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Ecological Study of Wattled Crane (*Bugeranus carunculatus*, Gmelin 1789) in the Boyo Wetland and Bale Mountains National Park, Ethiopia

By

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ABSTRACT

Ecological Study of Wattled Crane (*Bugeranus carunculatus,* Gmelin 1789) in the Boyo Wetland of Southern Ethiopia and Afroalpine Ecosystems of Bale Mountains National Park, Southeast Ethiopia

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Wattled Cranes (*Bugeranus carunculatus*) are the largest, rarest and most wetland-dependent of African cranes. Ecological information of this African resident species is limited in Ethiopia. This study was carried out in Boyo wetland, wintering habitat and Bale Mountains National Park, breeding habitat from 2015-2017. The aim was to study the diurnal time-activity budget, breeding and feeding ecology, population and distribution as well as the species interaction with local farmers. To collect data on population and distribution, total population count was employed and instantaneous scan sampling technique was used to deal with their daily activity patterns. ANOVA, Chi-Square test and Pearson Correlation were used to investigate differences and relationship parameters. Active breeding season was from September to October with majority (66.7%) of nests being built on islands of alpine lakes. Breeding behavior was influenced by density of alpine lakes (P= 0.000) and availability of food density (P= 0.000) in their breeding territory. Mean clutch size was 1.78±0.15, n=9. The mean egg length, width and weight was 93.11±1.29 mm, 65.07±0.34 mm, 250.69±4.73 g, respectively. Hatching and fledging successes were 37.5% and 100%, respectively in which a strong association was noticed in terms of nest-site fidelity. They forage on 11 plant parts including waste grains, tubers, rhizomes and grass seeds. However, the most preferred food items in the breeding habitats was *Koeleria capensis, Romulea fischeri* and *Commelina baghalensis* which have tubers. Foraging behavior was most prevalent accounting to 39.3% of the diurnal time budget followed by locomotion (20%) and the rest was allocated for resting, vigilance and comfort movement. A population of 319 individuals was estimated in the Central Rift Valley area, with a new population discovery (169 individuals) in Melka Wakena hydroelectric dam. Majority of local farmers in Boyo wetland had positive attitude to the wetland. However, 76.8% of them perceived Wattled Cranes as a pest animal causing high crop damage. This species needs conservation concern as it selectively occupies a unique feeding niche and breeding site, which are being under threat due to habitat degradation.

Keywords: Attitude, breeding, distribution, egg, habitat degradation, nest and wetland

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DEDICATION

This work is dedicated to my beloved mother W/o Roman Tadele, who envisioned the value of education and hardworking in me, even if she cannot read and write.

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Abbreviations Used

BMNP	Bale Mountains National Park
CBD	Convention on Biological Diversity
CRV	Central Rift Valley
CSA	Central Statistical Agency
EIA	Environmental Impact Assessment
ENMSA	Ethiopian National Meteorological Service Agency
EWCA	Ethiopian Wildlife Conservation Authority
EWCO	Ethiopian Wildlife and Conservation Organization
EWCP	Ethiopian Wolf Conservation Program
EWNHS	Ethiopian Wildlife and Natural History Society
IBC	Institute of Biodiversity Conservation
ICF	International Crane Foundation
ITCZ	Inter-tropical Convergence Zone
IUCN	International Union for Conservation of Nature and Natural Resources
OARDB	Oromia Agriculture and Rural Development Bureau
SNNPR	South Nations Nationalities and Peoples Region
SSC	Species Survival Commission

1. Introduction and literature review

1.1. Introduction

The crane family (Gruiformes: Gruidae) commonly consists of 15 extant species (Harris and Mirande, 2013) and 14 subspecies (Archibald and Lewis, 1996). They are among the most ancient and distinctive families of birds on earth (Meine and Archibald, 1996b). Their fossil record to date shows that there are at least 17 extinct species which were closely related to the African Crowned Cranes (Brodkorb, 1967), even if, no species was extinct within the recorded history (Archibald and Lewis, 1996). They can be defined by their large body size, long neck and leg, having a small and elevated hind toe, an elongated and tapering bill that is often longer than their head. They have a side opening nostril with oval or nearly linear in structure (Johnsgard, 1983).

They occur in five continents except in South America and Antarctica (Weitzman, 1993; Archibald and Lewis, 1996; Harris and Mirande, 2013). They inhabit in areas with vast wetlands and grasslands as well as agricultural habitats for breeding and wintering purposes (Provost *et al.*, 1992). Most of them undertake biannual migration, during which they use wetlands, grasslands, or agricultural areas as a stopover sites to replenish their depleted energy and nutrient reserves (Davis, 2003)

They are among the most celebrated animals in human history being recognized as symbols in stories and arts of humans in the world especially in East Asian cultures (Harris, 1994). In addition, their beautiful and magnificent appearance and spectacular vocalization have attracted crane watchers around the world. In the 1990's, it was a multimillion dollar tourist industry in Central Nebraska from tourists visiting the area to witness the spectacle of half a million cranes during that time (Lingle, 1992).

However, regardless of their extraordinary beauty and cultural significance in most parts of the world (Harris and Mirande, 2013), as well as their high visibility and dramatic behavior both in displays and vocalization (Ellis *et al.*, 1998); they are known to constitute one of the world's most endangered families of all birds (Meine and Archibald, 1996b). It was since the last 150 years where human beings started to pose a threat to cranes, even if, they have co-existed in harmony for millennia (Harries, 1994).

Their threat ranges, from habitat loss or ecosystem degradation that cranes depend upon to human related actions directly impacting to cranes (Harris and Mirande, 2013). In recent years, the growing threats from hunting, poisoning, collision with power lines and illegal trade of these charismatic and endangered families of birds are becoming a major threat to their future survival in the wild (Archibald and Mirande, 2010).

On the other hand, rapid human population growth and associated changes to wetland ecosystems as a result of intensive agricultural developments, flood control activities, diversion of water systems and dam constructions throughout the world are affecting the fragile wetland habitats of cranes (Harris, 2010). Bento *et al.* (2007) reported that construction of Cahora Bassa dam in Zambezi river negatively affected the natural cycle of Kafue Flats (which harbors large global population of Wattled Cranes) by extremely reducing *Eleocharis* tuber production and soil penetrability as a result of natural flooding control of the Zambezi River. The human population growth related impacts such as intensive land use practices with very poorly integrated environmental protection are severe in Asia and Sub-Saharan Africa (Harris and Mirande, 2013).

Wattled Cranes (*Bugeranus carunculatus*) are the largest and rarest of all six African crane species. They are one of the most wetland-dependent species of all African cranes (Meine and Archibald, 1996b). They are classified as vulnerable under the revised IUCN Red List of Threatened Species and the population is decreasing (Meine and Archibald, 1996a; IUCN, 2017). It is a nonmigratory and resident crane species of Sub-Saharan Africa (Johnsgard, 1983). In Ethiopia and other southern African populations, however, they undertake some kind of irregular movements in response to the change in availability of food, presence of breeding ground and flooding level of their wintering habitat. The species has three population distributions across three fragmented areas in Sub-Saharan Africa, with largest population in south-central Africa and smallest population in Ethiopia and South Africa (Meine and Archibald, 1996b). The presence of extensive riparian wetlands in south-central Africa, especially the Zambezi and Okovango delta are the reasons behind the occurrence of the largest population of the species.

Historically, the species was known to be abundant (Bento *et al.*, 2007) and widely distributed across the Sub-Sharan Africa especially across southern Africa. However, records from the last decades showed that, the population of the species has experienced significant decline across its range (Meine and Archibald, 1996b). This is due to the decline in quality and loss of wetland habitats across their range of distribution (Konrad, 1981) because of its high dependency in wetlands compared to the other five African crane species for foraging and breeding (Konrad, 1981; Johnsgard, 1983). The loss of aquatic habitat or wetlands has also affected the Blue Cranes (*Anthropoides paradise*) and Demoiselle Cranes (*Grus virgo*) which are least aquatic due to loss of grassland habitats for agricultural intensification and afforestation (Harris and Mirande, 2013).

Due to their extraordinary appearances, behavior and cultural significance, cranes in general have been intensively studied for many years throughout the world starting from their ecological study to intensive study on their movement using satellite tracking (Harris, 1994; Harris and Mirande, 2013), especially in North America, Europe and Asia. However, previous works on the ecology of Wattled Cranes were shallow in emphasis or treatment and incomplete for not incorporating all if not some of the ecological aspects of the species in its range of distribution in Africa especially in Ethiopia (Burke, 1996; Bento *et al.*, 2007; Abebayehu Aticho, 2017).

Even though limited information is available on their distribution (Urban and Walkinshaw, 1967; Konrad, 1981; Beilfuss *et al.*, 2000; Bento *et al.*, 2007), population survey (Motsumi *et al.*, 2007), activity pattern on captive individuals (Davenport and Urban, 2010) and molecular study (Jones *et al.*, 2006), information on the distribution, movement and general ecology of the species including its interaction with farmers in Ethiopia is lacking.

Wattled Crane is one of the four crane species that occurs in Ethiopia. Its distribution is known mostly in the upland or highlands of Ethiopia and was recorded within an elevation ranging from 2134 - 3999 m asl (Johnsgard, 1983; Meine and Archibald, 1996a). However, historical records show that this species has occurred across large areas of Ethiopia with its largest wintering contingent in Boyo wetland.

It is obvious that the application and implementation of any conservation measure towards a species or the habitat it depends, requires a scientific investigation of the target species and the habitat where they live and interact (Liu *et al.*, 2010). Wattled Crane is mostly dependent on a pristine wetland ecosystem and wetlands are the most productive ecosystems on earth. They support a diverse number of fauna and flora (Harris, 1994).

However, they are also the most threatened ecosystems by mankind due to expansion of agriculture, construction of dams and unsustainable utilization of water as well as pollution and climate change related threats (Brinson and Malvárez, 2002; Mitsch and Hernandez, 2013).

In Ethiopia, the main challenge to the biodiversity at present is unsustainable utilization of natural resources such as overharvesting, deforestation, conversion of natural vegetation to farmland and introduction of invasive species. Wetlands are the most important ecosystems in Ethiopia, supporting a wealth of flora and fauna, including many endemic plant species and several of Ethiopia's endemic or near-endemic as well as threatened birds (IBC, 2009). However, they are considered less important compared to other ecosystems and hence under pressure. Therefore, this detailed investigation about the ecological study of Wattled Cranes has its own significance for the conservation of the species and its habitat.

On the other hand, in order to evaluate the conservation status or extinction risk of potentially threatened taxa, there are several parameters that a conservationist should have to consider. It includes assessing the total population number of the taxa under consideration, knowing its breeding behavior, its geographic range and movement as well as habitat preferences and its interaction with its environment (Motsumi, *et al.,* 2007). However, information is lacking or too little so far on the Wattled Crane population of Ethiopia. Therefore, this study will provide original detailed information on all the above-mentioned subjects which are very crucial for the conservation of the species and the wetland habitat that it depends for foraging and breeding in the future.

In general, the results from this study will provide detailed ecological information on the Ethiopian population of Wattled Cranes which was not fully known in detail before and will be used also as a baseline knowledge for other populations in Africa. It will have also importance in creating awareness on the importance of Sanetti plateau and Boyo wetland for the conservation of Wattled Cranes and other water birds as well as the whole biodiversity of these ecosystems. Furthermore, it will provide a very crucial information on other future issues to be investigated on the different aspects of the species or the wetlands concerned to guide conservationists and policy makers on how and why they should consider the conservation and utilization of wetlands.

1.2. Literature review

Cranes are birds which are known by their large body size and elongated leg (Johnsgard, 1983). They are members of the order Gruiformes, family Gruidae (Ellis *et al.*, 1998). They are also the tallest of all flying birds, with the male Sarus Crane (*Grus antigone*) standing up to 1.7 m (Harris, 1994). Due to their striking appearance and behavior, cranes are amongst the most spectacular and beautiful birds on earth. Due to this, they are considered as the most celebrated with a great cultural significance since prehistoric times in most parts of the world especially in East Asian countries.

In many parts of the world, they are being valued and used in stories in Africa (Archibald, 1993), as well as a source of morality tales (Johnsgard, 1983). Not only this but also, due to their wariness and sociality, they have captured the human imagination and gave rise to a variety of legends, myths, folktales and knowledge (Johnsgard, 1983). Among these, the Greeks and Romans were using the crane migration as a sign of seasonal change, since migration of cranes is marked with large flocks and clamoring calls. In addition, they were represented on the dynasty of Egyptian tombs from the 5^{th} to the 18^{th} century (Armstrong, 1978). Likewise, in Chinese tradition, cranes are a common symbol of longevity and soul of dead is represented as riding to heaven on a crane's back (Johnsgard, 1983). The same is true also in several places in India, where Sarus Crane enjoys protection from local people because of devotion of pairs to life and thus representing the symbol of longevity, monogamy and good luck (Mukherjee, 1999).

In Africa, cranes also have some strong connotation with humans, where the Zulu prince or king in South Africa used the feathers of Blue Cranes as a head dress to signal their royal status (Magubane, 1998). Similarly, in some parts of Ethiopia especially in the Great Rift

Valley and in few places of Eastern parts of the Great Rift Valley around the Arusi area, arrival of Wattled Cranes to farmer's land is considered as a sign of rainy season.

There are 15 crane species (Ellis *et al.*, 1998) and 14 subspecies (Archibald and Lewis, 1996), currently recognized in the world. They occur in five continents with greatest diversity in East Asia harboring nine species followed by Africa (Harris and Mirande, 2013). Sexually, cranes are alike in plumage and they are monogamous regardless of their gregarious behavior during the nonbreeding season (Johnsgard, 1983).

Out of the 15 crane species, six of them are found in the continent of Africa (Harris and Mirande, 2013) and four (Black Crowned Crane (*Balearica pavonina*), Wattled Crane, Common Crane (*Grus grus*) and Demoiselle Crane) are found in Ethiopia. From the four species found in Ethiopia, Common Cranes and Demoiselle Cranes are Palearctic migrants which show a diverse migration strategy (Hansbauer *et al.*, 2014).

Wattled Cranes are one of the largest and rarest of these six African crane species which is endemic to Africa. Even though it was once widely distributed across many African countries, the distribution of Wattled Cranes is localized and discontinuous (Johnsgard, 1983). Currently, the species distribution is confined to 11 countries regardless of the variation in the population size across these countries, where the largest population is found in the southcentral Africa. The other fragmented population is found in South Africa and highlands of Ethiopia. However, the largest single population is found in Botswana, in the Okovango delta (Motsumi *et al.*, 2007) and in other four major flood plains of Zambia.

Wattled Cranes are distinct from other related crane species by their all-white neck, contrasting with a blackish crown, breast and back. Like the Blue Cranes (*Anthropides* *paradiseus*), they have a long and pointed secondaries that nearly reach the ground, but Blue Cranes lack a wattle or red on their neck (Johnsgard, 1983).

Wattled Crane is a winter-breeding wetland-dependent species with a peak breeding activity between May and August each year, although breeding activity has been recorded in all months of the year. The populations of Wattled Cranes in Ethiopia also breed starting from May or June as the high altitude wet season begins (Hillman, 1993). Wattled Cranes require a specialized habitat with undisturbed, pristine to semi-pristine high altitude shallow wetlands, grassland areas and associated vegetation for their sedge-based vegetation diet (Johnsgard, 1983). Because of their high dependency in wetlands either for foraging or breeding (Meine and Archibald, 1996a), their distribution is restricted across the vast wetlands of eleven African countries, ranging from Ethiopia to South Africa with the majority of the population occurring in the extensive floodplain systems of southern Africa's large river basins (especially Kafue, Okovango and Zambezi) (Johnsgard, 1983; Archibald and Lewis, 1996; Burke, 1996; Beilfuss *et al.*, 2007; Beall, 2011) (Fig. 1). However, historically it was more abundant with estimated population of 13,000 - 15,000 (Beilfuss *et al.*, 2007) and widely distributed across southern Africa than its present distribution (Burke, 1996).

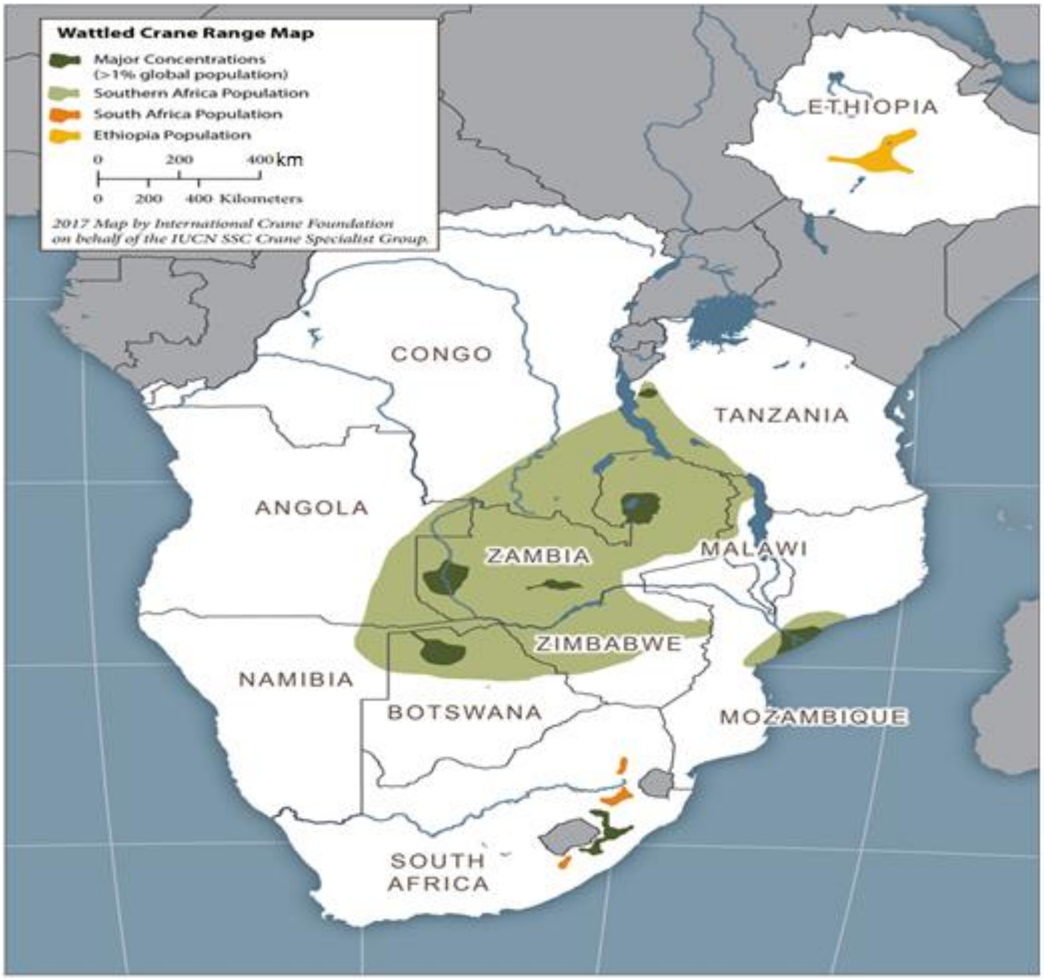


Figure 1: Map of Wattled Crane to show the distribution range (Source: https://www.savingcranes.org /where-do-cranes-live)

Wattled Cranes are one among four crane species, that also occur in Ethiopia (Urban and Walkinshaw, 1967; Beilfuss *et al.*, 2000). The population is confined to the highlands of Ethiopia, mainly within an elevation ranging from 2134 - 3999 m asl (Johnsgard, 1983; Meine and Archibald, 1996a). Historical records show that this species once occurred across large areas of Ethiopia (Burke, 1996). They are known to exist around the highlands of BMNP known for their breeding habitats (OARDB, 2007), around Gojam, Jimma area and Boyo wetland (Yilma Delelegn, 1998). In Gojam, Cheeseman and Sclater saw around

40 individuals of Wattled Crane assembled in one flooded depression in May 1929 and May 1930 (Cheeseman and Sclater, 1935, cited in Urban *et al.*, 1967). However, the main distribution areas are highland areas dominated by wetlands used for their feeding and breeding activities. They use the drier habitats or agricultural areas with adjacent wetlands for roosting and feeding around the Great Rift Valley during the non-breeding times of the year (Burke, 1996; McCann *et al.*, 2001).

In addition, recent surveys carried out during the national biodiversity inventory program by the Ethiopian Wildlife and Natural History Society, recorded the species at eleven different sites in Ethiopia, including Fogera Plains, Lake Tana, Finchaa and Chomen Swamps, Berga floodplain, Dilu Meki (Tefki), Koffe Swamp, Boyo wetland and BMNP, all designated as Important Bird Areas. Yilma Delelegn together with Beilfuss R., Gunter N. and Treuenfels C.V. discovered the largest group of Wattled Crane ever recorded in Ethiopia; 107 birds including 51 pairs at Boyo wetland feeding on extensive beds of tubers of the spike rush *Eleocharis*. The presence of most of the birds in scattered pairs across the flood plain suggests that Boyo may be the main breeding grounds for Wattled Cranes in Ethiopia.

The present world population status of Wattled Crane has been estimated on numerous occasions by different scientists and researchers throughout Africa, with estimates from 7,700 individuals by Pittman (2008), 6,000-8,000 individuals by Beilfuss *et al.* (2000) and fewer than 8,000 individuals Beilfuss *et al.* (2007). Even if, the population trend shows a sharp decline, the current rough population estimate is around 4000-5000 (IUCN, 2013), in an area of 2,300,000 km^2 (BirdLife International, 2014). The smallest population occurs in Ethiopia and the species is most abundant in southern Zambia, Mozambique and

Botswana (Table 1). The largest recorded concentration with a population of more than 2,500 individuals was reported in the Zambezi Delta in Mozambique (Burke 1996). However, the current population status and distribution of the species in Ethiopia is little known (Urban and Walkinshaw, 1967), due to lack of scientific studies and limited comprehensive survey undertaken so far. However, rough estimates of the population was recorded, from several hundred to fewer than 200 by the International Crane Foundation (2002).

Table 1: Estimated number of Wattled Cranes in different African countries 1985-2004. Source: (Beilfuss *et al.*, 2007)

Country	1985	1994	2004
Ethiopia	100	100s	<200
South Africa	Several 100s	250-300	250
Angola	500	500?	<200
Botswana	200	1,400-3,500	1,400
Malawi	250	50	<20
Democratic Republic of Congo	Several 100s	100s	<300
Mozambique	150	2,500-2,800	350
Namibia	300	200-300	60
Tanzania	Several 100s	100s	500
Zambia	11,000	7,000-8,000	<4,500
Zimbabwe	Few 100s	250	200
Total	13,000-15,000	13,000-15,000	<8,000

Wattled Cranes perform diverse behavioral patterns in their lifetime to perform diverse individualistic and group functions (Johnsgard, 1983). Majority of the cranes spent at least 83% of their time foraging, alerting or preening (Aborn, 2010). Most of the time, their activities are confined towards individualistic activities such as feeding and defecation, drinking, breathing as well as sleeping or resting which enable them to maintain their health. They also spend some time to perform activities like shaking, stretching, oiling and other actions which are only performed during their leisure time to gain comfort (Johnsgard, 1983).

Cranes in general are omnivores and some predominantly dependent on aquatic foods (Urban and Walkinshaw, 1967). They dig out by probing on wet sub-surfaces using their bill and take the food from the soil surface or vegetation (Archibald and Lewis, 1996). Access to food patches of varying quality is determined by thier own physiological needs and foraging efficiency (Stillman *et al.,* 2000). Likewise, cranes feeding preference and choice of food is mostly influenced by seasonal changes, following their breeding and wintering seasons. Food is found spatially and temporally clumped and effective foraging strategies must take this heterogeneous distribution into account (Higginson and Ruxton, 2015). During summer time, Whooping Cranes (*Grus americana*) are dependent on frogs, minnows, berries and large nymphal and larval forms of insects (Novakowski, 1966, cited in Archibald and Lewis, 1996). Similarly, Black Crowned Cranes feed on animal feeds such as insects during the breeding season, but during the nonbreeding season, they are mostly dependent on crop seeds (Shimelis Aynalem, 2017).

Sandhill Cranes (*Grus canadensis*) feed primarily on small grains (maize, wheat, barley, and sorghum) during fall, winter and spring, but during the nesting season (when they associate more with wetlands), the greater part of the diet consists of crayfish, plant tubers, chufa, rodents, frogs, berries, bird eggs, and nestlings (Bennett, 1978; Mullins and Bizeau, 1978; Iverson *et al.*, 1982).

Feeding and breeding activity in Wattled Crane is highly correlated with the presence of preferred food source (tubers from the sedge of *Eleocharis* spp.) (Beilfuss, 2000). However, during non-breeding season, they spend much of their time in the farm field or other habitats in search of other types of food (Johnsgard, 1983). They forage primarily by probing or digging on the wet substrate or loosely packed drier soils with their long and tapering bills. These types of bills are adapted to feed on aquatic plants growing in shallow water and dig them for their tubers and soft roots (Konrad, 1981; Archibald and Lewis, 1996). They also feed on seeds, insects and waste grain in drier habitats (Meine and Archibald, 1996b). As the result, they can be considered as omnivorous (Johnsgard, 1983). Wattled Cranes, even if they are omnivorous, predominantly feed on sedge tubers and rhizomes including *Cyperus esculentus*, *C. rotundus* and *C. usitatus* and also water-lily rhizomes (*Nymphaea* spp.) which are rich in carbohydrates (Urban *et al.*, 1986). Tuber productivity is closely related to seasonal flooding, with carbohydrate reserves stored underground during the long dry season to stimulate new shoot growth at the onset of the next flood season. Cranes prefer to occupy newly flooded habitats after the water level recedes.

Successful breeding formation depends on securing compatible mate or pair formation and creating breeding territory. In most cranes, breeding usually begins at the age of three to six years (Archibald and Lewis, 1996). On the other hand, their breeding season is associated either with the distinct seasonality of higher altitudes like those breeding in

Arctic to north temperate regions such as the Siberian Crane (*Grus leucogeranus*), Hooded Crane (*Grus monacha*), Common Crane and Whooping Crane or with the wet/rainy season in lower latitudes such as the Crowned Crane, Blue Crane, Sarus Crane and Wattled Cranes which usually breed on seasonal wetlands during the rainy season (Archibald and Swengel 1987; Konrad 1981).

Wattled Cranes usually mature at the age of three to four years forming a pair for life long (Johansgard, 1983). Wattled Cranes have been recorded breeding in all months of the year (Konrad, 1981), like in Zambia with peak in June. They breed mainly between May and August each year in Ethiopia at high altitude area when wet season begins (Johnsgard, 1983; Hillman, 1986*)*.

The reproductive biology of Wattled Crane is similar to all crane species and they are strictly monogamous (Urban *et al*., 1986). They have a long-term bond and a prolonged period of juvenile dependency, until the onset of the next breeding season. They have a limited reproductive potential because of their prolonged sexual maturity, small clutch size and limited re-nesting tendencies following the loss of a clutch or hatched young (Johnsgard, 1983).

Like other cranes, Wattled Cranes are highly territorial during the breeding season, defending an area greater than a km^2, which makes the breeding density smaller compared to Whooping Cranes and Siberian Crane with breeding density of 290 km^2 per pair (Flint and Sorokin, 1981, cited in Johnsgard, 1983). Konrad (1981) has reported that the 6,000 km^2 area of Kafue Flats might support some 300 breeding pairs or a breeding range of 20 km^2 per breeding pair which is the largest breeding population and territory of the species. Other areas surveyed had relatively lower estimated breeding densities. Pairs may not breed annually, rather on average of every 14 months (Urban *et al*., 1986). Their breeding behavior in some African countries is related with the flooding in which it breeds during the winter season in seasonally flooded marshes, such as in Okavango Delta of Botswana (Penry, 1994). Wattled Cranes are triggered to nest as flood waters begin receding after peak flooding (Kamwenshe and Beilfuss, 2002). Males and females cooperatively build their nest from grass and create a large nest platform in a shallow water (Beall, 2011).

All cranes exhibit a prolonged period of parental care toward their young, sometimes lasting well beyond the period required for fledging. During the time of searching for food, the male leads, then the female follows and the young arrives at last (Johnsgard, 1983).

Migration in animals has long fascinated human observers. Cranes undertake spectacular migration both local and continental either in search of nesting habitat or searching for wintering habitat. The Demoiselle Crane can fly at an altitude of 7.5 km which is the second high altitude flight next to Bar-headed Goose (*Anser indicus)* in crossing the Hindu Kush on migration between their nesting areas in central Asia and wintering areas in northwest India.

However, there is little information regarding the non-breeding range of Wattled Cranes, even if, there seems to be seasonal movement in some areas. The movement is not regular, it is based on changes in temperature, rather opportunistic related with changes in water levels of the wetlands *(*Meine and Archibald, 1996b). The Ethiopian Wattled Crane population, which is known to be the northern most of the three recognized populations is considered as migratory rather than nomadic regardless of the local movement (Burke, 1996).

The most important threat to birds and to biodiversity in general lies in the continuing erosion of the quality and extent of habitats across the entire landscape, as the result of increasing intensity of human use (Fishpool and Evans, 2001). In the presence of habitat destruction, excessive human predation, introduction of exotic species and other factors such as toxic chemicals as well as the natural, uncontrollable events can reduce the natural function of an organism in an area (Dorst, 1971).

According to the IUCN Red List, 11 of the 15 crane species are threatened with extinction with one Critically Endangered, three endangered and seven vulnerable (Johnsgard, 1983; Harris and Mirande, 2013). Most cranes are dependent on wetlands which are very important for their extensive food chain and the rich biodiversity they support (Mitsch, 1993) and they are under huge pressure due to loss of habitats (Konrad, 1981).

Throughout their range, Wattled Cranes are declining over time (IUCN, 2013). Loss and degradation of wetland habitats, intensified agriculture in the main areas of their distribution constitute the most significant threat to this species (Konrad, 1981; Burke, 1996; Kamweneshe and Beilfuss, 2002; Morrison and van der Spuy, 2006; Harris and Mirande, 2013). The decline of the species in South Africa was due to loss of wetlands to intensified agriculture, dam construction, industrialization and other related pressures (Meine and Archibald, 1996b). In other portions of the range, dams and other water development schemes have caused fundamental changes in the species' floodplain habitats (ICF, 2014).

Human disturbance at or near breeding sites is also a major threat because the species is well known for its sensitivity to human disturbance especially during the breeding season. In Zambia, a high degree of human activity such as fishing, agriculture, cattle herding and other human activities usually coincide with the breeding period of this species, directly affecting the breeding activities to a large extent (Kamwenshe and Beilfuss, 2002). Breeding success can be hindered by the establishment of human settlements too close to wetlands. According to Yilma Delelegn (1998), most individuals of this species are sensitive if one approaches at 40 m. Spraying of chemicals to control tsetse fly or generally agrochemicals also had a tremendous side effect on the breeding success of this species (Bousfield, 1987; Hancock *et al.,* 2003; Morrison and van der Spuy, 2006).

In addition to the above threats, the population is declining due to illegal collection of eggs and chicks for international trade as well as for local food consumption throughout its range (Pittman 2008; ICF, 2014). The destruction of vegetation by fire leaves adults more susceptible to predation and hunting and flood levels in turn influence the extent and intensity of fires (Morrison and van der Spuy, 2006).

Birds are excellent bio-indicators of healthy biodiversity in an area (Peakall and Boyd, 1987; Bibby *et al.* 1992; EWNHS, 1996; Ash and Atkins, 2009). They are also important in monitoring environmental changes because of their ecological diversity (Jarvinen and Vaisanen, 1979; Kleinheinz *et al*., 2006). However, there are some birds which are on the brink of extinction due to several factors, especially the human induced or anthropogenic factors (Dorst, 1971). Currently, habitat destruction is the largest single threat to biodiversity and the spread of agriculture into natural habitats alone threatens 1,065 species of birds (BirdLife International, 2008). Ethiopia, like a number of African countries, is experiencing serious environmental problems as a result of deforestation, overgrazing, agricultural encroachment and the unregulated use of agrochemicals.

In Africa, bird conservation is not a priority agenda. With respect to Wattled Crane, the African Wattled Crane Program in partnership with International Crane Foundation, the Endangered Wildlife Trust (South Africa) and organizations and individuals in the eleven countries where this species occurs are the responsible organs who are dealing with the conservation of this species. The program seeks to conserve their habitats in which the Wattled Cranes depend for feeding and breeding activities through promoting cooperation among African nations in partnership with people who live in the same habitat. In addition to this, the program works to build capacity through education and research all over the habitats of Wattled Crane (ICF, 2014). The program has made a range-wide survey to assess the global status and population of the species. Major field programs for Wattled Cranes are being undertaken in Mozambique, Botswana, Malawi, Zimbabwe, Zambia and South Africa (Beilfuss, 2003).

In Ethiopia however, there was no attempt to conserve this species from either the Ethiopian side or International Crane Foundation (ICF) to date. However, ICF and EWNHS have made extensive survey of the species in their previously known habitats. On the other hand, a study on Wattled Crane ecology has not been conducted to date. Therefore, by studying the ecology, population and distribution of the species we can have better knowledge about the species which can help to improve its future conservation status and the habitat where it lives.

1.3. Significance of the study

The application and implementation of any conservation measure towards a species or habitat requires, a scientific investigation (ecological study) of the target species and the habitat where it lives. Wattled Crane, is a species which is highly dependent on pristine wetlands and which are productive ecosystems that support a diverse number of fauna and flora. Wetlands are the most important ecosystems in Ethiopia, supporting a wealth of flora and fauna, including many endemic plant species and several of Ethiopia's endemic or near-endemic as well as threatened birds (IBC, 2009). However, they have been considered as less important compared to other ecosystems and they are under pressure.

However, in order to evaluate the conservation status or understand the vulnerability to different threats on a species, it is vital to know the population distribution. In addition, knowing the breeding and feeding behavior, its geographic range and movement, the rate of the population decline as well as habitat preferences and its interaction with its local people is worth knowing (Motsumi, *et al.*, 2007). But, the above points were lacking on the vulnerable Wattled Crane population in Ethiopia, where it is crucial to design a biologically sound conservation strategy. Therefore, this study will provide detailed information and science on the ecological aspects of the species, which are fundamental requirements for the conservation of the species and the wetland habitat it depends.

1.4. Research questions

- What is the reproductive capacity of Wattled Cranes nesting in the Afroalpine habitat with particular emphasis on the distribution and density of the breeding population?
- What are the major factors that influence nest site selection with regard to food availability, amount of rainfall, rodent activity, alpine lake density and other related factors?
- What is the average clutch size, hatching success and survival of chicks to fledging in the Afroalpine habitats of BMNP?
- What does the diurnal activity pattern of Wattled Crane look like in Boyo wetland and BMNP?
- What is the population size of Wattled Crane in Boyo wetland and its population dynamics during the wintering period?
- What factors influence population of Wattled Crane to fluctuate in its wintering habitat?
- What is the pattern of food use by Wattled Cranes in its wintering and breeding habitat?
- What factors influence foraging on a certain food type in its breeding and wintering habitat?
- What is the density and percentage of ground cover of food items consumed in the breeding habitat and factors that influence the density and ground cover?
- How do local communities surrounding Boyo wetland interact with Wattled Cranes?
- What are the main threats to Wattled Cranes and their habitat in the study area?

1.5. Objective

1.5.1. General Objective

The general objective of this study was to investigate the feeding and breeding behavior, estimate the population and identify the interaction of Wattled Crane (*Bugeranus carunculatus*) with local people in the Senetti plateau of the BMNP and Boyo wetland, Ethiopia.

1.5.2. Specific Objectives

The specific objectives were:

- To study the breeding behavior of Wattled Cranes;
- To study the population dynamics and determine the population size of Wattled Crane in the two habitats;
- To investigate the activity pattern and habitat preference of Wattled Cranes among the different habitat use types of Boyo wetland;
- To study the food and feeding ecology of Wattled Cranes;
- To study how local people in the Boyo wetland are coexisting with Wattled Cranes, and
- To recommend better conservations strategies on Wattled Cranes and their habitats

2. Materials and Methods

2.1. Description of the study areas

Ecological surveys and investigations related to Wattled Cranes diurnal time-activity budget, population and distribution as well as food and foraging ecology was conducted both in Boyo wetland and BMNP. In addition, studies related to the breeding ecology of the species and its interaction with local farmers were conducted exclusively in the Afroalpine habitats of BMNP and Boyo wetland, respectively.

2.1.1. Boyo wetland

Boyo wetland is found across the Great Rift Valley in the Central Rift Valley (CRV) area of Ethiopia, which is located between 07º28'-07º32'N and 38º00'-38º4'E (Fig. 2) (EWNHS, 1996). The Central Rift Valley area of Ethiopia, consists a chain of lakes, streams and wetlands with unique hydrological and ecological characteristics. In addition, its wide diversity of landscapes and ecosystems comprises extensive biodiversity-rich wetlands which support a wide variety of endemic birds and wild animals (Dagnachew Legesse and Tenalem Ayenew, 2006; Jansen *et al.*, 2007).

Boyo wetland, which is part of this extensive biodiversity rich area is located in Southern Nations Nationalities and Peoples Region (SNNPR) of Ethiopia. It is found 300 km away from Addis Ababa, 60 km far to the north of Hosaena town and 26 km north of Alaba Kulito, in the Hadya zone of Lemu district. The altitudinal range of the wetland varies from 1850 to 1900 m asl. The wetland is a fresh water lake and swampy (Yilma Delelegn, 1998).

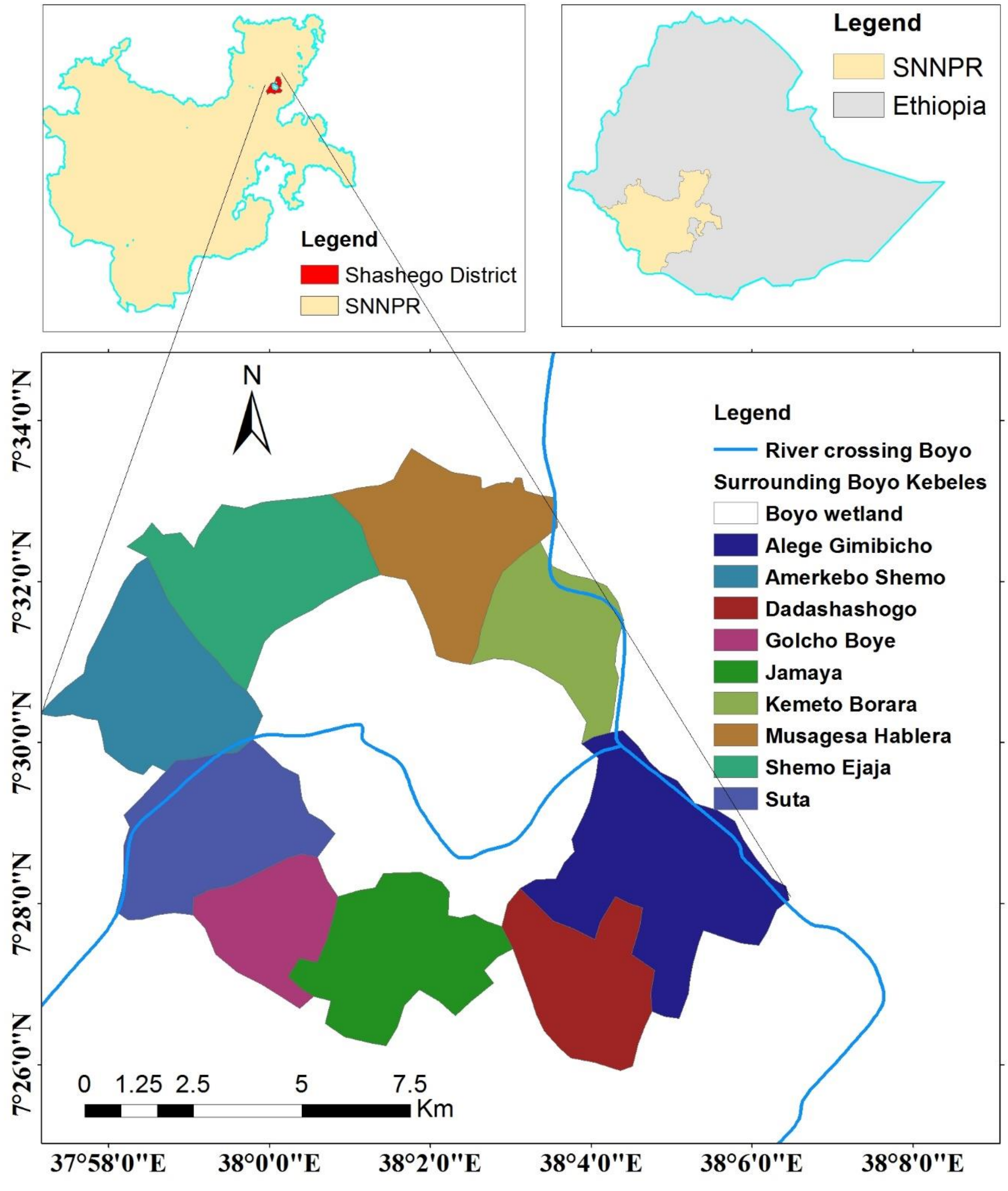


Figure 2: Map of the study area (Boyo wetland) and the 9 Kebeles surrounding the wetland

During the peak wet season of August and September, the whole area of the wetland becomes flooded and the water level rises higher, causing the vast area of the community's farmlands and a number of houses submerged under water. Particularly, the farmland areas to the north, south and west of the wetland become fully covered under water. It is during this time that the area of the wetland reaches its peak size covering around 4, 958 ha. During this time of the year, Wattled Cranes are absent from the area, since they are adapted to shallow wetlands. During the peak dry season, large part of the wetland which was under water dries out and changes to a vast area of grassland used for the purpose of uncontrolled grazing by communities residing around the wetland. The wetland is surrounded by hills and mountains, Bele Mountains to the north, northwest and west as well as Ambericho Mountain to the southwest. The small town of Dosha is located along the northeast and Bonesha town to the East. In addition, cultivation and settlements on the lower altitude are found along the four directions of the wetland (Fig. 2).

The wetland is part of the Bilate River basin that drains from the Gurage highlands south into Lake Abaya (EWNHS, 1996). The wetland has two main inflows or tributaries, Weira River from the southern highland areas of the wetland and Guder River from the Western mountains, near the Zonal capital, Hosaena and the two merges in Boyo wetland to outflow or join into Bilate River in the eastern part of the wetland. Guder is a main tributary of the wetland contributing a substantial amount of water during both seasons. Bilate River, drains the areas along southeast to join at an easterly point on the edge of the wetland (Yilma Delelegn, 1998). On the other hand, during the peak wet season, Bilate River diverts its direction and drains to Boyo wetland becoming a tributary of the wetland.

The surrounding highland areas especially those to the western and southern part of the wetland are the major feeders or main sources of flooding for the wetland. However, the surrounding hills and highland mountain areas are intensively farmed and deforestation rate is very high, growing every year. As a result, sediment yield to the wetland from these areas is substantially high, which is causing the wetland to decrease grass productivity.

Excessive land degradation, deforestation and over-irrigation result in huge sedimentation and increase in soil salinity due to anthropogenic factors (Dagnachew Legesse and Tenalem Ayenew, 2006). Likewise, Boyo wetland also suffers a huge human induced disturbance affecting its long-term survival. Rapidly growing population is the main factor where people are expanding their settlement to the wetland especially those people settling to the western and northern part (Fig. 2). In addition, the problem of soil erosion has also a significant impact on the existence of the wetland, where soil from the surrounding hills is being washed away to the wetland during the wet season (Plate 1).

In addition to this, during the last three years, government intervention such as excavation and building canals inside and surrounding the wetland have become another new threat to the wetland. The canals and drainage systems are being built to reduce flooding level to communities residing surrounding the wetland from being affected by flooding. However, the excavation and diversion work is being undertaken without any Environmental Impact Assessment or without knowing how the project affects the biodiversity of the wetland.

Plate 1: Highly degraded area due to deforestation along the catchment of the wetland

The climate of Boyo wetland is generally characterized by warm, wet summers (most of the rainfall occurring from July to September) and dry, cold and windy winters. Meteorological data for the area was taken from two stations which are very close to the wetland, one from the highland or Hosaena station which is found west of the wetland and the other from the lowland in Worabe station located to the north of the wetland.

Water volume of the wetland varies following the brief rainfall during the month of May and the rains in the months of July to mid-September. According to the data from the Ethiopian National Meteorological Service Agency (ENMSA) recorded from 2008 to 2017, the mean monthly rainfall of the area ranges from 9 mm in December to around 150 to 195 mm per month in May, July and August (Fig. 3). However, the mean maximum rainfall was recorded during the month of July (195 mm) while the mean minimum rainfall recorded in December (9 mm). Moreover, annual rainfall in the study area varies from 994.8 in 2015 to 2397.3 mm in 2009 (Fig. 4).

The temperature of the area can reach 27.4ºC during the warmest month of April and a minimum in the coldest month of December (13.6 ºC) with monthly minimal average temperature of 10ºC (Fig. 3). Therefore, the area can be characterized as a semi-arid climate with a long summer season bringing heavy rains from the Indian and Atlantic oceans because of its location in the CRV.

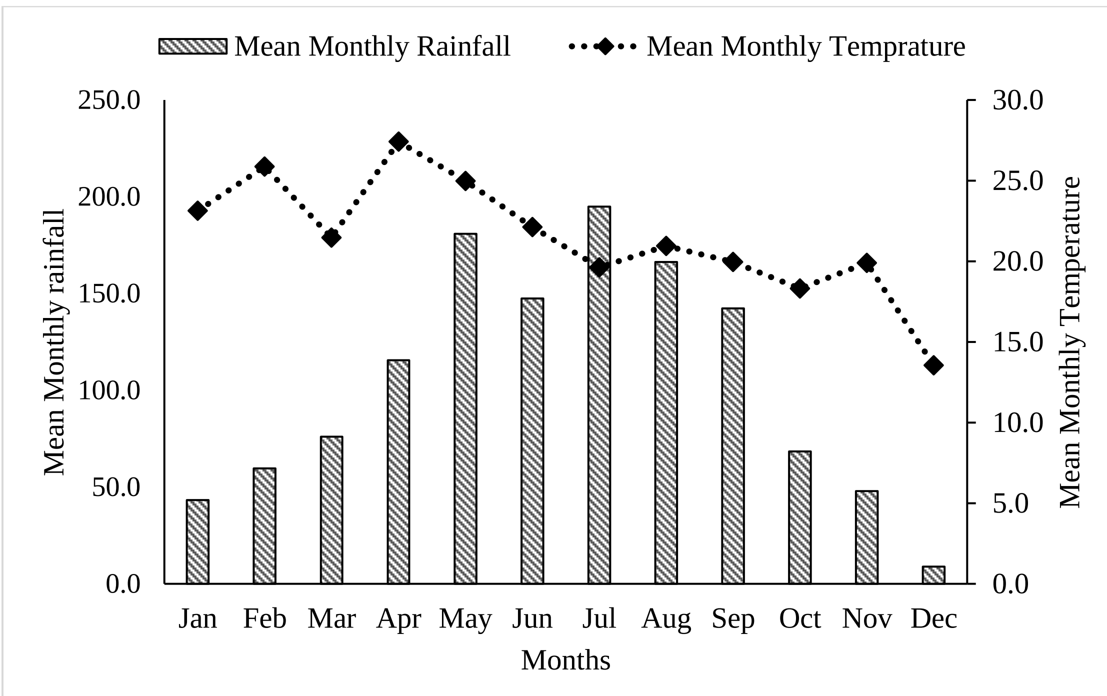


Figure 3: Mean monthly rainfall and temperature of Boyo wetland for ten consecutive years (2008-2017) (Source: Ethiopian National Meteorological Service Agency)

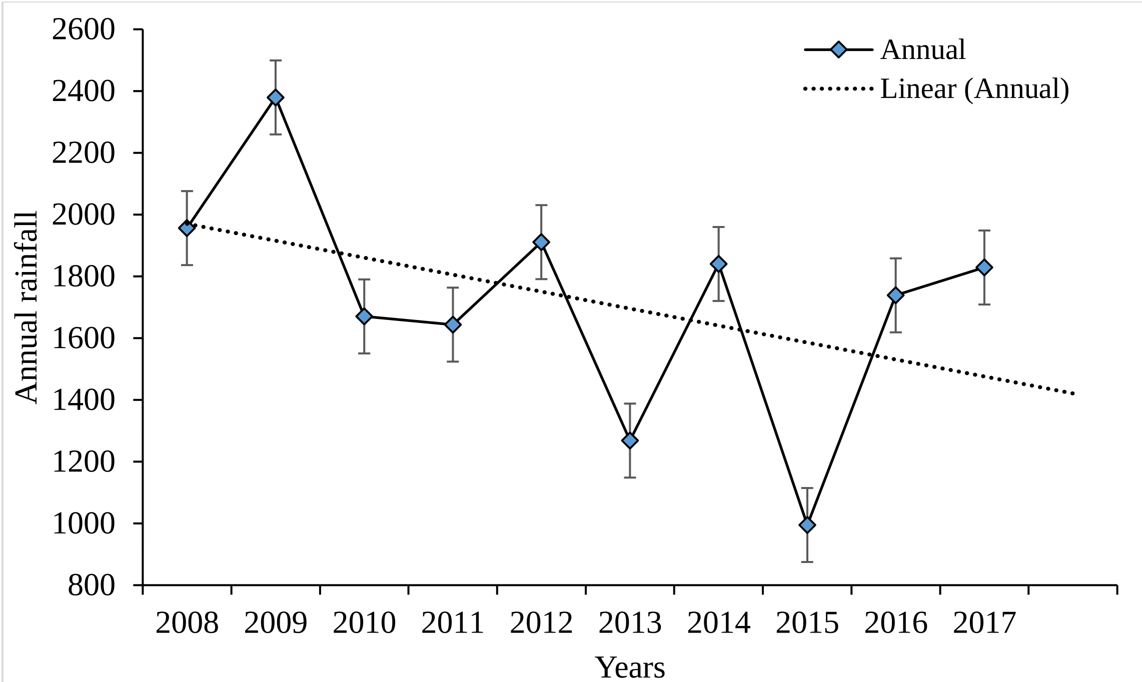


Figure 4: Annual rainfall of Boyo wetland (2008-2017) (Source: Ethiopian National Meteorological Service Agency)

Surrounding the wetland, the dominant land cover use is farmland and in the settlements around the wetland, there are vast scattered patches of Eucalyptus plantations such as *Eucalyptus globulus*. In addition, in the surrounding farmlands, there are sparsely scattered trees of *Ficus vasta* and some *Acacia* spp. However, inside the wetland, there are two dominant grasses *Eriochloa fatmensis* and *Eriochloa meyeriana* which are very important for cattle grazing and another dominant grass *Typha angustifolia* where local farmers use it for construction of huts. In addition, the dominant bush found inside the wetland is *Aeschynomene elaphroxylon* where local people use it for firewood. However, the plant is expanding at an alarming rate which may cause a negative impact on the wetland and its biodiversity, especially on the water birds of the area in the future.

In terms of fauna, the area was known to harbor a large number of Hippopotamus (*Hippopotamus amphibius*), as to local informants. According to the locals in the past, the wetland was full of grass and the number of Hippopotamuses was high. As the availability of grass in the wetland decreased due to sedimentation and overgrazing, the Hippopotamus started causing damage to farmer's crops resulting in direct conflict. Then, the farmers started killing the Hippopotamus by shooting and at present left with fewer than three adult Hippopotamus in the wetland. On the other hand, the wetland is known as one of the 69 important bird areas of Ethiopia. It supports a high concentration of water birds and a team of experts from EWNHS (1996), have estimated the total number of water birds in the wetland to exceed 20,000. It is also known as one of the best wintering areas for Wattled Cranes, Common Cranes and Black Crowned Cranes. Furthermore, the wetland is for its suitability for breeding Black Crowned Cranes.

Likewise, in the mountainous highland areas adjoining the wetland to the west, there are mammals, such as Vervet monkeys (*Chlorocebus pygerythrus*), Anubis baboons (*Papio anubis*) and Common warthogs (*Phacochoerus africanus*) even if, they are not common visitors to the wetland.

The wetland is bordered by more than ten Kebeles, which directly or indirectly use the wetland, to graze their cattle, to cut grass either for house construction or for their cattle fodder, to collect firewood from the wetland and to fetch water for their household activities. According to the data from the district office, the wetland is surrounded by a population of more than 42,014 individuals, 22,079 males and 19,935 females.

Surrounding the wetland, more than 99% of the people are farmers where they depend on subsistence agriculture (crop farming and cattle rearing). The major crops grown around the wetland are maize (*Zea mays*), wheat (*Triticum aestivum*), sorghum (*Sorghum bicolor*), teff (*Eragrostis tef*) and chilli (*Nahuati chilli*).

2.1.2. Bale Mountains National Park

Bale Mountains National Park is located in the southeast part of the Ethiopian plateau, Oromia National Regional State. It is located within Bale Zone of Dinsho Woreda, about 400 km southeast of Addis Ababa (OARDB, 2007). The Park encompasses 2,200 km^2 and lies between the geographical coordinates of 6º29' - 7º10'N and 39º 28' - 39º57' E (Fig. 5). It is known to harbor one of the most intact remnant of Ethiopia’s indigenous vegetation (Marino, 2003). The local boundary of the Park lies within five Woredas: Adaba (west), Dinsho (north), Goba (northeast), Mana-Angetu (south) and Berbere (east) (OARDB, 2007).

The altitudinal range covers from 1,500 to the highest peak 4,377 m asl at Tullu Deemtu which is the highest peak in southern Ethiopia (Hillman, 1986; EWNHS, 1998; Fishpoll and Evans, 2001). The Park possesses the largest piece of Afroalpine habitat that exists in our planet (area above 3000 m asl) (Marino, 2003; Ash and Atkins, 2009). It was first proposed in the late 1960s to protect the Afroalpine habitat and populations of the rare and endemic species of Mountain Nyala (*Tragelaphus buxtoni*) and the Ethiopian wolf (*Canis simensis*) (OARDB, 2007).

The Bale massif plays an important role in climatic control of the region where is attracts a large amount of orographic rainfall. The rainfall can occur at any month of the year peaking at some months. Data for monthly rainfall and monthly maximum and minimum temperature were obtained from the ENMSA and office of the Park management for the years 2008-2017.

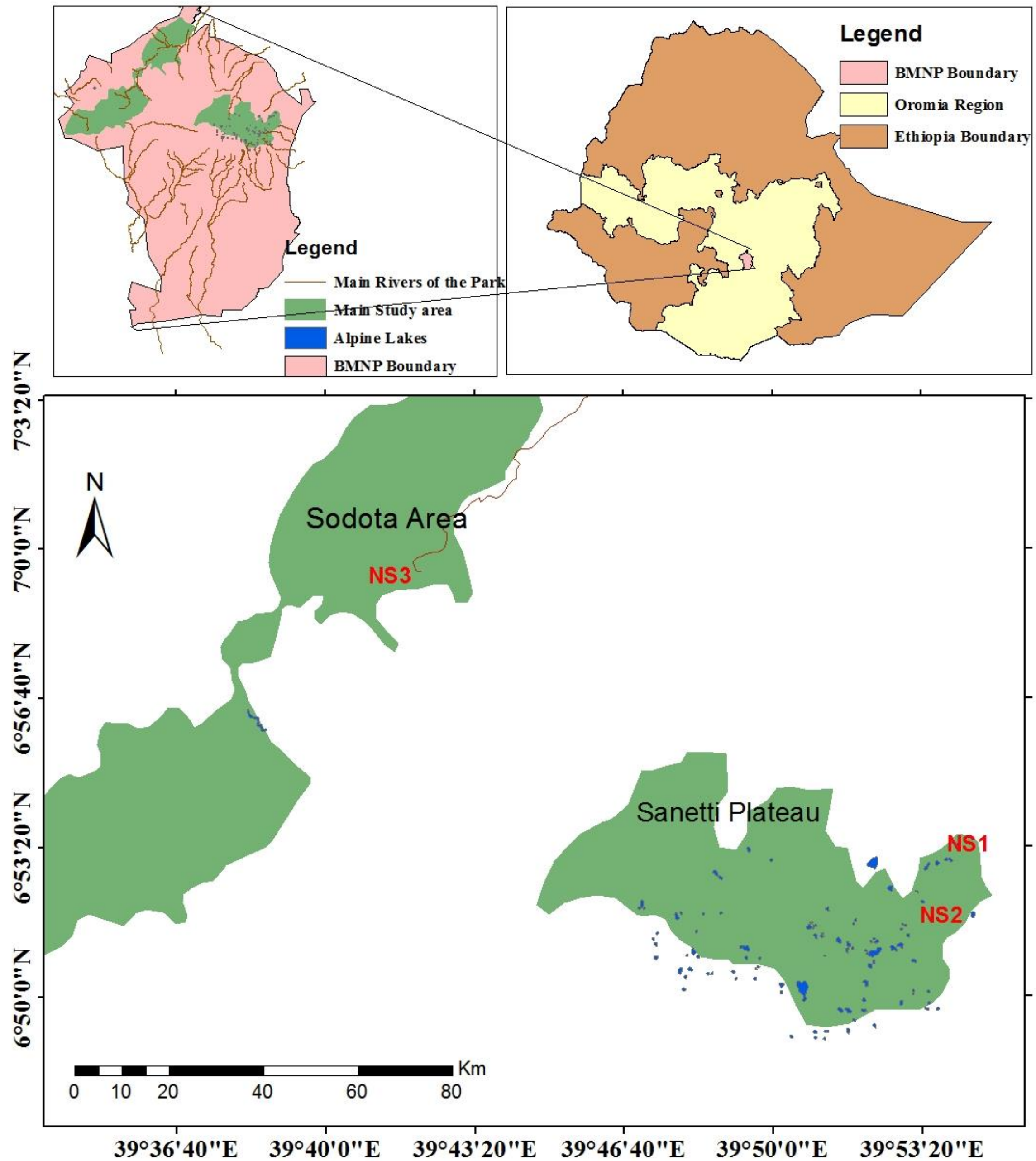


Figure 5: Map of the study area (Bale Mountains National Park) with green shaded areas as the main breeding sites

As in most Ethiopian highlands, the inter-tropical convergence zone (ITCZ), plus altitudinal and topographic features influence the distribution of the precipitation in the

Bale Mountains (Yoseph Aseffa *et al.*, 2011). Particularly, in the Park, the amount of rainfall varies from 600-1000 mm annually at the lower altitudinal areas and 1000-1400 mm in the higher altitudinal areas (OARDB, 2007). Annual precipitation rises with altitude from 925 mm at Goba (2720 m asl) to 1086 mm at Chorchora (3500 m asl) and 1061 mm at Koromi (3850 m asl) but is markedly lower at the highest altitudes 852 mm at Konteh (4050 m asl). Mean annual rainfall on the southern slopes is less (848 mm at Rira, 3000 m) but is more evenly distributed throughout the year (Umer *et al.*, 2007).

Data from ENMSA revealed that rainfall at BMNP is widely spread during the whole year, although, peak rainfall occurs between March and October with the highest record in July (157.2 mm) followed by August (154.4 mm) and to some extent in September (135.3 mm) (Fig. 6). However, the lowest mean monthly rainfall is recorded in January (4.5 mm). On the other hand, the area experiences temperature extremes, particularly in areas of higher altitudes during the dry season and more or less the same pattern of temperature during the wet season. According to Hillman (1986), the highest temperature was 18.4 ºC in February and the lowest 1.4 ºC in January. However, the data recorded for the year 2008 to 2017 showed that, the mean monthly temperature of the Park normally ranges between 11.2ºC and 15.6ºC. The highest mean monthly temperature was recorded in June 15.6 ºC and the lowest was recorded again in the months of November and December with a record of 11.2ºC (Fig. 6).

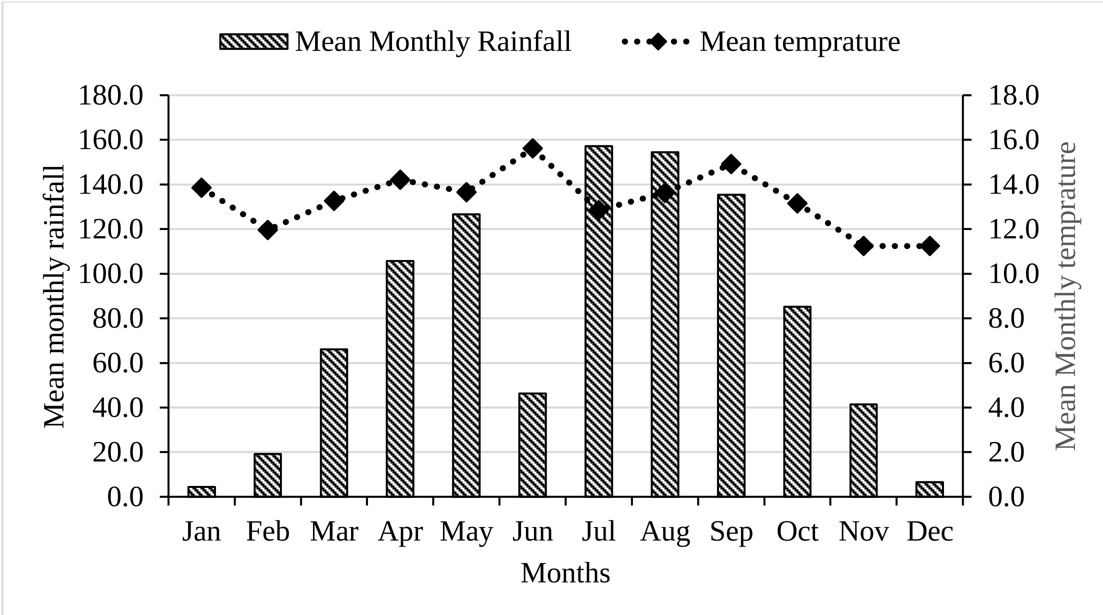


Figure 6: Mean monthly rainfall and temperature of BMNP for ten consecutive years (2008-2017) (Source: Ethiopian National Meteorological Service Agency)

In BMNP, several botanical explorations have been undertaken since 1906 by Smeds (1959) and Mooney (1963). However, Hedberg (1951, 1964, 1975 and 1986) has clearly analysed the vegetation and ecology of Afroalpine regions in Ethiopia. In addition, Weinert (1981) and Weinert and Mazurek (1984) have also published ecological studies on the vegetation of the Bale Mountains. In addition, floristic composition and physiognomy of the montane vegetation were conducted by Friis (1986) and Uhlig (1988) and Uhlig and Uhlig (1991).

The above exploration and surveys indicated that, the Park is known to support a wide range of habitats and encompasses the largest tract of Afroalpine vegetation in Africa (Fishpool and Evans, 2001) and is known as a biodiversity hotspot internationally (IBC, 2009). In Bale, there are at least 1,321 species of flowering plants with 163 endemics to Ethiopia and 23 of them unique to the Park (Hillman, 1986).

In general, the Park comprises five ecological zones: the northern grasslands and woodlands, the heather moorlands (3,100-3,400 m asl), the Afroalpine grasslands and moorlands above 3,400 m and the southern Harenna Forest (1,500-3,200 m asl) (Lisanework Nigatu and Mesfin Tadesse, 1989). The distribution of vegetation in the Park is correlated with altitudes varying based on climatic conditions. However, this particular study on the breeding ecology of Wattled Crane is confined to the Afroalpine grasslands and moorlands (area above 3400) which is commonly known as the Afroalpine habitat or Sanetti Plateau.

In terms of faunal diversity, the Park supports 68 mammal species (Fishpool and Evans, 2001) with 26% of Ethiopia's endemic species (one primate, Bale monkey (*Cercopithecus djamdjamensis)*), (one bovid Mountain byala (*Tragelephus buxtoni*)), (one hare, Starcks's hare (*Lepus starki*) and 8 species of rodents) are found in the area, including the Giant molerat (*Trachyoryctes macrocephalus*). In addition, in this area, there are several rare and endemic amphibian species (OARDB, 2007).

Over 170 bird species have been recorded in BMNP to date, which is equivalent to 20% of bird species recorded for Ethiopia. Among the endemic birds of Ethiopia, 57% are found in Bale Mountains (Hillman, 1986; OARDB, 2007). Bale is also the only known breeding site for a number of Eurasian species, such as the Golden eagle (*Aquila chrysaetos*), the Ruddy shelduck (*Tadorna ferruginea*) and Red-bill chough (*Pyrrhocorax pyrrhocorax*). The Park also has a breeding population of Wattled Cranes, where it is the only known site outside southern Africa and the only protected breeding area of the species in Ethiopia. In addition, it is an important over-wintering ground for migrant birds from Eurasia, particularly passerines and waterfowls (OARDB, 2007).

The watershed of BMNP is characterized by flat, swampy areas and contains many small shallow lakes that are crucial for water flow regulation. A total of 40 rivers rise from the Park area, contributing to five major rivers; the Web, Wabe Shebelle, Welmel, Dumal and Ganale. As a result, Bale Mountains is known to be a “water tower” due to the above reasons and its capacity to hold water in its swamps and lakes during the wet season and release it during the dry season. The Afroalpine wetlands and the Harenna forest hold the water, releasing it year-round to the arid and semi-arid areas of southeastern and southern Ethiopia, including the Ogaden and Somali agricultural belts. The livelihoods and food security of the people in these lowland areas is highly dependent on the good environmental management of this highland areas. This hydrological system is of critical importance to some 12 million people downstream users (OARDB, 2007).

According to IBC (2009), Ethiopia’s rich biodiversity is under serious pressure from deforestation and land degradation, overexploitation, overgrazing, habitat loss, invasive species and to some extent water pollution. The underlying causes for these problems emanate from poverty, unregulated population growth, lack of alternative livelihoods, inadequate policy support, inappropriate investment and inadequacy of law enforcement. As a result, a number of endemic mammals, birds and plants are reported to be endangered or critically endangered. Similar threats are also facing to the biodiversity of BMNP, such as forest clearing for firewood and timber production, habitat fragmentation and degradation (OARDB, 2007).

The Sanetti Plateau (between 3,800 and 4,000 m) and the broad valley bottom of the upper Web Valley (at 3,450-3,550 m) are the typical Afroalpine steppe habitats, dominated by short alpine grasses and herbs, with *Artemesia* sage brush, bushes of *Helichrysum* everlasting flowers and giant lobelias (*Lobelia rhyncopetalum*) scattered across the open uplands (Marino, 2003). It is in this type of habitat where Wattled Cranes prefer to breed due to the extraordinary habitat characteristics (vegetation and hydrology).

The Afroalpine areas experience regular night frosts, diurnal temperature fluctuations that far exceed seasonal ones and intense irradiation. Rodents can avoid extreme cold by going underground, whereas larger mammals such as ungulates and birds like Wattled Cranes cannot and so rodents are inherently well suited as the dominant herbivores of the Afroalpine ecosystem (Marino, 2003).

The area of the Afroalpine habitat is around 1000 km^2 or 17% of the total in the continent Africa (OARDB, 2007). The main features of this habitat type are, it harbors many of the Ethiopian and the Park's endemics including plants like *Lobelia* spp. and mammals such as the Ethiopian Wolf and Giant Molerat.

The plant communities of the Afroalpine habitats are those which can withstand the harsh environmental conditions such as extreme temperature and frost as well as the soil movement due to high rodent activity. *Helychrisum* dwarf-scrubs are the dominant plant formation in Tullu Deemtu or at the higher altitude of the Park. *H. splendidum* dominates, by forming rather dense 30 to 50 cm tall stands in which herbs are subordinate in magnitude. Towards the summits (4,000-4,200 m), the proportion of open substratum strongly increases, largely due to the high frequency of frost-induced substrate movement.

2.2. Materials

During the study period, a telescope (20-60x Swarovski model), binoculars (10x42 Bushnell model), measuring tape and pressing materials were used for observation, for taking measurement and for sample collection, respectively.

In addition, a six inch 150 mm Carbon Fiber Composite Verner Digital Electronic Caliper Ruler US with Accuracy of ±0.2 mm was used to measure the length and width of eggs. Digital Pocket Scale was also used to measure the weight of eggs. Garmin GPS 72 was also used to record the geographic coordinates of different positions in the study area.

2.3. Methods

2.3.1. Breeding biology

To investigate the breeding biology of Wattled Cranes, a field work was conducted for three consecutive breeding seasons (July through November 2015-2017) in BMNP. During these three breeding seasons, intensive ground searching to locate the possible nests of Wattled Cranes was undertaken in the Afroalpine habitat, which has an area of 1000 km^2 (OARDB, 2007). Beginning from July to October of 2015, searching was conducted at specific areas in the Afroalpine habitats which were considered to be potential breeding sites; based on the presence of Afroalpine lakes, lakes with islands, extensive marshes and swamps, including the availability of food in the areas, which are the basic requirements for nesting Wattled Cranes (Konrad, 1981; Johnsgard, 1983). Intensive nest searching was conducted using both on foot (40%) and on a horseback (60%) in the Afroalpine habitats. Then after, the next two wet seasons searching was restricted to potential sites, based on the previous year survey.

The search involved, direct search from vantage points and from the ground using a telescope (20-60x Swarovski model) and binoculars (10x42 Bushnell). Furthermore, information provided by local people both those seasonal and permanent settlers in the Afroalpine habitats as well as Park experts was used as a primary source of information.

When nests were observed, first, nest location was recorded with portable Garmin GPS 72. At the same time, nest platforms were classified and recorded as active (when breeding pairs were observed with egg or while incubating, hatched [at least one egg]) and attempted or inactive (when breeding pair was observed without egg, but with a nest) (Ivey and Dugger, 2008). However, whenever nests with cold, uncovered and intact eggs with no crane present were found, then nest was recorded as abandoned; but, later checking the nest status to confirm nest abandonment was undertaken (Austin *et al.*, 2007).

Nest dimension (nest diametric); such as the nest length, breadth (width), height of nest from water surface (H1) and water depth from the nest edge or rim (H2) from each cardinal direction was measured using measuring tape.

In addition, nesting materials and their surrounding vegetation was carefully noted. Plants used as a nesting material were collected and identified using the Flora of Ethiopia (Hedberg and Edwards, 1989; Hedberg *et al.,* 2003). If nests were located in an island, island length and width was also recorded to determine the island size.

Furthermore, nest concealment of all nests were recorded and rated as 1) poor- if a nest was visible at a distance >50 m, 2) fair- when the nest was visible at a distance between 10-50 m, 3) good- when nest was visible only from 2-10 m and 4) excellent when the nest was visible only from <2 m following Littlefield (2000).

In addition, when active nests were located, clutch size was recorded. For those pairs located before egg laying, their egg laying dates were recorded accurately when they lay their eggs through intensive follow-up. At the same time, egg dimension (length and breadth (maximum diameter)) and egg weight were measured using Carbo Fiber Composite Vernier Digital Electronic Caliper Ruler US and Digital Pocket Scale, respectively. For each egg, egg volume (V) and egg shape index (ESI) was calculated using the formula following (Hoyt, 1979).

(i) Volume (V)= $0.51*LB^2$

Where, V= egg volume, 0.51= scaling constant which was calculated by Hoyt (1979) where most bird species have values very close to this average, L= Egg length and B= Egg breadth

(ii) ESI= $\frac{B}{L} * 100$

Where ESI= Egg shell index, B= egg breath and L= Egg length

Egg weight measurement was adjusted with a correction factor of 199.7/200, in which every egg weighed in the field was multiplied by 0.9985 to get the correct weight of the egg.

Active nests were monitored by visiting four to six times during the incubation and post hatching period (August to December each year) to determine reproductive outcomes (hatching success and fledging success). Hatching or nesting success was determined by examining the fate of the eggs laid by the pair at the end of the incubation period or early hatching time and those nests which were considered successful were those which have hatched ≥ 1 eggs (Littlefield and Paullin, 1990). In addition, fledging or breeding success of Wattled Cranes was calculated by the number of young birds fledging/total number of egg hatched*100). Young birds reaching the height of their parents and starting to flee were considered as fledged (Mukherjee *et al.*, 2002).

In addition, nest or clutch initiation date was defined as the date the first egg was laid in a nest. This was determined through a series of weekly nest checks (Holderby *et al.*, 2012). However, for those nests which were found with incubating pairs, dates of nest or clutch initiation were extrapolated deducting days of incubation period from the dates of hatching. Such information helps in determining the peak breeding season (Mukherjee, 1999) of Wattled Cranes.

Presence of predators (a mammal or birds of prey) either during incubation or at post-hatching period was recorded through continuous follow-ups during the study period. Predators were considered if they showed a frequent presence in the nests, where Wattled Cranes incubate their eggs or show any sign of trying to flush the bird and feeding on the eggs. Similarly, birds or other animals which try to snatch the chick from the parent during post-hatching period were also recorded as predators.

During the whole survey period, careful observation was followed to reduce disturbances to the breeding pairs in their breeding habitat. Because, Wattled Crane in particular (Tarboton *et al.,* 1987) and cranes in general are highly sensitive to disturbance in which they can abandon their nest during the nesting period, if their wetland habitat is repeatedly disturbed (Boise, 1975).

During this survey, at least 95% of the Afroalpine habitat was assessed during the three breeding seasons. However, from the whole Afroalpine habitat the potential breeding areas found were 2,305 ha in Sanetti plateau area and 1,280 ha in Sodota area (Fig. 5). This helps to know the nesting density of the species in the Afroalpine habitat, calculated by dividing the total pair of Wattled Cranes that had pairs with the potential nesting area.

2.3.2. Population and distribution

To know and estimate the actual population size and seasonal distribution of Wattled Cranes wintering in Boyo wetland, a total count method was employed. However, prior to undertaking a population census, preliminary observation was conducted to assess and understand the activities of the species in the different habitats of the study area. Following the survey, it was observed that Wattled Cranes spent more time of the day scattered all over the harvested farmlands surrounding the wetland and then return back to the wetland during the mid-day for mid-day roosting and late in the afternoon for night rooting. Based on this, fixed census route was determined around the wetland for population count while roosting. The census route was decided with a consideration 1) to have a reliable population estimate and good accessibility to motorcycle driving, 2) to have a maximum coverage of the study area and maximum observation around the wetland up to 600 m to all sides. However, slight changes were made on the census route to adjust with the change in roosting sites by Wattled Cranes, as they made slight shift due to changes in water level in the wetland.

On the fixed census route, night roosting count was conducted in the wetland when Wattled Cranes were coming to roost in the shallow part of the wetland forming a large aggregation which is also common in other cranes like Sandhill Cranes (Sudgen, *et al.,* 1988; Ivey *et al.,* 2014). The census was conducted, during the optimum night roosting hours from 16:00 to 19:00 h as they flew into a roosting site. All cranes present in the wetland and others arrived were counted until dark.

While counting, all Wattled Cranes sighted while driving from a motorcycle in the fixed census route at a slower speed of 10 km per hour, were recorded using a telescope (20-60x Swarovski model) or binoculars (10x42 Bushnell). In addition, periodic stopping of the motorcycle at systematically selected vantage points was used to scan the area for rechecking the presence of Wattled Cranes in the census area.

Population observation was classified as adults and juveniles. Adults were distinguished by their larger size having a long well-developed wattle, very black crown part and very elongated inner secondary feathers. Juveniles were distinguished by their smaller size, less prominent wattles, less contrasting black crown and short inner secondaries (Johnsgard, 1983).

Crane count was made on a monthly basis (four times per month), from October 2015 to June 2016 and October 2016 to June 2017, to estimate the mean monthly population pattern and movement from the study area. Since it rains in April and June, counting was avoided during the rainy days and counting was not conducted in the months of July, August and September as populations were absent during these months. The distribution of Wattled Cranes is known in small wetlands in CRV (Archuma, Chuche, Wanchicho, Gololcha and Mandifa). Therefore, to estimate the population size wintering in these wetlands and Boyo wetland, complete survey was conducted in the second week of April and May to get an estimate of the population size in Ethiopia.

2.3.3. Diurnal time-activity budget

To assess and investigate the diurnal time-activity budget of Wattled Cranes in Boyo wetland, first, four habitat types were recognized. 1) agricultural land (farmland), 2) grassy field, 3) mudflat and 4) shallow water or wetland. The same procedure was employed to undertake the activity time budget of other crane species in different parts of the world (Aborn, 2010). In Boyo wetland, agriculture and grassland habitat types were located close to villages, where human activities such as cultivation and grazing animals were more frequent. Whereas, the third and the fourth habitats were found more or less within low human disturbance part of the wetland due to their distant location to settlements.

Behavioral observations and habitat use data were conducted for two winter seasons from October to June 2015/2016 and 2016/2017 in Boyo wetland and for three consecutive wet seasons from June to November 2014-2017 in the Afroalpine habitats of BMNP. Observations were made from early in the morning to late in the afternoon (06:00-18:00 h). To reduce temporal bias, no systematic effort was made to gather a particular number of samples in a given period of time.

Once flocks or pairs were found, instantaneous scan sampling was carried out (Altmann, 1974; Sutherland, 2004), to collect the daily activity time budget of the species in its wintering and breeding habitat. Instantaneous scan sampling is an instantaneous measure of individual bird's behavior which provides an overall estimate of proportions of an individual engagement in different behaviors. This involved scanning each individual in turn and categorizing its behavior (e.g. sleeping, walking, alerting and others).

Individuals from a flock in visible fields were scanned for five minutes, during which instantaneous behavior was recorded at 15 seconds interval (20 observations per focal bird)

(Zhou *et al.*, 2010). In addition, the total number of birds present in each flock and the habitat within their close area were clearly noted. Flock was considered those consisting of two or more cranes occurring within 10 m from one another which is more common in cranes (Wang *et al.*, 2011). However, observations were restricted to adult birds because the number of juveniles in the wintering habitat was too low to collect enough data on the juveniles. Consequently, age was omitted from the analysis as an explanatory variable. In addition, sex was not determined and considered during data collection time, since male and female Wattled Cranes look similar in size and plumage. On the other hand, focal individuals flying outside the observation area were assumed to be in flight for the balance of the 5 munities period and observations were resumed at the start of the next period from the location where the bird took flight.

Similarly, in other parts of the world, such studies were conducted on different crane species such as Siberian Cranes (Jia *et al.,* 2013), Sandhill Cranes (Tacha, 1988), Common Cranes (Alonso and Alonso, 1993; Avilés and Bednekoff, 2007), Black-naked Crane (Kong et al., 2008), as well as Wattled Cranes even if they were in captivity (Davenport and Urban, 2010).

Furthermore, Six behavioral states were distinguished; foraging, resting, comfort movement, locomotion, vigilance and social interaction. Foraging refers to a crane picking, digging or drinking (Wang *et al.*, 2011) and searching for food while walking with lowered head (Zhou *et al.*, 2010). Resting refers to a crane pausing or sleeping. Comfort movement refers to cleaning or preening as well as muscle stretching. Vigilance or alert behavior refers to scanning its area by erecting its head upward (Tacha, 1988). Locomotion includes walking while raising the head, running, flight and flapping. Social interaction refers to behaviors of intraspecific interactions such as dancing and agonistic behaviors. However, while recording their activities, whenever more than one behavioral states occurred at the same time, the more frequent one was taken (Davenport and Urban, 2010).

In order to determine the influence of the time of the day on behavioral activities, days were divided into 3 (four-hour times) blocks from sunrise to sunset: morning (06:00-10:00 h), mid-day (10:01-14:00 h) and afternoon (14:01-18:00 h) following Aborn (2010). Similarly, to see variation on the preference of Wattled Cranes across the different habitats and their activity period, the type of habitat for each flock located was recorded. In addition, observations were reasonably well-balanced across time periods, among habitats and between seasons, to see variation and relationship of activities to varying variables.

2.3.4. Food and foraging behavior

Data on the food and foraging behavior was recorded during the dry season in Boyo wetland and wet season in BMNP. To study and investigate what type of food items Wattled Cranes feed, groups or individuals randomly selected in the feeding habitat were intensively followed and carefully observed. The use a magnifying telescope (20-60x Swarovski model) and binoculars (10x42 Bushnell) in both habitats made it possible to view the birds from a reasonable distance of 40 to 50 m. Although, other cranes are wary of people walking and frequently flew when approached within 400 m (Littlefield, 2002), Wattled Cranes in Boyo wetland were approached as close as 40 to 50 m, which helped to identify the type of food item consumed with good accuracy. During their breeding habitat in BMNP, they were a bit sensitive to disturbance and data were recorded only by approaching to a distance of 150 to 200 m.

Useful information on the food items consumed was obtained by direct observation (involving watching the bird searching for and eating food) on different habitat types where the birds feed (Adeyemo and Ayodele, 2005). Unknown food items such as grains, seeds and left-over plant parts encountered were collected for subsequent identification. In addition, feeding techniques or type of foraging adopted by Wattled Cranes to obtain different edible parts of a plant was observed and carefully recorded by classifying into walk or pick foraging and dig foraging in various feeding sites, following the classification by Sauey (1985). All observations were carried out between the hours of 06:30-11:30 h and 14:30-18:00 h. These time periods were chosen because, they were found to be the active periods of the birds that coincided with their feeding times (Ash, 1992; Bibby, *et al.,* 1996). Data collection was made once per week from October to June 2015/2016 and 2016/2017 in Boyo wetland and from August to September of 2016-2017 in BMNP. To minimize the effect of temporal variations, observations were made at varying times of the day and different habitat types.

In BMNP, Wattled Cranes were observed feeding restrictively on tubers, rhizomes and soft roots of grasses and herbs. Therefore, collection and careful identification of each grasses and herbs consumed by Wattled Cranes was conducted using the flora of Ethiopia (Hedberg and Edwards, 1989; Hedberg *et al.,* 2003). Following this, habitat analysis was conducted within and outside the breeding territories (selected purposively based on the frequency of Wattled Crane observation to the areas), to assess the availability and abundance of food items in the Afroalpine habitat. But, to investigate why Wattled Cranes select one area over another to establish a breeding territory, two areas were systematically selected. The first was inside the breeding territory (Wattled Crane home range) and second area was outside the breeding territory or home range.

In each habitat, percentage ground cover, composition and density of each food items identified were estimated, counted and carefully recorded using quadrat sampling method of 0.3 × 0.3 m (Maphisa *et al.*, 2009). In each habitat, five points (central positions) were randomly selected, then, from each central position four quadrats were randomly laid along each four directions at an interval of 50 m distance. In addition, the level of rodent activity within and around the quadrat was recorded as high, medium, low or no digging sign to see the relationship with availability of food. Moreover, alpine lake density within 100 m of the quadrat was recorded as high, medium and low level to see if there is any relationship between the availability of food and lake density. Data collection on habitat analysis was undertaken during the optimum growing and flowering period of the food items (plants) identified or in the last two weeks of August, which made identification, estimation and counting much easier.

2.3.5. Wattled Crane and local people interaction in Boyo wetland

To investigate and understand the level of interaction between local farmers and Wattled Cranes in Boyo wetland, communities surrounding the wetland were contacted and interviewed. First, an introductory explanation about the study was made to the randomly selected respondents to familiarize with the study aims then invite their participation. Because, notifying and explaining to people about a study beforehand increases cooperation as well as increase the response rate as respondents have the opportunity to ask questions or express concerns (Benson, 1988; Cao *et al.*, 2009). In addition, local farmers were clearly notified that, the data would be published but were assured of confidentiality.

A total of 120 farmers were randomly selected from the surrounding wetland. Then, a semi structured and face to face interviews were used to collect data which have power to elicit landholders' attitudes and perceptions more accurately than posted questionnaires, telephone or electronic surveys (McDowell, 1988). Half of the interviews were conducted between March to June 2016 and the other half was conducted from March to June 2017.

To compare and ascertain the difference in farmer's perception and attitude about Wattled Cranes and the damage, to know their level of understanding with the species in particular and the wetland and its conservation in general, equal number of farmers (30) were selected from each direction/regions of the wetland habitat. Selection of respondents from each direction was undertaken using random selection methods (everybody having equal chance of being selected) from the settlement scattered in the four regions or directions which are close to the wetland. A map showing houses from the four directions of the wetland was extracted from google earth, then houses were selected and marked from the map randomly. Then household heads were selected from the selected houses. If household heads were not present, then the next older family was selected for the interview.

Most of the participants were very interested to participate on the research regardless of some who were very concerned and not interested on the research due to their uncertainty with the research objectives. However, for the sake of minimizing bias on the attitude and perception of sampled farmers towards Wattled Crane damage, their view was fully considered (Van Velden *et al.*, 2016).

The minimum response rate was calculated as the number of completed interviews/ (complete interviews) + (refusals + non-contacts) (AAPOR, 2010) and 90 %, 80 %, 86 % and 73 % was obtained for north, south, east and west of the wetland, respectively.

The interview schedule used in this study was, semistructured interview combined questions of a more quantitative, closed-ended nature with less qualitatively oriented, open-ended questions aiming at collecting both factual and attitudinal data (McNeill and Chapman, 1985). The closed-ended questions provided a greater uniformity of responses, which are more amenable for quantitative analysis, whereas the open-ended questions allowed to get access to certain issues in more depth (Kelley *et al.*, 2003).

The question list was divided into four main sections with interview duration varying from 30 to 40 minutes depending on the amount of discussion the interviewee wants to share and the quality of data generated. Moreover, general observation of the fields affected or damaged by Wattled Cranes both during the wet and dry seasons as well as informal conversation with elderly and credential farmers was made to get evidence-based results or affirm the responses and have a firsthand information on the damage (Wang *et al.*, 2006).

A rationale for the inclusion of sets of questions and the way in which key variables were measured is provided below as well, the interview questions were pretested on seven farmers and then edited.

2.4. Data analyses

All statistical analyses were carried out after the raw data collected was organized in an excel sheet. Data normality was checked using a Shapiro-Wilk's test, because it is highly recommended by researchers as well as its higher power of the measure of the value of test normality (Ghasemi and Zahediasl, 2012). Following this, those data which had satisfied the standard normal distribution criteria were subjected to parametric test such as ANOVA, Chi-Square test (x^2), Independent Sample t-test and Pearson Correlation. However, for those data that were not normally distributed, a non-parametric statistical test such as Independent Sample Mann-Whitney U test, Kruskal-Wallis test and Spearman's correlation were used. Mean comparisons were made using Tuakey HSD for variables whose F-values showed significant variation. Two tailed significance and differences were considered statistically significant with 95% confidence intervals. Statistical Package for Social Sciences (SPSS) Version 20, was used to compute all statistical analysis.

3. Results

3.1. Breeding biology

3.1.1. Nest location and characteristics

During the three breeding seasons in the Afroalpine habitats of BMNP, a total of nine Wattled Crane nests were found and information was recorded. From all these active nests, three (33.3%, n=9) were nests built on wetlands, whereas six (66.7%, n= 9) were built on two islands in three different breeding seasons. Three nests were found in Sodota area and the other six were located in the Sanetti Plateau of the Afroalpine habitats. Wattled Cranes preferred to nest in Sanetti Plateau than in Sodota area with six and three nests, respectively. During the breeding season of 2015, two and in 2016, four active nests were built. In addition, in 2017 three nests were built in the whole Afroalpine habitats of the Park.

Sanetti Plateau is known for its big number of alpine lakes and Sodota area harbors only one big wetland. As a result, Wattled Cranes which nested in the Sanetti Plateau have built their nests in pure islands with very little vegetation cover around the nest even if there was very short grass predominantly covered with *Koeleria capensis*. However, those pairs which nested in Sodota area built their nests in a big wetland covered with dense and tall grasses especially with the dominant grass of *Luzula abyssinica.*

Nests were built at different altitudinal patterns with an average altitude of 3848.60±76.092 ranging from 3502 to 4034 m asl. There was a significant variation in the altitude of nests built between the two habitats ($U= 22$, $P= 0.038$). The six nests built in the Sanetti Plateau were built at higher altitudes (3997.14±12.19) ranging from 3962 to 4034 m asl than those three nests built in the Sodota area (3502.00±0.00 m asl) (Table 2). Wattled Cranes build their nests either on a pure island or on a marshy wetland. The closest nest to the mainland was built in the Sanetti Plateau, 8 m away from the main land. The mean distance of nests from the main land was 250.2±120 m with a maximum distance from the mainland measuring 800 m in Sodota area (Table 3). In the Afroalpine habitat other than the alpine lakes and wetlands with islands, the other wetlands and alpine lakes without islands were not preferred by Wattled Cranes to build nests

The active breeding season of Wattled Cranes in the Afroalpine habitat was from September and October where intensive egg laying was observed where 4, 44.4%, n= 9 had their first clutch during September, 4, 44.4%, n= 9 during October and 1, 11.1% n= 9 had clutch initiation during August (Fig. 7).

During the breeding season of 2015, one of the clutches was laid during the fourth week of September and the other clutch was laid during the second week of October. Whereas during 2016, one clutch was laid in the second week of September and the rest three were laid during the first week of October. However, in 2017, the breeding season spanned from third week of August with one clutch laid and the other two clutches were laid during the first and second week of September (Fig. 7).

The distribution of Wattled Crane nests in the Afroalpine habitat was similar among the three breeding seasons, where they nested on the same two islands from 2015-2017 in the Sanetti Plateau and on the same wetland but with minor difference in nest location in Sodota area. With regard to the inter-distance between nearest nests in the Afroalpine habitat, the closest inter-distance was 1.67 km between the nests in Sanetti Plateau and the maximum was 25.61 km between nests of the Sanetti Plateau and Sodota area (Table 2

Table 2: Nest location, nearest distance from the mainland and altitude, 2015-2017

Nest No.	2015				2016					2017				
	Site name	Nearest distance to mainland (m)	Nest location	Alt. (m asl)	Site name	Nearest distance to mainland (m)	Nest location	Water depth in (cm)	Alt. (m asl)	Site name	Nearest distance to main land (m)	Nest location	Water depth in (cm)	Alt. (m asl)
1	Sanetti	25	Island	3962	Sanetti	25	Island	0.59	3972	Sanetti	8	Island	0.78	4034
2	Sodota	800	Wetland	3502	Sanetti	8	Island	0.86	4027	Sanetti	25	Island	0.59	3962
3					Sanetti	8	Island	0.87	4027	Sodota	800	Wetland	0.3	3502
4					Sodota	800	Wetland	1.28	3502					

Table 3: Nest distribution of Wattled Cranes in the Afroalpine habitats 2015-2017.

Nest No.	2015					2016					2017				
	Site name	Nest Id	Nearest distance to mainland (m)	The nearest nest pair	Inter distance between nests (km)	Site name	Nest Id	Nearest distance to mainland (m)	The nearest nest pair	Inter distance between nests (km)	Site name	Nest Id	Nearest distance to main land (m)	The nearest nest pair	Inter distance between nests (km)
1	Sanetti	Sa_N1	25	Sa_N2	1.67	Sanetti	Sa_N1	25	Sa_N2	1.67	Sanetti	Sa_N1	8	Sa_N2	1.67
2	Sodota	So_N1	800	Sa_N2	25.61	Sanetti	Sa_N2	8	Sa_N1	1.67	Sanetti	Sa_N2	25	Sa_N1	1.67
3						Sanetti	Sa_N3	8	Sa_N1	1.67	Sodota	So_N1	800	Sa_N1	25.62
4						Sodota	So_N1	800	Sa_N2 and Sa_N3	25.61					

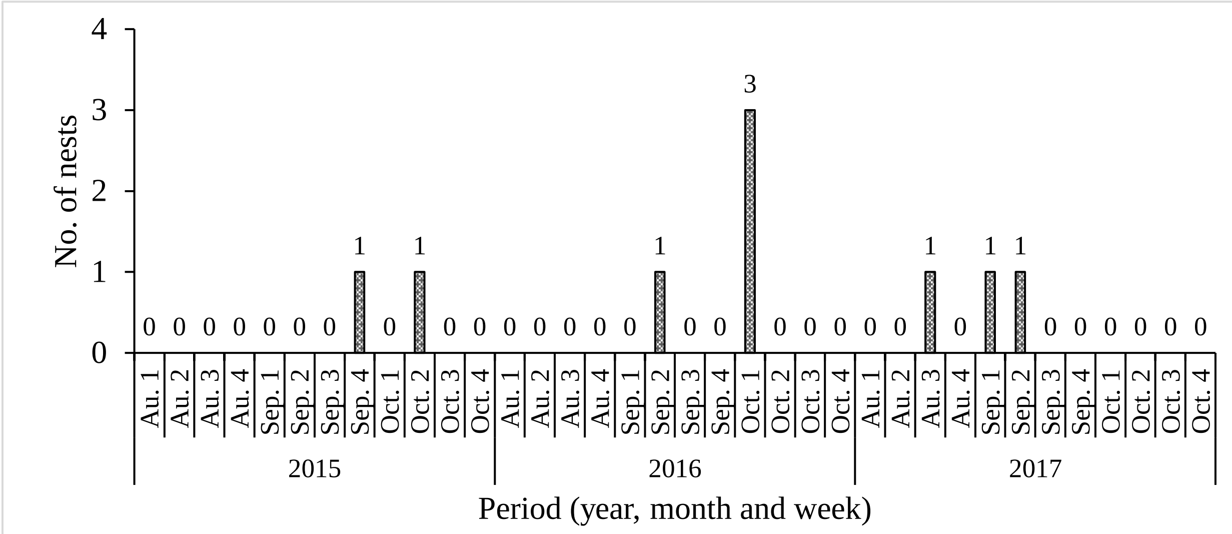


Figure 7: Frequency of nest initiation at different weeks (2015-2017)

3.1.2. Nest materials and nest morphometry

3.1.2.1. Nest Material

Wattled Cranes in the Afroalpine habitat build their nests in a varying landform and size either on an island (66.67%, n=9) in Sanetti Plateau (plate 2A) or on the wetland (33.33%, n=9) in Sodota area (Plate 2B).

In Sodota area, the nests were built in a marshy area with elevated spot surrounded by water or a very marshy surrounding. The nest materials which were predominantly used to build the nests were *Luzula abyssinica* and *Koeleria capensis*. The parents cut and pull the grasses from the nest surrounding and they continuously cut fresh grasses throughout the incubation period. It helps them to improve the height of the nest against the surrounding water level rise which was a protection strategy from nest submerging (Plate 2b). Whereas, in Sanetti Plateau they built nests on islands where the surrounding area was full of water. The islands were fully surrounded by shallow water where the parents can walk through and was a perfect strategy against predators especially mammals. In these islands, vegetation cover and height were too low compared to the nests in the wetland habitats of the Sodota area. Moreover, in one island, nest was built by digging the ground to create a slightly depressed central portion but with little grass roots of *Koeleria capensis*, *Alchemilla pedata* and some of its weathered feathers to create comfort. However, on the other island, construction of nest was using residual vegetation of dried *Kniphophia foliosa*, herb of *Cotula abyssinica* and grasses of *Koeleria capensis*. In general, in both areas and during the whole three breeding seasons, Wattled Cranes have used five nesting materials *Luzula abyssinica*, *Koeleria capensis*, *Cotula abyssinica*, *Kniphophia foliosa* and *Alchemilla pedata* (Table 4). *Koeleria capensis* was the nesting material which was used in all nests by Wattled Cranes to build their nests and occurring in high proportion in almost all nests.

The two islands used for nesting were different in size. The larger island measured 72 m^2 and the smaller island 24.75 m^2.

A. Island nest B. Wetland nest

Plate 2: Location of different nests in different sites of the Afroalpine habitat

Table 4: Nest materials and their proportion used by Wattled Cranes (Sa= Sanetti and So= Sodota)

Year	Area	Nest_Id	Nest material	Percentage (%)
2015	Sanetti	Sa_N1	*Koeleria capensis*	80
			Alchemilla pedata	20
	Sodota	So_N2	*Luzula abyssinica*	78
			Koeleria capensis	22
2016	Sanetti	Sa_N3	*Koeleria capensis*	90
			Alchemilla pedata	10
		Sa_N4	*Koeleria capensis*	55
			Kniphophia foliosa	40
			Cotula abyssinica	5
		Sa_N5	*Koeleria capensis*	55
			Kniphophia foliosa	40
			Cotula abyssinica	5
	Sodota	So_N6	*Koeleria capensis*	20
			Luzula abyssinica	80
2017	Sanetti	Sa_N7	*Koeleria capensis*	100
		Sa_N8	*Koeleria capensis*	55
			Kniphophia foliosa	40
			Cotula abyssinica	5
	Sodota	So_N9	*Koeleria capensis*	30
			Luzula abyssinica	70

3.1.2.2. Nest morphometry

Mean nest length was 78.22±14.75 cm, n=9 with a range 40-140 cm. Mean nest width was 74.00±8.73 cm, n=9 ranging from 52-130 cm and the mean nest height from the surrounding water surface was 41.89±51.89 cm n=9 ranging from 20-78 cm (Table 5).

Table 5: Nest diametric (nest morphometry) measurements in the two breeding microhabitats of Afroalpine habitat

		Nest diametric (cm)			
Breeding area (microhabitat)	Sample (n)	Nest length (mean ± SE)	Nest width (mean ± SE)	Nest height from the water surface (mean ± SE)	Water depth around the nest (mean ± SE)
Sanetti	3	79.00±17.88	74.00±7.31	47.83±6.06	81.33±9.22
Sodota	6	108.33±29.20	80.67±24.77	30.00±5.77	79.33±28.29

In Sodota area, nests were built on wetlands in which the mean nest length, width and height from the surrounding water surface was 80.67±24.78 cm, n=3, 76.67±31.80 cm, n=3 and 30.00±57.74 cm, n=3, respectively. However, in the Sanetti Plateau, nests were built in a perfectly situated islands with the mean nest width, length as well as nest height from the surrounding water surface, 70.67±7.31 cm, n=6, 79.00±17.88 cm, n=6 and 47.83±6.06 cm, n=6, respectively (Table 5). Maximum nest length was recorded on the wetland of Sodota area with a measurement of 140 cm in 2015 and minimum nest length of 40 cm was also recorded in the same area but in 2016. On the other hand, maximum nest width (52 cm) and the maximum nest height from the surrounding water surface (130 cm), were recorded in Sanetti Plateau in 2017 and in Sodota area in 2015, respectively. However, the minimum or shortest nest width (40 cm) and the minimum nest height from the surrounding water surface (30 cm) was recorded in Sanetti Plateau in 2016 and Sodota area in 2015, respectively.

Using Independent Sample Mann-Whitney *U* test, the nest morphometry parameters showed no significant variation in nest length (U= 8, df= 1, P= 0.905) and width (U= 7.5, df= 1, P= 0.174), between the two microhabitats. However, there was significant variation with regard to the nest height from the surrounding water surface with (U=8, df= 1, P= 0.048), where the mean nest height (47.83±6.06 cm) from the surrounding water surface on island nests in Sanetti was higher than the nest height from the surrounding water surface of wetland nests (30.00±5.77 cm).

The mean water depth around the nest was 80.33±10.11 cm ranging from 30 to 128 cm. There was significant variation in the water depth surrounding the wetland between the two microhabitats (U=9, df= 1, P= 0.524) where the water depth on island nests of Sanetti Plateau was higher (81.33±9.22 cm) than the water depth in wetland nests of Sodota area (79.33±28.29 cm) (Table 5).

Nest height from the surrounding water surface and water depth relationship was observed using a Spearman's rho and there was a negative correlation between the two variables even if their relationship was weak (R= -0.270, P= 0.483).

Nest concealment in Wattled Cranes was rated as poor (44.4%, n=9), fair (44.4%, n=9) and excellent (11.1%, n=9) (Fig. 8). This indicates that the majority of nests had poor and fair nest concealment rate, but with very few nests having excellent nest concealment rates.

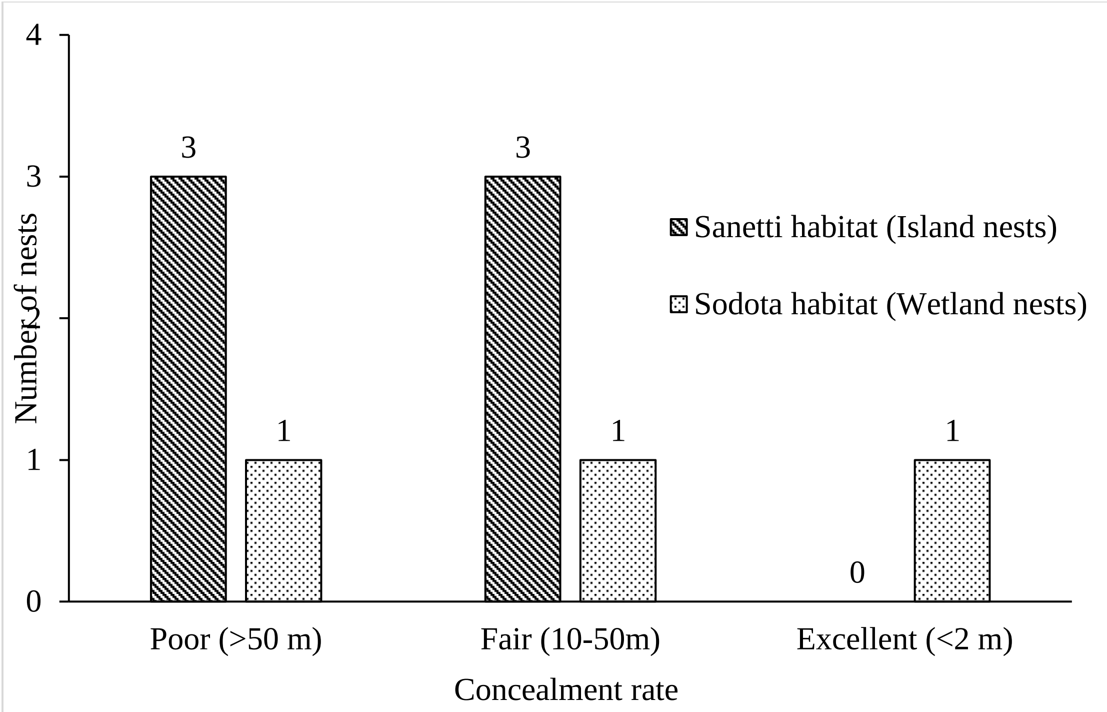


Figure 8: Nest concealment rate in the Afroalpine habitat

3.1.3. Clutch size and egg morphometric measurements

3.1.3.1. Clutch size

In the Afroalpine habitats of BMNP, a total of nine nests were constructed where, (11.1%), (44.4%) and (44.4%) were constructed in August, September and October, respectively and all the nine nests had eggs. Duration of nest construction and initiation of first clutch of eggs were from August to October. However, records of first or last clutch were not found either in the months of July or November (Fig. 9).

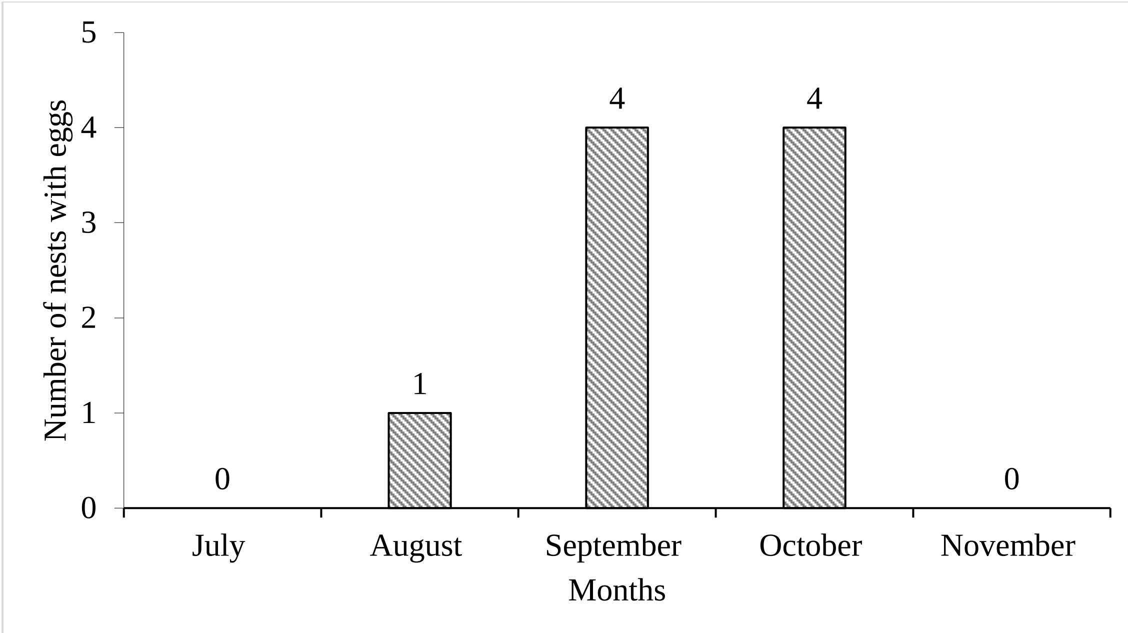


Figure 9: Nests constructed and the first clutch recorded

The clutch size in two nests (22.2%) was one, whereas the clutch size in the other seven nests (77.77%) was two. However, there were no nests found with a clutch size of three (Fig. 10) and the mean clutch size in the study area was 1.78±0.15 eggs per nest.

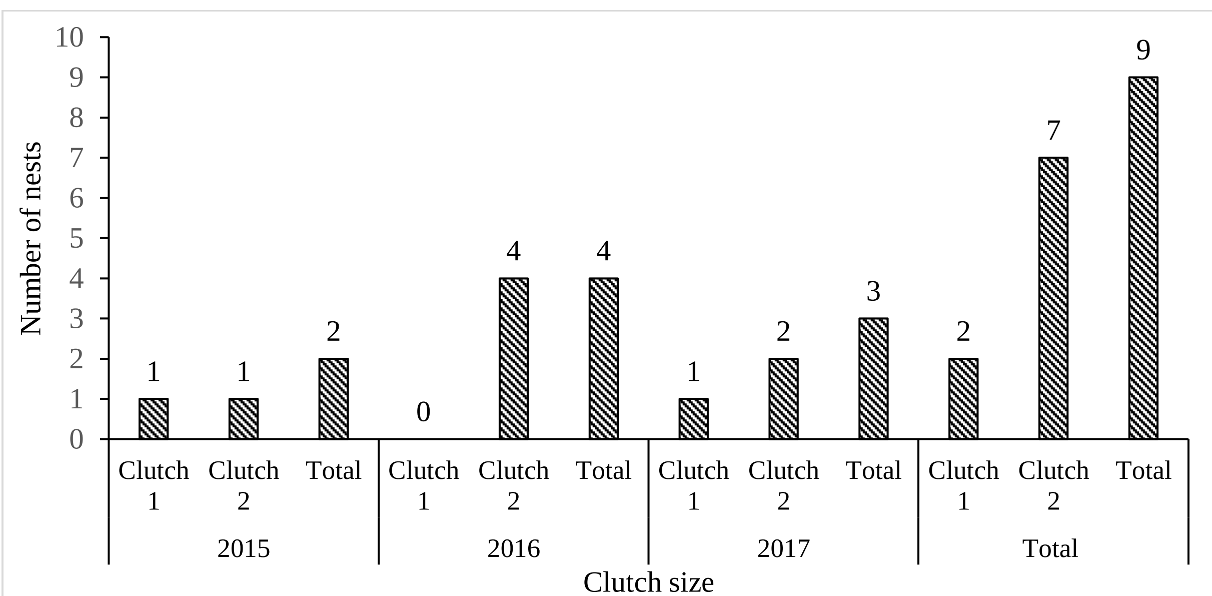


Figure 10: Clutch size and eggs laid during the study period

3.1.3.2. Egg morphometry

During the field survey, the shape of the eggs was found to be long and oval with little variation in size. Within the nine active nests located, the diametric of 16 eggs were recorded and the measurement showed that the mean egg length was 93.11±1.29 mm ranging from 87-101 mm. The mean egg width was 65.07±0.34 mm with a range of 59-71 mm as well as mean egg weight was 250.69±4.73 g ranging from 218-281 g (Table 6).

Table 6: Egg morphometry of Wattled Cranes (2015-2017)

Year	Particulars	n	Egg length (mm)	Egg width (mm)	Egg weight (g)
2015	Mean ± SE		94.67±4.10	61.0±1.16	245±17.90
	Range	3	87-101	59-63	221-228
2016	Mean ± SE		93.38±1.72	65.38±0.75	250±7.27
	Range	8	85-99	63-68	218-281
2017	Mean ± SE		91.75±2.41	67.02±1.72	255.20±3.77
	Range	5	85-99	62-71	241-261
2015-2017	Mean ± SE		93.11±1.29	65.07±0.34	250.69±4.73
	Range	16	85-101	59-71	218-281

There was no significant difference in egg length (x^2 = 0.826, df = 2, P= 0.688) and weight (x^2 = 0.575, df = 2, P= 0.771), but there was a variation in egg width (x^2 = 6.074, df = 2, P= 0.037) during the three breeding seasons (Table 7).

Table 7: Kruskal Wallis Test, on egg diametric variation among the three breeding seasons of Wattled Cranes

Variables	Mean ± SE	df	x^2	Sig
Egg length (mm)	93.11±1.29	2	0.826	0.688
Egg width (mm)	65.07±0.34	2	6.074	**0.037**
Egg weight (g)	250.69±4.73	2	0.575	0.771

The mean egg length in the Sanetti Plateau of the Afroalpine habitats, was 93.25±1.668 mm ranging from 85 to 101 mm (n = 11). Mean egg width was 64.83±1.007 mm ranging from 59 to 70 mm (n = 11). Whereas, mean egg weight was 246.00±6.05 g ranging from 181 to 218 g (n = 11). But, the mean egg length in Sodota area was 92.80±2.15 mm ranging from 87 to 99 mm (n = 5), mean egg width 65.60±1.66 mm ranging from 61 to 71 mm (n = 5). The mean egg weight was 261.00±5.32 g ranging from 248 to 280 g (Table 8). However, with respect to the two habitat types there was no significant variation in mean egg length (U = 24, df = 1, P= 0.724) and weight (U= 17, df = 1, P= 0.253). In addition, there was also no significant variation in egg width (U = 24, df =1, P= 0.762).

Table 8: Egg diametric of Wattled Cranes in Sanetti and Sodota habitats of BMNP

Year	Particulars	n	Egg length (mm)	Egg width (mm)	Egg weight (g)
Sanetti	Mean ± SE		93.25±1.668	64.83±1.007	246.00±6.053
	Range	11	85-101	59-70	218-181
Sodota	Mean ± SE		92.80±2.154	65.60±1.661	261.00±5.320
	Range	5	87-99	61-71	248-280

Egg Shape Index and Egg Volume was calculated from freshly laid eggs or from three clutches whose egg laying sequences was known through continuous follow-up. The egg sequence in the diametric data below (Table 9) shows that the first egg in the clutch was larger than the second egg in the same clutch. The mean difference in egg length, width and weight between the first and second eggs in the clutch was 5.67±0.43 mm, 3.00±1.15 mm and 7.00±-0.84 g, respectively. In addition, the mean difference in egg volume and ESI between the first and second egg in the clutch was 30.97±4.48 mm^3 and -1.18±2.59, respectively.

Table 9: Egg diametric with reference to the sequence in clutch

Year	Egg length (mm)		Egg width (mm)		Egg weight (g)		Egg Volume (cm^3)		ESI	
	1st Egg	2nd Egg	1st Egg	2nd Egg	1st Egg	2nd Egg	1st Egg	2nd Egg	1st Egg	2nd Egg
2016	96	89	64	66	234	221	200.54	197.72	66.67	74.16
2016	90	85	68	63	281	267	212.24	172.06	75.56	74.12
2017	94	89	71	65	255	261	241.67	191.77	75.53	73.03
Mean	93.33	87.67	67.67	64.67	256.67	249.67	218.15	187.18	72.58	73.77
SE	1.76	1.33	2.03	0.88	13.59	14.44	12.23	7.76	2.96	0.37

3.1.4. Breeding performance

3.1.4.1. Nest account

From the total of nine nests recorded, only six (66.67%) have hatched one chick each, whereas the other three (33.33%) were destroyed due to the different factors. Re-nesting ability was not detected or recorded following the nest destruction due to various reasons.

An empty nest (nests with abandoned eggs but no incubating Wattled Cranes) due to abandonment and/or predation of birds of prey was the most common evidence of nest failure. Nest failure in 2015 was 0%, 25% in 2016 and 66.7 % in 2017 (Table 10). Nest predation by birds of prey or Thick-billed raven (*Corvus crassirostris*) was (1, 11.1%), mammals 0% and due to unknown factors (2, 22.2%) (Table 9). During the observation in 2016, Thick-billed raven arrived at the nest in Sanetti area when the incubating female moved 20 m far from the nest just for frequent feeding and the raven flew over the nest and started smashing the egg with its beak. However, before feeding on the broken egg, the Wattled Crane came back and chased away the raven. After sometime, Wattled Crane started feeding on its own broken eggs yolk and cleaned the area by removing the egg shells to the lake. Then it continued incubating the other unbroken egg. But, after two days of incubation, it abandoned the other egg too.

Table 10: Percentages of nest failure

Year	Total nests found	Primary causes of failure			Total failure (% of failure)			
		Abandonment	Predation	Others	Birds of prey	Mammal	Unknown	Total
2015	2	0	0	0	0	0	0	0
2016	4	0	1	0	25	0	0	25
2017	3	2	0	0	0	0	66.7	66.7

3.1.4.2. Egg mortality

Out of the total of nine nests, measurements of 16 eggs were recorded. Except in two nests, all the other nests had clutch of two eggs. Egg mortality was quite high (10, 62.5%) due to the varying external factors (egg mortality includes those eggs even destroyed or predated after first chick was hatched). A total of six eggs (62.5%) failed to hatch either due to the abandonment of the second egg after their first egg hatched or due to abandonment of the whole nest (Table 11). Whereas, two out of 10 eggs (20%) were destroyed by Thick-billed raven in 2016. However, the other eggs were destroyed by unknown factors most probably predated by Thick billed raven. Flooding was not a factor for egg mortality in either of the two microhabitats. But, one abandoned egg was collected after the pair hatched its first egg and left the other egg.

3.1.4.3. Hatching success

Incubation period was not estimated for those nests (six nests) found or located late and were excluded from the analysis. However, incubation period of three nests were well recorded. The mean incubation period of the three nests was 34.33±1.2 days with maximum incubation period of 36 days and minimum incubation period of 32 days both in 2016.

From the total of 16 eggs laid and recorded, only six eggs (37.5%), were hatched successfully (Table 11). From those six chicks hatched, no chicks were killed or predated. However, several attempts were made by Tawny eagle (*Aquila rapax*) to take the young Wattled Crane in 2015 and 2016 but defended by parents. Independent Mann-Whitney *U* test showed that there was no significant variation in the hatching success of Wattled Cranes between the two microhabitats (U = 4.50, df = 1, P = 0.262).

3.1.4.4. Fledgling success

In the study area, all the six chicks hatched successfully flew to their wintering habitat. In this regard, the fledging success was 100%. This indicates that there was no variation in the fledging success of Wattled Cranes with regard to the year of the breeding season. Moreover, survival of six chicks to fledging level from the total of 16 eggs laid indicated that the breeding success of Wattled Crane was 37.5 %.

Table 11: Breeding performance of Wattled Crane

Variables	2015		2016		2017		Pooled	
	No.	%	No.	%	No.	%	No.	%
A. Nest								
1. Total nest	2		4		3		9	
2. Nest where clutch was destroyed	0	0	1	25	0	0	1	11.11
3. Nest with one chick	2	100	3	75	1	33.33	6	66.67
4. Nest where clutch failed to hatch	0	0	0	0	2	66.67		22.22
B. Egg								
1. Total egg laid	3		8		5		16	
2. Egg mortality	1	33.33	5	62.5	4	80	10	62.5
a. Predation	0	0	2	25	0	0	2	20
b. Failed to hatch	1	33.33	3	37.5	2	40	6	60
c. Unknown reason	0	0	0	0	2	40	2	20
C. Chick								
1. Total chicks hatched	2		3		1		6	37.5%
2. Chick mortality	0	0	0	0	0	0	0	0
a. Predation	0	0	0	0	0	0	0	0
b. Unknown reason	0	0	0	0	0	0	0	0
B. Fledged	2	100	3	100	1	0	6	100

3.1.5. Nest sight fidelity and nesting density

In Sodota area, Wattled Cranes nested in the same wetland habitat with little difference in the specific nest location of previous nesting habitat. However, in Sanetti area, they nested at the same location of two islands, year after year during the three breeding seasons. In one of the islands, they have nested for three consecutive breeding seasons on the same location of the island. The same was true in the second island, where pairs of Wattled Cranes have nested twice on the same island location in 2016 and 2017. There was a high percentage (66.67%) of nest fidelity in the species. But, not sure whether the breeding pairs were similar over the breeding seasons since pairs were not ringed.

In 2015, a total of two pairs nested in the Afroalpine habitat, one in Sanetti and one in Sodota and the nesting density in the study area was two nests per 3,585 ha. In 2016, a total of four pairs with eggs were recorded, three in Sanetti area and one in Sodota, where the total nesting density was four nests per 3,585 ha, three nests per 2,305 ha in the Sanetti area and one nest per 1,280 ha in Sodota. On the other hand, in 2017, three nests with eggs were recorded with two pairs recorded in the Sanetti area and one in Sodota area, with a nesting density of two nests per 2,305 ha and one nest per 1,280 ha, respectively.

3.1.6. Chick defending strategy in Wattled Cranes

In the Alpine habitat, Wattled Cranes were observed using different strategies to defend their young. One strategy was direct confrontation, which was observed in 2015 in the Sanetti Plateau when Tawny eagle (*Aquila rapax*) tries to snatch their chick. Then, one tried to defend the enemy by flapping up or jumping and chasing the prey. At the same time, the other led the young to hide it inside a *Helichrysum formasisium* shrub which they used it as a hiding spot (Plate 3a). Camouflaging was another strategy used from the early stage of hatching till they were able to fledge. During the early stage of one to two weeks of age, parents hide their young when they move to feed into distant area, as chicks were unable to move long distances at this stage. They hide them in a grass called *Charex monostachya* which was very similar in color (brown) with the chick (Plate 3b and c). Then when the chicks grow older, the color changes and can move with their parents, but unable to run which makes it susceptible to predators and others like humans. At this stage, when they notice danger, they hide their young inside a shrub called *Helichrysum splendidum* which is very difficult for the predator to detect, because of camouflaging color of the young with the shrub color (Plate 3d). However, if the enemy gets closer to the place where they hide their young, they produce a loud and elongated intimidation call by both pairs to deter or distract the enemy.

A. Pairs with their chick under *Helichrysum formasisium*

B. Pairs with their chick under *Charex monostachya*

C. Pairs with young chick in *Charex monostachya*

D. Pairs with a young chick in *Helichrysum splendidum*

Plate 3: Wattled Cranes with their chicks on the natural habitat of Sanetti Plateau chicks encircled by red

3.2. Population and distribution

Wattled Cranes in Boyo wetland were recorded in all months of the year, except in the months of July to September. The result showed that in the wetland, the mean monthly total population size of Wattled Cranes recorded was 93.63±4.25 individuals (Fig. 11) with the highest number (139 individuals) recorded in March and minimum of 48 in June. Mean population size of 88.61±5.86 individuals (range 53-154) were recorded in winter 2015/2016 and 90.22±6.23 individuals (range 43-146) were recorded in 2016/2017 (Fig. 12). However, the population size was not significantly different during the two-wintering periods ($t = 0.188$, $df = 1$, $P = 0.85$).

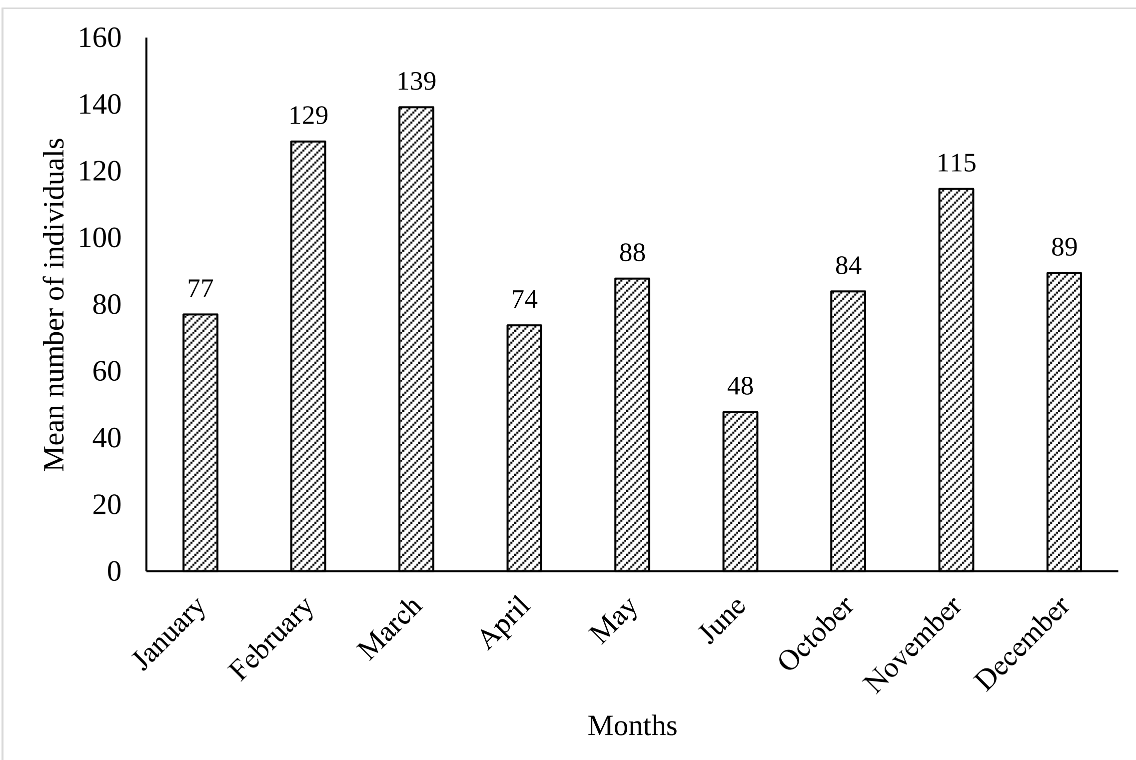


Figure 11: Mean population size of Wattled Crane in Boyo wetland (2015/16 and 2016/17)

The mean maximum monthly population size was recorded in the month of March 2016 with a mean of 141.5±5.21 and 136.75±3.61 individuals in March 2017. On the other hand, on a monthly basis, few cranes were recorded in the month of October with a mean of 49.5±6.4 individuals in 2016 and 42.5±19.42 in June 2017.

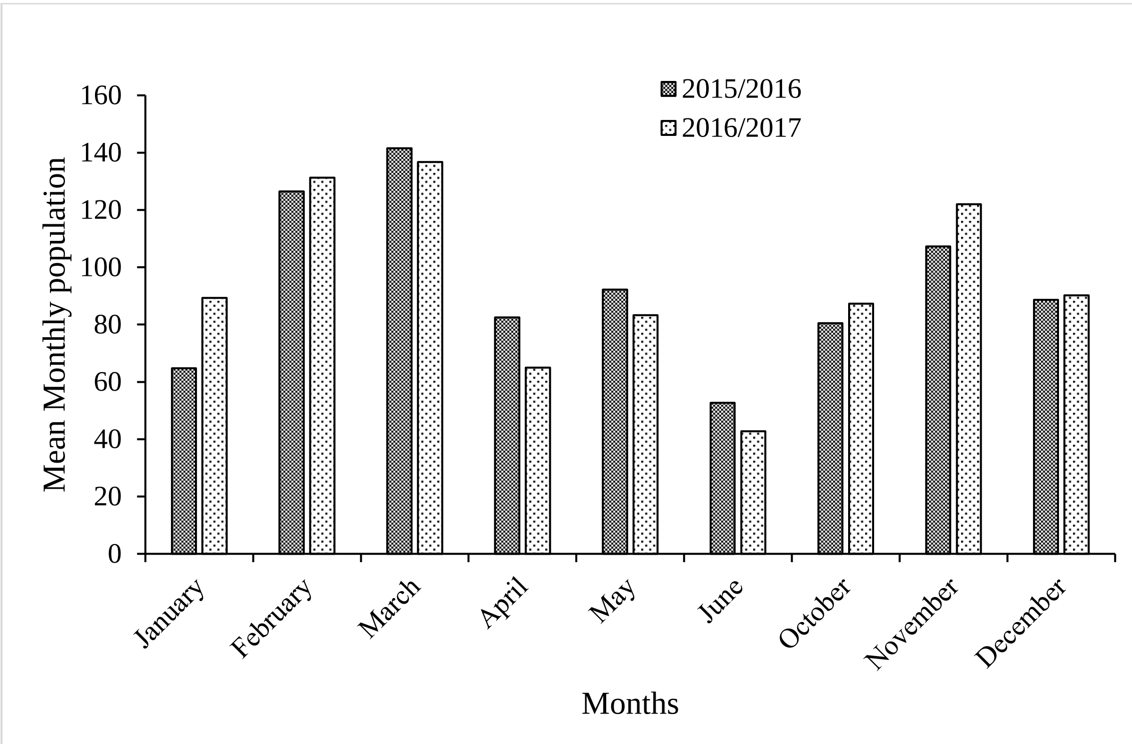


Figure 12: Mean monthly population size of Wattled Crane in Boyo wetland in winter 2015/2016 and 2016/1017

The mean monthly number of juveniles recorded in the study area was 1.41±0.25 (range 0-5), with the highest number of juveniles (five) recorded in May 2016 and March 2017 (Fig. 13). Moreover, the mean monthly number of juveniles recorded in the year of 2015/2016 and 2016/2017 was 1.42±0.247 (range 0-5) and 1.67±0.285 (range 0-5), respectively. However, the number of juveniles did not show any significant difference between the two wintering periods (t=0.664, df= 1 P= 0.509). In the months of October and November, juveniles were not recorded. This indicates that breeding Wattled Cranes did not started arriving to their wintering habitat (Boyo wetland).

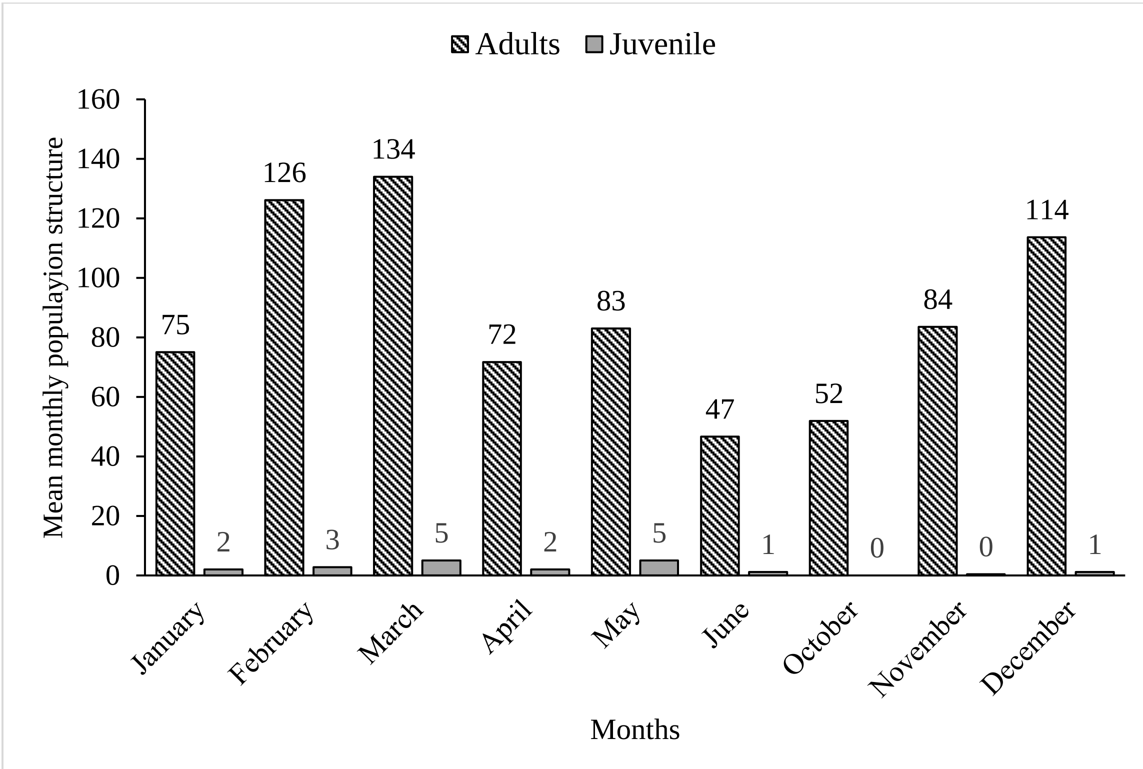


Figure 13: Mean monthly population structure of Wattled Crane in Boyo wetland (2015/16 and 2016/17)

Most of the time, Wattled Cranes spent their time feeding on the farmland. However, in the mid-day, they return back to the wetland for mid-day roosting and drinking then return again back to the farmland area for afternoon feeding. Starting from the late afternoon they start coming back to their roosting site in the shallow wetland for night roosting.

The population in the wetland was not uniform throughout the year, rather it fluctuates from month to month. The number gradually increases starting from the first week of October to March and shows a sharp decline in April and then in May it increases slightly.

Finally, it starts to decline beginning in June and the number of individuals in July and August becomes zero.

In March 2017, following an aerial survey for commercial flight from BMNP to Addis Ababa with International Crane Foundation cofounder, we observed a flock of Wattled Cranes at the shallow part of the Melka Wakena Hydroelectric dam, which was not known as a distribution area of Wattled Cranes before. Following this new discovery, ground observation and census was made in March 28/2017. During this time period, a total of 169 individuals of Wattled Cranes (160 adults and 9 juveniles) were recorded within a single count. This discovery indicated that the estimated population of the species in Ethiopia might be higher than predicted by many authors for decades. Then, to estimate the total population of the species in the CRV, a comprehensive survey was conducted soon following the new discovery both in April and May 2017. The survey revealed that the population of Wattled Crane in the CRV area was 319 individuals in the month of April and 241 individuals in the month of May (Table 12). Therefore, the estimated population of Wattled Crane during this study period was closer to the predicted population size, but with slight increase.

Table 12: Total population estimate of Wattled Crane in CRV

Census period	Boyo	Melka Wakena	Archuma	Chuche	Wanchicho	Mendifa	Gololcha
Second week April 2017	78	169	16	0	38	6	12
Second week May 2017	123	0	43	15	41	8	11

During the wet season, the population size recorded in BMNP was three pairs (six) in 2015, four pairs (eight) in 2016 and another three pairs (six) in 2017.

3.3. Diurnal time-activity budget

In both Boyo wetland and BMNP combined, a total of 452 focal observations or individuals representing 2,226 minutes or 37.1 hours were gathered. A total of 134 (29.6%) focal observations were conducted in the agricultural field whereas 102 (22.6%), 105 (23.2) and 111 (24.6) focal observations were made in the mudflat, grassland and shallow wetland habitats, respectively.

Wattled Cranes spent most of their time to foraging (39.3%) with a mean of (7.74±0.59) ranging from 0-20 per 5 minutes. For locomotion they spent 20% of their time either for looking food or other type of movements. The least time was spent on social behavior, which accounted 2% with a mean of 0.3 ± 0.11 and the rest of their time was allocated for resting and comfort movement (Table 13).

Table 13: Activity-time budgets of Wattled Cranes in Boyo and BMNP

Behavior	Total number of Activity	Percentage (%)	Mean	Range per 5 minutes interval
Foraging	3500	39.3	7.74±0.59	0 - 20
Locomotion	1775	20	3.93±0.04	0 - 20
Vigilance	1378	15.5	3.05±0.35	0 - 20
Comfort movement	1289	14.5	2.85±0.49	0 - 20
Resting	824	9.2	1.82±0.40	0 - 20
Social behavior	134	1.5	0.3±0.11	0 - 15

In Boyo wetland the daily pattern or percent of time spent foraging and locomotion showed two peaks, in the agricultural habitat and grassland habitats, whereas they spent less time foraging in the mudflat and shallow wetland habitats. Percent time devoted to vigilance, resting and comfort movement followed an inverse pattern, peaking at mudflats and shallow wetland when Wattled Cranes gathered at drinking and roosting sites and less time spent for the above activities in the agricultural and wetland habitats when they were feeding in the areas (Table 14). If each activity was considered in relation to the four different habitat types, there was a significant variation in frequency of foraging activity, resting, comfort movement, vigilance and locomotion of Wattled Cranes among the four habitat types with the value of ($x^2_{(3)}$ = 35.728, P= 0.000), ($x^2_{(3)}$ = 39.682, P= 0.000), ($x^2_{(3)}$ = 56.287, P= 0.000), ($x^2_{(3)}$ = 12.108, P= 0.007) and ($x^2_{(3)}$ = 43.400, P= 0.000), respectively. However, there was no significant variation in the activity level of social behavior (x^2 $_{(3)}$ = 6.157, P= 0.104), among the different habitat types of the study area.

Table 14: Time budget of Wattled Crane across the different habitat types at Boyo wetland

Behavior		Habitat type			
		Agricultural habitat	Shallow wetland	Grassland	Mudflat
Foraging	Mean	9.97 ± 0.86	5.40 ± 1.16	8.44 ± 1.26	6.66 ± 1.34
	Range	0-20	0-20	0-20	0-20
Locomotion	Mean	5.51 ± 0.76	2.65 ± 0.77	4.10 ± 0.89	3.05 ± 0.77
	Range	0-20	0-20	0-20	0-20
Vigilance	Mean	3.14 ± 0.76	3.76 ± 0.95	2.03 ± 0.48	3.21 ± 0.82
	Range	0-13	0-20	0-29	0-20
Comfort movement	Mean	0.49 ± 0.52	4.83 ± 1.09	2.75 ± 1.02	3.90 ± 1.23
	Range	0-12	0-20	0-20	0-20
Resting	Mean	0.69 ± 1.23	2.72 ± 0.77	2.21 ± 1.00	1.94 ± 0.91
	Range	0-20	0-20	0-20	0-20
Social behavior	Mean	0.13 ± 0.13	0.53 ± 0.28	0.34 ± 0.30	0.21 ± 0.19
	Range	0-8	0-8	0-15	0-8

Time spent for foraging (x^2 $_{(2)}$ = 40.037, P = 0.000), resting (x^2 $_{(2)}$ = 52.483, P = 0.000), comfort movement (x^2 $_{(2)}$ = 30.866, P = 0.000), vigilance (x^2 $_{(2)}$ = 23.180, P = 0.000) and locomotion activity (x^2 $_{(2)}$ = 24.489, P = 0.000), showed a significant difference with the time blocks of the day or showed a rhythm within a day. In this case, most often foraging activity occurred or peaked in the morning (06:00 - 10:00 h) and least during the afternoon

(14:00 - 18:00 h). Contrary to this, the rhythm for resting and comfort behaviors were mostly frequent during the afternoon than the morning and mid-day. Moreover, rhythm of vigilance behavior was peaked in the morning and then decreased at the mid-day finally reached its lowest level in the afternoon. However, locomotion activity was significantly higher in the morning than mid-day and afternoon. The time spent for preening becomes high as birds come to roost and aggregate together for overnight roosting and during the mid-day when they came back for drinking and mid-day roosting (Fig. 13).

With regard to time spent on social behavior, the variation was not significant across the time period of the day ($x^2{}_{(2)}$ = 4.778, P = 0.092), even if the frequency of time spent for the social behavior was higher during the afternoon than morning and the mid-day.

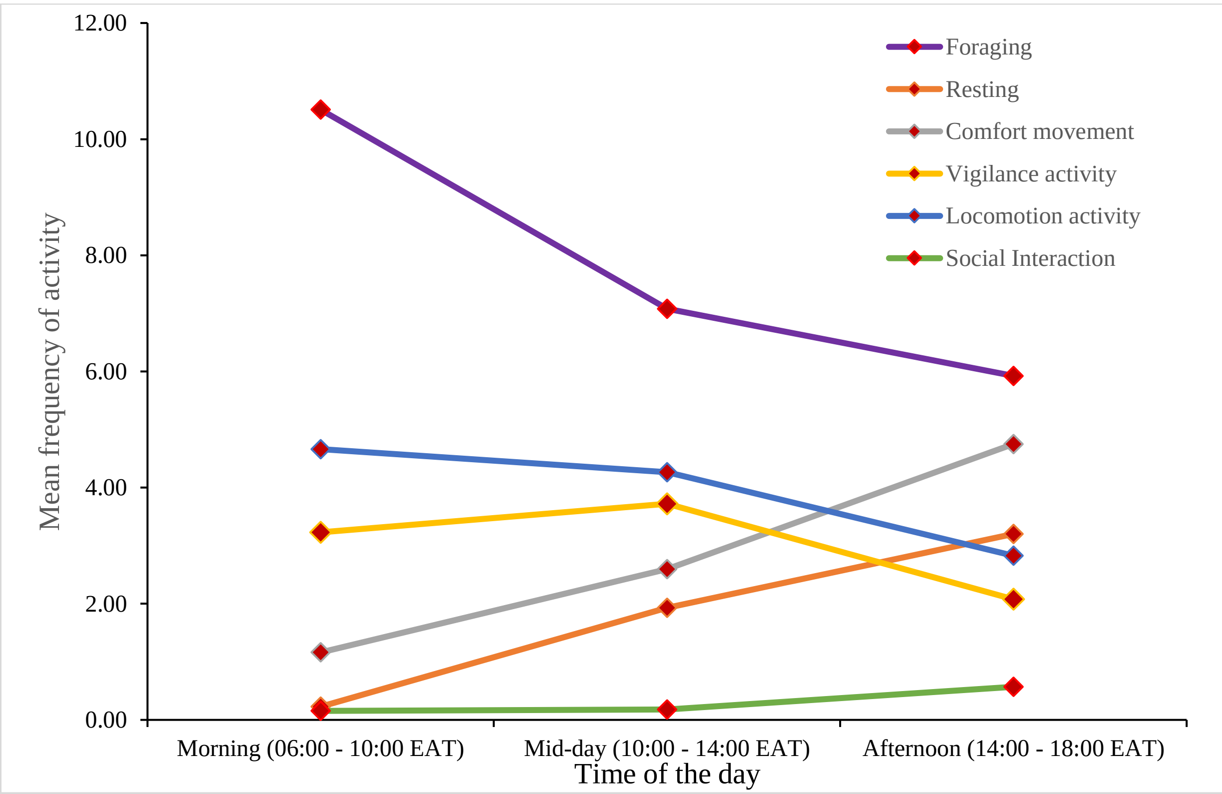


Figure 14: Mean frequency of different behavior types during the day in Boyo and BMNP

Independent Mann-Whitney *U* test showed that, foraging behavior significantly varied between seasons (U= 22,325, P= 0.025). Foraging was most prevalent during the breeding time or wet season (8.42 ± 0.83) than the dry season (7.16 ± 0.83). In addition, the observed frequency of vigilance behavior was significantly greater during the wet season (3.83 ± 0.58) than the dry season (2.38 ± 0.40) with (U= 19,797, P= 0.000). However, the time spent for comfort movement and resting was higher during the dry season than during the wet season with (U= 22,857, P= 0.034) and (U= 22,702, P= 0.009), respectively (Fig. 14).

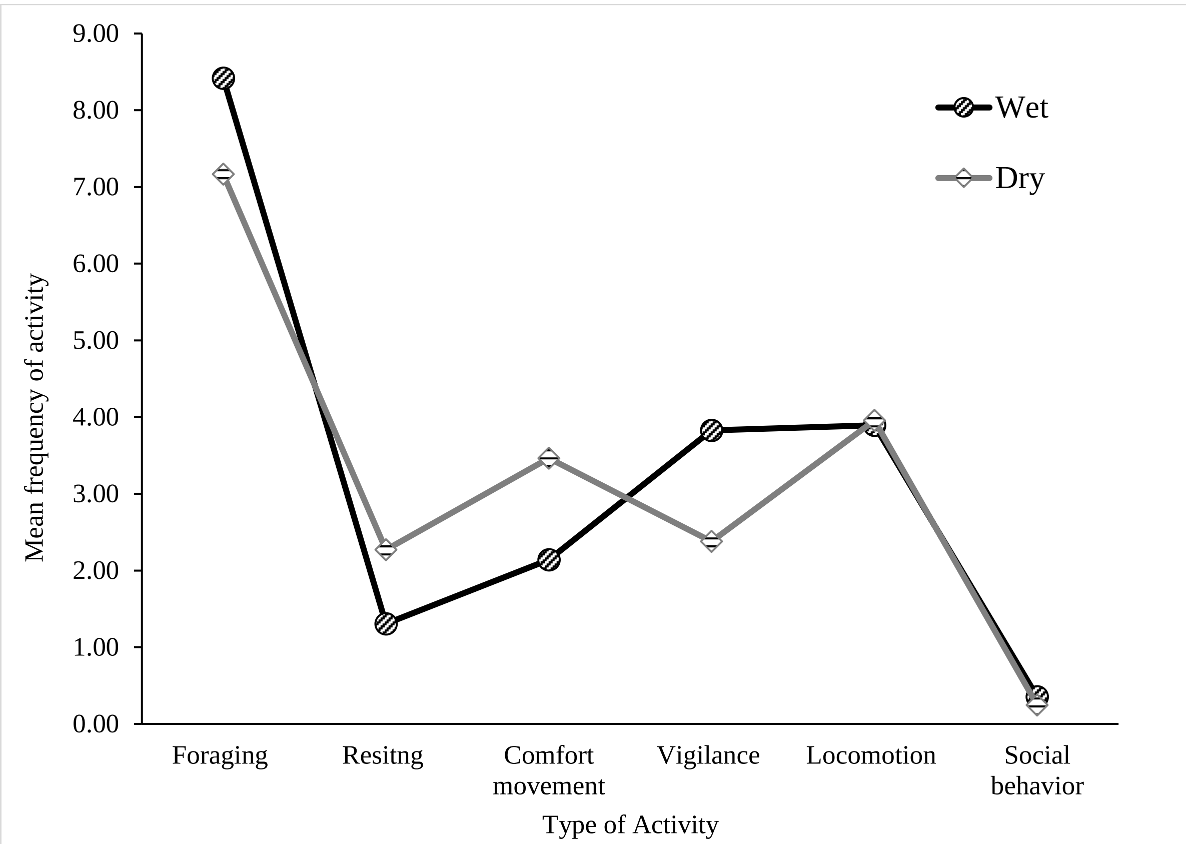


Figure 15: Mean frequency of different activity types of Wattled Crane at different seasons

A total of 452 flocks were observed during the study period and the mean flock size was (4.67± 0.44) range (2-29). Significant difference in flock size was observed among the habitats types in the study area ($x^2{}_{(3)}$ = 13.1, P = 0.005), where the flock size in the shallow water or wetland habitat was large (6.48 ± 0.41) compared to the flock size in the other habitat types (Fig. 15).

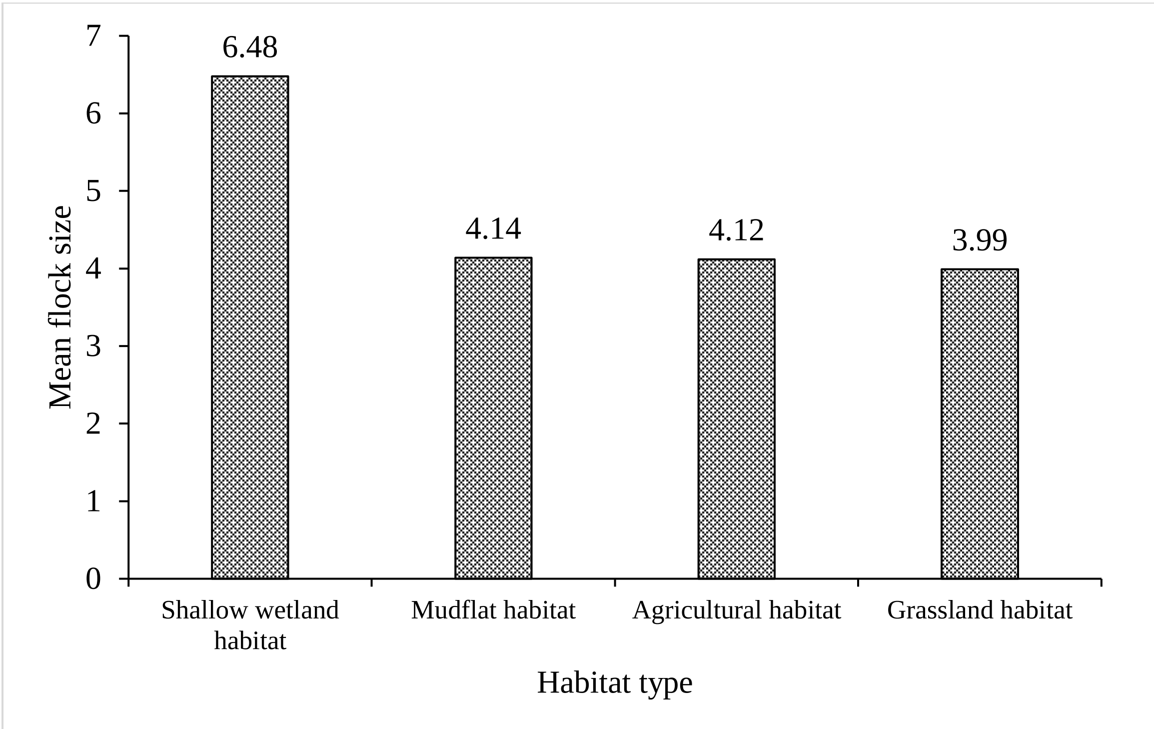


Figure 16: Variation in flock size of Wattled Cranes across the four habitat types

Flock size was also significantly different ($x^2_{(2)}$ = 6.55, P = 0.04) across the three-time categories of the day, where the mean flock size in the afternoon was (6.44 ± 1.15) range (2-29) was much greater than the mid-day (3.42 ± 1.22) range (2-24) and morning (2.04 ± 0.343) range (2-11) (Fig. 16). Similarly, significant observation was also observed in flock size among the three-time periods, where flock size was very much larger in the afternoon than the morning and mid-day time periods.

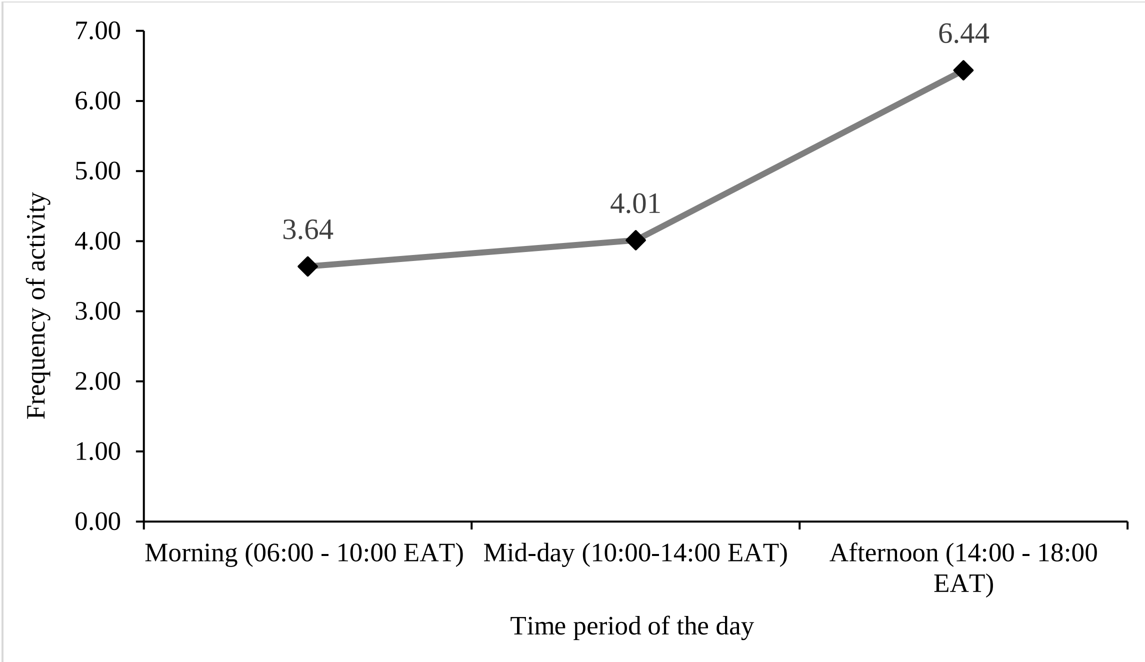


Figure 17: Variation in flock size of Wattled Cranes across the three-time periods

Independent Sample Mann-Whitney *U* test showed that, there was significant variation in flock size between the dry and wet seasons (*U*=32,377, P= 000). The mean flock size during the dry season was 5.67 ± 0.713 which is very much greater than the wet season 3.14 ± 0.425. When flock size was considered, there was negative correlation with vigilance behavior (r^2 = -0.145, P= 0.002). As flock size increases the time spent for vigilance decreases and vice versa. In addition, flock size was also negatively correlated with foraging, (r^2 = -0.232, P= 0.000) as well as locomotion (r^2 = -0.147, P= 0.002). However, flock size was positively correlated with comfort movement and social behavior with values of (r^2 = 0.223, P= 0.000) and (r^2 = 0.295, P= 0.000), respectively.

During the evening (late afternoon) when Wattled Cranes arrive for roosting from the agricultural area, Wattled Cranes perform a very spectacular kind of courtship behavior by leaping upwards to the sky and tossing objects such as sticks and cattle dung from the ground. During the courtship display, they stretch their wings up and fold it 90º sideways and dance with their leg straight to the ground. This behavior was mostly prominent during the roosting period of the day, soon after landing. However, such types of courtship behavior or activities of Wattled Cane were rarely observed during the winter period even if pair bonding was too high either during the wintering season or during the breeding time.

3.4. Food and foraging behavior

Breeding cranes in BMNP and wintering in Boyo wetland were observed feeding on a wide variety of food items, including various plant parts and rarely on animal parts. However, they were heavily dependent on the different parts of various plant matters such as waste grains, rhizomes, tubers and grass seeds. In addition, the food items they depend upon were very different in composition between habitats and followed a seasonal shift in their diet.

In general, a total of 12 food items (one animal and 11 plant parts) were consumed by Wattled Cranes across the different habitat types and seasons. However, the preference level of each food item was different.

In the agricultural habitats of Boyo wetland, wintering Wattled Cranes mainly fed on four waste grains, maize (*Zea mays*), sorghum (*Sorghum bicolor*), wheat (*Triticum aestivum*) in harvested fields and stubbles as well as in unharvested teff (*Eragrostis tef*) fields during the wintering season. Both cereals were the major cultivated crops by farmers surrounding the wetland. But, they were rarely observed feeding on standing crops of the above food items, rather they were observed frequently pulling on the grain part or gleaning the seed part from standing teff, in which local farmers complain about.

However, during the brief periods of the day when they came back to the wetland from the agricultural habitat, either for a mid-day roosting or night roosting in the wetland, they feed predominantly on the rhizomes and seeds of the dominant grasses of *Eriochloa fatmensis* and *Eriochloa meyeriana* (Plate 4a). When they were feeding on the rhizomes of the above two dominant grasses in the shallow wetland, they submerge their entire head to the water to get access to the food part. But, for those growing in the soft part of a riverbed or in the very shallow part of the wetland, they easily dug the ground and fed on the rhizome. On the other hand, during the month of December, they were observed gleaning on the seed part of these two grasses.

During May, farmers surrounding the wetland start growing maize following a brief rainfall. Then, Wattled Cranes start to feed on the soft root part of a newly planted maize by farmers in the farmlands surrounding the wetland (Plate 4b). In addition, they were also observed feeding on undigested grains from a cattle dung, especially on the backyards of farmers houses where there was collected dung by farmers. In Boyo wetland, apart from feeding on cereals, grass seeds and rhizomes, they were rarely observed feeding on animal parts. However, on two occasions, they were observed feeding on frogs along the riverbed of the wetland. In Boyo wetland, even if they were feeding on various plant and plant matters mentioned above, cereal grains were the most important part of their diet.

a. Rhizome of *Eriochloa fatmensis b.* Newly germinating maize (*Zea mays*)

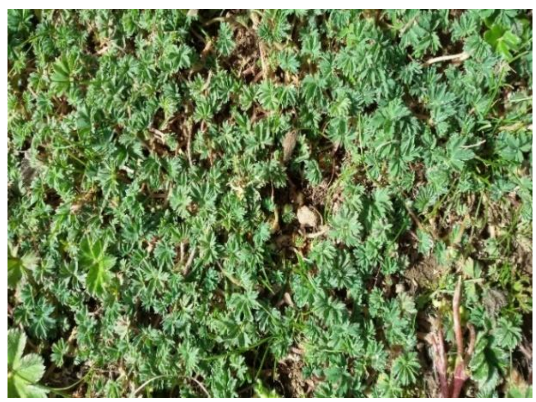
c. unharvested teff (*Eragrostis tef*)

Plate 4: Different food items Wattled Cranes depend upon in Boyo wetland

On the other hand, Wattled Cranes in the Afroalpine habitats were observed feeding on a total of five plant parts; tubers, roots, rhizomes and seeds. They feed on these plant parts mostly by digging out using repeated probing on the soft tubers and roots. Then once the grass or herb is uprooted, they cut the tuber part from the leaf and engulf it. Similar techniques were used also for those plants with soft rhizomes and roots. They feed by gleaning the seed panicles of *Koeleria capensis*, in which they held the seed part at the base of the grass and pull it upward to separate the seeds from the panicle.

A grass of *Romulea fischeri* and herb of *Commelina baghalensis* had tubers where Wattled Cranes depend as the main source of food in the Afroalpine habitat, where they spent most of their time searching and feeding on these two plants (Plate 5, a and b). Similarly, it was feeding on the soft rhizomes of other two herbs, *Alchemilla pedata* and *Cotula abyssinica* (Plate 5, c and d). From the observation, they were predominantly observed feeding on the tubers of *Romulea fischeri* and *Commelina baghalensis* and thus two food items made up the bulk of this bird's diet at BMNP. On the other hand, it was observed feeding on soft roots and seeds of a grass called *Koeleria capensis* (Plate 5e). The *Romulea fischeri* grass mostly grows in a swampy habitat scattered within the *Charex monostachya* grass, which was the most dominant grass species in the breeding territories of the species.

a. Romulea fischeri *b. Commelina baghalensis*



c. Cotula abyssinica *d. Alchemilla pedata*

e. Koeleria capensis

Plate 5: Different food items Wattled Cranes depend upon in the BMNP

However, starting from January, the amount of food available for Wattled Crane in the Afroalpine habitat decreased due to the decline in rainfall and the wetland starts to dry out. During this time period, pairs leave the area to feed on the harvested wheat farmlands located very far from the Park by leaving their prefledged young in the Afroalpine. Apart from this, in its breeding area, it was observed feeding on one animal part or only its own egg after a Thick-billed raven destroyed the egg.

Concerning the foraging behavior in both habitats, Wattled Cranes used two types of foraging techniques; where 61.1% were feeding by dig foraging with a mean of (11.22±0.35) per five minutes and 38.9% were feeding using walk foraging with a mean of (7.13±0.37) per five minutes to obtain food. Independent Sample Mann-Whitney *U* test showed that there was a significant variation between the foraging techniques employed to obtain their food (U= 69302, df= 1, P= 0.000). They use walk foraging when they were wading slowly through the wetland or walk in a grassland and farmlands. Then pick the food items such as grains from the ground in the farmland or from a cattle dung and seeds from the grasses in a wetland. However, they were observed using dig foraging in a shallow wetland and grassland areas both in BMNP and Boyo wetland. In shallow wetland they immersed their entire head and dig for the rhizomes of *Eriochloa fatmensis* and *Eriochloa meyeriana*. To feed on tubers they stationed in one area and dig the tuber vigorously using their beak. However, Independent Sample Mann-Whitney U test revealed that the foraging behavior used was significantly different between the two different habitats, dig foraging (U= 8401, df= 1, P= 0.000) and walk foraging (U= 6680.5, df= 1, P= 0.000). The dynamics of the foraging behavior revealed that, in Boyo wetland, walk foraging was the most important technique used by Wattled Cranes to obtain food from the ground with a mean value of 10.98±0.47 per five minutes. However, they used a dig foraging technique with a mean of 7.81±0.45 per five minutes, when they were feeding in the wetland for a brief period in the mid-day and afternoon or in farmland as maize starts to germinate in May.

Contrary to this in BMNP, they heavily depend on tubers and rhizomes of the Afroalpine wetland and grassland plants. Therefore, they mostly obtain their food through dig foraging (15.76±0.34) per five minutes than using walk foraging (1.99±0.23). This clearly shows that, the variation in foraging techniques used by Wattled Cranes in different habitats was dependent on the type of food items they require. Their long bill and toes and serrated beak were specialized for probing tubers from the swamps and grasslands of the Afroalpine habitat enabling them to access the food source from the ground easily.

Except observations of feeding on frog in two occasions and eggs of its own in one occasion, Wattled Cranes rarely showed indications of chasing either for insects as well as jabbing quickly or repeatedly on something in both habitats. Most of the food items consumed by Wattled Cranes in the wintering and breeding habitats were grains, rhizomes and seeds as well as tubers which are generally considered as plants and plant parts.

Habitat analyses revealed that, among the food items consumed in the Afroalpine habitat, *Koeleria capensis* had the highest mean density 75±6.62 followed by *Romulea fischeri, Alchemilla pedata, Cotula abyssinica* and *Commelina baghalensis* with a mean density of 37.32±2.73, 10.39±2.16, 9.61±3.37 and 6.48±2.73, respectively.

Similarly, *Koeleria capensis* had also the highest mean percentage of ground cover with 17.59±.1.57% followed by *Alchemilla pedata, Romulea fischeri, Cotula abyssinica* and *Commelina baghalensis* with a mean percentage ground cover of 2.16±0.39%, 2.65±0.57%, 1.22±0.43% and 0.61±0.24%, respectively.

The density of food items between in and outside the breeding territories was significantly different for *Romulea fischeri* (t= 2.178, df= 167.57, P= 0.031), *Commelina baghalensis* (t= 2.043, df= 84, P= 0.018) and *Koeleria capensis* (t= 4.984, df= 135.59, P= 0.000). However, there was no significant difference in density of *Alchemilla pedata* (t= 1.611, df= 136.293, P= 0.109) and *Cotula abyssinica* (t= -1.384, df= 102.777, P= 0.169) between the two areas (Table 15).

Table 15: Density of food items (mean±SE) inside and outside the breeding territories

Species name	Mean density (±SE)		df	t	Sig.
	Inside	Outside			
Romulea fischeri	49.93±8.40	24.71±7.98	167.57	2.178	0.031
Commelina baghalensis	12.94±5.38	.01±.01	84	2.043	0.018
Koeleria capensis	106.67±10.70	44.83±6.27	135.595	4.984	0.000
Alchemilla pedata	13.86±3.69	6.93±2.18	136.293	1.611	0.109
Cotula abyssinica	4.97±2.14	14.26±6.36	102.777	-1.384	0.169

*Density= number of food items/0.09 m^2 quadrat

On the other hand, percentage ground cover of the food items recorded was also significantly different for *Commelina baghalensis* (t= 2.379, df= 85.703, P= 0.02) and *Koeleria capensis* (t= 4.809, df= 135.134, t= 0.000) between areas in and outside the breeding territories. However, there was no significant variation in density of *Alchemilla pedata* (t= 0.123, df= 168, P= 0.902), *Cotula abyssinica* (t= -1.310, df= 112.089, P= 0.193) and *Romulea fischeri* (t= 1.001, df= 168, P= 0.318), between the two areas (Table 16).

Table 16: Percentage ground cover of food items (mean±SE) inside and outside the breeding territories

Species name	Mean cover in % (±SE)		df	t	Sig.
	Inside	Outside			
Romulea fischeri	2.55±.44	1.76±.66	168	1.001	0.318
Commelina baghalensis	1.16±.47	.05±.05	85.703	2.379	0.020
Koeleria capensis	24.71±2.56	10.48±1.49	135.134	4.809	0.000
Alchemilla pedata	2.72±.80	2.58±.82	168	0.123	0.902
Cotula abyssinica	0.66±.33	1.78±.79	112.089	-1.310	0.193

On the other hand, the abundance or density and percentage ground cover of the food items in the Afroalpine habitat was influenced by the density of alpine lakes. In this case, the density of the food items such as *Koeleria capensis*, *Romulea fischeri* and *Cotula abyssinica* varied significantly ($F_{(2, 164.92)}$ = 17.03, P= 0.000), ($F_{(2, 100.04)}$ = 6.379, P= 0.002) and ($F_{(2, 55.06)}$ = 3.712, P= 0.031), respectively with respect to the density of alpine lakes. This shows that, the mean density of *Koeleria capensis* (106.67±10.7), *Romulea fischeri* (49.94±8.4) and *Cotula abyssinica* (23.75±10.43) was higher in areas where there was high density of alpine or swampy areas than in the areas with low or moderate lake density. However, the density of *Alchemilla pedata* did not differ significantly with respect to the alpine lakes density ($F_{(2, 165.96)}$ = 1.94, P= 0.147).

Likewise, there was strong relationship or association between the density of the alpine lakes in the Afroalpine habitat and selection of breeding territory ($\chi^2_{(2)}$ = 170, P= 0.000), where there was high lake density in the breeding territory than the outside the breeding territory. In addition, there was also a strong association between lake density and available food items in the Afroalpine habitat ($\chi^2_{(6)}$ = 68.14, P= 0.000), in which there was significantly higher food availability in areas of high lake density than medium and low alpine lake density.

Furthermore, the density and percentage of ground cover of the food items have a relationship with the level of rodent activity in the Afroalpine habitat. The density of *Koeleria capensis*, *Romulea fischeri* and *Cotula abyssinica* varied significantly in relation to rodent activity in the Afroalpine habitat ($F_{(3, 91.62)}$ = 2.83, P= 0.043), ($F_{(3, 82.45)}$ = 3.87, P= 0.012) and ($F_{(1, 44.86)}$ = 6.22, P= 0.001), respectively. However, the density of *Alchemilla pedata* did not vary significantly with respect to the rodent activity ($F_{(3, 75.92)}$ = 2.35, P= 0.079). The mean density of *Koeleria capensis* (111.64±20.38), *Romulea fischeri* (69.44±15.79) and *Cotula abyssinica* (32.58±12.31) was higher in areas where there was low, no rodent activity, respectively than in areas with high and medium rodent activity. Furthermore, there was strong association between alpine lake density and level of rodent activity in the Afroalpine habitat ($\chi^2_{(6)}$ = 38.23, P= 0.000), where in areas where there was high alpine lake density there was low rodent activity and high food availability.

3.5. Wattled Crane and local people interaction in Boyo wetland

3.5.1. Demographic Characteristics of respondents

From the total respondents contacted, 34.3% and 31.3% were in the age categories of 18-30 and 31-40, respectively and the rest were between ages of 41-50 (18.2%) and > 50 (16.2%). The average age of the respondents was 38.8 ± 1.46 years (range 18-90). But, average age of respondents in the four directions or regions of the wetland was not statistically significant ($F_{(3, 95)}$ = 0.426, P = 0.735). The average age of male respondents surrounding the wetland was 38.89±1.8 years (range 21-90) and for females it was 38.69±2.41 years (range 18-81). The Independent Sample Mann-Whitney U test showed no significant variation between gender (U= 1128, P = 0.543).

The majority (62.6%) of the respondents were Muslims. In addition to this, most of the respondents (81.8%) were married. Fairly large number (44.5%) of the respondents never went to school and (36.4%) were attained primary level of education.

3.5.2. Livelihood activities and strategies

The majority of the respondents (89.9%) were dependent on growing crops or crop farming and cattle herding. The major crops grown were maize, wheat, sorghum and teff where, 100% of farmers grow maize, (23.2%) teff, (16.2%) chilli paper, (14.1%) wheat, (7%) sorghum and (2%) grow bean. The average number of crop varieties grown by respondents or farmers surrounding the wetland was 1.28 ± 0.08 crops per farmer (range 0 - 4). The average farm size owned by the respondents was 1.01 ± 0.08 ha (range 0 - 4). However, there was significant difference in the farm size owned by respondents residing in different regions of the wetland ($F_{(3, 95)}$= 4.051, P = 0.01).

The average number of cattle possessed by respondents in the study area was, 11.75 ± 1.14 (range 0-62). There was no statistically significant difference in the number cattle owned by the farmers among the four regions of the wetland ($x^2_{(3)}$ = 1.196, P = 0.754). However, there was a significant difference in the number of cattle in the study area between the year of the study period and two years before ($t_{(98)}$ = -10.815, P = 0.00). Farmers residing near and around the wetland area were dominantly dependent in agriculture such as crop farming, where 84.8% have no alternative income sources.

On the other hand, the majority (88.9%) of the respondents surveyed reported crop damage by Wattled Cranes whereas, 11.1% did not suffer any crop damage. On the other hand, 76.8% of the respondents those who suffered crop damage consider Wattled Crane as pests which cause damage to crops. Farmers residing to the south, east and north have higher damage than the west direction of the wetland. 76.8% of the respondents reported that Wattled Cranes are more harmful during the wet season than any other period of the year. The main crop primarily targeted and being damaged by Wattled Cranes was maize (Table 17). Farmers in Boyo wetland start growing their maize from first to third week of May. The maize they sow start to grow in six to eight days' time and it was at this growing stage where Wattled Cranes start to cause damage to the germinating maize and keep causing damage until it fully grows.

Average flock size of 14.52±2.23 range (2-150) of Wattled Cranes were reported visiting farmers farms during the wet season but was significantly different among the regions ($x^2_{(3)}$ = 37.91, P= 0.000).

They cause damage by uprooting the freshly germinating maize, then they cut and feed the tuber like root and leave the leaf part killing 100% of the plant (Plate 6 a-e).

A). Wattled Cranes feeding on maize field

B). Farmer looking after damaged maize field by Wattled Crane

C). Most prefered stage of maize by Wattled Cranes

D). Least prefered stage of maize by Wattled Crane

Plate 6: The impact of Wattled Crane on newly grown maize field

Table 17: Crop preference of Wattled Crane in Boyo wetland

	Reported crop damage and their preference rank and a Stage of damage		
Crop type	Preference	During germination	During harvest
Maize	1st	✓	No
Teff	2nd	No	✓
Wheat	3rd	No	✓
Sorghum	4th	No	No

Overall, respondents within the four regions of the wetland have experienced a kind of crop damage by Wattled Cranes. On the other hand, there was statistically significant association ($x^2_{(9)}$ = 47.496, P = 0.000) in the number of visits per day by Wattled Cranes during maize sowing among the regions, where respondents residing to the north, south and east part of the wetland have experienced substantial or higher frequency of visit with 2.89, 2.83 and 2.35 visits per day, respectively.

Most respondents (91.9%) use crop protection strategy using various deterring mechanisms. In particular, 45.5% of the farmers who used to scare and chase away Wattled Cranes from their farms use only stoning from their newly growing maize fields, whereas 15.2% use both stoning as well as guarding and 13, 13.1% use to scare Wattled Crane using stoning and making noise which are both nonlethal methods of scaring Wattled Cranes (Table 18, Fig. 17). The use of protection strategy by famers in the wetland was strongly associated with the attitude of famers to Wattled Cranes $x^2_{(1)}$ = 10.388, P = 0.001, where most of those respondents who consider Wattled Cranes as harmful or a pest use a protection strategy and vice versa. However, there was no significant association in using crop protection strategy and the rate of visit by Wattled Cranes to their farm, $x^2_{(3)}$ = 5.294, P = 0.095.

Table 18: Types of protection strategies against Wattled Crane damage

Protection techniques	Frequency	Percent (%)
None	7	7.1
Stoning	45	45.5
Making Noise	8	8.1
Guarding	2	2.0
Stoning and Making Noise	13	13.1
Stoning and Guarding	15	15.2
Making Noise and Guarding	2	2.0
All	7	7.1
Total	99	100.0

3.5.3. Perception of respondents to wetland and wetland resources

Majority (70.7%) of the respondents residing surrounding the wetland had a good awareness on the wetlands potential benefit to their survival and the rest have responded as it had nothing to do to their survival. With regard to their perception to the wetland, there was no significant difference between men and women $t_{(97)}$ = 0.36, p = 0.72).

However, there was statistically significant difference ($x^2_{(3)}$ = 11.34, p = 0.01) in the perception of respondents surrounding the four regions of the wetland with regard to the value of the wetland for their survival. Respondents residing to the western and southern regions of the wetland feel positive compared to the respondents residing to the eastern and northern part of the wetland, respectively.

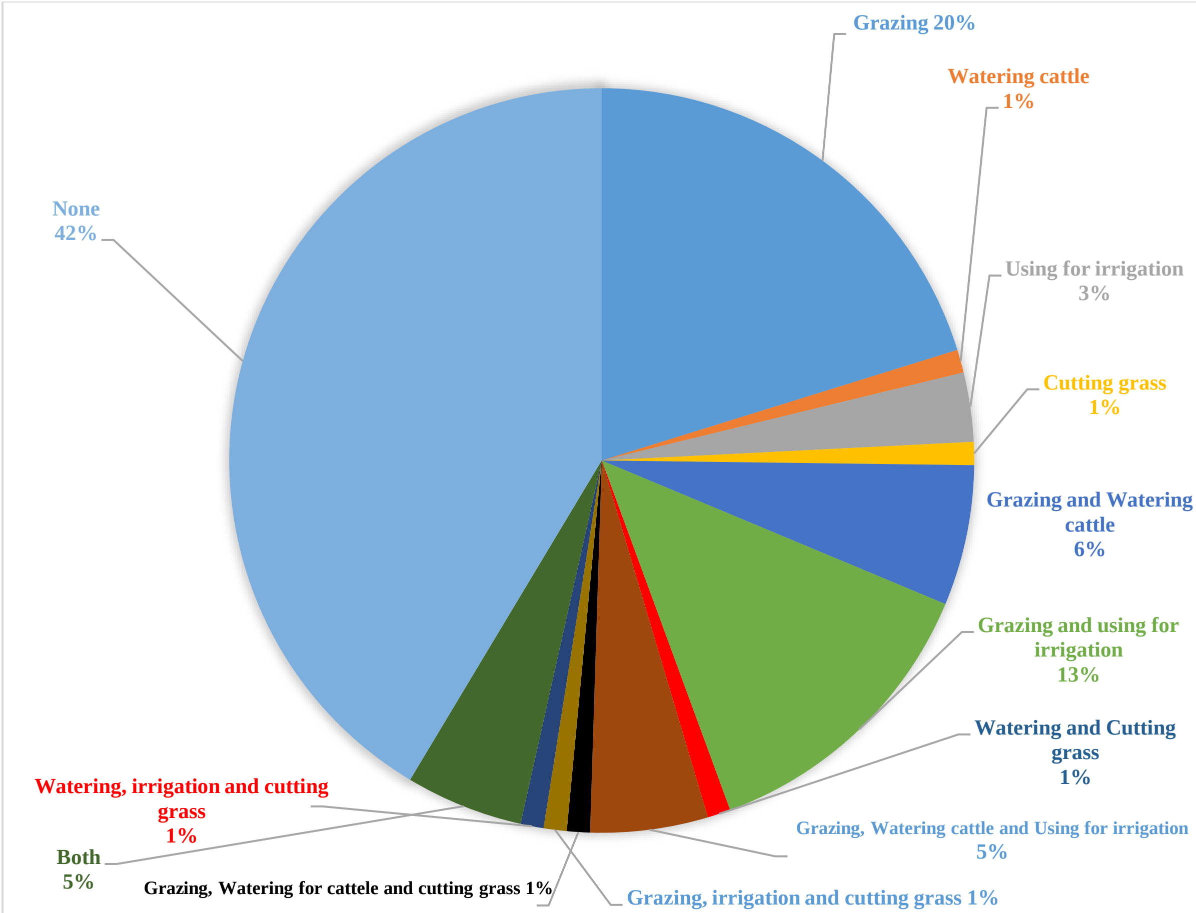


Figure 18: Respondents view on the benefits they access from Boyo wetland

Most respondents (44.4%) in the wetland reported that, they get high level of benefit from the wetland as well as (36.4%) and (19.2%) reported that they get medium and low level of benefit from the wetland. However, there was no significant variation in respondents report to the level of benefit they get from the wetland among the four regions of the wetland ($x^2_{(3)} = 6.98$, p = 0.072) as well as among age groups and education level of the respondents with a level of significance ($x^2_{(3)} = 4.58$, p = 0.21) and ($x^2_{(3)} = 4.01$, p = 0.41), respectively.

More than half of the respondents (79.8%), believed that if any conservation activity is conducted in the wetland their livelihood would have been improved in the near future. In addition, there was no significant variation in respondent's perception of the wetlands conservation for their livelihood improvements ($x^2_{(3)}$ = 7.22, p = 0.065).

There was a significant or strong association between perception of respondents to livelihood improvement by conserving the wetland and respondent's residence with regard to the wetland, $x^2_{(3)}$ = 7.84, p = 0.044). More number of respondents residing to the east, north and south are very optimistic if some conservation activity is undertaken; their livelihood might be improved.

Respondent's awareness on their choice of development to be implemented on the wetland is too limited, because most respondents (43.4%) were not aware what should have to be done in the wetland for their livelihood development. But, 24.2% from those who need some kind of development in the wetland need a kind of grass restoration to the level where they had been accessing before from the wetland. Few (10.1%) needed factory development and 5.1% irrigation development (Table 19).

From the total respondents involved in this study, 15.1% of respondents were involved in off farm activity. However, there was no significant association between farmers perception to the wetland and their involvement in the off-farm activity ($x^2_{(1)}$ = 0.059, P = 0.808). There was also no significant association between farmers residing in different regions in the wetland and farmers involvement in off farm activities ($x^2_{(3)}$ = 5.386, P = 0.13.

Table 19: Respondents preference on alternative development projects

Development activity	Frequency	Percent (%)
Irrigation development	5	5.1
Grass restoration	24	24.5
Factory development	10	10.1
Irrigation and Grass restoration	4	4.1
Irrigation and Factory development	1	1.0
Grass restoration and Factory development	8	8.2
Grass restoration, irrigation and factory development	3	3.1
No answer	43	43.9
Total	98	100.0

The overall attitude of the respondents on their perception to the main threats facing the wetland shows that, most respondents (79.8%) believe that the wetland is not under threat from different factors. However, the wetland is under extensive pressure from human encroachment and associated agricultural expansion especially in the western part of the wetland. Overgrazing is also the other threat to the wetland since the area has shown a 35% increase in the number of cattle population only in the last five to ten years. However, the main threat which is heavily degrading the natural quality of the wetland is siltation and sedimentation from the catchment area due to deforestation problem and associated agricultural expansion.

With regard to the level of perception on their knowledge related to human induced threats to the wetland, there was no significant variation among the four regions of the wetland (x^2

$_{(3)}$ = 5.67, p = 0.129) and education level (x^2 $_{(4)}$ = 3.04, p = 0.551), however, there was significant difference among the age groups (x^2 $_{(3)}$ = 12.95, p = 0.005).

Most of the respondents (73.7%), residing around the wetland are very willing to participate in a community-based conservation activity in the wetland and its surrounding habitats, without any subsidies from either the government body or from other non-governmental organizations. However, there was significant difference in the respondent's willingness to participate in the community-based conservation activity among respondents residing around the wetland (x^2 $_{(3)}$ = 16.291, p = 0.001).

The majority (56.6%) of the respondents residing surrounding the wetland have the knowledge of sustainable natural resource utilization and wetland conservation activity. However, only 51.5% of the respondents have only previously involved in natural resource conservation (Table 20). There was significant difference in respondent's awareness and involvement towards soil and water conservation as well as afforestation programs among the different region of the wetland (x^2 $_{(3)}$ = 11.975, p = 0.007).

Table 20: Percentage of farmer's involvement in different biodiversity conservation activity

Biodiversity conservation techniques	Frequency	Percent (%)
Soil and water conservation	4	4.0
Afforestation	2	2.0
Both Soil and water conservation and afforestation	45	45.5
None	48	48.5
Total	99	100.0

27.3% of the respondents believe that education should be delivered to the communities to increase their understanding on the wetland and its resources (Table 21).

Table 21: Respondents view on alternatives to increase on communities understanding on the wetland

Alternatives	Frequency	Percent
Education expansion	27	27.3
Awareness creation	1	1.0
Both Education and awareness creation in the area	35	35.4
No answer	36	36.4
Total	99	100.0

Most respondents (65.7%) are optimistic that there is a conducive environment to promote and implement any community-based conservation activity related either to the wetland or the Wattled Crane in the area (Table 22). They believe that communities are positive to any conservation intervention on the wetland and its resources.

Table 22: Respondents view on future opportunities/promises to promote community based Wattled Crane conservation in the wetland habitat

Response	Frequency	Percent
No	10	10.1
Yes	65	65.7
No response	24	24.2
Total	99	100.0

4. Discussion

Wattled Cranes are known to breed during the wet season, when ample water is available and sedge growth rejuvenates, despite records in Zambia where they nest throughout the year peaking in August (Konrad, 1981). However, in the Afroalpine habitats of BMNP, they were only observed nesting during the peak wet season of August to October. At this time of the year, the Afroalpine habitat gets a large amount of orographic rainfall ranging from 1000-1400 (OARDB, 2007). In the Afroalpine habitat, Wattled Cranes prefer to nest at an average altitude of 3848.60±76.092 ranging from 3502 to 4034 m asl. This might be due to high rainfall in this part of the Park compared to the other parts. Similarly, Miehe and Miehe (1994) have reported that areas of BMNP with an altitude of 3500 m asl at Chorchora to 3850 m asl at Koromi get rainfall of 1061 mm and 1086 mm, respectively which is the highest in the Park. Likewise, the reason behind preference to breed in the Afroalpine habitats, might be due to the presence of many alpine lakes with islands perfect to build their nests and due to extensive marshes and swamps (Marino, 2003), as their feeding ground. Similarly, breeding sites of Black-necked Cranes (*Grus nigricollis*) are concentrated in plateau meadows, swampy meadows and marshes, where herbaceous plants are abundant as well as shallow-water wetlands are available (Zhang and Luo 1991; Kuang *et al.,* 2010). In addition, Urban and Walkishaw (1967) have also predicted that, nesting of Wattled Cranes seems to be correlated with the long rains in Ethiopia, especially from late May to early September. Konrad (1981) in his study also reported that nesting in Wattled Cranes is directly related to the amount of available food which is also dependent on the amount of rainfall in an area. Not only in Wattled Cranes, but also in other cranes like that of Whooping Crane, where pre-nesting winter precipitation and water elevation were positively correlated with an index of nesting (Spalding *et al.*, 2009).

The other reason on Wattled Crane's preference to breed in the Afroalpine habitat might be due to the minimal human disturbance in the area, as it is inside the BMNP which is legally protected from any human disturbance. McCann *et al.* (2001) have noted that Wattled Cranes prefer to nest in wetlands with minimal human disturbance. Similar to Wattled Cranes, Black-necked Cranes usually prefer to breed in wetlands far from human interference and are thus the safest place for foraging which help them to nest and raise young safely (Kuang *et al.,* 2010).

Birds are known to perform several behavioral activities like courtship rituals during their breeding period, through dancing, vocalization and territoriality (Bengtson, 1970; McCann *et al.*, 2001). However, such kind of behaviors were not obvious among the breeding pairs of Wattled Cranes in the Afroalpine habitat except in some occasions. In 2016, pairs were observed jumping and dancing for a brief period during the mid-day before the female laid its first egg during that day. Similar behavior was also observed in pairs of Wattled Cranes in South Africa (McCann *et al.,* 2001). However, there was no record of boundary conflict between breeding pairs of Wattled Cranes in the area, even if, the distance between nests in Sanetti Plateau was 1.67 km. This might be due to a large nesting density in the study area or because of having enough territory to obtain substantial amount of food. In addition, there was no overlap in feeding habitat between breeding pairs in the area. This might be the reason behind rare boundary conflict between breeding pairs in the Afroalpine habitats of BMNP. Similarly, it is also known that in the southcentral Africa's breeding population of Wattled Cranes, the breeding territory is <1 km^2 (Konrad, 1981), which is smaller than the breeding territory in BMNP.

The nesting habitat of Wattled Crane varies from small wetland habitats to larger wetlands with shallow water as floodwater recedes (Konrad, 1981) or in sites with good natural grasslands and wetland coverage (Johnsgard, 1983; Wojtaszekova, 2008). In the Afroalpine, Wattled Cranes did not clear the areas or vegetation around the nest, unlike Sarus Crane (*Grus antigone*) (Mukherjee *et al.*, 2000) and Black Crowned Crane (*Balearica pavoninia ceciliae*) (Shimelis Aynalem, 2017), for clearer observation of the predators around their nest. Contrary to this, Johnsgard (1983) stated that Wattled Cranes which nest in marshes stripped of plants for a distance of up to four meters from the nest. In the Afroalpine habitat, this activity was not carried out, because it might be due to the specific nest location in islands with little vegetation cover around the nest as well as in the wetlands where there was no observation problem. This was supported by the result of concealment rate where the majority of nests in the Afroalpine habitat had poor nest concealment. This indicates that, Wattled Cranes breeding in the Afroalpine habitats were not wary of disturbance since the area is under protection, this could have helped them to have poor concealment rate.

The nest materials mostly used were *Koeleria capensis* and *Luzula abyssinica* and were locally dominant in the area. Nest height above the water surface in the study area varied from 40 to 140 cm, which was slightly higher than Black Crowned Cranes (30-130 cm) (Shimelis Aynalem, 2017) and Sarus Crane (41-95.67 cm) (Mukherjee *et al.*, 2000). This might be due to the difference in the nesting behavior of the species (Shimelis Aynalem, 2017), where Wattled Cranes in the Afroalpine habitat nested mostly (66.67%) in islands which are located higher in height than wetland nests due to the land formation and water level. Similarly, Mukherjee *et al.* (2000) have reported that nest height from the surface of the water and the use of nest material was influenced by the level of the water.

The clutch size of Wattled Crane was only either one or two with an average clutch size of 1.78 with the majority of nests having a clutch size of two. However, no nest was found with a clutch size of three or more. This was similar with Wattled Cranes in South Africa where the majority of the pairs in KwaZulu-Natal population lay two eggs (McCann *et al.*, 2001). On the other hand, Konrad (1981) has reported an average clutch size of 1.6 eggs in 91 Wattled Crane nests. This slight variation in average clutch size might be due to the difference in breeding altitude, since Pomeroy (1980), reported that breeding populations of high altitude areas have larger clutch size than those populations breeding in low altitudes. Contrary to this, Greater Sandhill Cranes (Maxson *et al.*, 2008), Black Crowned Crane (Shimelis Aynalem, 2017), Sarus Crane (Mukherjee *et al.*, 2002) and Common Crane had an average clutch sizes of 1.92, 2, 1.99 and 1.83 eggs per nest in the wild which is slightly greater than Wattled Cranes. This shows that Wattled Cranes do have a very small clutch size compared to other cranes. Moreover, by considering the results of Konrad (1981) with clutch size of 1.6 eggs from 91 nests, Johnsgard (1983) described the species as having the smallest clutch size of all cranes in the world.

During the study period, peak egg laying periods in the Afroalpine habitats were August, September and October. This peak egg laying event coincides with peak rainfall time of the year in the Afroalpine habitat (OARDB, 2007). But contrary to this, a 13 year information collected on captive Wattled Cranes in New York Zoological Park showed that the peak egg laying periods were, February (9 eggs), March (10 eggs) and April (11 eggs), but no eggs were laid during August, September and October (Conway and Allegra, 1977). This might be due to seasonal difference in the two areas which determine the amount of rainfall in the breeding habitat directly affecting the breeding performance and availability of food to their chicks. This was also true in Florida Sandhill Cranes (*Grus canadensis pratensis*), where their reproduction was stimulated when there is high rainfall in March and January (Layne, 1983). On the other hand, the same was true for Wattled Cranes in Kuwa-Zulu Natal area where they breed during the months of May to August in the high rainfall regions of South Africa (McCann *et al.*, 2001).

The mean egg weight in the study area was 250.69±4.73 g ranging from 218 to 281 g, but the data on egg weight of captive Wattled Cranes in New York Zoological Park showed insignificant difference with a range of 199 to 258 g (Conway and Allegra, 1977). Johnsgard (1983), reported an average egg weight of 265.3 g, but, slightly larger than the weight recorded in the Afroalpine habitats. According to Mein and Archibald (1996), Wattled Cranes have the longest incubation period of any cranes with incubation period of 32-40 days. The incubation period from this study shows a similar result where average incubation period of the three nests was 34.33 ± 1.20 days with maximum incubation period of 36 days and minimum incubation period 32 days.

Hatching success in Wattled Crane was 37.5% which seems very low compared to Greater Sandhill Cranes (69.2%) (Provost *et al.*, 1992) and Black Crowned Cranes (91.3%) (Shimelis Aynalem, 2017). This indicates that, they have a low reproductive rate compared to other cranes. Korad (1981) has also reported that Wattled Cranes have the lowest reproductive rate of all crane families.

Nest failures are common in birds in general and cranes in particular. The causes might be predators like mammals, birds of prey or other unknown factors. In Sarus Cranes, some mammals such as Jackal (*Canis aureus*), Feral dogs (*Canis domesticus*) as well as birds such as House crows *(Corvus splendense*) were observed predating on eggs (Mukherjee *et al.*, 2002). In addition, Greater Sandhill Cranes (*Grus canadensis tabida*) have lost 20% of their eggs to Coyotes (*Canis latrans*), 9% to Raccoons (*Procyon latrans*) and 15% to Common ravens (*Corvus corax*) (Littlefield, 1995). The major cause of nesting failure in the study area was due to unknown factors (66.7%). However, predation of eggs in the Alpine habitat was observed only by Thick-billed raven in one nest. But also, Wattled Cranes were observed feeding on their own broken eggs after chasing the predator. Similarly, Wattled Cranes have histories of breaking and eating their own eggs (Burke, 1993). On the other hand, even if there were Ethiopian wolves (the closest relatives of Coyotes which cause 20% of egg loss in breeding Greater Sandhill Cranes (Littlefield, 1995), there was no observation and record of predation of eggs or chicks of Wattled Crane by Ethiopian wolf or other mammals in the Afroalpine. This could be because of the nests location in deeply situated islands surrounded by deep and very cold water of the alpine lakes.

Fledging success can be increased if nesters or breeders are very experienced, which helps them to nest early and selection of wetlands with bigger size (Nesbitt, 1988; Ivey and Dugger, 2008) or availability of food (Holderby *et al.*, 2012). On the other hand, Coverdale and McCann (2009) have also reported that pair formation of Wattled Crane with older and with more experience, allows a pair to successfully fledge a chick. This might have helped Wattled Cranes to have 100% fledging success with 0% of chick mortality in the study area. On the other hand, this could be either due to the defensive ability of the species against predators or the advantages of the Afroalpine habitat for camouflaging strategy. Their cooperative defense strategy against predators like that of Tawny eagle, or distracting ability to hide their young by making guard call against enemies was another advantage for Wattled Cranes to have a good fledging success. Reports from Johansgard (1983), indicated that in Sandhill Crane and all other species of cranes, pairs and flock mates respond to the approach of intruding conspecifics and some other disturbances by performing loud, guttural squawks (often in series) which is considered as guard-call. Likewise, low density of predating mammals in the Afroalpine habitat might have also contributed to the higher fledging success of Wattled Crane in the area. On the contrary, Greater Sandhill Cranes which lived in an area of high predating mammal density like Coyotes in their breeding area, cause loss of eggs (Littlefield *et al.*, 2001).

On the other hand, breeding inside the Park which is fully protected from human disturbance might have also helped for the higher percentage of fledging success. Human related deaths of chicks in Sarus Cranes as a result of crop harvesting (Mukherjee *et al.*, 2002) and Black Crowned Crane due to deliberate killings of chicks by local communities (Shimelis Aynalem, 2017) have decreased the fledgling success. For instance, in Florida Sandhill Cranes (Nesbitt *et al.*, 2008) and Sarus Crane (Mukherjee *et al.*, 2002), chick mortality was 44.74 %, 8.7%, respectively due to various factors which is much higher than that of Wattled Crane chick mortality. Littlefield and Paulin (1990) and Cooper (2006) have also reported that breeding success of Sandhill Cranes was influenced by human related impacts such as overstocking and development of wind farms, respectively.

In the study area, nest failure in 2017 was much higher than in 2016 and 2015. However, the reason behind the high percentage of nest failure in 2017 was not clear. But, it might be due to the high level of rainfall during the wet season of 2017. Cranes in general are very sensitive to a very high rainfall which could lead flooding of their nest, even if that was not the case in the Afroalpine habitats of the BMNP. In breeding Florida Sandhill Cranes, more rainfall lead to increase in water level causing flooding of nests.

Re-nesting was not observed in Wattled Cranes in the Afroalpine habitats. This might be due to lack of favorable environment in the area as the breeding season progresses either related to available food or nesting habitat. Similarly, Florida Sandhill Crane re-nesting chance was very dependent on the prevailing favorable environmental conditions. Shimelis Aynalem (2017) has also reported that late nesters had lower breeding performance than those which nest early.

This study revealed that, in the Afroalpine habitats of BMNP, the main challenge to breeding Wattled Cranes comes from the raptors in the area. BMNP is known in the world for its high diversity of raptors (BirdLife International, 2005), due to its extraordinary diversity and density of rodents it maintains in the area (OARDB, 2007). Thick-billed raven predate on the eggs of Wattled Cranes. Regardless of their hatching success, the challenge follows with other type of raptor species, Tawney eagle which predate on the young of Wattled Cranes.

However, in terms of other human related threats, more serious threats are observed in the wintering habitat than in the breeding area. Similar problem was observed in the wintering ground of Black-naked Crane (*Grus nigricollis*) in Napahai wetland, China (Liu *et al.*, 2010). The reason behind might be because of the legal protection of their breeding habitat which can reduce the human related disturbances.

Wattled Cranes are considered as the most highly wetland-dependent of all African cranes because of their dependency on wetlands for foraging and breeding (Konrad, 1981; Johnsgard, 1983). However, during the study period in Boyo wetland they were observed spending the majority of their time in the farmland habitat to forage on waste grains of harvested wheat fields, corn stubbles and newly germinating corn fields. Despite this, they were heavily dependent on Afroalpine habitat wetlands during their breeding period. The same was true for Common Cranes wintering in Boyo wetland, where they spend majority of their time feeding in the farmland and roosting in the shallow parts of the wetland. Therefore, one can conclude that the Wattled Crane populations of southcentral Africa and South Africa depend highly on extensive floodplains which are the preferred habitats for feeding and nesting purposes (Konrad, 1981; McCann, 2001). On the other hand, limited food availability in the wetland associated with high level of sedimentation might be the reason for Wattled Cranes to spend more time in the farmland than the wetland habitat. Likewise, Shimelis Aynalem (2017) reported that Black Crowned Cranes were more distributed in the wetland habitat than in the farmlands due to good vegetation cover and food availability as well as less disturbance.

In Boyo wetland, even if there were records of Wattled Crane population in all the nine months of the year (October to June), there was no record in the months of July to September. This might be due to maximum flooding of the wetland during these months of the year, which makes them difficult to roost and reduce the availability of food in and surrounding the wetland. Similarly, Wattled Crane populations of southcentral Africa undertake seasonal migration due to heavy seasonal flooding from large wetlands to Magadigadi wetland which is solely used as a wet season concentration area (Konrad, 1981). In addition, crane's selection of migration routes, stopping over areas and wintering sites is determined based on the availability of food resources and associated roosting sites (Ivey *et al.*, 2014).

During the population count in their night roosting habitat, Wattled Cranes did not show too much movement which helped to reduce the chance of double counting and help to recount them again. According to Mukherjee (1999), night roosting count were more accurate to estimate actual population size of Sarus Crane by counting everyone in a flock than none or noon roosting counts. Similarity, night roosting count were applied to other cranes such as Common Cranes (Guzmán *et al.*, 1999). But, morning count was not conducted as Wattled Cranes depart from their roosting area to forage in the farmland during the early morning. Similarly, counting outside roosting areas in the farmland habitat was not conducted as Wattled Cranes were dispersed all over the farmland area which affects detectability due the vegetation in the farmland leading to an underestimation of Wattled Crane population in the wetland.

Based on this, there was no significant difference in estimated population size of the species between the two winter seasons. This might be due to the short duration of the study period. On the other hand, long-lived species with low reproductive rate and late age at breeding like cranes, population parameters tend to change slowly and the change in population size might be difficult to detect. Similarly, Wattled Cranes have the lowest reproductive rate of crane family (Konrad, 1981), due to longer period of dependency of the young on their parents and late age at breeding (Johsgard, 1983). On the other hand, no trend was established between the number of Wattled Cranes actually recorded during this study and the number in the past. Because, in the past there were no actual counts made to estimate the population size of the species in the wetland.

Wattled Cranes, start arriving at Boyo wetland in big flocks beginning from October. This was the time where farmers surrounding the wetland start harvesting and the cranes get abundant food resource. Therefore, abundance of food during this time might have attracted Wattled Cranes. Davis (2001) reported that peak number of Sandhill Cranes during spring in Central Nebraska is associated with the availability of waste corn in the harvested fields. Similarly, peak wintering period of Common Cranes and the change in population size was positively correlated with intensive farming activities of maize production and rice farming by farmers and associated presence of waste grain (Guzmán *et al.,* 1999, Prange, 2010). On the other hand, Sandhill Cranes in the Canadian prairies prefer to forage in the cereal fields and roost on certain wetlands during their southward migration (Sugden *et al.*, 1988; Sparling and Krapu, 1994). Still, this is in line with other studies showing that harvested fields are attractive for large grazing birds during staging period including cranes (Gill, 1996; Rosin *et al.*, 2012). Beside this, the wetland flooding level starts to recede during this time of the year which provide suitable roosting site for Wattled Cranes and help them to easily access the rhizomes of *Eriochloa fatmensis* and *Eriochloa meyeriana* which were the natural/wild food items in the wetland.

Population dynamics in animals can be influenced following the variation of habitat quality both in terms of availability of food and shelter. In addition, Tacha (1988) noted that the most important factor regulating crane numbers in one area is habitat availability. Therefore, findings of this study demonstrated that, average monthly Wattled Crane population showed two dispersion periods due to different factors. The first dispersion was from end of March to April (from 138 to 74), where they might have dispersed into other small wetlands and lakes in the CRV area. The dispersion factor could be, scarcity of food in the farmland as farmers begin to plough their farmland and due to sharp decline in water level of the wetland habitat. Gichuki (2007) reported that cranes are more dispersed during the pre-rainy season or towards the end of the dry season due to competition of resources as a result of food scarcity. Similarly, pheasant chicks feeding on arthropods living within crops in arable farmland show population fluctuation following the rise and fall of arthropod population (Hill, 1985). In addition, Reinecke and Krapu (1986) noted that population of Sandhill Cranes start to depart to other areas, as the mean density of waste corn decreases from 399 kg/ha in November to 128 kg/ha during the end of March.

On the other hand, the dispersion might be due to the availability of substantial amount of food (waste grain of wheat) in the state farm of Adaba Dodola area and presence of safe roosting area around Melka Wakena hydroelectric reservoir during this time period. Similar results were observed by Alonso *et al.*, (1987) where a decrease in total food availability forces Common Cranes to fly longer distances to access new foraging areas. However, starting from early May some Wattled Cranes come back and the population starts to build up again to >88 individuals. This is the time where rainfall starts to rain and farmers start growing maize and Wattled Cranes start feeding on newly germinating maize fields of farmers. They also get a roosting site in the wetland due to slight flooding.

The second fluctuation period was, from mid-June 48 to 0 in end of June, July, August and September), where Wattled Cranes start to disperse into other unknown areas. This might be, due to the scarcity of available food resource in the wetland as a result of extensive flooding of the wetland. In addition, the farmland area was covered with crops during this period which was not preferred by Wattled Cranes for feeding.

Highest population size in the study area was recorded in Boyo wetland (154) in March 2017 during the dry season of the year. This result coincides with Shimelis Aynalem (2017) where more cranes were recorded in Lake Tana during the dry season than the wet, due to food availability during the dry time. The result also showed that Boyo wetland supports the highest population of wintering Wattled Cranes in Ethiopia, even if a new population of 169 individuals was discovered in Melka Wakana hydroelectric reservoir in Arusi zone which was previously unknown to science. But, the difference could be, Wattled Cranes use Boyo wetland for a very long period of time (at least nine months) and Melka Wakana hydroelectric dam might be used only for a brief period of time. Therefore, this difference demonstrates that, Boyo wetland is the key wintering area for Wattled Cranes as their roosting and foraging area. In addition, other small wetlands in Silte Zone such as Chuche, Archuma, Wachincho, Gololcha and Mandifa are other known wintering areas of Wattled cranes in the CRV. In addition, the most important implication of the new population discovery is that comprehensive survey should be conducted to know more about the distribution of Wattled Crane population and their movement in Ethiopia.

In the past, the population of Wattled Crane in Ethiopia was roughly estimated to be <200 individuals (ICF, 2012; Beilfuss *et al.,* 2007). But this study revealed that the population of Wattled Crane in Ethiopia has recorded 319 individuals in April 2017. Therefore, the population of the species in Ethiopia is >300 individuals which is much greater than previously estimated.

The main activity of Wattled Cranes during the study period was foraging, to which they devoted 39.3% of their daily time budget. Similarly, Konrad (1981) in his study reported that procurement of food takes up the greater part of the day for Wattled Cranes in the wild. But contrary to the expectations, Wattled Cranes in captivity spent less time or 25% of their time budget to foraging than those freely moving in the wild (Davenport and Urban, 2010). This might be in captivity, animals are provided with food where there is no need to go around, search food and eat. Rather, they move to a certain area and take whatever is provided and take a rest which is contrary to those riding in the wild. Similar to Wattled Cranes in Boyo, others such as Canvasbacks (*Aythya valisineria*) (Hohman and Rave, 1990) and Siberian Crane (Jia *et al.*, 2013), spent more time searching more for food or foraging than the other activity types.

Diurnal time-activity budget of Wattled Cranes varies in relation to varying habitat types, across the time intervals of the day as well as seasonally. Wintering Wattled Cranes in Boyo wetland spent more time foraging and moving activity either in the farmland, shallow wetland, the grassland or mudflat habitats, whereas they spent less time for the other activities such as social behavior and calling. Likewise, diurnal time-activity budget of wintering Hooded Cranes (Zhou *et al.*, 2010), revealed also that they spent more time in foraging than any other activity.

Wattled Cranes spent more time feeding in the agricultural habitat than the other three habitat types in Boyo wetland, even though it is considered as the most wetland-dependent of Africa’s cranes (Konrad, 1981). This might be due to the abundant food resources or waste grains in the farmlands of maize and wheat fields combined with the scarcity of food in the wetland due to habitat degradation. Similarly, Black-necked Cranes have been forced to choose new habitats of traditionally cultivated fields with abundant potato residues available compared to wetland habitats which were degraded due to increased human disturbance (Wu *et al.*, 2013)

There was a significant variation (P = 0.000) in frequency of time spent by Wattled Cranes across the diurnal time period for each activity. Percent time spent for locomotion was more frequent in the morning than during the mid-day and afternoon. This might be due to the fact that, in the morning Wattled Cranes spent more time searching for food but less time during the mid-day and afternoon. This was true also for wintering Common Cranes (Alonso and Alonso, 1992).

Time spent for vigilance was higher or significant at the breeding season or wet season than during the dry season. This might be due to flock size difference where at breeding area, Wattled Cranes mostly occur in pairs due to their territorial behavior or small flock size (3.14 ± 0.425), but during the dry season or at their wintering area, the flock size was high (5.67 ± 0.713). Similar results were obtained in studies of Black-naked Cranes where, as flock size increased the time spent for alert decreased (Yang *et al.*, 2007). On the contrary, it might be due to a shift to a new environment forcing them to display more time for alerting than foraging (Jia *et al.*, 2013).

The vigilance rate in Red Crowned Crane (*Grus japonensis*) (23.6%) (Wang *et al.*, 2011), seems higher than Wattled Cranes (15.5%). This might be due to less or no killings, shooting by the locals as well as Wattled Crane’s adaptive behavior to humans especially during the wintering time in Boyo wetland. Similarly, vigilance was more pronounced in areas where there is human disturbance which had forced Red Crowned Cranes to spent more time on scanning for danger than foraging in Yancheng Biosphere Reserve, China (Wang *et al.*, 2011).

During the study period, even if flock size was positively correlated to comfort behavior and social interaction, it was negatively correlated to vigilance, foraging and locomotion of Wattled Cranes or scanning. The reason behind negative correlation between flock size and vigilance might be when the number of individuals in a group increased, the time allocated to scanning for danger decreased due decrement in share of time spent for vigilance per time period for each individual in a group. Such a situation is called a many eye hypothesis (Roberts, 1996). Similar results were also observed in Common Cranes (Avilés and Bednekoff, 2007), Red Crowned Cranes (Wang *et al.*, 2011) and other vertebrate animals like Columbian ground squirrels for the sake of risk dilution or to minimize the likelihood of being captured with larger group size (Fairbanks and Dobson, 2007). Contrary to this, when group size increases the level of foraging competition increases and the time spent for vigilance decreases (Roberts, 1996).

Time spent foraging was also significantly different between seasons, where Wattled Cranes spent substantial amount of time foraging during the wet season than the dry season. This might be either due to the high energy demand during the breeding season or the scarcity of available food in the Afroalpine habitat in which to compensate the scarcity of food they need to search for food for longer time. Similar results were obtained by Hohman and Rave (1990), where the difference in time allocation for foraging between sites was due to characteristics of the food, mode of foraging, disturbance level and characteristics of the habitat.

Energy demand in high altitude birds is too high compared to lowland area because of high basal metabolism rate due to lower temperatures leading to elevated thermoregulatory costs (Londoño *et al.*, 2015). This might be the other reason behind Wattled Crane's higher percentage of time spent foraging in BMNP than in Boyo wetland, where the Afroalpine habitat is known for its very low temperature, high wind and with high frost level during the night.

Contrary to this, it might be due to the difference in foraging strategy they apply in the two areas or during the two seasons. With this regard, during the breeding season or at the breeding area, Wattled Cranes feed mostly on tubers or soft root of grasses by applying a dig foraging strategy. Whereas, during the dry season, Wattled Cranes mostly feed on farmlands searching for waste grains feeding by pick foraging strategy. This means that time spent to dig one tuber takes much time than, the time spent for picking one grain from the ground in the farmland. This might be the reason that they spent more time foraging during the breeding season than the dry season.

Flock size showed significant variation both among the habitat types and across the three-time periods, where large flock size was observed in the shallow wetland habitat and during the afternoon time period respectively. This might be due to large flock formation at the shallow wetland during the mid-day for mid-day roosting and drinking as well as during the afternoon time particularly when Wattled Cranes come for night roosting. Cranes typically roost on the ground or while standing in shallow water to protect themselves from danger (Johnsgard, 1983). Similar results were obtained by Allan (1995), where Blue Cranes preferred habitats which have enough food resources with less danger.

The data analysis was restricted to adult birds because the number of juveniles in the wintering habitat was low which was not possible to collect enough data on the juveniles and if found they tend to be less vigilant, e.g., Sandhill Crane (Tacha, 1988), Common Cranes (Alonso and Alonso, 1993; Avilés and Bednekoff, 2007). But in general, what was known about the vigilance variation between adults and juveniles was that juveniles devote most of their time on feeding. However, adults with juveniles seem to scan their area more frequently (Avilés, 2003).

Availability of food, suitable breeding sites and protective cover are the most important factors influencing the habitat selection of birds (Read, 1999). Therefore, it might be this factor which influenced Wattled Cranes preference to winter in Boyo wetland and breed in the Afroalpine habitats of BMNP.

Walkinshaw (1983), in his finding noted that Wattled Cranes are primarily vegetarian and insect eating species with few records feeding on frogs and snakes. Similarly, this study revealed that the species most important food items were various plant parts such as tubers, rhizomes, seeds and waste grains. However, on some occasions it was observed feeding on frogs, which were dominant amphibians in the riverbeds of Boyo wetland. In another occasion, it was observed feeding on its own egg after being destroyed by Thick-billed raven in BMNP. Similar to this, other cranes such as Sandhill Cranes were observed feeding on their own eggs (Walkinshaw, 1973).

Wattled Cranes were rarely showed indications of chasing either for insects as well as jabbing quickly or repeatedly on something in both habitats. Most of the food items consumed by Wattled Cranes in the wintering and breeding habitats were waste grains, rhizomes and seeds as well as tubers which are generally considered as plants and plant parts.

Generally, the quality and quantity of foods selected at any given time is influenced by the biological demands and morphological adaptations of the bird, its behavior and ecology of the food (Swanson *et al.*, 1974). With this regard, food items selected and consumed by Wattled Cranes in Boyo and BMNP habitats were different both in composition and availability. During the study period in Boyo wetland, Wattled Cranes were heavily dependent on waste grains of wheat and sorghum fields as well as maize stubbles in the agricultural habitat. This might be due the presence of more abundant food resource in the agricultural habitat than in the wetland habitat. Likewise, during the winter time in the Cheolwon area of South Korea, cranes spend 60-80% of their time in fields in search of rice grains that fall during the harvest (Pae and Won, 1994). Similarly, Sandhill Cranes wintering in Saskatchewan also heavily use harvested agricultural fields due to the presence of large abundance of waste grain (Sudgen *et al.*, 1988). However, wintering Red-crowned Cranes in China prefer original wetland habitats other than wheat fields (Ma *et al.*, 1999). In addition, Li *et al.* (1997) reported that in the overwintering regions, 76.54 % of Black-necked Cranes food was underground plant tubers followed by stalk-like stems, flowers, fruits/seeds and leaves. However, despite its less dependency, Wattled Cranes were also observed feeding in the wetland on rhizomes of *Eriochloa fatmensis* and *Eriochloa meyeriana* which were natural food items for a brief period in the mid-day and late afternoon when they try to roost.

Farmers in Boyo wetland begin to plough their farmlands starting from the end of March and the number of Wattled Crane previously feeding in the field decreases dramatically.

This might be a clear indication of reduction in the amount food such as waste maize and wheat in the field. Similar results were observed in Cheolwon area of South Korea, where more White-naped Cranes (*Grus vipio*) were observed foraging in unplouged fields than in ploughed fields due to more food resource in the former field (Lee *et al.*, 2007). This result also indicated that Wattled Cranes were highly dependent on food items in the agricultural habitat than food items in the wetland.

However, during the month of May, farmers that surround the wetland start growing maize following a brief rainfall and Wattled Cranes increase their number and start to forage on the newly growing maize in a farmland. During this month of the year, farmers complain on the damage caused to their crops. The reason behind foraging on germinating corn might be due to limited alternative food available in the wetland because of wetland degradation caused by heavy sedimentation, wetland canalization and overgrazing. Bishop (1996) reported that human activities such as irrigation projects, dam construction, transformation of uncultivated land to farmland, river canalization, overgrazing and sedimentation pose serious threats to the birds' overwintering sites. In addition, Song *et al.*, (2014) in their finding noted that when natural food sources are insufficient to meet demand, farmlands on the periphery of wetlands become the new food sources for cranes. Similarly, in Huize, Yunnan Province, extensive loss of wetland and meadow has led Black-necked Crane to forage on seeds, radish and potato from farmland, causing significant economic loss to the local farmers leading competition for land between humans and cranes (Li *et al.*, 2009).

In the Afroalpine habitat, breeding Wattled Cranes predominantly fed on the rhizomes, tubers and roots from wetlands on the plateau. Similarly, Black-necked cranes fed more on wetland plant species in breeding regions than in overwintering regions (Kuang *et al.*, 2010). This might be due to availability of high energy food in the tubers and its presence in high abundance in BMNP which is very crucial during the breeding season of Wattled Cranes. Similarly, Sauey (1985) in his analysis of nutritional analysis on tubers revealed that, tubers have high energy value than other plant parts due to their carbohydrate makeup but with low protein value.

The vegetation investigation revealed that, the density as well as the percentage ground cover of the food items was much higher inside than outside the breeding territory. Therefore, the presence of such food source inside the breeding territories might be the reason behind Wattled Crane's breeding territory establishment in this part of the Afroalpine habitat. Similarly, habitat selection and use can be influenced by a range of factors including food availability, competition pressure and predation risk as well as reproductive and social behaviors (Ellis *et al.,* 1998; Bystr *et al.*, 2003; Morris and Dupuch, 2012). Therefore, it is clear that the alpine lakes and the swampy areas in the Afroalpine habitat provide substantial amount of food and are indispensable habitats for breeding Wattled Cranes. Likewise, there was a strong association between the density of the alpine lakes in the Afroalpine habitat and breeding territory, in which there was higher lake density inside the breeding territory than outside the breeding territory. This might be due to the presence of suitable nesting sites and abundant food source in the part of the Afroalpine with high alpine lake and swamp density. Similar to Wattled Cranes, Black-necked Cranes were highly dependent on water and plateau wetlands as a reflection of their instinctive needs for energy, nutrients and security (Song *et al.,* 2014). Ethiopian Wolf Conservation Program (EWCP), in their monitoring and assessment, the place where

Wattled Crane breed or the breeding territory in this finding they call it “crane lakes” (Marino, 2003).

Wattled Cranes were particularly dependent on dig foraging than walk foraging to obtain their diet. Similarly, Konrad (1981) noted that most of their day, Wattled Cranes spend in foraging, primarily by digging in a wet substrate. However, feeding activities can be changed significantly when food availability within the aquatic ecosystem change (Swanson *et al.,* 1974). The same was true for Wattled Cranes where there was a difference in the foraging behavior they adopted to obtain the food items in the two habitats. In Boyo wetland they were mostly dependent on pick or walk foraging than dig foraging, but in BMNP the reverse was true. This might be due to seasonal difference in food availability in the two different habitats. In the farmland, they feed on waste grains of wheat, sorghum, maize and teff where they apply either pick or walk foraging. On the other hand, they apply dig foraging to uproot newly germinating maize in the farmland or to feed on the rhizomes of grasses in the wetland. Similarly, food availability and feeding behavior in birds vary between seasons and among habitat types (Milner and Harris, 1999). Alternatively, it might be simply because of the seasonal difference in the quality diet requirement during the breeding season. Swanson *et al.* (1974) noted also that the quality and quantity of foods selected at any given time is influenced by the biological demands and morphological adaptations of the bird.

Wattled Cranes in the Afroalpine habitat prefer to feed and breed in areas with high density of alpine lakes and swamps. This might be due to the higher density of food items available for the species in those areas than areas within low alpine lake densities. Swanson *et al.* (1974) reported that undisturbed temporal and seasonal wetlands were very important for breeding Blue-winged teals (*Anas discors*) as they provide abundant and readily available food resource. In general, Wattled Cranes are very selective in occupying a unique feeding niche available in the Afroalpine habitats especially on those seasonal wetlands and swamps.

Since pre-historic times, cranes and people had a long and complex relationship (Harris, 1994). Historically, they are among the most celebrated animals and recognized as symbols in stories and art of humans in the world especially in East Asian cultures (Harris, 1994). However, since the last 150 years, human beings started to pose a threat to cranes, even if, they have co-existed in harmony before for millennia (Harries, 1994). This might be due to a wide range of threats, from habitat loss or ecosystem degradation that cranes depend upon to human related actions directly impacting cranes (Harris and Mirande, 2013). The same is true for Wattled Cranes in Ethiopia, where they had been gracing the sky of the CRV for centuries and were living in harmony with local communities.

Human-wildlife conflict incurs a substantial amount of economic cost to farmers and crop damage by wildlife can impact livelihoods (Wang *et al.*, 2006). Moreover, regardless of the economic loss, human-wildlife conflict has its own impact in reinforcing a negative attitude among farmers and far reaching stakeholders (Thirgood *et al.*, 2005). In Boyo wetland, majority of the respondents (88.9%) had experienced a crop damage especially to their maize field during the wet season. And also, majority of them consider Wattled Cranes as pests due to the extent of crop loss to farmers as they do not have any alternative livelihood options. Likewise, local farmers in some Great Rift Valley areas dislike Common Cranes, as flocks arrive when cereal crops are close to being harvested and they decimate some crops and are particularly fond of sorghum, to such an extent that farmers in areas where cranes are regular visitors have had to abandon sorghum cultivation and use other crops such as maize (EWNHS, 1996).

However, the attitude and perception of some farmers to the species was not negative. This might be due to low level of damage as a result of small population during the wet season which could be very easy to protect. Harries (2010a) states that perception and attitude of farmers to crane damage is dependent on the extent of loss they make to their farms in the area. Farmers in the Western United States were also complaining more on Sandhill Crane damage due to increasing population which is tough to manage (Austin, 2010) as well as the increase in geese population in Europe and North America in the last 50 years and the growing damage to agricultural crops (Tombre *et al.*, 2005; Tombre *et al.*, 2013; Simonsen *et al.*, 2016).

There was significant variation in crop damage incurred by Wattled Cranes surrounding the wetland. The reason for this might be due to the proximity of their farmland to the main roosting site of Wattled Crane in the wetland. Similar studies by Austin (2010) revealed that the damage by Sandhill Crane to farmer's fields was positively correlated to the proximity of their farmland to Sandhill Crane habitat. The same is true also in studies by Nilsson *et al.* (2016) that cranes that cause damage is linearly related to distance of roosting site, with a probability increase of crane presence from 0.05 to 0.09 when distance decreased from 5 to 1 km. Selection of suitable roosting site by cranes in a wetland is dependent on the depth of the wetland where they prefer shallow wetland within close proximity to appropriate feeding grounds (Alonso and Veiga, 1984). The same is true also to farmers in Wisconsin who have farms close to habitats of cranes where they experience a varied relationship (Harris, 2010a). In addition, it might be also due to the variation in flock size visiting these regions which indirectly result in differences in the perception of crop damage by farmers. Similar results were found by Van Velden *et al.* (2016) where presence of damage and attitudinal score of farmers were related to the size of flocks on the farms.

The main crop where Wattled Cranes cause damage and farmers most predominantly complain about was maize. But, they do not cause damage on maize when it grows taller. The same was true in other cranes where they incur an extensive damage to newly planted corns (Su, 2004) and are expanding their distribution in Europe and North America due to opportunities provided by corn (Harris, 2010a). The reason behind the damage to newly germinating maize fields might be due to the loss of the *Eleochrea* spp. (especially *Eriocholoa fatmensis* and *Eriochola meyeriana*) which were once dominant in the wetland according to farmers and are the main natural food resources for Wattled Cranes. The loss and reduction of these dominant grass species is due to high siltation level as well as overgrazing in the wetland. It is also true that the conflict with Sandhill Cranes along the western United States was aggravated due to loss and degradation of wetland (Austin, 2010). Similarly, the loss of natural wetland has forced Sarus Cranes in Nepal to move to adjacent farmlands and moist agricultural lands (Shrestha, 1994).

In addition to this, diversion/switch of Wattled Cranes to newly germinating maize in mid-May might be due to the low level of food availability in the wetland and surrounding farmland. The same result has been found by Nowland (2010), where Common Cranes have switched from harvested areas to newly sown fields as a result of technologically advanced harvesting machinery and crop fields being ploughed shortly after harvesting.

During this time, Common Cranes disappeared from the wetland and migrated to their breeding habitat in Europe.

Most respondents use nonlethal methods as a protection strategy such as guarding, making noise (scaring) and stoning to protect their maize field. Similar strategies were applied in the Jigme Singye Wangchuck National Park in Bhutan, in which farmers use nonlethal methods to protect problem animals from their farms (Wang *et al.*, 2006). Farmers in northern Norway have also reduced the impact of geese damage on their farm through nonlethal intensive scaring (Tombre *et al.*, 2005). Such a method was found very effective in assisting to alleviate goose-agriculture conflicts (Simonsen *et al.*, 2016). However, as a countermeasure, local farmers in Guizhou Province of China use dogs to drive away Black-necked Cranes foraging in their farmland (Han, 1995). On the other hand, many Demoiselle and Common Cranes in Nepal were killed by farmers during migration when they stop over to feed on grains in farmlands (Shrestha, 1994).

Majority of the respondents state the decreasing tendency of Wattled Cranes due to degradation of the quality of the wetland. Similarly, the other crane species in different parts of the world showed reduction in number over time (Johansgard, 1983), such as Black Crowned Cranes, Wattled Crane and Siberian Crane (Meine and Archibald, 1996a).

Farmers residing to the western part of the wetland have good access to the grass available to the wetland due to low level of siltation, where they use the grass for fattening and selling in the market for their livelihood improvement. The same is true to the farmers residing to the southern part of the wetland where they use the wetland for grazing purpose regardless of the negligible impact by flooding. But, those respondents residing to the northern part of the wetland are those who are negatively impacted due to heavy flooding. They abandon their area especially during the wet season and loss their farm. The low level of grass to the east might be due to the heavy siltation which indirectly affects the amount of grass in the area and indirectly affects the amount of the grass available for their cattle or other purposes.

If community-based conservation programs such as direct dialogue with communities about the wetland resources and sustainable resource access are applied in the wetland, communities will develop a positive attitude to the wetland in general and the Wattled Crane in particular. Such activities and programs have brought positive support from communities around lake Mburo National Park, Uganda (Infield and Namara, 2001). Majority of the respondents have agreed that there is an optimism in the wetland protection and conservation in the future if the combinations of education and awareness creation were implemented. Sufficient results could be achieved in conservation biodiversity if public cooperation and awareness creation are given priority (Shrestha, 1994).

Boyo wetland is one of the main spots in Ethiopia to see the largest aggregation or population of Wattled Cranes with large population of both Common and Black Crowned Cranes as well as other wetland and woodland birds. It is very advisable to boost crane-based tourism in the area where local communities can get benefit and farmers could protect the wetland and cranes in the area for future long coexistence. This will indirectly reduce the confrontation and conflict of farmers and Wattled Cranes in Boyo wetland. Such crane-based tourism is functional in many areas around the world; in the Rügen-Bock region of northeast Germany (Nowland, 2010).

Incorporating Boyo wetland as a Ramsar wetland will have a positive impact on the protection of Wattled Crane and other crane species including other wetland birds.

Increasing the number of habitats to be protected under Ramsar Convention helped recovering population of some wetland bird species in Japan including cranes (Amano, 2009).

5. Conclusion and recommendations

Wattled Cranes are the largest and rarest of the African cranes, that show discontinuous distribution across many African countries. Its population is declining from time to time, due to various factors from wetland degradation to illegal trade. However, information regarding on ecology and its population status of the species in Ethiopia is inadequate. This study was intended to fill the gap in our knowledge about the population size of Wattled Cranes, with regard to population estimate and distribution, breeding and feeding ecology, its daily activity pattern as well as interaction and attitude of the farmers in Boyo wetland and BMNP. Such studies will have a crucial implication in a future conservation intervention of Wattled Cranes in Ethiopia and beyond.

The result of this study revealed that Wattled Cranes require a pristine and undisturbed area for breeding, as they were very sensitive for disturbance. For breeding, they prefer an area which has an elongated rainy season, abundant food resource as well as alpine lakes with island structures to build their nests. Availability of hiding spots or presence of vegetation for their young and less disturbance were the main determinant factors for Wattled Cranes breeding performance in BMNP. Most of their rime they spent feeding in the farmland in Boyo wetland and feeding in swampy and grassland area in BMNP. Boyo wetland harbors the largest population of Wattled Cranes in Ethiopia and supports the population for longer period of time providing a food resource and roosting site during the whole winter season. However, starting from the end of March Wattled Cranes undertake local movements in the CRV to find alternative food resources.

Foraging ecology of Wattled Crane in general is not diverse compared to other cranes. The result also shows that, local farmers in the Boyo wetland are suffering crop damage by

Wattled Cranes and their attitude seems negative. In addition, the local farmers residing around Boyo wetland are not aware of the value of the wetland and Wattled Cranes for future conservation. However, more recently, the suitable habitat of Wattled Crane in Boyo wetland is under threat due to heavy sedimentation from the surrounding watershed. In addition, the natural flow of water from the wetland has been altered by draining the wetland through excavation to reduce the problem of flooding. As a result, the two main grasses of the wetland *Eriochloa fatmensis* and *Eriochloa meyeriana* which are the only natural food items of Wattled Cranes in the wetland are being affected.

Therefore, the following recommendations are suggested to better conserve Wattled Cranes in their breeding and wintering habitat in the future

- In the Afroalpine habitat, illegal grazing inside the Park should be controlled.
- A strong collaboration should be established with the Ethiopian Wolf Conservation Program in BMNP. Because, breeding Wattled Cranes share the same habitat with Ethiopian Wolf and EWCP's regular monitoring of Ethiopian wolf would help to get information on the breeding pairs of Wattled Cranes in the future and promote future conservation.
- Breeding potential of Wattled Cranes in Afroalpine habitat was influenced heavily by factors such as presence of alpine lakes with islands, presence of swampy areas and availability and abundance of food. Therefore, establishment of artificial islands to attract breeding pairs in shallow alpine lakes, with large swampy habitats should be implemented.
- Within a short period of time, a habitat restoration activity should have to be implemented in Boyo wetland to rehabilitate the natural food items (*Eriochloa*

fatmensis and *Eriochloa meyeriana*) of Boyo wetland since grassland habitats are being destroyed by sedimentation and overgrazing.

- Due emphasis should be given to collect enough fecal samples and investigate the food proportion of the species both during the breeding and wintering habitat.
- Other than the few known breeding pairs in BMNP, Lake Tana area and Jimma area, there is no clear information, on where the other populations spent their wet season. Therefore, in order to know their movement and monitor their activity between the wintering and breeding grounds as well as to find other potential breeding areas, it is necessary to undertake a detailed investigation using radio telemetry.
- GIS based land-use/land-cover change information for Boyo wetland should be conducted in order to see and assess land-use/land-cover pattern changes in the past and take corrective measures based on the result.
- Boyo wetland is one among the 69 important bird areas and is known as a Key Biodiversity area harboring a large diversity of birds. The area is known for having a large aggregation of Wattled Cranes. Therefore, it is necessary to effectively conserve the wetland by promoting avitourism which can enhance the socioeconomic status of local community through active participation.
- Community-based conservation should be implemented on the watersheds of the wetland to reduce sedimentation to the wetland by reducing soil erosion.
- Awareness creation among the communities should be carried out, to understand the essence of sustainable use of natural resources in the wetland and conservation of Wattled Crane in particular.

- Alternative source livelihood opportunities such as off-farm employment, trade, skill labor should be provided for the local people to help them survive without over-dependence on natural resources of the wetland and surroundings.
- Alternative crop protection strategies should be studied and implemented to reduce the damage Wattled Cranes incur to local farmers.
- Indeed, work should be done to register Boyo wetland as “A Ramsar site” to benefit and get attention from international community for its future conservation and sustainable development.

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7. Appendices

Appedix I : **Questionnaire**

Purpose: The purpose of this study is to "Assess how Wattled Cranes and local communities coexist or interact with local farmers in Boyo wetland". It is hoped that the information you will give to design appropriate ways of identifying the main challenges that occur with Wattled Cranes and design appropriate conservation measures for the species and the wetland as well as the local communities' in the near future.

1. Background characteristics of the Respondent and Family Members

Sex[1]	Age	*Religion*[2]	*Marital status*[3]	Education	Current occupation[4]	Direction to the wetland[5]	Kebele

Code 1 *1) Male 2) Female* **Code 2** 1) *Orthodox 2) Muslim 3) Protestant 4) Catholic 5) Other (specify)* __________ **Code 3** 1) *Married 2) Unmarried 3) Divorced 4) Widowed 5) No response* **Code 4** 1) *Jobless 2. Daily Laborer 3) Government employee 5) Farmer 7) House wife 8) Student 9) others (Specify)* ***Code5*** 1) North 2) South 3) East 4) West

2. Land and Livestock property

a. Total farm size owned ________________ **(hectare) ("Timad")**

b. Livestock holding and utilization in (January 2014 – January 2016)

Livestock	**Before two years**	**At present**
Ox		
Cow		
Donkey		

Sheep		
Goat		

3. Knowledge and perception towards birds in general and Wattled Cranes in particular

   a. Do you feel happy when you see birds or hear their songs in the wetland or nearby areas? Yes/No

   b. Do you know Wattled Cranes? Yes/No

   c. Since when do you know Wattled Crane?

   d. Do you think Wattled Cranes are harmful? Yes/No

   e. At what season do Wattled Cranes visit your farm?

      i) During wet season ii) dry season iii) All year round

   f. How often do they visit your farm in a day?

      i) Once a day ii) Two times iii) three times iv) more than three times a day

   g. In what number and when did you see the maximum number of Wattled Crane in the wetland?

      ____

   h. Have you noticed any change in the population status of Wattled Cranes in this area since long time ago?

      1. Increasing 2. Decreasing 3. No difference 4. Indeterminate

   i. Have you seen any kind of illegal hunting or killing of Wattled Cranes by the local people before? Yes/No

      If yes for what purpose do they kill Wattled Cranes?

      1. For food 2. Being as a pest 3. Just for recreation 4. Not known

   j. What type of crop do you plant mainly?

l. Corn ii. Wheat iii. Bean iv. Sorghum v. Others

a. Do Wattled Cranes cause any harm/damage to your farm? Yes/No

m. Which type of crop do they prefer more?

n. Corn ii. Wheat iii. Bean iv. Sorghum v. Others

a. At what stage do they preference to feed?

o. Just before germination ii. During first stage of germination iii. After fully grown iv. During harvesting v. After harvest

p. Do you use any mechanism to deter Wattled Crane from damaging your crop? Yes/No

If yes, what kind of deterring mechanisms do you use?

i. ________________________________

ii. _________________________________

iii. __________________________________

q. Perception and knowledge towards the wetland

a. Do you think that this wetland has a potential benefit for your survival? 1) Yes 2) no

If yes/ How?

____

b. Level of benefits, if yes to the above question 1) High 2) Medium 3) Moderate

a. For what purpose do you use the wetland

i. Grazing ii. Irrigation iii. To access drinking water iv. Grass

c. Do you believe that livelihood improvements can be possible by conserving this wetland 1) Yes, 2) No

If No/// Reasons---

If Yes/// Indicate the means of doing it--

a. Do you think this wetland is at risk due to human induced factors? 1) Yes 2) No

If Yes/ Give rank to the following major human factors which may cause the wetland at risk:

1. Deforestation and soil erosion ____________
2. Absence of strong abiding common rules and regulations to the wetland ________
3. Overgrazing ____________
4. Over crop land and cultivation area expansion_____________
5. The area is very exposed to marginalized poor _____________
6. Absence of well-structured property right system (if so, specify) ____________
7. Investment ________________
8. Intra-resource use conflict________________
9. Absence of trust among the community members_____________
10. Free riding problems____________________________
11. Other specify ________________________________

b. Do you know the existence of sustainable NR utilization and wetland conservation methods? 1) Yes 2) No

c. If Yes, fill the following table

No	Type of NRC program	Program participation 1.Yes, 2. No	Efficiency of the program Rank**
1			
2			

***1) Best 2) Good 3) Low 4) Don't know*

d. Do you believe that conservation practices to the wetland will benefit the local people residing near the wetland in the long run?

1. Yes, 2) No

If No, Reasons---

If Yes, Indicate the means of doing so---

a. Would you be willing and able to use community-based conservation measures without the subsidies or support from government or NGOs? 1) Yes 2) No

2. **Off farm income**

a. Do you or your family member work on off – farm activities? 1) Yes 2) No

b. If yes fill in the following table:

No	Types of off-farm (non- farm) activity			Total income obtained in one year (birr), approximately
1	Selling of fire wood			
2	Labor hire			
3	Remittance from family			
4	Interest from loan and bank saving			
5	Food for work			
6	Selling grass from the wetland			
7	Other, list			

21. What do you suggest to improve the perception of local communities towards biodiversity (birds in the area) conservation?

____

22. Are there opportunities that promote the community based Wattled Crane conservation activities in your area?

A. yes B. No C. Unknown

23. If yes, what are they? ---

8. Plates

Plate description: A and B Collection of food items and their tubers for identification C: Habitat analysis using quadrat sampling D: Egg and nest measurement E: Wattled Crane incubating in Sodota area F. Boyo wetland during flooding G: Questionnaire survey H. Wattled Crane with their juveniles while taking rest