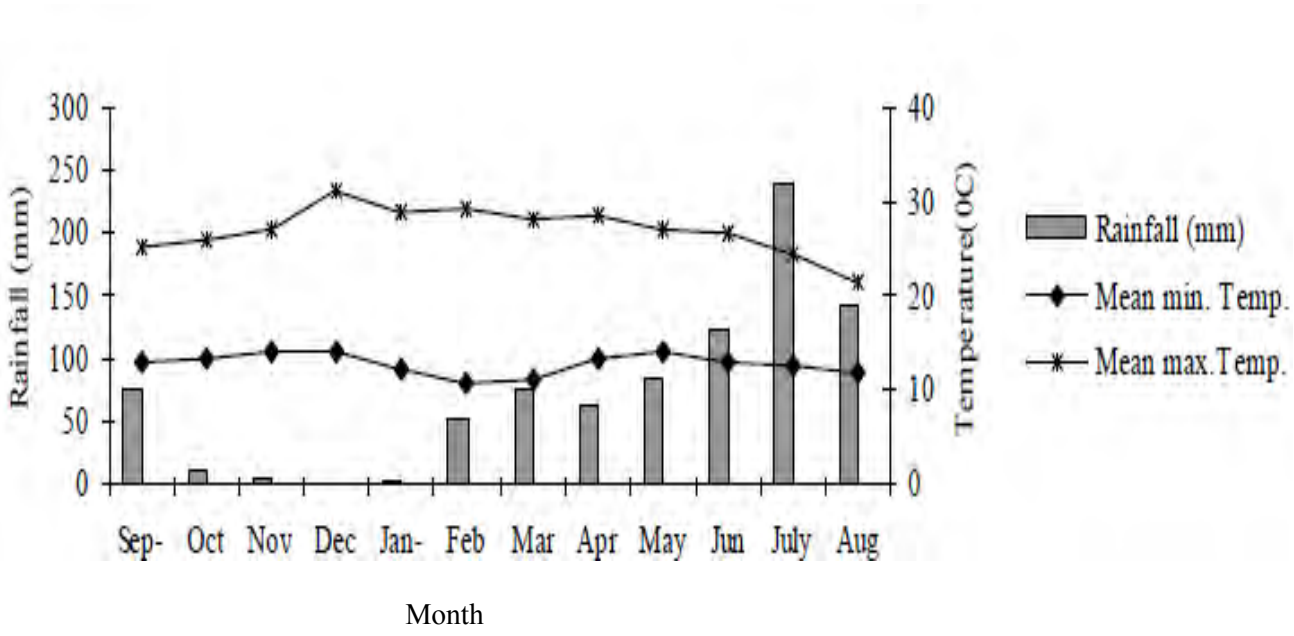

Figure 3. Average monthly rainfall (mm) and temperature (^{0}C) of the lake (2006-2016) (Source: National Meteorological Service Agency, 2016)

Flora

The shallow nature of the water has led to the production of a wide shoreline. The pan supports the growth of wetland vegetation, which in turn makes the wetlands productive and life supporting. Aquatic plants found at Chelekleka Lake include *Typha* spp., sedges, rushes, *Potamogeton* spp., *Persicaria* spp. and *Odontelytrum abyssinicum*. Around the lake, some remnant natural forests is found comprising tree species such as: *Afrocarpus falcatus*, *Prunus africana, Albizia gummifera*, *Aningeria adolfi-friederici*, *Cordia africana*, and *Croton macrostachus* occur. Plantation woodlots with exotic tree species such as *Eucalyptus* species, *Gravilea robusta*, and *Cuprunus lustanica* are common. At homestead and farm boundaries, agro-forestry activities are commonly practiced.

Fauna

Wetland birds recorded at Chelekleka Lake include a variety of storks, herons, ducks, geese, waders, ibises and birds of prey. Chelekleka Lake is an Important Bird Area (IBA) where rare waterfowls and birds of prey occur. The site holds more than 20,000 water birds seasonally. The shallow waters form significant roosting site for more than 18,000 common cranes, *Gurus gurus* from October to March.

The lake is intensively cultivated on the fringes by local farmers who grow chick peas and different kinds of vegetables like tomatoes and cabbages. Besides the local farmers, various agro-industrial enterprises have land holdings around the wetland. These industries use different pesticides and fertilizers during their production processes. Effluents enter surface or underground into the wetlands. The wetland, over time, has accumulated toxic substances

in its substrate. The wetland and all life forms that depend on the area are at great risk of being contaminated (Daniel Assefa, 2015).

Sediments occur in the Chelekleka Lake as a result of various human actions including land use/cover changes and agricultural practices, changing dramatically the volume of water resources. In addition, inadequate and very little consideration was given by stakeholders especially the government to alleviate the impacts of a recently increasing high sediment loads from the construction of new roads and other infrastructures.

These impediments excessively affect the volume of the lake's freshwater systems and threaten its habitats, local community, income from tourists and other natural resource endowments. Therefore, it is crucial and appropriate to undertake investigation on the watersheds of Chelekleka Lake. Having the knowledge and understanding of the reality would help to take any appropriate concrete remedial and corrective actions protecting the lake from pollution.

6. Materials and methods

6.1. Materials

The materials that were used during the study period were measuring tape, field shoes, rain coats, binoculars (10 x 42 Bushnell), global positioning system; GPS (Garmin 72), digital camera, compass, plastic bags, labeling pen, pressing materials, Vernier caliper, tape recorder, Pesola spring balance, wader and stationery.

6.2. Methods

6.2.1. Preliminary Survey

Ecological survey of birds in and around Lake Chelekleka was carried out to gather relevant information. In this survey, an overall view of birds specifically to Wattled ibis of the area was conducted. Information was collected from concerned governmental, non-governmental authorities, and local people living around the study area. The topographical features as well as vegetation cover of the area was assessed.

6.2. Data Collection

.Based on the information collected and site selected during the preliminary survey, field data were gathered. Data were taken on monthly basis (20 days) for two years depending on weather conditions and time of the season when most of the Wattled ibises were active. Data were collected early in the morning from 6:30 to 10:00 a.m and late afternoon from 3:30 to 6:00 p.m (Spencer, 1963; Centerbury *et al.*, 2000).

Binoculars as well as naked eye observation were used. Field data sheet was used to record the activity pattern and foraging behavior of the Wattled ibis. In addition, photographs were

taken to confirm their activities. Bird calls were recorded whenever possible using tape recorder (Peterson, 1949). The location of the observed birds was recorded with the help of GPS in the study area.

6.2.2. 1. Population status and habitat association

In order to assess the population of Wattled ibis and other bird species,, total count method was used. The census was done by classifying the study area into four habitats. The habitats were forest, farmland, grassland and settlement area. The distribution pattern of the Wattled ibis was studied at and around Lake Chelekleka.

6.2.2.2. Foraging Behavior

The foraging behavior of Wattled ibis was sampled using 2 minutes focal observations of foraging individuals during wet and dry seasons (Altman, 1974). Sampling was undertaken during periods of prevailing fine weather and observation was made randomly throughout the day.

During each observation, the focal bird was recorded using a video camera (Sony digital camera) from a distance of 10-60 m. Recordings were replayed in slow-motion (approximately 1 frame per second) and transcribed directly into a database, foraging behavior was timed to the nearest second. The replay was slowed, paused or repeated when required. Foraging behaviors were categorized based on definitions by Kushlan (1976) and Kelly (1993). Foraging success was calculated as the number of successful captures per 2 minute observation bout. Successful captures were readily identified by a distinctive backward jerk of the head and visible swallowing motions (Frederick, 1987).

Data about foraging behavior were collected through repeated standard observations following Hartley (1953). Useful information was obtained by directly observing where birds feed. Time spent strictly for feeding (head down) was recorded. Focal sampling was carried out by watching an individual for 10 minutes. Data on the time spent for foraging activity was carried out during foraging like vigilance, antagonistic or cooperative interactions. An individual bird was followed at a distance of 5-10 m. Data collection activities were held early in the morning from 6:30 to 10:00 a.m. and in the afternoon from 8:00 to10:30 p.m, when most of the birds were active both during wet and dry seasons (Buskirk and McDonald, 1995). Based on diurnal activity of Wattled ibis, daily habitat use was recorded. The time used for foraging per day was determined. Seasonal changes in habitat use were analyzed.

6.2.2.3. Activity Pattern

The activity pattern of Wattled ibis was recorded using scan sampling method throughout the study period following Altman (1974). Various activities were recorded using the method during both dry and wet seasons. During the observation period, a group or an individual bird was followed at a distance of 5-10 m. Three minutes scan sampling was taken at intervals of 15 minutes. The activities included feeding, preening, resting, walking and scanning. Time spent on each activity was also recorded.

6.2.2.4 Breeding and nesting ecology

During the breeding seasons (October and July), an inventory of Wattled ibis was carried out on monthly basis. The observations were made two to three times a week. Each nest was checked at least four times per day at regular intervals to determine clutch size and breeding

success. Observation was made on nest location, their construction, clutch size and hatching success in two habitats (forest and farmland) around Chelekleka Lake.

Nestling were weighed using a Pesola scale and measurements using a vernier caliper were taken at the same time of day (between 10:00 and 11:00) at 1-3 day intervals from the time when chicks had hatched. Activity in the colony at the Chelekleka Lake was studied by recording all birds departing and arriving, their flock sizes and flight directions.

The distribution of nests was recorded. The density of breeding nests at each breeding site was determined and compared; and also the association of nests with the vegetation type was evaluated. The hatchability and reproductive success of Wattled ibis was evaluated.

Intensive nest searching in the study area was carried out using a spotting scope and binoculars. Nests found in different macro-habitats were measured. The dimension in terms of length, breadth, height from water surface (H_1=height from the ground and H_2= at one meter distance from the nest rim) was measured using measuring tape. Presence, type and height of the vegetation were also recorded. Plants used as the nesting material was collected and identified using the Flora of Ethiopia (Tadesse Mamo, 2004).

The length, breadth and weight of the egg found in the nest were measured using vernier caliper and a Pesola spring balance, respectively. The relation of egg characteristics to their subsequent fate in terms of hatchability and fledging probability was assessed. To study the behavioral pattern of egg laying, the placement of each egg in every nest the time or duration between each successive egg was recorded by taking the dimension and the distance between

them. Incubation period, hatchability and fledging success were recorded by climbing, checking each nest, egg, taking measurements by Vernier caliper, taking weight.

6.2.2.5. The land use/cover change of Chelekleka Lake

To determine the study area land use samples, the aerial photograph taken in 1972/73 and topographic map of the 1986/87 of the study area were considered. These two sources were the only input help to determine the appropriate catchment area of Chelekleka Lake, watersheds and its swamp areas. After having the exact delineated study site for each category under investigation, analysis was made by considering the four different periods: 1973, 1986, 2000 and 2010 satellite images. Satellite images were downloaded from (Source: *www: Earth explores* to begin change examinations. The downloaded satellite images are in tiff format and were stacked in software and developing function in it to stack each layer to produce one single layer composed of each band. From the stacked band, the study area was extracted. The processing of these images were geometrically corrected with road and river intersection on the images themselves and the topographic map of the study area at a scale of 1:250,000. After the raw data were georeferenced, they were clipped with the boundary of the study area for further processing.

In order to know the anthropogenic factors of Chelekleka Lake, the socio-economic status of the local community settled around the lake was investigated. Three Kebeles were selected on the basis of their direct interactions (adjacent to) with Chelekleka Lake and its surroundings. Multi-stage sampling procedure was applied to select the households. The Kebeles were selected by involving key informants from the office of Agricultural and Rural Development. Sample respondents were randomly selected from the households registered

as residents of the selected Kebeles, since they are homogenous in their ethnicity, socio-economic characteristics and educational background. Accordingly, 10% of the household sample size from each selected three Kebeles was drawn and a total of 120 heads of farm households were randomly selected. The survey was conducted using questionnaire method and Focus Group Discussion (FGD).

The major issues addressed in the discussion were socio- economic features of the households, means of livelihood and income generation, land sources and their utilization, wetland crop and livestock production and output losses attributed to natural and human made factors

Focus group discussion was also arranged to support the data obtained from household survey. Different stakeholders were interviewed. Discussions were made with farmers and different social groups. Elders were important source of information sharing their observations and experiences on the change in the natural resource bases and their values. A total of 25 people participated in the group discussion. Checklists were prepared to guide the discussion. The major focuses of the discussion were to generate information at community level that can complement the survey data in the value (importance) and threats of wetlands. Discussion was also held with different Kebele administrators and other social institutions selected based on their responsibilities related to natural resource administration. Data were analyzed using Microsoft excel.

6.3. Data analysis

The geographical coordinates where Wattled ibises occur were recorded and mapped using Arc GIS 9.3 Software to show where Wattled ibises were concentrating. Abundance (density) was estimated using distance 5.0 Beta 5 software (Bibby *et al*., 1992; Sutherland, 1996; Lloyd, *et al*., 1998).

The preference for or avoidance of a particular habitat by Wattled ibis was determined by Chi-square test (Gichuki,1993). Spearman's rank correlation coefficient used for determining the consumption of different types of foods.

A one-way analysis of variance (ANOVA) using Tukey's HSD post-hoc test was used to analyze the difference in foraging success and handling time among the habitat types. The assumptions of ANOVA were met as the data were randomly sampled and drawn independently from each habitat type. They were normally distributed (evaluated using a normal quantile-quantile plot), and had equal variance among groups. Tukey's HSD post-hoc test was deemed suitable because the sample sizes in each group were equal, and it is a simple and reliable multiple comparison test (Quentin *et al*., 2006). Statistical analyses were performed using SPSS version 20 (SPSS, 2015).

Simple correlation analyses as well as multivariate models were conducted to explain nest locations. Placement of the nests on a sub-branch, distance of the nests from the tree trunk, number of nest supporting twigs, and flight pathways were recorded and compared between repeated and single used nests by applying student's t-test. Measurement was taken once the nesting season was over.

To analyze the relationship between tree height and a canopy radius, tree height and nest height, a correlation coefficient was calculated. Student's t-test was applied between the characteristics of single and multiple time selected trees and nests to assess the significance of multi use of the nests and analysises were carried out between the tree heights, nest heights, canopy cover and Diameter at Breast Height (DBH).

7. Results

7.1. Species diversity and population status

A total of 54 species of birds categorized under 17 families were observed during wet and dry seasons (Table 2).

Table 2. Bird species observed in the study area

Family	Common name	Scientific name
Accipitridae	African Fish Eagle	*Halicaetus vocifer*
	Pallid Harrier	*Circus macrourus*
	African Marsh Harrier	*Circus ranivorus*
Anatidae	Cape Teal	*Anas capensis*
	Egyptian Goose	*Alopochen aegyptiacus*
	Garganey	*Anas querquedula*
	Knob-billed Duck	*Sarkidiornis melanotos*
	Tufted Duck	*Aythya nyroca*
	Northern Shoveller	*Anas clypeata*
	Spur-winged Goose	*Plectropterus gambensis*
Areidae	Black-headed Heron	*Ardea melanocephala*
	Cattle egret	*Bubulcus ibis*

	Great white Egret	*Ardea alba*
	Grey Heron	*Ardea cinerea*
	Little Egret	*Egretta garzetta*
	Little Bittern	*Lxobrychus minutus*
	Black Heron	*Egretta ardeslaca*
Charadriidae	Crowned plover	*Vanellus cotonatus*
	Black winged Plover	*Vanellus melanocephalus*
	Little ringed Plover	*Chradrius dubius*
	Kittlitz's Plover	*Charadrius pecuarius*
	Spot-breasted Plover	*Vanellus melanocephalis*
Ciconiidae	Marabou Stork	*Leptoptilos crumeniferus*
	White Stork	*Ciconia ciconia*
	Yellow-billed Stork	*Mycteria ibis*
Gruidae	Black Crowned Crane	*Balearica pavonina*
	Common Crane	*Grus grus*
Jacanidae	African Jacana	*Actitis hypoleucos*
	Lesser Jacana	*Microparra capensis*

Laridae	Black-headed Gull	*Chrolococephalus ridibundus*
Pandionidae	Osprey	*Pandion haliaetus*
Pelecanidae	Great White Pelican	*Pelecanus onocrotalus*
	Pink-backed pelican	*Pelicanus rufescens*
Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*
Phoenicopteridae	Greater Flamingo	*Phoenicopterus roseus*
	Lesser Flamingo	*Phoenicopterus minor*
Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*
	Pied Avocet	*Recurvirostra avosetta*
Scolopacidae	Black tailed Godwit	*Limosa limosa*
	Common Sandpiper	*Actitis hypoleucos*
	Dunlin	*Calidris alpa*
	Little Stint	*Calidris minuta*
	Ruff	*Philamachus pugnax*
	Sanderling	*Calidris alba*
	Temminck's Stint	*Calidris temminckii*
Scopidae	Hamerkop	*Scopus umbretta*

Sternidae	Gull-billed Tern	*Gelochelidon nilotica*
	Black tern	*Chilidonias niger*
	White-winged Tern	*Chilidonias leucopterus*
	African Spoonbill	*Platalea alba*
	Glossy Ibis	*Pegadis falcinellus*
Threskiornithidae	Sacred Ibis	*Thereskiornis aethiopicus*
	Wattled ibis	*Bostrychia carunculata*
	Hadada ibis	*Bostrychia hagedash*

The number of individuals counted during the wet and dry seasons was 3598 and 3148, respectively. The number of birds varied according to the season. Species with large number were Egyptian Goose (573), Spur-winged Goose (261), Ruff (365), Marabou Stork (251) and Sacred ibis (494), all observed in wet season. The total population of Wattled ibis was 170 and 191 during both dry and wet season, respectively (Table 3).

Table 3. Mean number of bird species in the study area

Species observed	**Mean No. of species observed during the wet season**	**Mean No. of species observed during the dry season**
African Fish Eagle	9	4
African Jacana	15	4
African Marsh Harrier	11	9
African Spoonbill	19	12
Black Crowned Crane	14	3
Black Heron	8	2
Black tailed Godwit	29	20
Black tern	24	17
Black winged Plover	15	6
Black-headed Gull	7	11
Black-headed Heron	7	2
Black-winged Stilt	49	34
Cape Teal	5	8
Cattle egret	125	79
Common Crane	21	16

Common Sandpiper	12	4
Crowned plover	15	9
Dunlin	217	200
Egyptian Goose	573	540
Garganey	10	8
Glossy Ibis	9	1
Great Cormorant	28	23
Great white Egret	19	15
Great White Pelican	14	26
Greater Flamingo	48	30
Grey Heron	81	68
Gull-billed Tern	3	1
Hadada ibis	27	13
Hamerkop	7	3
Kittlitz's Plover	2	2
Knob-billed Duck	69	58
Lesser Flamingo	21	10

Lesser Jacana	9	1
Little Bittern	12	11
Little Egret	37	33
Little ringed Plover	10	15
Little Stint	1	1
Marabou Stork	251	233
Northern Shoveller	73	54
Osprey	17	11
Pallid Harrier	13	25
Pied Avocet	59	44
Pink-backed pelican	31	18
Ruff	365	350
Sacred Ibis	494	483
Sanderling	1	1
Spot-breasted Plover	117	110
Spur-winged Goose	261	255
Temminck's Stint	19	10

Tufted Duck	19	9
Wattled ibis	191	170
White Stork	60	42
White- winged Tern	16	14
Yellow-billed Stork	29	18
Total	**3598**	**3148**

Variation in the number of Wattled ibis was observed among the four habitats. During the dry season, farmland was the highest (46) and settlement area (17) had the lowest number of ibises. During the wet season, the number of wattled ibis was 27 and 56 in settlement area and forest, respectively. During both seasons, the mean number of Wattled ibis was 35 and 56 in settlement area and forest habitat, respectively (Table 4).

Table 4. Species richness

		Habitats			
	Season	Forest	Farmland	Grassland	Settlement
Number of species	Wet	56	42	34	27
Mean ± SE	Wet	49 ± 5.48	65 ±11.27	52 ±7.74	16 ±1.5
Number of species	Dry	39	46	25	17
Mean ± SE	Dry	67 ±16.22	50 ± 6.61	85 ±15.78	14 ±1.62

The concentration of Wattled ibis was high in the forest during the wet season and farmland during the dry season. The probability of occurrence of Wattled ibis in the forest was 80-100 % whereas, it was 78-89 % in the farmland (Fig. 4).

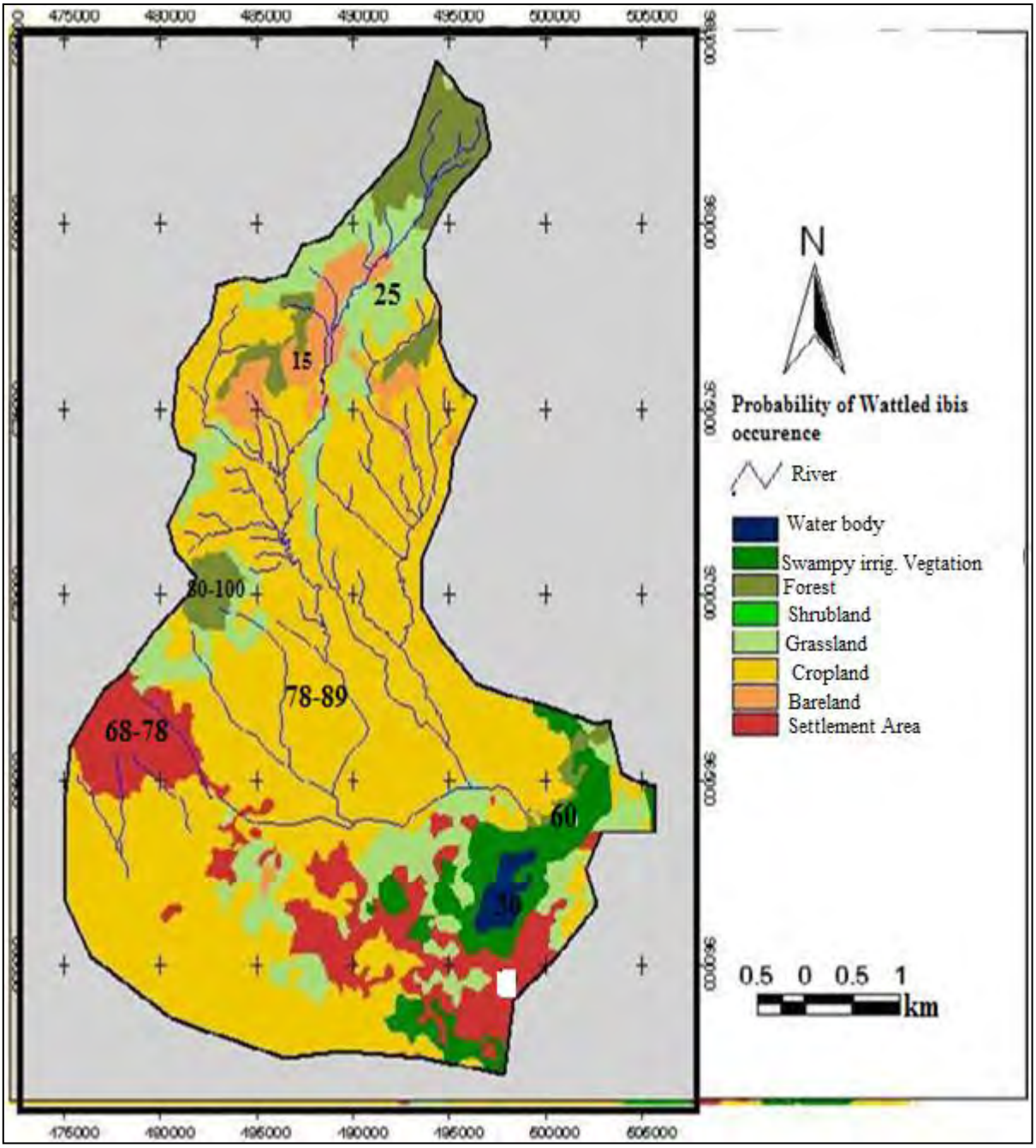

Figure 4. Percentage occurrence of Wattled ibis in different habitat

7.2. Foraging behavior

Worms and insects were the main diets of Wattled ibis. However, the use of each food item differs during the wet and dry seasons. Worms are more available during the wet season than the dry season. Worms were the most consumed food items. During the long dry season, Wattled ibises were observed collecting insects from cattle dung and those hiding in vegetated areas. Wattled ibis flocks were observed feeding in the pastureland and the surrounding habitats. During the wet season where the pastureland was flooded, they were restricted to muddy microhabitats following the margin of the marshland with water level not higher than their feet. However, the frequency of occurrence in those microhabitats differ significantly (x^2 =228.05, df =2, p <0.005).Sixty seven percent of Wattled ibis foraged in densely vegetated muddy area, 22 % in less densely vegetated muddy area and 11% in open muddy area (Fig. 5).

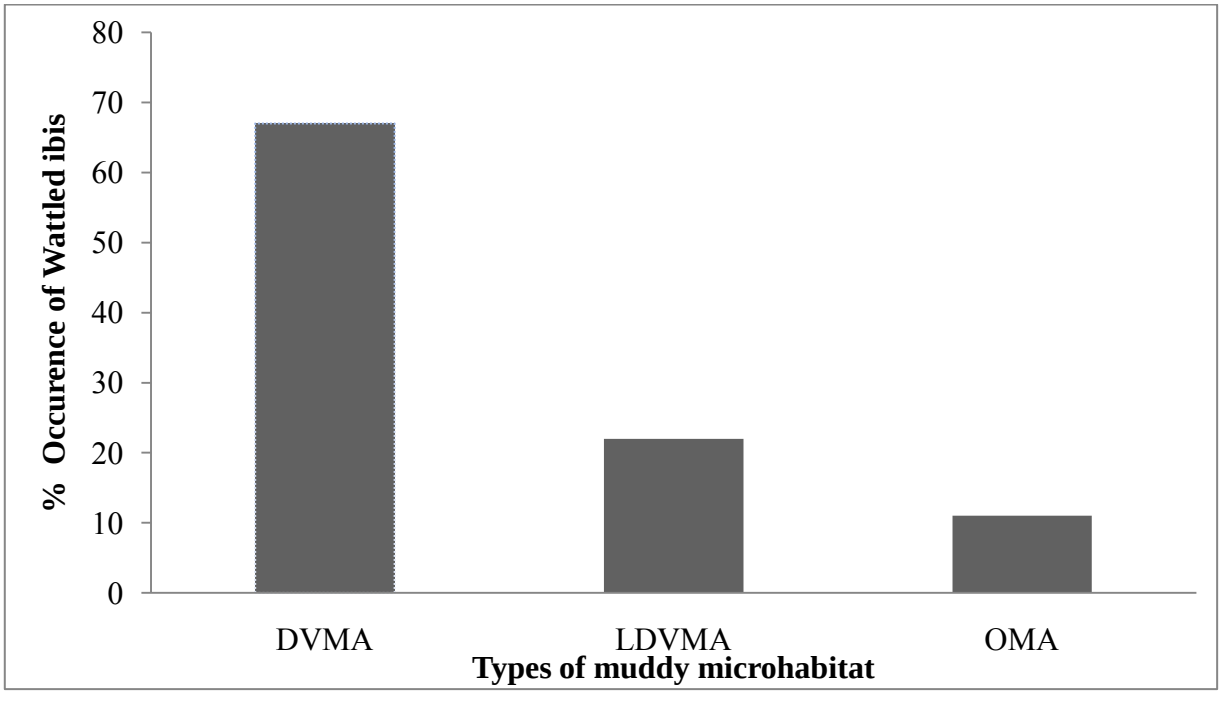

Figure 5. Foraging habitat preference of Wattled ibises during the wet season (DVMA: Densely Vegetated Mud area, LDVMA: Less Densely Vegetated Mud Area, OMA: Open Mud Area)

During the dry season, Wattled ibises used other habitats in addition to the grassland for foraging. They were observed searching for prey items all over the grassland, moist ground of plantations with patches of grass and settlement area. The use of these habitats by ibises were significantly different (x^2=106.08.05, df =2, p < 0.005). Most frequently, the flocks were observed foraging on the grassland (71%). The use of farmland and settlement area was not frequent, 18 % and 11%, respectively (Fig. 6).

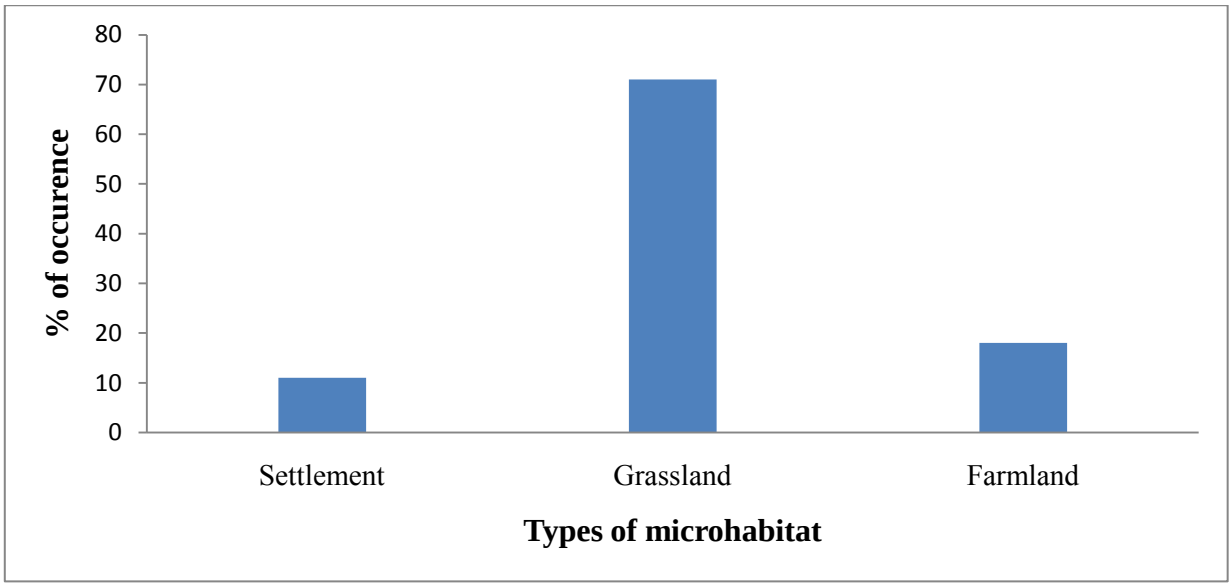

Figure 6. Foraging habitat preference of Wattled ibis during the dry season

During foraging, Wattled ibises stayed motionless and continuously probed the mud lowering the head down to filter out prey materials. They also pecked at food on the surface of the vegetation while walking. The other unusual foraging strategy of the bird was observed during the dry season. They forcefully pull out the grass and collect prey material in the root region. Unlike most birds, Wattled ibises were not observed probing the mud or digging the ground using their feet in search of prey. Wattled ibises were actively engaged in foraging during early morning (81%) and late afternoon to early evening (76%). Most hours of the mid-day was used to rest (68%) (Table 5).

Table 5. Percentage occurrence of Wattled ibises: roosting versus feeding flocks

Time of the day	% Feeding	% Resting
Morning (06:30-08:30) (N=20	81	19
Mid-day (11:00-13:00) (N=18)	32	68
Late afternoon (16:00-18:30) (N=16)	76	24

Variation in vigilant behavior of individual Wattled ibises with flock size was observed. The frequency of scanning their surroundings was negatively correlated with flock size ($r = - 0.121$, $p < 0.05$). The rate of scanning (number of head-up scanning per minute) decreased as flock size increased. Individual Wattled ibises were highly interrupted during feeding and frequently scan the area with head-up position when they were in small number.

7.3. Diurnal activity pattern

Wattled ibis were observed daily engaged in activities like foraging, resting, walking, scanning, preening, flying and showing minor antagonistic social behaviors. The recorded data indicated variation in day time duration among the most commonly observed activities in the same season and among seasons: Foraging activity (33.3%) comprised highest during the wet season (Fig. 7).

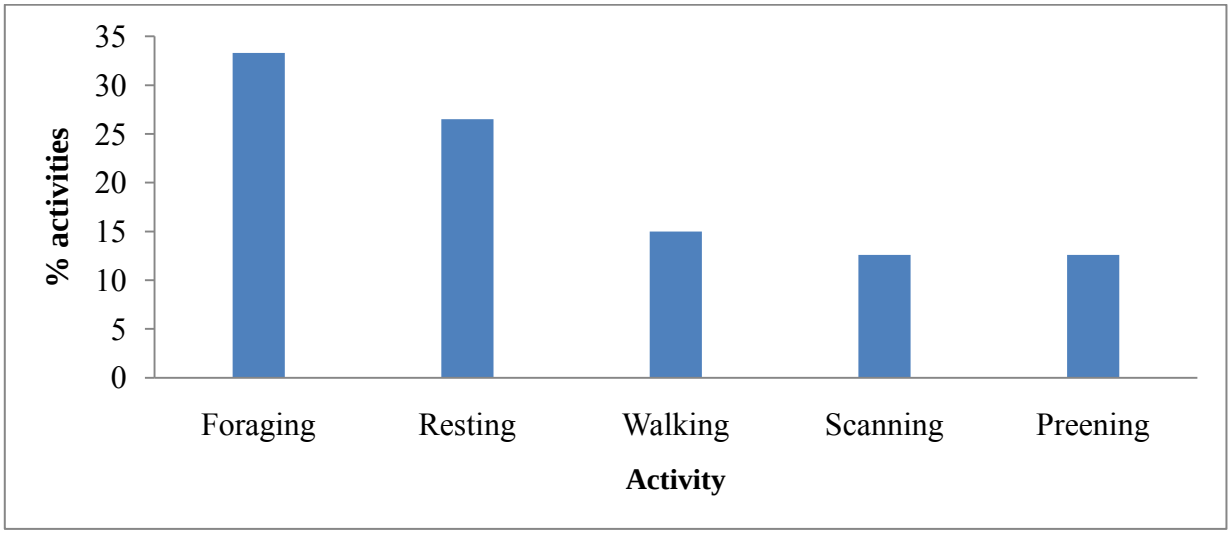

Figure 7. Diurnal activities of Wattled ibis during the wet season

During the dry season: foraging activity was again the highest (41.6%) (Fig. 8). The second most important diurnal activities are resting (27%), during the wet season and walking (29%), during the dry season.

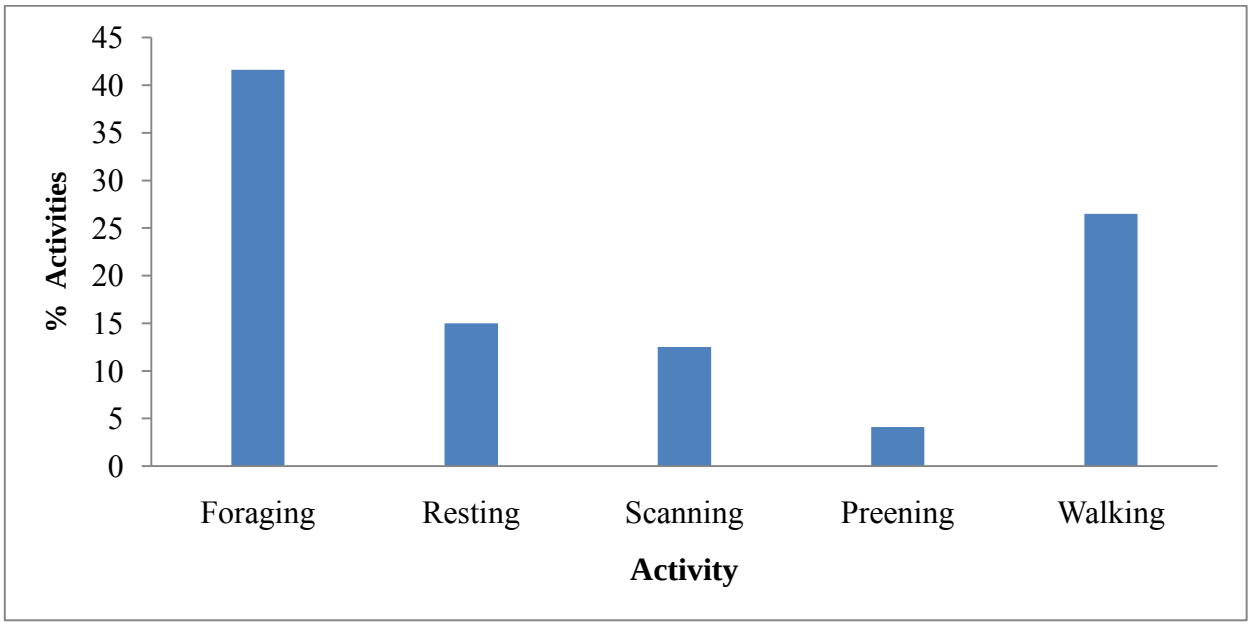

Figure 8. Diurnal activities of Wattled ibis during the dry season

Pair-wise comparisons of the main activity categories for the wet season through multiple comparisons demonstrated that feeding and preening were significantly different values ($p < 0.05$) because of the allocation of more time compared to walking and resting. Feeding and preening time budgets were significantly different ($p < 0.05$). Walking time budget was significantly more than resting time budget ($p < 0.05$). During the dry season, Wattled ibises allocated time for the main activities in the same trend during the wet season.

There were seasonal differences in the activity budgets of Wattled ibis. The proportion of time allocated for different activity categories by the Wattled ibis varied with season, except for preening and scanning as presented in Table 6.

Table 6. Mean proportion of time spent in different activities of Wattled ibis

Proportion of time spent (%)				
Activity	Wet season	Dry season	F	P
Foraging	53.1 ± 4.7	60.1 ± 4.7	32.843	0.001
Walking	11.9 ± 3.2	16.3 ± 4.0	22.326	0.001
Resting	12.1 ± 3.6	9.3 ± 3.2	9.675	0.030
Preening	17.3 ± 3.4	17.8 ± 3.9	0.242	0.625
Scanning	1.2 ± 0.6	1.1 ± 0.7	0.069	0.794

In the forest, first Wattled ibises departed from the colony at 4: 30 (i.e. approximately half an hour before sunrise). The last birds arrived at the roosting site between 19:15 and 19:30 (i. e. approximately half an hour after sunset). Two peaks of this activity occurred: one between 7:00

and 10:00; and 11:00 and 12:00. During cloudy days, the pattern was erratic: birds were less active in the morning and more active around noon (Fig.9).

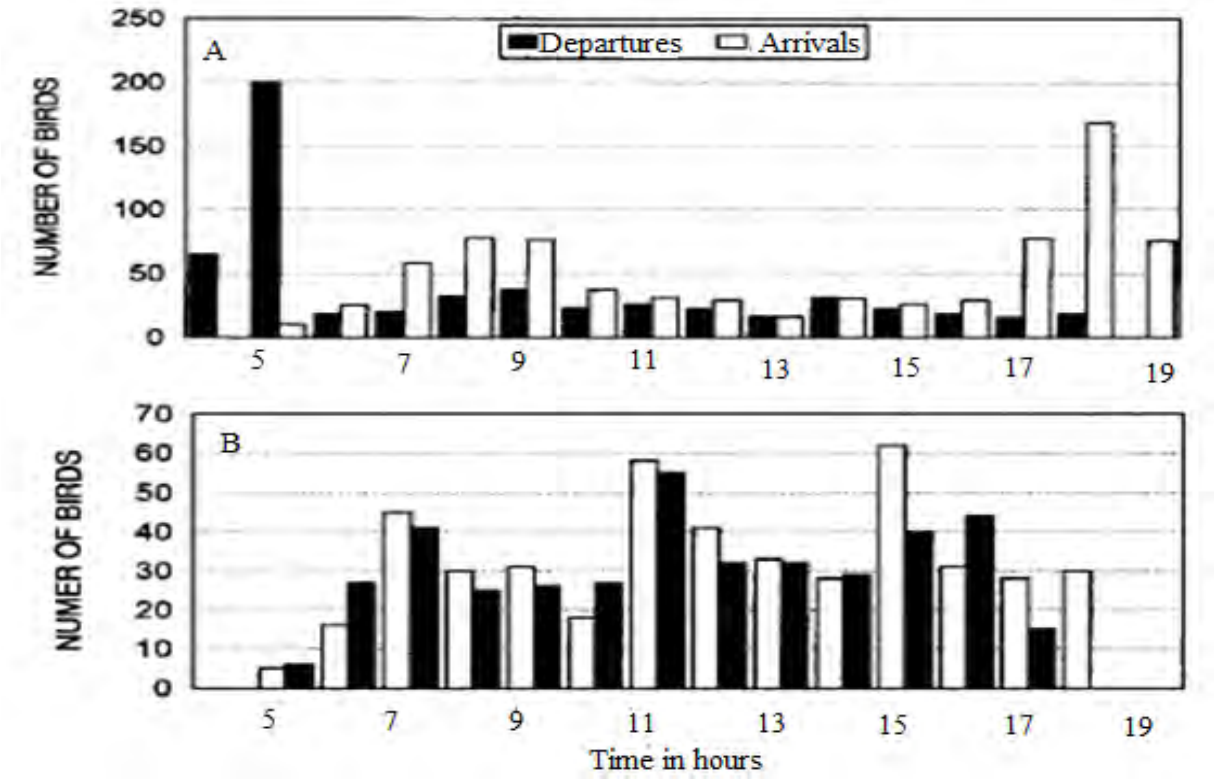

Figure 9. Diurnal flight patterns of the Wattled ibis at the forest during breeding season (A. Sunny day and B. Cloudy day).

Wattled ibises flew singly (60%) or in flocks, comprising usually of 2-10 birds (40%). Birds departed more often in flocks (47.8%), while they arrived more often singly (63.6%). They clearly preferred (78%) an easterly direction when departing for food towards the lake situated 4-5 km away. Some of the ibises (16.2%) flew to larger farmland which is 5 km south of the colony (Fig. 10).

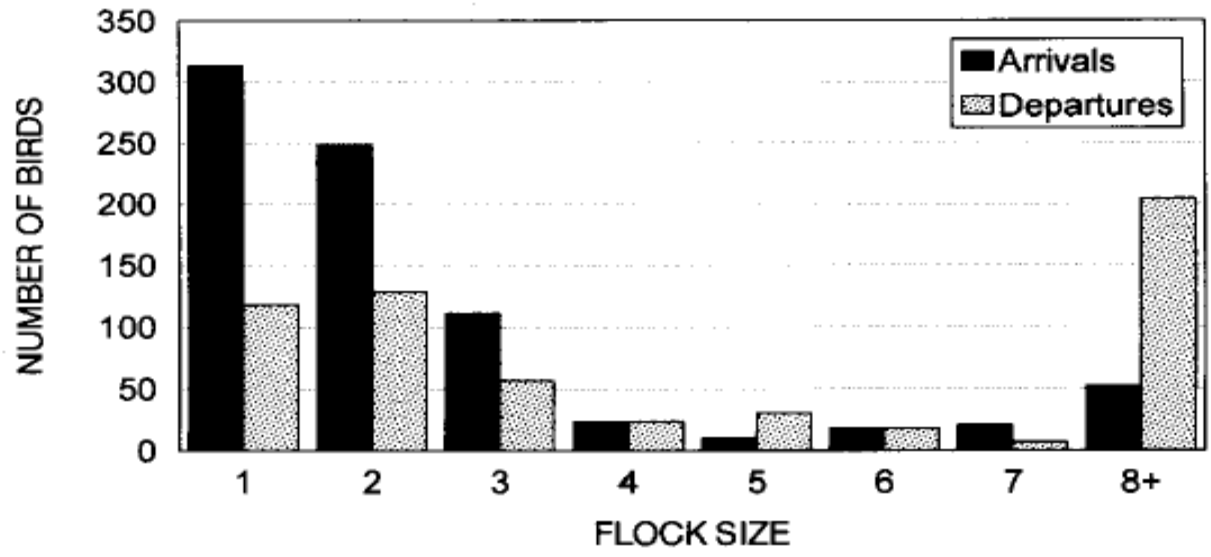

Figure 10. Flock size of Wattled ibis departing and arriving to the colony

Foraging Behavior

When diets were considered as the types of food that were utilized, there was an overall preference primarily for worms throughout the year. Worms accounted (range=54-90 %) of the annual diet of Wattled ibis. Insects were the second most dominant food, which contributed (range = 3.5%-36.5%) of the overall diet. Wattled ibis also consumed other food items, such as frogs (range = 0-5 %) and small mammals (Mice), (range=0-3 %), which made a very small contribution to the annual diet. There were significant differences in the average consumption of each food type between the wet and dry seasons. The proportion of consumption of different food types by Wattled ibis varied with season, except for frogs and mice. The diet of Wattled ibis was mainly depended on the availability of worms and insects (Table 7).

Table 7. Seasonal contribution of different food items in Wattled ibis

Food items	Wet season (%)	Dry season (%)	F	P
Worms	84.0	64.5	17.90	0.001
Insects	3.6	11.6	5.162	0.027
Frog	0.7	0.6	1.354	0.249
Mice	3.7	1.2	11.70	0.001
Others	1.3	1.5	10.83	0.002

The mean monthly worm and insect diversity in the annual diet was 0.45 ± SD 0.1 (range=0.26-0.67). Wattled ibises used a mean of 12 ± SD 3.0 worms and insects per month as sources of food (range= 7-15 species). Dietary diversity was high during December and November and low in May. The mean monthly dietary evenness index (*J*) was low at 0.67 ± SD 0.2, ranging from 0.39 in May to 0.84 in November (Table 8).

Table 8. Monthly food diversity and evenness indices during in Wattled ibis

Month	Diversity index, H'	Evenness index, J
May	0.26	0.39
Jun	0.44	0.67
Jul	0.40	0.61
Aug	0.37	0.55
Sep	0.52	0.78
Oct	0.41	0.61
Nov	0.56	0.84
Dec	0.67	0.81
Jan	0.54	0.83
Feb	0.52	0.78
Mar	0.33	0.50
Apr	0.37	0.55
Mean	0.45 $\pm$ SD 0.1	0.67 $\pm$ SD 0.2

Spearman's rank correlations demonstrated that across months, the consumption of worms decreased as the consumption of insects, frogs and mice increased and these relationships were statistically significant. However, there was a significantly positive correlation between the consumption of insect and frog and insect and mice. Similarly, there were positive correlations between the consumption of frogs and mice. There was no significant correlation between the consumption of other food types (Table 9).

Table 9. Spearman's rank correlation coefficients for different food types

Food type		Insects	Frogs	Mice	Others
Worms	r_s	-0.433	-0.584	-0.306	-0.742
	P	0.001	0.001	0.017	0.001
Insects	r_s		0.289	0.271	0.233
	P		0.025	0.036	0.073
Frogs	r_s			0.289	0.215
	P			0.025	0.099
Mice	r_s				0.099
	P				0.452

7.4. Nesting Ecology

A total of 170 breeding pairs were identified in eight nesting sites of the study area. During the breeding season, 38 and 33 nests were found at the forest and farmland habitats, respectively. Wattled ibises nested colonially also at settlement, bareland and swampy irrigated vegetation during the breeding season (least number of nests observed at bareland (4) and water body (5), respectively (Table 10).

Table 10. Number of occupied nests of Wattled ibis colonies

Habitat	**N**
Forest	38
Farmland	33
Settlement	30
Water body	5
Swampy irrigated vegetation	26
Grassland	15
Bareland	4
Shrubland	19
Total	**170**

The nest of Wattled ibis comprised a platform, 27-37 cm in diameter Mean ($\bar{x}$ = 30.9 cm; n = 25) and 10-15 cm in height (x= *13.3* cm; n = 8). It is composed mainly of sticks, 10-140 cm in length and 0.2-2.5 cm in diameter with a mixture of weed stems, their roots and grass clumps. In some nests, artificial items, such as nylon rope (30 cm), wires (60 cm) and a cable (40 cm) were found. Large number of sticks (188) and mosses (98) were used for nest construction. Weed stem (100), sticks (100) and weed roots (100) are the most frequency used nest material by Wattled ibis (Table 11).

Table 11. Nesting materials used in Wattled ibis

Nesting materials	Frequency	Mean	SD
Twigs	25	86	23.4
Weed stem	100	76	13.4
Sticks	100	188	8.0
Mosses	100	98	7.4
Weed roots	25	21	5.4
Strips of bark	100	44	3.2
Other plants*	88	12	1.7
Artifacts**	50	5	0.7

*other plants: *Cirsium* sp (6), *Rhus pyroidex* (3), *Acacia karro* (2), clumps of grass (2)

**artifacts: plastic rope (2), cable (1) and wire (2)

Many sticks of plant species were used in the nest construction at the forest as these were commonly available in the colony. At farmland, although sticks were used as main nesting material, large proportions of dry stems were also used. Dry parts of plant species were recorded as the main nesting material in nests situated on the tree top.

At the forest, 70 nests were composed items numbering from 38- 66 (Average= 53 items). The nest material was loosely bound, resulting in nests falling into pieces towards the end of

the breeding season. Of the 70 nests in the forest, only nine (12.9 %) were still intact one week after the last fledglings left the colony.

Branches were quite often brought to the nests by Wattled ibises. Grasses were collected and leafy willow twigs gathered from a tree standing nearby. These items were often seen in the nests during the incubation phase. A similar survey conducted at farmland during hatching period. The most frequently used plant species for nest construction on the forest was *Afrocarpus falcatus* (24%) and *Odontelytru abyssinicum* (21.2%), respectively. Similarly, *branches of Prunus africana* (14.4) and *Gravilea robusta* (14.4%) were used at the farmland (Table 12) (Plate 2).

Table 12. Plants used for nest construction in Wattled ibis

Plant Species	**Forest**	**Farmland**	**Total**	**%**
Afrocarpus falcatus	22	3	25	24
Odontelytru abyssinicum	19	3	22	21.2
Prunus africana,	-	15	15	14.4
Gravilea robusta	4	11	15	14.4
Potamogeton spp	5	-	5	4.8
Persicaria spp	3	-	3	2.9
Cuprusus lustanica	-	2	2	1.9
Typha spp	2	-	2	1.9
Cordia Africana	2	-	2	1.9
Water plants	1	1	2	1.9
Eucalyptus sp.	-	1	1	1.0
Asteracae sp.	2	-	2	1.9
Albizia gummifera,	1	-	1	1.0
Cyperus sp.	-	1	1	1.0
Poacae sp	1	-	1	1.0
Acacia spp	1	-	1	1.0
Rhus spp	1	-	1	1.0
Unidentified	-	3	3	2.9
Total	64	40	104	100

Plate 2. Wattled ibis constructing nest (Photo: Kalkidan Esayas, 2015)

Nests were grouped in smaller sub-colonies. The sub-colony size ranged from two to 43 nests (x = 13.3; N=16). In the forest, eight clumps were established and their size ranged from 2 to 17 nests (x = 8.5). Only two pairs nested solitarily. At the farmland, no nest was sighted on its own. All nests were clumped in 8 groups comprising three to 43 nests (Mean = 18; N = 155). Within the sub-colony of Wattled ibis, nests were situated close to one another (Range: 0.3-3 m). In larger groups (10 or more nests) those nests placed in the center were so close to one another (Range: 30-60 cm, Mean = 47; N=52) forming a kind of common platform. Five platforms at forest and six at farmland were established.

On the forest, 42 nests were located on *Acacia* spp, *Afrocarpus falcatus* (n=7) and *Rhus spp* (n=21). Nest height varied from 1 to 5.2 m (Mean=2.6 m; N = 33) and the average nest height was 2.7 m ranging from 1.9 to 3.2 m (N=15). Most nests were located on *Acacia* spp. above 2 m in height while most of *Rhus spp* were below 1.5 m.

At the farmland, 43 nests were situated an *Acacia* spp, 43 nests on *Prunus africana*, 33 nests on Rhus spp, 7 were on *Cordia africana* and 18 were on top of *Potamogeton* spp. Nest height varied from 0 to 3.5 m (x =2.0 m; n=144), with most being between 1.5 and 2.5 m. At settlement area, all 105 nests were located on *Acacia* spp, 3-5 m above the ground. On the grassland, bareland and water body, all nests were found on the ground.

7.5. Breeding ecology

In the forest habitat, egg laying started at the beginning of October and ended, towards the end of October. However, in the second half of November other birds started laying eggs, completing their clutches in the middle of December. The last fledglings left the nests towards the end of February (Fig. 11).

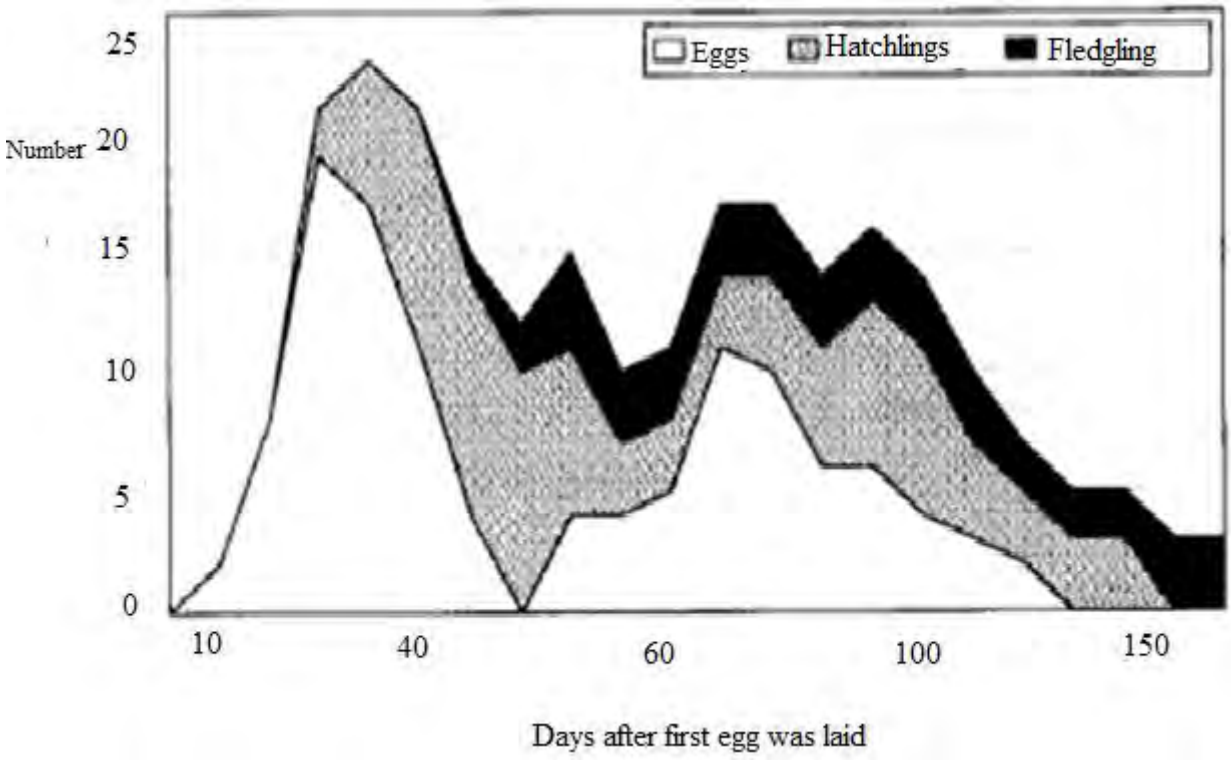

Figure 11. Timing of breeding of Wattled ibis (The two peaks are egg laying)

At the farmland, breeding activity was synchronized to a similar extent, two thirds of females laid eggs between 20 and 30 October. In the same breeding season, birds began to lay eggs 7-9 weeks later, i.e. 1-2 weeks after the rains began, at settlement area.

Mean clutch size in the forest and farmland habitats were similar (2.55 and 2.18, respectively) (x^2=1.82; p > 0.05). Likewise, no statistical difference in mean clutch size was found between the breeding season (x^2 = 0.12; p > 0.05). Overall mean clutch size for 170 nests was 2.36. Most clutches contained 2-3 eggs (82%). The mean clutch size at the farmland was higher at the beginning of incubation (at least 2.69) than at the end of the incubation phase, 2.40, when many eggs were ejected or dropped from the nests (x^2=2.18; p >0.05). A total of 52 such eggs were found on the nests, 32 of which were examined: 16 (50%) contained embryos, another 16 (50%) were without embryos (some infertile, in others embryos might have died in an early stage of the embryogeny). No difference between the clutch size and nest height location has been recorded.

Three Wattled ibises that constructed nests at forest habitat and six on farmland, shared nests with cattle egrets. There were usually single eggs of the Wattled ibis and 2-3 eggs of the cattle egret in those mixed clutches. Although all Wattled ibis eggs failed to hatch, the eggs of cattle egrets hatched in those mixed clutches (Plate 3).

Plate 3. Eggs of Wattled ibis (Right position) and cattle egret (Left position)

(Photo: Kalkidan Esayas, 2015)

At farmland, the mean clutch size for the sub-colony on the ground was only slightly higher (mean (*x)*=2.56) than that in the entire colony (x = 2.40) (x^2 = 0.68; p > 0.05). One colony on the bareland and another on water body was observed. There were 20 breeding pairs, with the mean clutch size of 2.30. At shrubland, the mean clutch size was 1.6 (n = 19 nests). On the forest and swamp irrigated vegetation, the mean clutch size was 2.5 (n= 38 nests) and 2.2 (n= 26), respectively.

Both parents incubated the eggs and fed young ones. The young ones left the nest 2-3 weeks after hatching. Adult Wattled ibises fed principally on aquatic insects, insect larvae and other small aquatic animals. Chicks primarily fed on worms and insects on the aquatic habitat. After fledging, they started to forage for insects on dryland during periods of aquatic prey shortages. During the breeding season, Wattled ibises were gathered in huge colonies near water. Pairs were predominantly monogamous and both parents care for the young. Males

tend to engage in extra-pair copulation with other females to increase their reproductive success. Males were observed to pirate food from unmated females and juveniles during the breeding season.

One or two days before hatching, the chick made a small hole (5 mm in diameter) and often uttered a weak call. Chicks in a clutch hatch at 1-3 (usually one) day intervals. Hatching took place throughout the day, with an apparent peak during the afternoon. At the farmland, at least 25 chicks just released from egg shells or just hatched were observed between 15.00 and 16.00. Egg shells were usually ejected on the rim of the nest.

At the forest, the mean number of hatchlings per nest with eggs was 1.7 and the average number of hatchlings per nest was 2.3 (x^2= 3.30; p > 0.05). Hatching success was 66%. Only clutches of two and three resulted in hatching. At farmland, the mean number of hatchlings per nest with eggs and per nest with hatchlings was 1.6 and 2.3 (x^2 = 0.07; p > 0.05 and x^2=0.00; p >0.05*),* respectively. The hatching success was 88.4%. The average number of hatchings in the sub-colony situated at the farmland was higher, i.e. 2.6 (x^2= 4.47; p = 0.05) and 2.5 (x^2=0.04; p > 0.05) hatchlings per nest with eggs and hatchlings, respectively. Hatchling success was 89.9 %. Only 2 infertile eggs were found around the sub-colony (Table 13).

Table 13. Hatching success of Wattled ibis at the study area

Number of hatchlings per nest	Ne 1	Ne.2	Ne 3	Ne4	Total
Number of nests	16	42	40	1	99
Total number of hatchlings	16	92	120	4	232
Percentage of nests	6.9	39.7	51.7	1.7	100

Ne 1= Nest 1, Ne 2= Nest 2…….

At the forest, the average number of fledglings of Wattled ibis per nest with eggs was 1.5. The average number of fledglings per nest with hatchlings was 1.9 and the average number of hatchlings per nests with fledglings was 2.1. Fledgling success of wattled ibis in 2014 was 57.8 %. The fledgling success of Wattled ibis in 2015 was 51.4 %. The average number of fledglings per nest with eggs was 1.1 (x^2 = 8.00; p = 0.01). Of the 33 chicks found dead, 13 dropped from the nests and died on the ground from starvation, 9 were found dead in their nests, 4 were found drowned in the lake, two were dead on branches, and 1 chick showed possible evidence for cannibalism.

After hatching, the chicks weighed 40 g with culmen (16 mm in length), skull (38 mm), forearm (20 mm) and tarsometatarsus (18 mm). They were covered with delicate whitish down, except for the head which was black. During the first three weeks of life, the growth curves of all parameters were similar among older and younger chicks. After 5-6 days, the tarsometatarsus of Wattled ibis grew more rapidly. At the age of 20 days, when the fledglings of Wattled ibis left their nests, their culmen (64 mm) and skulls (152 mm) were growing in four fold in size and tarsometatarsus were growing five fold (90 mm) compared to the size measured during hatching period (Fig 12).

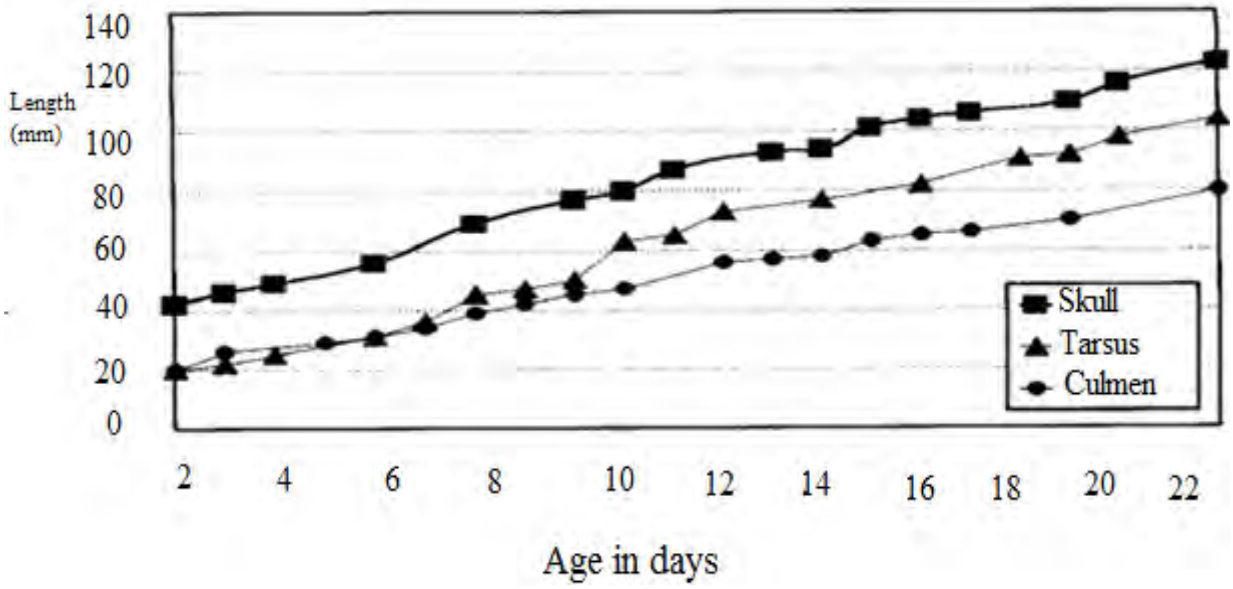

Figure 12. Growth rate of chicks

During the first three weeks of life, the weight of chicks increased exponentially, although marked differences among the chicks were recorded. Within 4-5 days, their mass had doubled and by 8-9 days exceeded 10 times their natal mass. At age 22 days, they weighed approximately 1000 g and thereafter the growth slowed down (Figure 13).

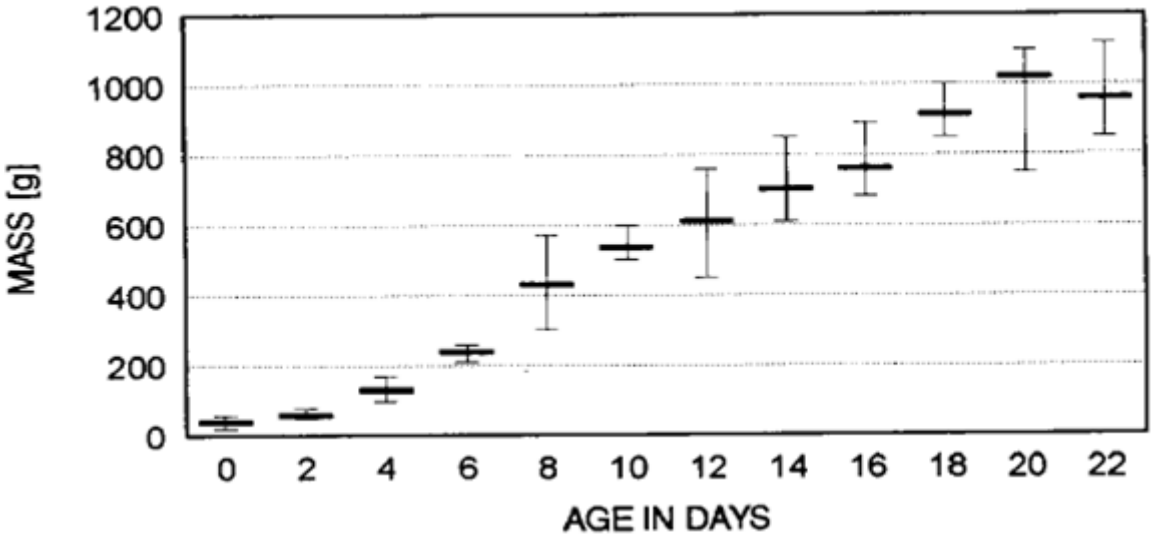

Figure 13. The body mass of chicks

First primaries of Wattled ibis emerged at five days, while the shafts erupted 1-2 days later. The proportion of the shafts to the vane was more or less equal by 17 days. But at 22 days, the shaft length markedly exceeded that of the vane. First retrices were noted at age of seven days. At 14 days, the proportion of the shaft to the vane in the retrices was equal while at 22 days, the shaft length was twice as long as that of the vane.

7.6. Land use/cover change of Chelekleka Lake

The extent of land use/cover change in Chelekleka watersheds during the investigation of 1973 shown, about 134.5 (1.4%), 338.0(3.6%), 286.6 (3%) 1049.2 (11%), and 7692.3 (81%) hectares of land use were covered by surface water body, swamp vegetation, forest, grassland and crop land, respectively. Land use /cover change investigation verified the absence of degraded bareland, shrubland and population settlements during 1973. There was no or insignificant rate of deforestation and soil degradation within the watersheds in this period though dominantly covered by cropland.

During the 1986 land use/cover change, some land use types like shrubland, degraded bareland and settlement covers appeared which was absent in 1973 detections and comprised about 1.2 %, 0.6 % and 1% of the total watersheds in this period. As a result of land use/cover changes, agricultural land, forest covers, swamp vegetation covers especially near to the lake Chelekleka dramatically declined. The acute expansion of degraded lands and surface run of water within the watersheds during this period resulted in surface water body rise from 134.5 ha of land in 1973 to 230.1 ha of land cover in 1986. Surface coverage of water bodies did not only increase by water streaming to the lake regions, but because its

accompanied denudation, siltation and sedimentation of eroded materials in the water bodies, uplifted catchment areas.

Moreover, the northwestern part of the Chelekleka watersheds was dominated by grasslands which was previously occupied by forest and shrubland. The exacerbated deforestation in this upper parts of water sources negatively affected the downward swamp areas including Chelekleka Lake. In addition, the land use/cover changes investigation revealed, around Lake Chelekleka, there was noticeable initial expansion of small scale irrigated swamp land uses especially to the northern and southeastern part the lake. This was also accompanied by rapid population settlement expansion in southern and southeastern parts of the Chelekleka Lake.

During the period of 1986 land use/cover change investigation, the lake was adversely affected by deforestation and soil degradation which was caused by intensive land use for agricultural purposes in upper parts of the watersheds. These aggregated causes in turn enhanced surface run water and sedimentation of soil, sand and gravel in to Chelekleka Lake which changed its color from deep dark blue and compacted shapes during 1973 to slant shallow and light blue color shapes in 1986. Besides the lower parts, areas very near to the lake were replaced by irrigated swampy vegetation and urban population settlements from south and southeast.

Furthermore, the land use/cover change detection during the period of 2000 verified in the Chelekleka watersheds, surface water body coverage confirmed acute reduction notably near to Lake Chelekleka, i.e. decreased from 2.4 % to 1.9 % in the watersheds. The change in the surface water coverage during this period was highly associated with dramatic land use/cover

change growth in degraded bareland and population settlements from 0.6 and 1% during 1986 to 9.5% and 5.2% in 2010, respectively.

An expansion of the bareland within the watersheds slowly expanded downstream to Chelekleka Lake. This degraded bare land was caused by massive land use for agricultural purposes. Agricultural expansion within the watersheds played a great role for land degradation and deforestation. This was the most influential agent ultimately intensifying the dying of Lake Chelekleka and its swamp areas.

Furthermore, in similar pattern during 2000 land use change detection, the surface water body coverage was overwhelmingly reduced in the watersheds, i.e. reduced from 1.9 % during the 2000 to 0.88 % in 2010. This figure confirms the surface water coverage loss by more than double rate in the watersheds. The reduction of water volume and surface coverage was dominantly enhanced especially by sharp disappearance of Lake Chelekleka and its swampy areas. More interestingly, because of current government initiations and efforts exerted in preservation of the natural resources including afforestation and soil protections, the amount of forest lands in the watersheds was showing increasing trends, which positively affected the reduction of degraded bare lands from 9.5% during 2000 to 3.7% in 2010 land use/cover change investigations.

Human settlements dominated the southern, southwestern and western parts of the Chelekleka Lake watersheds. Most of these land use were currently covered by settlements which were formerly covered by agricultural lands. This reduced agricultural land from 60.1% during 2000 to 58.8% in 2010 land use /cover change detection.

Percentage changes of surface water bodies in the Chelekleka watersheds during 1973-2010 were very discouraging. For instance, there was loss of 51.3 hectares of surface water coverage lost (reduced) in the watersheds. Hence, following the drying water areas especially very near to the Chelekleka Lake, the land was replaced by irrigated horticulture. Besides, the land use/cover change growth from 1973-1986 was relatively minimal. But in the subsequent land use change analysis, between 1986-2000 and 200-2010 population settlement increased by 494.46 and 1035.45 hectares of land covers, respectively.

During 1973, land use /cover change detection, Chelekleka and its swamp area composed of two land use types; namely the main water body part and its surrounding swamp dominantly in the northern and to some extent the southern parts. Accordingly, during this period, the lake water body covered about 134 hectares of land use and the swampy area covered 288.5 hectares. The swampy land use occupied more than double size of Lake Chelekleka. Moreover, during this period of land use/cover change investigations, other type of land use/cover types was not detected from land satellite image.

During 1973, the lake's main water body had dark blue color and compact shape which verified the presence of in depth water volume. Thus, it confirms presence of insignificant level of erosion from degraded bare lands and agricultural lands.

Contrary to the 1973 land use/cover change investigations, the 1986 land use/cover change detection showed Lake Chelekleka and swampy areas were characterized by five land use types. These included water body, swamp vegetation, grassland, irrigated horticulture and settlements which composed of 53.3%, 36.1%, 3.5%, 3.8% and 3.3% from the total land covers. The area of the lake's main body inflated its surface coverage areas, which resulted

from accumulation and sedimentation of different materials in the inner part of the lake. Hence, the lake water expanded on the nearby swampy areas, as its depth decreases during the time of considerations. Moreover, most part of the swampy vegetation cover areas during 1973 was changed to other land use/cover types, which included grassland, irrigated horticulture and settlements.

In addition, the land use/cover change detection for Lake Chelekleka and the associated swamp during the same period revealed, the presence of acute changes in the main water body of Lake Chelekleka both in shape and color. These changes made the lake to have diagonal long tail shape and light blue color, characterizing the shallowness of the lake. This resulted from depth reduction of the lake.

Furthermore, the surface water coverage of Lake Chelekleka and its swamp area during the period of 2000 showed increasing trend. Major factors responsible for this fact were the overwhelming expansion of irrigated horticultures in areas previously covered by the lake's water body and its swamp's. Besides, the expansion of urban population settlement to the lake was also among the main factors exacerbating the drying of Lake Chelekleka.

In conformity with the above result, the land use/cover change map of Chelekleka and swamp habitats during 2000, the inner and border areas of the Lake Chelekleka was dramatically changed into irrigated vegetation and grasslands. Hence, during the period of land use/cover change investigation, the drying of the lake was already starting from upper and expands to its central areas

The water coverage of Lake Chelekleka during the land use/cover change investigation of 2010 was reduced by more than three times compared to the 2000. The reason for this

reduction was broadly associated with rapid growth and expansion of irrigated horticulture following the retreat of the lake. Settlement land covers also aggressively increased and occupied large parts of the lake.

Land use/cover map of Chelekleka and swamp area during 2010 revealed, large part of the northern part of the lake was disappearing and changed to irrigated horticulture, swamp vegetation and grasslands. The southern part of the lake was also aggressively changed to settlements and irrigation areas.

Chelekleka Lake watersheds and its surroundings were highly occupied by irrigated horticulture, as confirmed by field study. Thus, in all sides of the lake, horticulture expansion is seen following the retreat of water bank and water drilling (Plates 4A and B).

Plate 4A. Horticulture expansion

Plate 4B. Irrigation through water drilling

Diverting the natural stream of water flow was internationally and nationally banned activities. The field observation verified the recent mega projects of the country like the rail way line and the express way roads blocking the natural stream flows to the lake (Plate 5).

Plate 5. Diverted stream flow

The other challenge to the lake was diversion of runoff coming from urban built-up area to Lake Chelekleka (Plate 6).

Plate 6. Diverted built-up area runoff

Sample composition of the survey consisted of 10% of each respective Kebeles; and 29, 41 and 50 households were taken from Kebele 1, Kebele 2 and Kebele 3, respectively. About 98 % of the household respondents were within the age group of 20-65. This depicts that more than 90 percent of the total sample size had high chance of fertility and to have many children for high population growth (Table 14).

Table 14. Respondents' age distribution

Age	Frequency	Percent
20-30	38	32
31-40	40	41
41-55	20	17
56-65	10	8
65+	3	2
Total	120	100

The survey result showed that the household size ranged from 1 to 17 with an average of 8 persons (Table 15).

Table 15. House hold size of sampled population

Household size	Frequency	Percent
1-6	58	48
7-10	49	41
11-17	13	11
Total	120	100

More than 80 % of them had no formal education. About 13% of the respondents attended primary education and the number of farmers who completed secondary education is low (Table 16).

Table 16. Educational status of sampled households

Education Level	Frequency	Percent
No Formal education	70	58
Adult education	30	25
Primary education	15	13
Secondary Education	5	4
Total	120	100

More than 90 % of the sample households used the wetlands resource as a source of food for their livestock. The survey result indicated that 41 % of the sample households were dependent on animal husbandry followed by crop production before 1970s (Table 17). However, at present time, more than 50 % of the sampled households rely on mixed farming to earn their livelihood.

Table 17. Response of Households' to their income

Source of Income	Before 1970s*		At present time	
	Frequency	%	Frequency	%
Crop production	44	37	25	21
Animal husbandry	50	41	28	23
Mixed farming	20	17	60	50
Fuel wood	6	5	---	6
Total	120	100	120	100

Income from above activities increased for some of households while it decreased for others. However, it appears that income from livestock production declined for some significant number of households and more than 60% of the respondents obtain their income from selling firewood (Table 18).

Table 18. Proportion of respondents indicating changes in income from different sources (%)

Income source	Direction of change relative to 10 years ago						Total	
	Increased		Decreased		No change		Freq.	100
	Freq.	100%	Freq	100%	Freq.	100%		
Crop	55	46	40	3	25	21	120	1
Livestock	59	49	51	4	10	8	120	1
Selling wood	26	22	76	6	18	15	120	1
Sand	31	26	74	6	15	12	120	1
Tourist guide	30	25	50	4	40	33	120	1

8. Discussion

The population of birds that inhabit Chelekleka Lake was declining from time to time. This may be due to change in habitat and absence of enough food especially during the dry season. This was in agreement with McArthur and McArthur (1961) that the declines in the quality of habitat result in the loss of habitat leading to a decline in the resident avifauna.

The foraging association of Wattled ibis with cattle egret has no effect on the declining of population. Besides, descriptions of foraging habitat and behavior confirm that the species of ibises coexist with considerable partitioning of the foraging resource even during the dry season.

The highest number of Wattled ibis was recorded in the farmland during both seasons. This is due to the adaptable nature of birds to live in settlement areas. The openness of the sites compared to natural habitats with relatively forest habitat might have also contributed for easy identification of the species. This explanation is similar to the work of Sisay Hailu (2008) that as open area becomes easily accessible, sighting of birds for clear identification and counting gets better.

The highest number of individuals of birds was observed in the farmland and forest. This is probably due to the diversity of vegetation that provides heterogeneous habitat for different bird species and the availability of food to attract birds. The presence of ample resource, especially adequate food supply can increase the abundance of bird species at a given area. Birds respond to changes in vegetation composition and structure, which in turn affects their food resources. The area consists of foraging habitat and also nesting plantations. However,

the dry season was the hardest time to Wattled ibises. They spent additional energy to forcefully pullout grass and spent more time to search prey. They show fewer tendencies to explore other potentially better microhabitats which would probably bring negative consequence on the population of the species in the future. But, there were no major disturbance observed except for domestic dogs and herders.

On the other hand, the number of bird species during the wet season was high compared to the dry season. There is a significant variation in the number of bird species between seasons. In this study area, there was predictable seasonal change in temperature and rainfall. This is probably due to the positive relationship between habitat and season i.e. during the wet season, the productivity and yield of habitat increase as a result, the species richness increases. These ideas agree with the wok of Dawit Asmare (2009); Kalkidan Esayas and Afework Bekele (2011) where during the wet season additional bird species were observed. In a predictable seasonally changing environment, different species may be suited to conditions at different times of the year. Hence, more species might be expected to coexist in a seasonal environment than a constant one.

Wattled ibises were concentrated in the narrow area. This might be due to narrow range of habitat and availability of food. Habitat structure affects distribution of individual species. Besides, habitat size, foraging modes (Marone, 1991) and floristic composition have influence on the distribution of birds. Dawit Asmare (2009) concluded that bird species richness and distribution is influenced by vegetation structure, which is the principal determinant factor of bird species abundance.

Through direct inventory of the foraging spots, the main prey items of Wattled ibis were identified to be worms and insects. Indeed, similar result was obtained by del Hoyo *et al.* (1992). Wattled ibises were not observed feeding amphibians. The long and curved morphology of the beak is the most fitted foraging structure of Wattled ibises in relation to the nature of their foraging habits. As indicated, probing using the curved beak is a widely used strategy to filter out prey from mud. They were also observed pulling aside grass using the beak to make the mud easily accessible. Moreover, Wattled ibises were observed forcefully digging out grass and probing the root region probably indicating how much the dry season is challenging them. Nevertheless, other than the above mentioned foraging strategies, Wattled ibises were not observed, catching prey in air, filtering prey through inserting the beak in water or using their feet to dig the ground in search of prey. This would restrict the food preference and habitat of Wattled ibis.

One of the factors reducing foraging efficiency in birds is watching predators. Group foraging enables wattled ibis to maximize foraging through minimization of time spent for vigilance. The frequency of scanning around during foraging is less in larger flock size than in small aggregation. This is more pronounced during the wet season where there is a decrease in prey abundance that might have resulted in wattled ibis to forage in small groups increasing the cost of scanning. Group feeding in Wattled ibises reduces vigilance time by reducing the scan frequency than scan duration regardless of seasons.

Wattled ibis prefer to feed on muddy vegetated areas especially during the wet season. They were restricted to densely vegetated muddy habitats foraging in large aggregation. These habitats are rich in prey items and they rescue the species from predators by providing cover. During the dry season, Wattled ibises showed the tendency to explore more habitats.

Instead of forming large groups size, they preferred to forage in small groups but more number of flocks with great dispersion throughout the grassland and less frequently in farmland and settlement area.

However, the dry season is the hardest time to Wattled ibises. They spent additional energy to forcefully pullout grass and spent more time to search prey. They show fewer tendencies to explore other potentially better microhabitats which would probably bring negative consequence on the population of the species. During foraging, Wattled ibises, preferred different microhabitat based on food preference and season. Kushlan (1976) reported that during the wet season Scarlet ibises often foraged on moist ground that was not inundated by standing water.

Wattled ibises forage around the water according to availability of food. Scarlet ibises did not forage out of water, suggesting that the dynamics of soil-dwelling prey may limit the dry season foraging in inundated areas. Wattled ibises fed on insects, worms, frogs and mice. Observations confirmed that the majority of foods eaten during the dry season by ibis species are insects, together with small numbers of anurans, crustaceans, gastropods and oligochaetes. As shown, Wattled ibis could forage in association with cattle egret. This is not observed in other species of ibises such as Scarlet ibises and Glossy ibises.

Wattled ibis formed colony with cattle egret. The same was reported as Madagascar Sacred ibises nesting in a mixed colony together with more than 100 Cattle egrets. Wattled ibises spend most of their activity on feeding. Similarly, Madagascar Sacred ibises spent long hours each day probing their bills into the mud searching for food before returning to their

roost sites. Investigation of the substrate in their feeding areas showed that worms, small crustaceans, snails and insects were among potential food items.

Wattld ibis foraged in different micro-habitats. This was supported by Cresswell (1994) that White-faced ibis foraged very close (< 1 m) to emergent vegetation. Differences between bird foraging locations and random sites were not based on specific vegetation types or heights. Some wader species avoid foraging close to emergent vegetation possibly to reduce the risk of predation (Cresswell, 1994). White-faced ibis have been shown to exhibit increased levels of vigilance in tall vegetation in agricultural fields. There was no risk of predator observed in the study area on Wattled ibis. The same was reported by Creswell (1994) who did not find evidence of predation on White-faced ibis in the grasslands.

In natural environments, ibises are considered tactile, non-visual foragers (Hancock *et al*., 1992; Kushlan, 1976). Wattled ibis used probing as a foraging behavior. This idea is supported by Kushlan (1976) that while feeding in mudflats and wetlands, the basic feeding technique of the American white ibis was probing into the water or soil with the bill held agape at the tip (Kushlan, 1976). Predators that hunt by sight can search and handle prey, and can cover more area than predators hunting by touch alone (Kushlan, 1976). As presented, Wattled ibis mainly used probing and pecking techniques of foraging. Kushlan (1976) guaranteed that Australian white ibis exhibited a wide range of foraging techniques, which included both visual (fossicking and pecking) and non-visual foraging behaviors (jabbing and probing). This flexibility of foraging behaviors allows Australian white ibis to obtain a broad range of food items in a wide range of habitats.

The types of habitats in which ibis were recorded foraging influenced foraging success. Foraging success of Wattled ibis was high in the forest habitat. Australian white ibis foraging at waste landfills were more than twice as successful at obtaining food items as in any other habitat. However, foraging at waste landfills presents considerable hazards for a long-legged water bird, including the possibility of leg injury in the unstable substrate and the risks associated with the presence of heavy machinery (Coulson *et al*., 1987).

In Chelekleka Lake, Wattled ibises built their nests in discrete groups (subcolonies). This has also been observed in Sacred ibis at Lake Victoria in Kenya (Parson, 1977) and at Lake Shala in Ethiopia (Urban, 1974) and in western Tanzania (Stromach, 1968). Parson (1977) showed that Fish Eagle *Haliaeetus vocifer,* was the main predator of Sacred ibis. However, there was no predator of Wattled ibis at Chelekleka Lake in the study area.

At Chelekleka Lake, incubation of the eggs begin after the first egg has been laid, similar to what was recorded in Sacred ibis observed in Ethiopia (Urban, 1974) and in Tanzania (Stromach, 1968). However, in Kenya incubation begins when the entire clutches have been completed (Parson, 1977). At Chelekleka Lake, predation did not markedly affect reproductive success while at the Lake Victoria in Kenya very high Fish Eagle predation was recorded for Sacred ibis. This suggests that synchrony hatching may switch on under such conditions, when 'swamping' a predator with prey might be an effective anti-predator strategy.

In the Wattled ibis, a few factors controlled chick mortality (Stromach, 1968; Urban, 1974; Parson, 1977; Tomlison, 1979), namely heavy rains or drought, predation and falling from the nests to the ground (these factors are linked with nest height and wind velocity). None of

these factors played an important role in this study. Hence, high breeding success was recorded.

Heavy rains are important in the initiation of breeding in the Wattled ibis (Urban, 1974; Brown *et al.,* 1982; Anderson, 1997). Although in this study they did start to breed after heavy rains at settlement and farmland, they began to breed during a prolonged drought (2 months before rains fall). At the forest, where they nest, very low water level expose small and shallow bays, preferred by the birds as feeding places. Such places may resemble a flooded area where Wattled ibises were known to breed in dry season (del Hoyo *et al.,* 1992).

Wattled ibis preferred *Acacia* spp and *Prunus africanus* trees for nesting. The reason may be the availability of suitable height and canopy of these trees. The selection of nesting trees in birds is also based on the previously performed successful breeding (Klopfer, 1963). Considering the characteristics of the *Prunus africanus* and *Acacia* spp, their larger canopy covers provide number of crotches to support the nest at the proper locations. In breeding months, *Acacia* spp and *Prunus africanus* trees usually used by ibises for nesting come into leaf and may be a factor in nesting. The dense cover of the canopy provides sustained protection by minimizing direct heat loss in the open sky (Morse, 1980). As per Burger and Hahn (1989), a dense canopy cover reduces the thermal stress to vulnerable young and provides hide from the potential air predators. Moreover, a well covered nest does not require wing shading provided by parents to their chicks, which considerably reduces energy loss to the parents. Like Hadada ibis, Wattled ibises built nests on the upper third of the nest trees (Klopfer, 1963).

A positive correlation between tree height, canopy and nest height makes nesting successful. The height and higher nest elevation provides easy access to escape when there is a danger by the ground predator. Although non-significant, differences between DBH of permanent nesting tree and temporary trees have supported the theory of safer site selection based on an experience of no collapsing of the nest during occupancy; but least related to the size of the tree at its base. A choice of the nest height in birds seems to be determined with the consideration of climatic pressures such as wind speed, temperature, heavy rain and potential predation including human disturbance (Dhinsa *et al.*, 1989).

The significant variation in the supporting twigs of the nest shows the sturdier the nest happened to be selected repeatedly. The nest placement on the sub-branch and its distance from the trunk has significance of minimizing exposure, easy flight pathways and escape. Besides to the characteristics of the tree and nest vicinity, consideration of the foraging sites in imminent horizon is also equally important. The Wattled ibis tends to built nest near the feeding sites. Similarly, Kushlan (1976) reported that the American White ibis (*Eudocimus albus*) select the nesting colony site depending on the availability of the foraging habitat.

Many bird species are reported to occupy previously used nesting area (Catchpole, 1972; Greenwood and Harvey, 1976; Harvey *et al*., 1979; Newton, 1979; 1982; Aumann, 1989; Warkentin *et al*., 1991). Breeding site fidelity was more often observed in the successful individuals than the unsuccessful one (Darley *et al*., 1977; Newton, 1982; Coulson and Thomas, 1983; Shields, 1984; Gavin and Bollinger, 1988; Gauthier, 1990; Beletskey and Orians, 1991). Familiarity to an area enables to take advantages of favorable foraging, predator avoidance and nesting site that enhances reproductive success (Hinde, 1956; Greenwood and Harvey, 1982). This seems quite possible factor affecting nest site selection by the Wattled ibis as the entire nest sites were also used as roost sites throughout the year.

Wattled ibis prefer to nest nearby the roosting sites that may be due to familiar environment and their location mainly near the foraging sites and hence facilitate easy settlement of breeding pairs. Availability of food is another factor affecting nest site selection. In some localities, roost sites and nest sites of the White ibis were often shifted from one site to the other depending on food availability (Kushlan, 1976).

Re-use of old deserted nests and takeover of active nests were recorded in many bird species as a consequence of scarcity of nest sites or nest materials (Dusi, 1968; Burger, 1978a; b). Stealing of nest material was recorded occasionally in some ibises due to the same reason (Urban, 1974; Sahin, 1982). Wattled ibises often reuse their conspecific or heterospecific nests. However, stealing of nest material by the Wattled ibis was not recorded during the present study. By preferring old nests, ibises could save energy required in search of safer nest site and by shortening the period of nesting. Frequent flights are required to gather nest material from nearby area. To build a nest, each flight consumes on average 0.25 kcal/m energy (Pennycuick and De Santo, 1989). Thus, male Wattled ibises had to invest much time and energy to build a new nest. Therefore, re-use of nest involves apparent benefit of time and energy saving by not building a new nest. Early pre-laying period was significantly short when a pair re-used old nest. If the same pair reuses the site, then it could minimize the cost of territory establishment. It also acts beneficiary by skipping prolong virtues of courtship. This would facilitate the possibilities of repetition of breeding in a one calendar year.

Nesting trees selected for nesting near the water resources were comparatively bigger in size due to their good growth. The good canopy of these trees provided suitable nesting sites as far as thermal heat regulation is concerned. Urbanization is uprooting the nesting trees of these birds. Thus, the ibis preferred to nest on the trees along with the roads in spite of their

exposure to wind and noise of traffic. It can be concluded that Wattled ibis whether build nests near the water resources, road sites, city sites garden sites and agriculture fields, they were always near the feeding grounds.

Nesting of other ibises in a colony was reported by Naik (1989) and Mundkur (1991). Chavda (1997) has observed ibis nesting on one of the Palm species. Ali and Ripley (1983) have reported 3 to 4 nests of the ibises on a single tree. Further, it has been sighted that the majority of the Ciconiiformes species are known to be a colonial breeder. According to Lack (1968), birds that feed alone use the nest solitarily. Though, ibis is a Ciconiiformes and a flock feeder, it was found to be mainly solitary breeder by nature. Besides all above mentioned evidences, it shows that such a divert behavior has been apparently set forth as an adaptation following the availability of food. Hence, flexibility has been developed to avoid any potential competition for the breeding as well on the restricted foraging ground. This could be compared with the mixed colonial egrets and herons, which also maintain a certain distance among their nests depending upon their body size for comforting and to avoiding competition (Burger, 1978a).

Change in land use/land cover may result in land degradation that manifests itself in many ways depending on the magnitude of changes. For instance, natural vegetation which may provide environmental and socio-economic services can change drying up of water courses. shrinking of wetlands and soils become eroded and reducing its productivity and forms of sedimentation.

All of these manifestations have potentially severe impacts on land users. The dynamic change detected in the Chelekleka Lake water shades surroundings, within the Chelekleka Lake watersheds and surroundings during the periods of 1973-2010 was revealed during investigation of the land use. Hence, land use/cover change dynamism of Lake Chelekleka

watershed and surroundings has verified both positive and negative surface water coverage changes. The detection of land use with specific to the lake and its swampy area also confirmed increase of surface coverage of water bodies during 1973 to 1986 and 1986 to 2000 but declined during 2000 to 2010.

The expansion of urban population settlement to the lake areas is also exacerbating the probability of the dying of Lake Chelekleka. Therefore, if not urgent and timely consideration are taken by all concerned stakeholders to sustain the lives of the lake, the probability of losing this natural gift is high. These are consequences of high human population pressure (Lemlem Sisay, 2003). The current study similarly showed deforestation at the catchment area to the lake as another perceived evidence for fluctuation and decline in water bird species composition, abundance and distribution change.

The rates of change in land use/land cover units have not been uniform across the land use classes. The variations are distinct from small scale to three fold. This is also similar to the findings of Amanuel Abate and Mulugeta Limenih (2014), land use/ land cover dynamics trend in Nadda Asendabo Watershed, southwestern Ethiopia. The increase in agricultural land and built up area due to unlimited human activity was accountable for the decrease in areas covered by wetland, water body forest, shrubland, woodland and grassland. Besides, the study undertaken by Daniel Assefa (2015) in Southern Ethiopia showed remarkable decline in coverage of wetlands and water bodies land use change detection in Odo and Shakiso district, respectively. Similarly, Yoseph Samuel (2014) described from results of land use/land cover dynamics and rural livelihood perspectives in Anferara-Wadera High Forest Southern Ethiopia, coverage of wetlands and water bodies decreasing extensively. Moreover, the study conducted by Gete and Hans (2001) in northwestern Ethiopia

documented a drop in natural forest cover from 27% to 0.3% while cultivated land increased. Similarly, Gessesse Dessie and Kleman (2007) revealed that natural forest declined from 16 to 2.8 % between the periods of 1972-2000. Conversely, cultivated land increased by 82 % between the periods of 1972-2000 in the south central Rift Valley of Ethiopia.

The agro-ecological condition of Bishoftu is suitable for agriculture. Due to this, crop cultivation and livestock rearing is the basic economic activity in the area. Haile Girma and Assefa Mamo (2012) revealed decrease in shrubland and grassland by 29.31% with an increase of agricultural land by 3.94% in Angereb watershed, northern Ethiopia (Eyayu Molla *et al.,* (2010).

Chelekleka Lake is a habitat for thousands of birds. The feeding guild in and around the lake is being changed due to degradation. The alteration of the surrounding environment of freshwater by land use change result in negative consequences on bird community structure. Furthermore, the change in bird community structure could be associated with the destruction of native vegetation cover. Destruction of woodland vegetation cover to agriculture had led to lower bird species richness, diversity and feeding guild resulting disruption in bird community structure and other biodiversity. Soni (2006) showed that each land use type had considerable number of birds that were not seen in others. This might have been the reason for fluctuation of bird species richness and diversity in and around Lake Chelekleka. Fluctuation of bird species richness and diversity could be associated with increase in cultivated land and a decrease in the woodland vegetation cover in the surrounding areas of the lake. The present study found fragmentation of Lake Chelekleka by small scaled agriculture. This has contributed to the decline in the diversity and abundance of bird species

Due to rapid population growth and unlimited human interest varieties of habitats are forced to change into built up area in the watersheds of Lake Chelekleka and its surroundings. The study by Messay Mulugeta and Tsetargachew Legese (2013) showed that built up area increased by about 6.3% in the central Ethiopia between 1986-2010 at the expense of shrubland, grassland and wetland. Tekle Kidane and Hedlund (2000) also showed an increase in the size of open areas and settlements at the expense of shrubland, wetlands and forests.

In the watersheds of Lake Chelekleka and its surroundings, most of the farmers rear livestock and want to maintain large number as a source of wealth and status. Due to large number of livestock population, grazing land was degraded aggravating soil erosion. In line with this finding, Diress Tsegaye *et al.* (2010) also indicated that livestock production is under increasing threat due to shortage of grazing land and soil degradation enhanced by natural vegetation dynamics. Similarly, the interviews during this study revealed that terrestrial habitat destruction, siltation and water diversion may have caused contraction in the birds' habitat. Previous studies and the present investigation has also indicated a contraction of wetland habitats and decrease in lake volume due to woodland destruction and diversion of water for agriculture (EWNHS, 1996).

In the study area, fire wood collected from the adjacent forest and charcoal production are the primary sources of energy and household income. Firewood collection and charcoal production are the major causes of deforestation that change forest, shrubland and woodland cover in the area resulting in land use/land cover dynamics in the watersheds of Lake Chelekleka and its surroundings.

9. Conclusion

The potential for the integrated sustainable management of Chelekleka Lake is at critical stage. Even though the status of Wattled ibis is categorized under in the least concern, the destruction of the lake will affect its population and other bird species through time. An integrated and holistic approach at the national, regional and local level is needed to provide an effective framework for sustainable management of Chelekleka Lake and other wetlands. Sustainable wetland management has a direct positive impact on the environment through stabilization of micro climate. Nature can play a great role in wetland regeneration if human actions/interferences are controlled or minimized. Wetland degradation occurs due to anthropological factors to maintain the socio-economic activities to lead livelihoods. Agricultural expansion, deforestation, overgrazing and land use change. Conversion of a given land in to other land is the major ones responsible for wetland degradation. Therefore, to bring sustainable wetlands management; good policy (political commitment /political will) and the involvement of local communities in the management system of wetlands are crucial issues. Thus, the development of wetland management should take into account the harmonization of human activities with that of sustainable wetland utilization

Wetlands such as swamps, marshes, floodplains and mudflats are considered unproductive and unhealthy 'wastelands'. The biodiversity component of these wetlands is never considered important. Wetlands and their management are poorly addressed issues in Ethiopia. There is little or no awareness of the current status, threats, values of wetlands, the need for their conservation and sustainable utilization. Although there are individuals in various organizations with some sort of wetland expertise and awareness, no coordination

exists between these organizations for conservation, management and wise use of wetlands in Ethiopia. Besides, the mandates of stakeholder institutions to address wetland issues are not clearly defined.

The major gaps with regard to wetland issues in Ethiopia are summarized as follow:

- Lack of awareness on the context of wetlands: definitions, resource base threats, traditional use and wise use of wetlands, their appropriate management and the need for their conservation.
- Insufficient resources: human resources, expertise/technical knowledge, financial, working documents such as manuals, guidelines and spreadsheets. Besides, lack of capacity for research, data collection, information, networking, documentation and communications.
- Lack of advocacy tools/documents that can give rise to the formulation of wetlands policy, strategies, action plans and legal frameworks.
- Lack of a single focal institution/inter-ministerial steering committee that can serve as an entry point to initiate wetland conservation activities and advocacy roles.
- Lack of ownership/responsibility: the government is neither giving due attention nor allocating enough resources and support for wetland initiatives. Although the mission and roles of stakeholders with regard to the wetlands of the country is not clearly defined, there exist various government institutions that are directly or indirectly involved in wetland-related activities. Unfortunately, the roles of many of these conflict among themselves and there is inadequate coordination and collaboration amongst them. Because of lack of awareness of the current status of wetlands, there is no concerted conservation effort.

Recommendations

The critical role of wetlands in the water cycle and water related ecosystem services, need to be at the heart of the transition to a sustainable economy.

- Management of water and wetlands should focus on the full suite of benefits and not on only a single issue whether biodiversity or a single ecosystem service.
- Conservation of Chelekleka Lake is needed in order to maintain the population of Wattled ibis and other bird species.
- Ensuring that the wide range of ecosystem services continues to be delivered. Whether food and clean water to local communities or carbon storage for global benefits requires maintaining wetlands.
- The increase in the value of ecosystem services can outweigh the restoration costs. The actual level of benefit is site-specific.
- Improving the state of water and wetlands can have a positive effect on poverty alleviation by contributing to food, water and energy security.
- By addressing several policy objectives, it creates a more sustainable foundation for management action to protect and enhance water and wetland ecosystem services. It can help implementing the broader sustainable development agenda, including access to water as a human right.
- Incorporating traditional knowledge and practices of farmers/community can lead to effective restoration and wise use of wetlands.
- Awareness-raising and education are also crucial, increasing acceptance and buy -in.
- Stakeholders should play a great role in the wetland management.
- Family planning system should be enhanced.

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Appendices

Appendex 1. Topography of the study area (Photo:Kalkidan Esayas,2015)

Appendix 2. Wattled ibis Foraging in the grassland (Photo:Kalkidan Esayas,2015)

Appendix 3. Wattled ibis foraging close to Plantation (Photo:Kalkidan Esayas,2015)

Appendix 4. Wattled ibis preening each other (Photo: Kalkidan Esayas,2015)

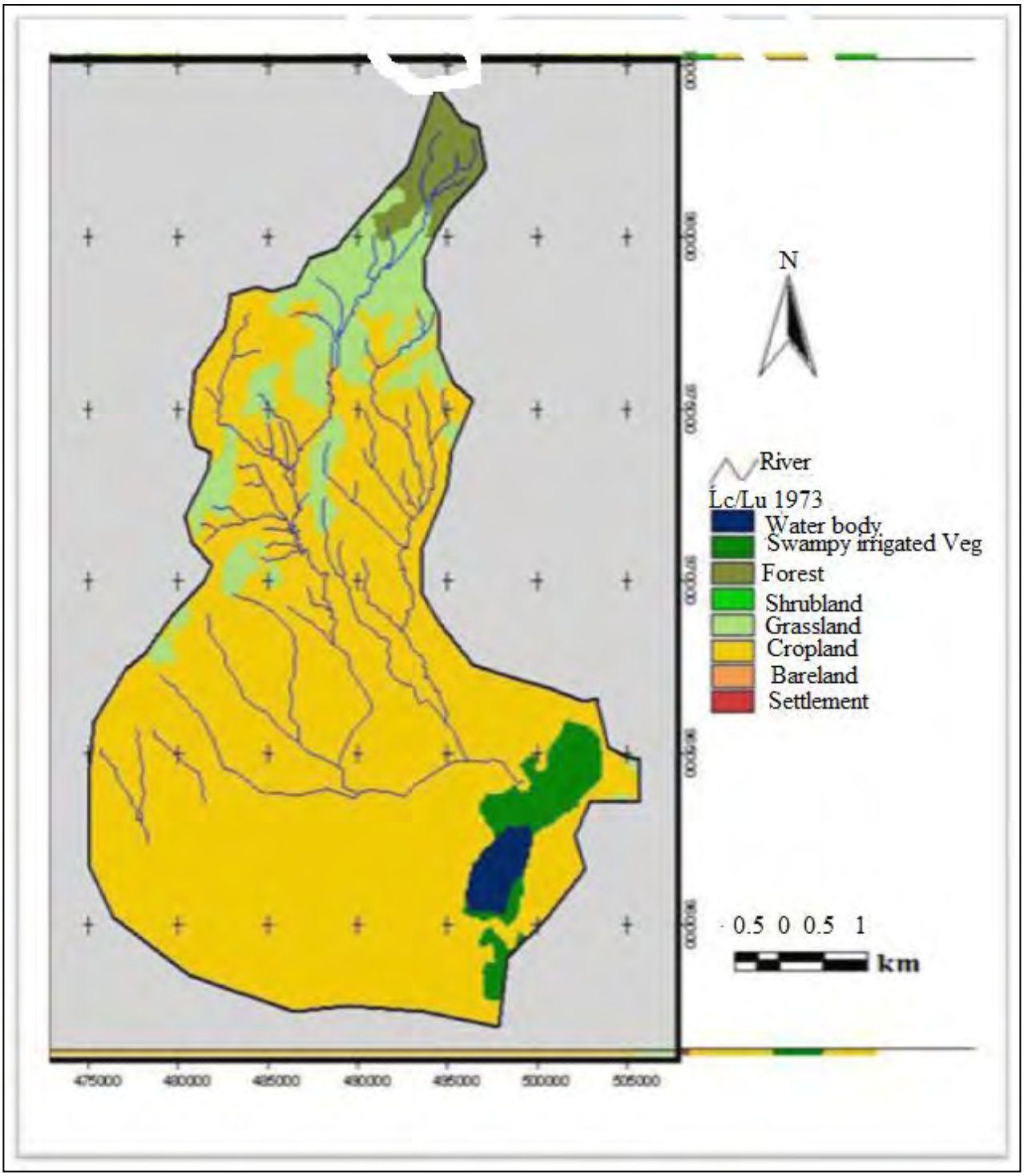
Appendix 5. Wattled ibis resting on trees((Photo: Kalkidan Esayas,2015)

Appendix 6. Wattled ibises forage in association with cattle egret

Appendix 7. Types of land use/cover changes in Chelekleka Lake watersheds during 1973

No.	Lu/Lc type	1973	
		Ha	%
1	Surface water body	134.5	1.4
2	Swampy vegetation	338.0	3.6
3	Forest	286.6	3.0
4	Shrubland	0.0	0.0
5	Grassland	1049.2	11.0
6	Cropland	7692.3	81.0
7	Bareland	0.0	0.0
8	Settlement	0.4	0.0
	Total	9500.9	100

(Source: Satellite Image Land use/Cover Output in 1973)

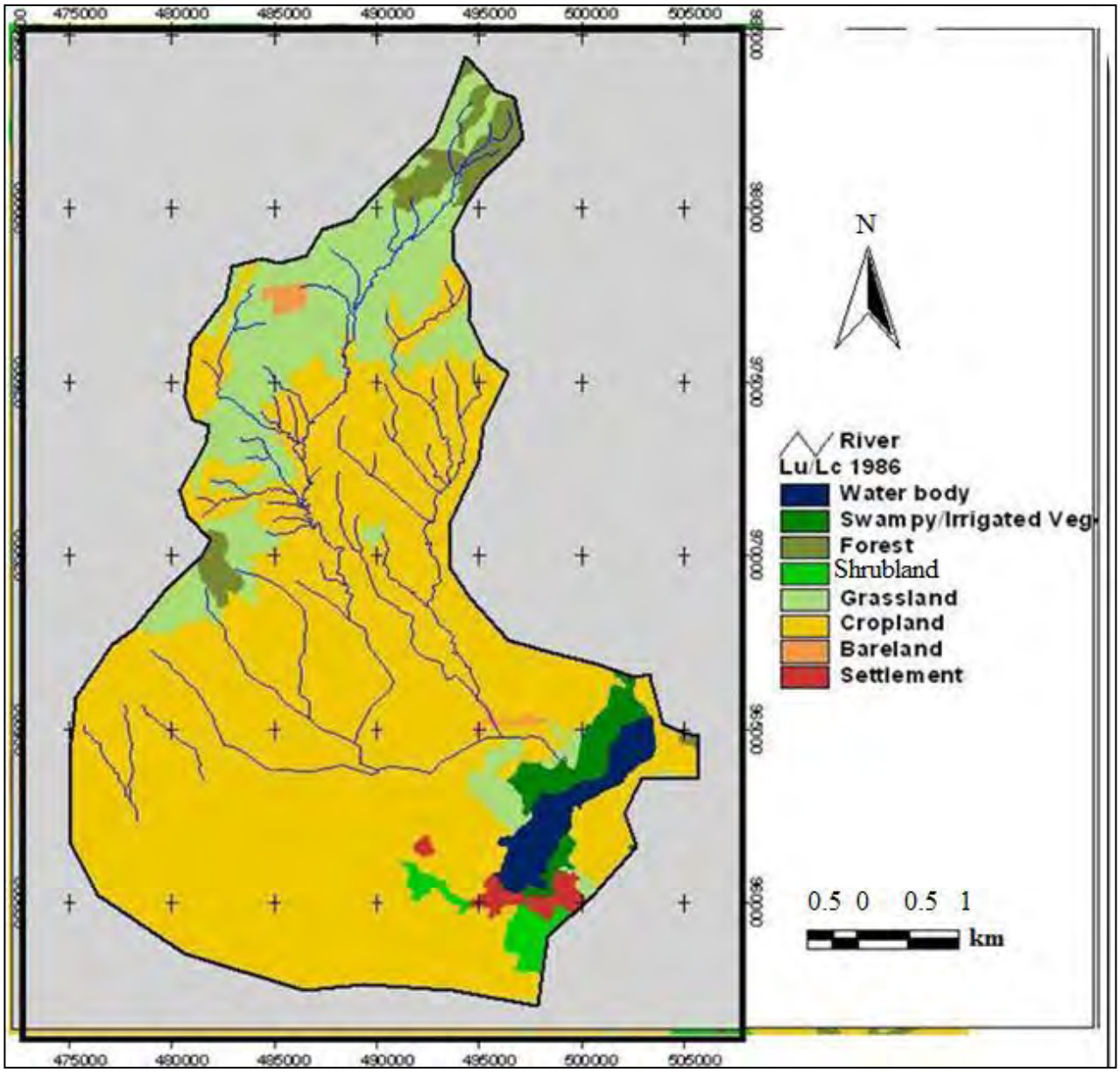


Appendix 8. Land use/cover map of Chelekleka Lake and its surrounding,1973

Appendix 9. Land use/cover change of Chelekleka Lake watershed during in 1986

No.	Lu/Lc type	1986	
		Ha	%
1	Surface water body	230.1	2.4
2	Swampy vegetation	200.2	2.1
3	Forest	278.0	2.9
4	Shrubland	113.3	1.2
5	Grassland	1596.9	16.8
6	Cropland	6937.0	73.0
7	Bareland	53.9	0.6
8	Settlement	91.4	1.0
	Total	9500.9	100

(Source: Satellite image land use/cover output in 1986)

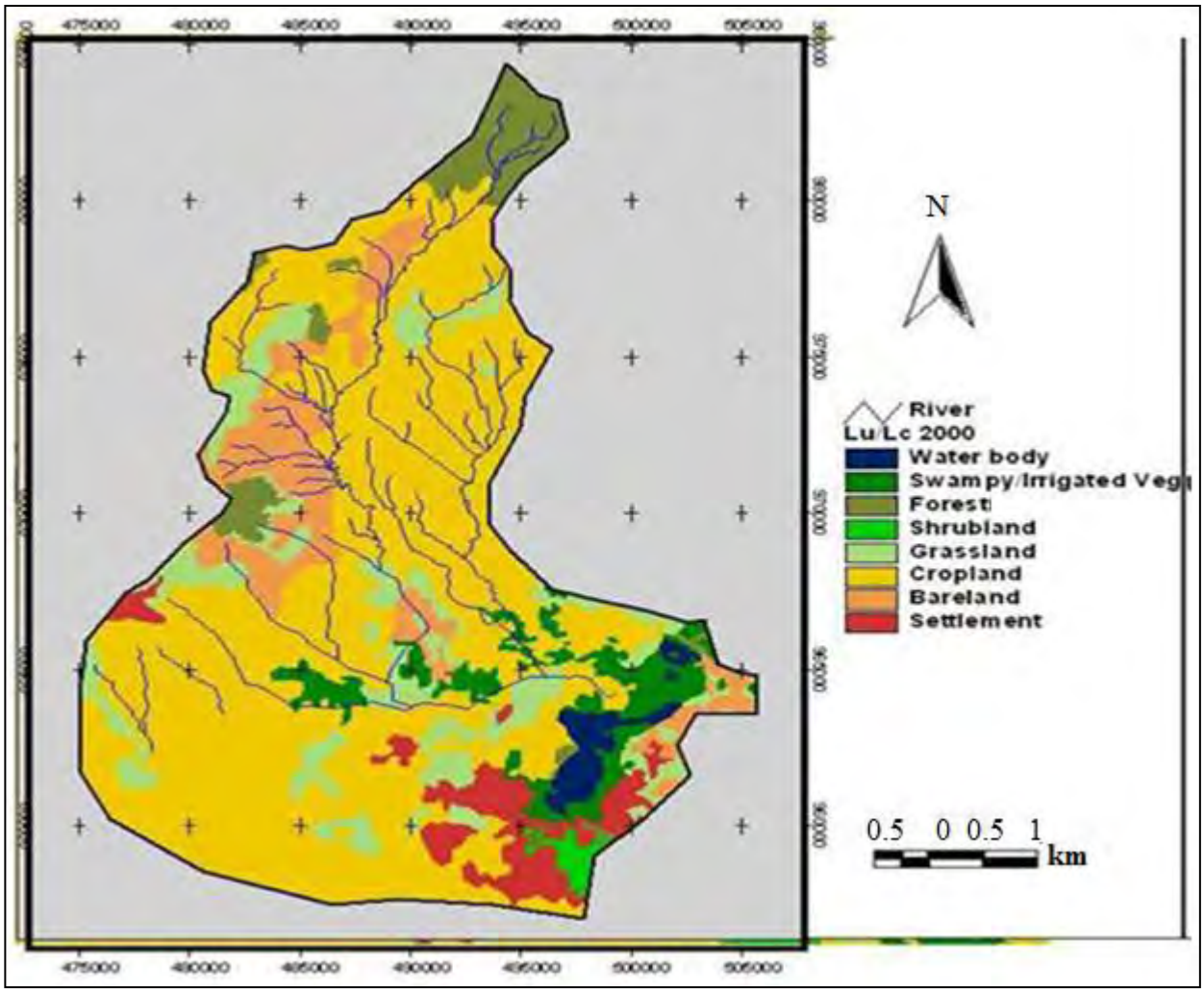


Appendix 10. Land use/cover map of Chelekleka Lake and its surrounding,1986

Appendix 11. Land use/ cover type during 2000

No.	Lu/Lc type	2000	
		Ha	%
1	Surface water body	178.830	1.9
2	Swampy irrigated vegetation	534.2	5.6
3	Forest	481.5	5.1
4	Shrubland	71.8	0.8
5	Grassland	1129.8	11.9
6	Cropland	5709.0	60.1
7	Bareland	900.9	9.5
8	Settlement	494.8	5.2
	Total	9500.9	100

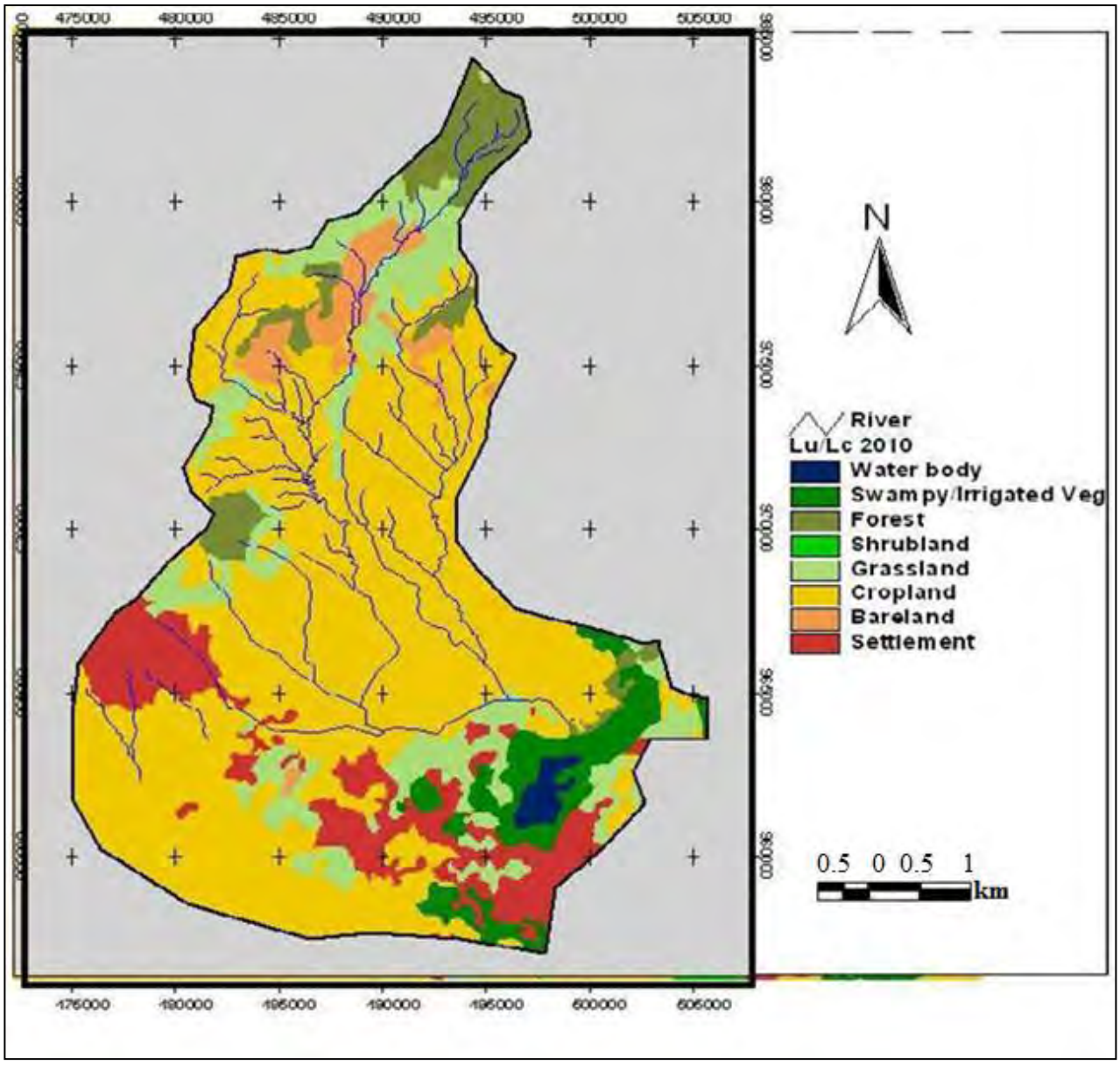
(Source: Satellite image land use/cover output in 2000)



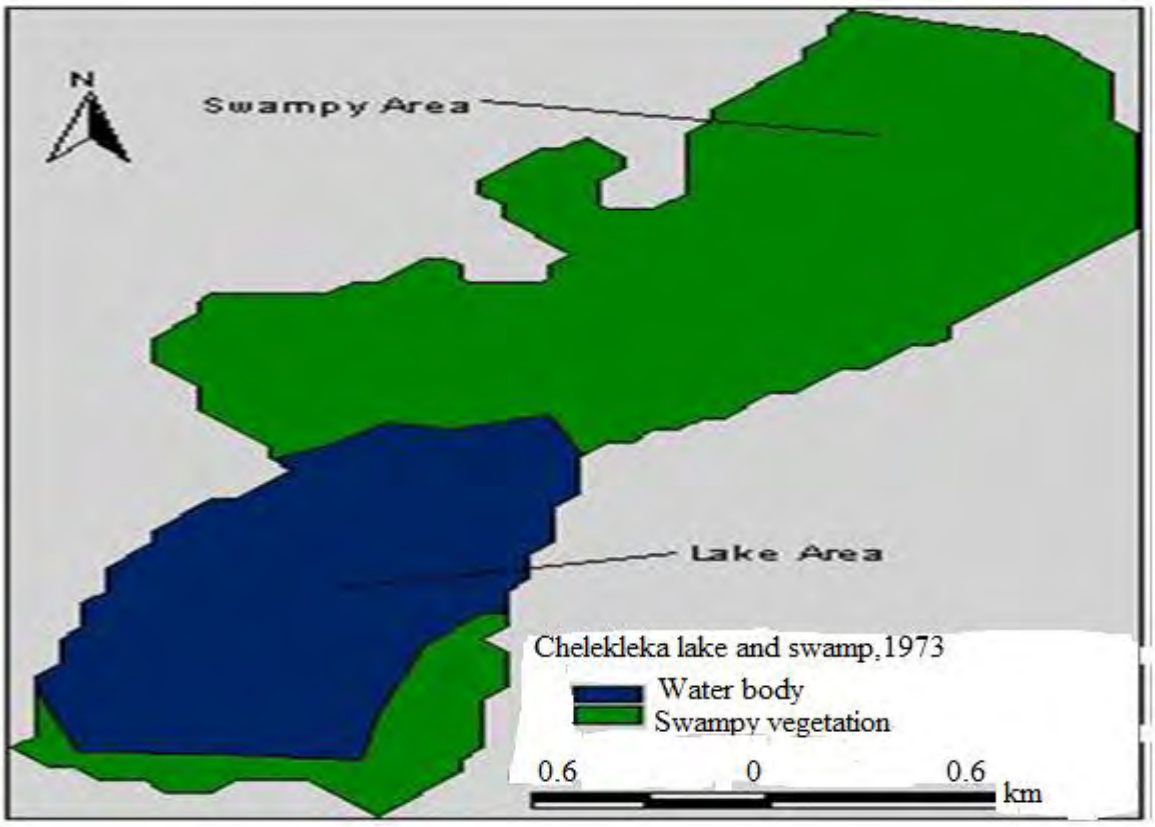
Appendix 12. Land use/cover map of Chelekleka Lake and its surrounding,2000

Appendix 13. Land Use/Cover changes in Chelekleka Lake watershed during 2010

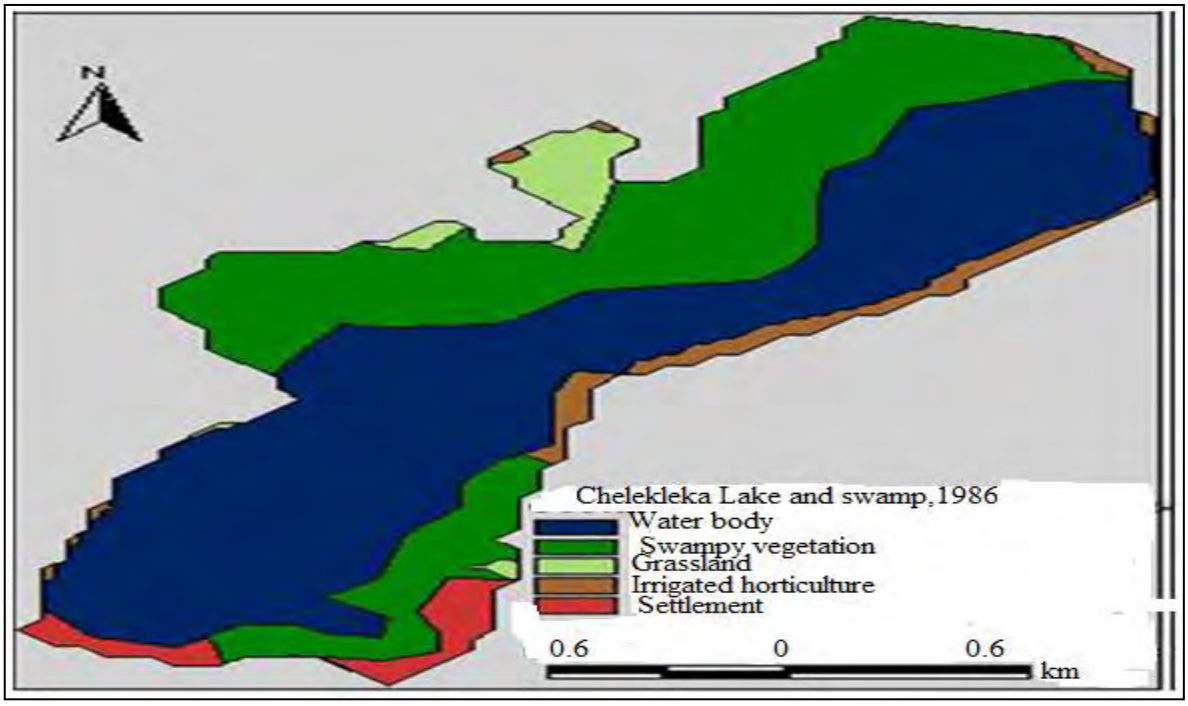
No.	Lu/Lc type	2010	
		Ha	%
1	Surface water body	83.2	0.88
2	Swampy irrigated vegetation	534.6	5.6
3	Forest	582.2	6.1
4	Shrubland	0.0	0.0
5	Grassland	1324.2	13.9
6	Cropland	5584.9	58.8
7	Bareland	356.0	3.7
8	Settlement	1035.8	10.9
	Total	9500.9	100.0



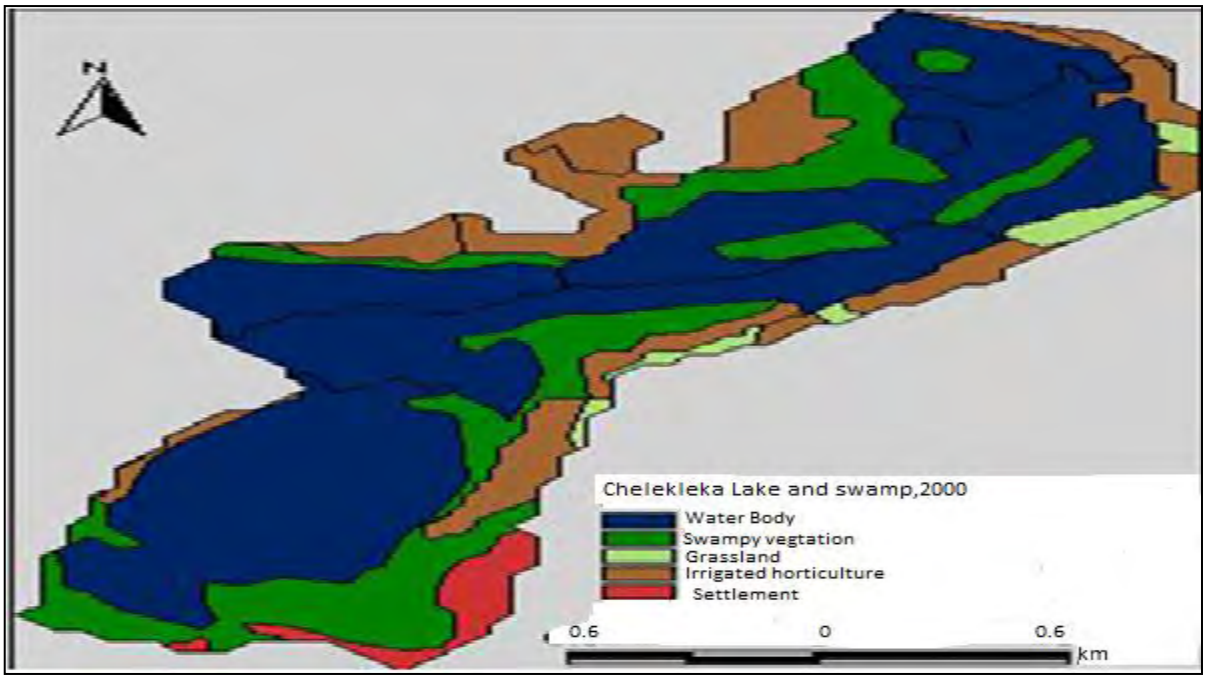
Appendix 14. Land Use/Cover changes in Chelekleka Lake watershed during 2010



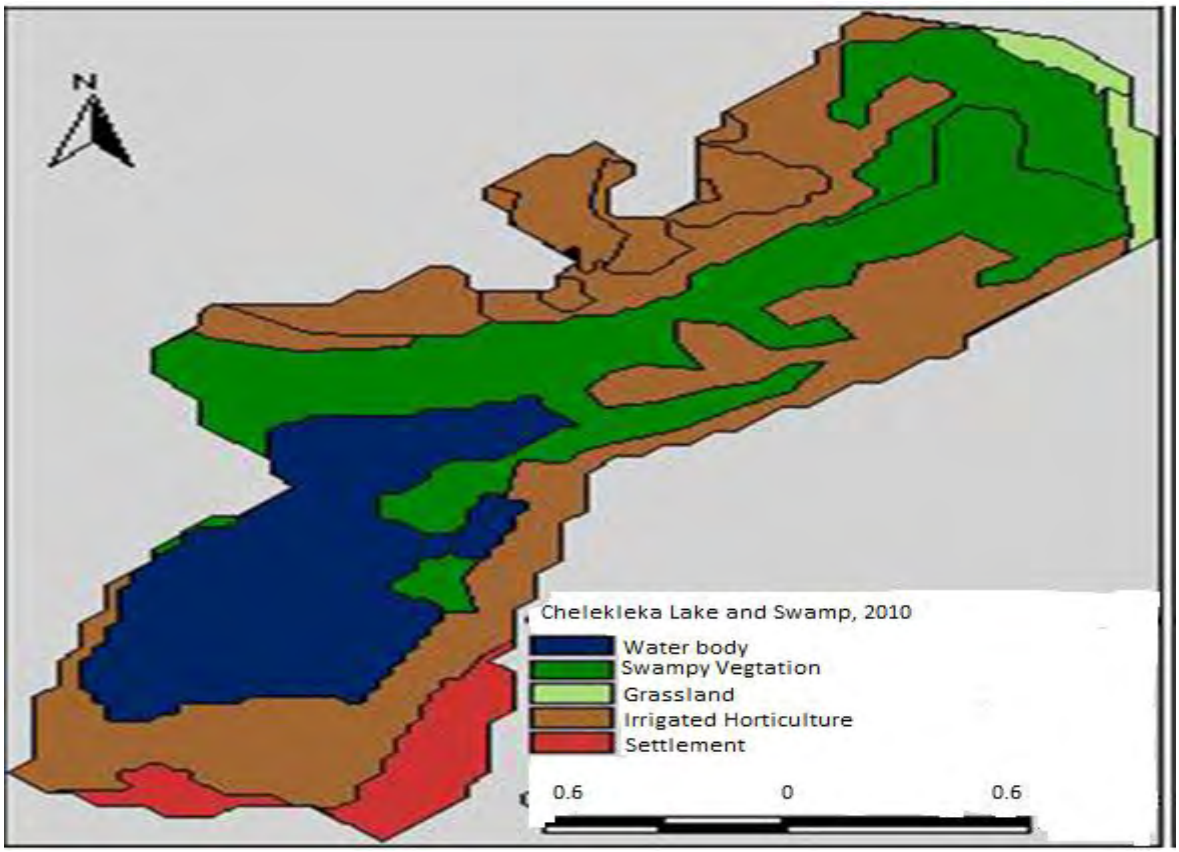
Appendix 15. Chelekleka lake and swamp,1973



Appendix 16. Chelekleka lake and swamp,1986



Appendix 17. Chelekleka lake and swamp,2000



Appendix 18. Chelekleka lake and swamp,2000

ADDIS ABABA UNIVERSITY
College of Natural Sciences
Department of zoological sciences
Ecological and systematic zoology stream

Dear respondent

The Purpose of this questionnaire is to gather information and Opinion regarding the land use change of Lake Chelekleka, Bishoftu, Ethiopia and strategy for conservation. This study is undertaken as academic requirements of PhD in the department of zoological sciences. It also helps to gain practical knowledge on the topic under investigation and other prospective researchers will use it as a stepping stone to carry out further investigation. Finally, I want to assure that this study is only for academic purpose authorized by Addis Ababa University. I will be very grateful if you could take a few minutes to complete this questionnaire. Your feedback is very important and all data obtained from you will be kept confidential.

Note;

1. No need of writing your name on the questionnaire
2. Put the (√) mark for your response on the space provided.
3. Write your additional comments and suggestions on the given spaces.

Thank you

Region: Oromia

Zone: East Shewa

Woreda/District: ----------

Town: Bishoftu___

1. Name...

2. Age

2. Role/ employment.....

3. Education: .....

4. Which division/ area do you work in? .....

5. How long have you worked here?

6. How would you explain the management situation of Chelekleka Lake?

7. What experiences does your organization have in the past in terms of collectively managing natural resources including Chelekleka Lake and its water shade areas?

8. How are boundaries of the lake defined and preserved?

9. How are decisions made locally and nationally in accordance of preserving the sustainability of the lake?

10. Do you feel that the local communities agree with the decisions?

11. How would you explain the importance of the Chelekleka Lake for the people surrounding?

12. What ecological and hydrological changes occurred in the Chelekleka Lake and its water shades?

13. In your understanding, what factors enhance water volume diminishes and moves it to die Lake Chelekleka?

14. For the future what remedial measures the government intends to sustain the life span of the lake?

Thanks