

Effect of Wildlife Hazard on Aviation Industry at Bole International  
Airport, Addis Ababa, Ethiopia.

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A Thesis Submitted To  
College of Development Studies Center for Environment and  
Development.

Presented in Partial Fulfilment of The Requirements for The Degree of  
Master of Arts (Environment and Sustainable Development)

Addis Ababa University  
Addis Ababa, Ethiopia  
July 2020

Addis Ababa University  
School of Graduate Studies

This is to certify that the thesis prepared by **Fekadu Assefa Teshome** entitled: *Effect of wildlife hazard on aviation industry at Bole International Airport, Addis Ababa, Ethiopia*. And submitted in partial fulfillment The Requirements for The Degree of Master of Arts (Environment and Sustainable Development) complies with the regulation of the university meets the accepted standards with respect to originality and quality.

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## **Abstract**

Effect of Wildlife hazard on aviation industry at Bole International Airport, Addis Ababa, Ethiopia.

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*Different wildlife's commonly causes damage to aviation industry around the world. This study assessed the effect of wildlife hazard on the aircraft operation at Bole International Airport, Addis Ababa, Ethiopia. Focus group discussion, key informant interview, point count and transect count method were employed to gather relevant data. The study findings recorded about 70 species of wildlife including plants during the study period. The study results illustrated that some of the wildlife animals (e.g., wildlife, mammals, reptiles and amphibians) either living in or visiting the airport have often caused threats to aircraft operation in the airport directly or indirectly. Only between 2014 and 2018, 416 strikes were reported at the airport. Highest number of strikes recorded in November during sunny days. The total amount of cost due to wildlife strike for the last six years was estimated at 4, 768,310.00 USD. Thus, it is recommended that Addis Ababa Bole International Airport should establish proactive systematic approach to deal with wildlife hazard than reactive or traditional approach.*

*Keywords: Aircraft, Airport, Aviation, Wildlife, Hazard, Wildlife strike*

## **Acknowledgements**

First, I would like to say **Glory to the Almighty God forever**. I would like to forward my acknowledgement to my advisor, Dr Feyera Senbeta, for his guidance from the foundation of this paper till the end. My heart full salutation goes to my parents that exerted their maximum effort and for what they did while I was on study.

I also forward my heartfelt acknowledgement to those who helped me in giving materials and information that is critical for my research. To mention: all instructors, The different departments of the Ethiopian airport enterprise /EAE (all environmental and safety officers), the Ethiopian civil aviation authority ECAA, Safety departments of Ethiopian airlines/ EAL.

**DECLARATION**

I declare that, this thesis is my original work and has not been presented for a degree in any university and all the sources of materials used for the thesis are duly acknowledged.

Fekadu Assefa\_\_\_\_\_

Signature

\_\_\_\_\_

Date

This thesis has been submitted for the examination with my approval as an Advisor:

Feyera Senbeta (Ph.D.)\_\_\_\_\_

Signature

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Date

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## **Abbreviation**

ADM	Aerodrome
CAA	Civil Aviation Authority
CLUP	Compatible land use planning
Doc	Document
EAE	Ethiopian airport enterprise
EAL	Ethiopian Airlines
ECAA	Ethiopian Civil aviation authority
FAA	Federal Aviation Administration
AABIA	Addis Ababa Bole International Airport
ICAO	International Civil Aviation Authority
RWY	Runway
TWR	Air traffic control Tower
WHMC	Wildlife Hazard Management Committee
WHMP	Wildlife Hazard Management Plan

# **Chapter One. Introduction**

## **1.1 Background**

People have always tried to enhance their comfort. In so doing, they intervene in natural habitats and greatly decreased the area of naturally functioning ecosystems worldwide (Hannah et al., 1994&Remes, 2003). Diversity and extent of natural habitats was continuing to decline as human populations increase and alter landscape for development (Petit et al., 1999). Such activities transformed natural areas by establishing towns, building houses, gardens and public parks, which create entirely artificial environments.

The development and the continual expansion of urban areas have not only destroyed natural habitats, but also have drastically changed the environmental and ecological conditions of these areas. Consequently, species that have settled in these new man-made ecosystems are exposed to considerable alternations in environmental conditions (Partecke et al., 2005). For example, wildlife is important for the ecosystem as they play various roles as bio-indicators of different kind of environmental changes like urbanization (Padmavathy et al., 2010). Urban environments provide wildlife with considerable quantities of food and roosting sites especially in gardens and parks (Dorst, 1974).

Factors determining which species can coexist with human settlement include the presence and patch size of native vegetation as well as competition with exotic species and non-native predators. The structure and floristic attributes of planted vegetation as well as supplementary feeding by humans affect the level of such coexistence (Chace and Walsh, 2006). The effective management of human activities in wildlife areas is an important conservation issue, as the footprint of human influence continues to expand, and incidental impacts of human activities spread into more areas. Such expanding anthropogenic activity is widely perceived to lead to negative consequences for the wildlife beyond habitat loss alone. Understanding how animals respond to anthropogenic activities is fundamental to resolving potential conflicts between humans and animals. There are numerous ways in which it is possible to study animal responses, but changes in an animal's behavior are often the most obvious consequences of anthropogenic activities (Beale, 2007).

The history of the aviation industry has its root in the year 1783, when the first human lighter – than-air flight in a hot air balloon but the most remarkable year was 1903 when the Wright brothers fly in a powered and controlled aircraft. Due to the development of designing larger and reliable aircrafts, air transport has begun for passengers and cargo transportation. After this remarkable period, the aviation industry has shown an immense and dramatic development till these days by which air transport is the most reliable, fastest and safest mode of transportation for passengers and cargo compared to other modes of transport (Crouch, 2008).

Aviation and associated activities are one of the areas where human footprint significantly visible. Aviation is the design, development, production, operation, and use of aircraft, especially heavier-than-air. Without airports aviation industry is unthinkable. An airport is a location where aircrafts such as fixed wing aircraft, helicopters and blimps takeoff and land. Aircraft may be stored or maintained at an airport. An airport consists of at least one surface such as a runway for a plane to take off and land, a heliport or water for takeoffs and landings, and often includes buildings such as control towers, hangars and terminal buildings. Airports are vital part of the entire air transport system and key for the economic growth of every nation. This 21<sup>st</sup> century provides the aviation industry a great deal of opportunity for long term growth. The industry has a complex nature that has a likelihood of an anticipated success with fastest technical and organizational changes that are redefining the practice of airport systems, planning and design, service offerings and customer and cargo handling manners (Neufville, 2003).

The year 1944 was the most important year in the history of the aviation industry by which the foundation of the International Civil Aviation Organization was realized at Chicago, USA. It is a special part of the United Nations aimed at promoting safe and orderly development of the sector throughout the world (Mackenzie, 2010). The Organization has responsibility of formulating rules and regulations regarding safety, security, efficiency, regularity and environmentally friendly of the sector. In addition, it gives standards for airports, licenses for operators and aircraft manufacturers and coordinates with the national aviation authority of its members with the compliance of the rules set by the organization in line with the national laws to bring uniformity. It also inspects and audits the civil aviation of the member states (Huang, 2009).

Air Traffic was almost certainly continuing to grow substantially. Most of the world rarely flies, and the market is far from saturated. Plausible increase in population, national wealth, the length of paid vacations, and the tendency of members of younger generations to fly, even if only a few percent per year, was led to more traffic. Increased globalization was impelling long-distance travel for business and personal reasons, in general only realistically feasible by air. (Neufville, 2003).

Airports are one of the structural features in urban environments. The natural environment and other human activities inside and near the vicinity of airports attract a good range of wildlife including wildlife. Airports provide a good sort of natural and human made habitats that provide food, water and canopy. Most airports support ample and diverse food items such as seeds, leaves, insects, earthworms and small mammals in the vicinity. Airport areas provide certain wildlife with nesting, roosting, food, shelter and other facilities (Brown et al., 2001 & Sutherland et al., 2004).

Due to the availability of wildlife appealing features inside the airport Wildlife have been a potential hazard to aircraft since the beginning of air travel. Wildlife strikes were a negligible risk in the early days as there were few airlines in the air flying at comparatively low speeds. Damage to aircraft was, consequently, restricted to crushed windshields, smashed leading edges, and some impairment to the fuselage. The price of repairs was minor and airplanes operators and airdrome authorities recognized wildlife strikes as an ordinary hazard of aviation. As population of wildlife in and around airport increase, collisions between aircraft and wildlife have been acknowledged since the primary aircraft started flew over 100 years ago. Wildlife strikes still be a significant safety concern for aviation regulators, airlines and airports.

Occasional high-profile incidents, like the crash of Flight 1549 into the Hudson river, bring the problems to the eye of passengers and therefore the public, but for the most part this is a risk that is not fully appreciated, even within the industry itself. It is not just the high-profile incidents that make the headlines that are of concern. Thousands of minor incidents, most causing no damage to

aircraft, result in precautionary turn backs, engine checks, delays, cancellations and minor repairs that add up to at least \$1.2 billion per year in operational costs to the world civil aircraft fleet. <http://wildlife.faa.gov>.

Air transport in Ethiopia has started in the year 1929 on Gefersa, 18 kilometer west of Addis Ababa. In addition to previously mentioned area Janmeda, Lideta and Akaki were a place for remarkable airstrips and spots that have contributed more for the development and construction of more airports throughout the country and which has increased the role of air transport for the domestic use. (EAE, 2010)

Addis Ababa Bole International Airport was established at the beginning of the 1960's. The construction of the runway was commenced in 1961 and completed in 1964. As time goes on expansion carried-out and the runway becomes 3,800 meter in length and 60 meter in width plus 100 meters stop ways at both ends of the runway. Thus, now the airport has the potential to accommodate huge, modern aircrafts as big as Boeing 747 and MD-11. Currently the Apron can accommodate 53 large aircrafts at a time excluding the cargo apron capacity, the General Aviation parking area of the many small aircrafts and the Ethiopian Airlines Hangar capacity. (Ethiopian Airports Journal, 2010)

The present study focuses on gathering information on the species composition, and abundance of wildlife during this area. Monitoring wildlife numbers, activity pattern and abundance within the study area generates a complimentary source of data, which is more suited to the management of wildlife control programs. The survey administered also assessed the strike risk posed to aircraft by wildlife and other wildlife.

The present study aimed to assess the effects of wildlife hazards at Bole International Airport, Addis Ababa, Ethiopia. Monitoring wildlife numbers and other wild animals, activity pattern and abundance within the study area generates a complimentary source of data, which is more suited for developing efficient hazard management mechanisms.

## **1.2. Statement of the problem**

With aviation industry predicted to grow for the foreseeable future, and increasingly successful efforts being put into wildlife conservation, it's likely that the danger posed to aircraft by wildlife also will increase, unless simpler measures are put in place to manage the matter. Available data supports this view, with reported wildlife strikes increasing in frequency year by year. There is clearly a need to prevent wildlife strikes, but opinion is split about whether new technology is that the solution, or just proper application of long-established wildlife hazard management methods. This research reviewed airport community understanding on wildlife hazard management and therefore the latest developments in wildlife strike prevention and assesses several the explanations why we still struggle to urge on top of such a long-standing flight safety risk.

In Ethiopia, occasional high-profile incidents, like the crash of a Boeing 737-200 in September 1988 ranks, with 35 fatalities, out of 104 people on board, bring the problems to the eye of passengers and therefore the public, except for the foremost part this is often a risk that's not fully appreciated, even within the industry itself. It's not just the high-profile incidents that make the headlines that are of concern. Thousands of minor incidents, most causing no damage to aircraft, end in precautionary turn backs, engine checks, delays, cancellations and minor repairs that add up to a minimum of \$1.2 billion per annum in operational costs to the planet civil aircraft fleet(Sharing the Sky,2008) and millions of dollars annually in Ethiopia(ECAA,2020). Thus, there is a need to assess the patterns of aircraft accident at Bole International Airport for designing a proactive management intervention. Although the problem seems serious but there have been limited studies conducted in this regard. The two studies conducted so far focused on ecological aspect meaning the abundance and distribution of avian species in the airport and bird strike. whereas, this study addresses the pattern of wildlife incidents in the airport for the last five years, wild animals including avian and their role in the wildlife hazard, wildlife attractants inside the airport, and finally it has addressed the effect of wildlife hazard on the aviation sector.

### **1.3 Objective of the study**

#### **General Objective**

The overall objective of the study was to assess the wildlife Hazard Effect on the aviation industry at Addis Ababa Bole International Airport.

#### **Specific Objectives**

More specifically, in this research it was planned to:

- Assess the major wildlife and their attractants inside the airport.
- Investigate the patterns and trends of wildlife strike on aircraft at the Airport.
- Examine the effect of wildlife hazard on aircraft at the airport.

### **1.4 Research question**

The research questions include:

- How the patterns and trends of wildlife strike looks like on aircraft operation at Bole International Airport?
- Which contributing factors are there for wildlife hazard on aircraft operation?
- How does wildlife hazard affect the aviation sector?
- Identifying wildlife hazard on aircraft operation?

### **1.5 Scope of the study**

Thematic area of the study focus was on the wildlife hazard on aircraft operation at Addis Ababa Bole International Airport and the distance is approximately 4430m from east to west and 1867m from north to south extent and it covers about 900ha. This is because the airport is one of the busiest airports in Ethiopia as a result yearly there are several wildlife strikes reported to aerodrome safety department. The study covered the whole area of the airport. Its major targets were assessing the major wildlife and their attractants inside the airport, investigating the patterns and trends of wildlife strike on aircraft operation plus to that examining the effect of wildlife hazard on aircraft strike. Reviewing wildlife strike reporting data base and recording local wildlife species based on their strike rate in Addis Ababa Bole international airport.

## **1.6 Significance of the study**

The finding of this study provides several significances. First it provides ecological information regarding the wildlife hazard related issues for the government (Ethiopian civil aviation sector stake holders) or policy makers (ministry of transport) and it also provides the reader what a wildlife hazard poses to an aircraft operation and helps to understand the cause and effect of this aviation safety dilemma. It will help an aerodrome operator in the preparation of an airport wildlife hazard management plan so that they can save millions of dollars.

It helps civil aviation stakeholders to contribute their part in an airport wildlife hazard management program. It will contribute for the civil aviation sector safety management system improvement by providing information regarding the status of wildlife hazard and its trend in Addis Ababa Bole International Airport. It will provide an input to the preparation of Addis Ababa Bole international airport wildlife hazard management program. Finally, it provides an idea for those who want to carry out further studies on aviation safety and wildlife hazard issues at different nation.

## **1.7 Limitation of the study**

The basic limitation of this study was the problem to get many aviation communities due to Covid-19 pandemic. But the researcher figured it out by communicating representative aviation safety personnel from all stakeholders (Civil aviation authority, Ethiopian airlines and Ethiopian airports) before the pandemic. Therefore, the researcher is forced to use only focused group discussion and key informant interview for few people to abide to the state emergency that follows the spread of the Covid 19.

The sector had difficulties in calculating all expenses caused by wildlife strike so that it is difficult to get the total cost of the wildlife strike. For instance, it can be easy to calculate the cost associated with maintenance, but it is difficult to calculate customer's dissatisfaction on aircraft operators and loss of liability due to wildlife strike encountered. So, such expenses can be calculated roughly than clearly so that was the limitation during the research. Even if the above limitations were in place during the study period the researcher tried to address the research questions and exerted maximum determination to accomplish the study in a very prolific manner to accomplish the objectives stated.

## **1.8 Definition of terms**

**Aerodrome:** A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft. (ICAO, 2001)

**Aerodrome Control towers:** A unit established to provide air traffic control service to aerodrome traffic. (ICAO, 2007)

**Aircraft:** Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface. (ICAO, 2001)

**Apron:** A defined area, on a land aerodrome, intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo, fueling, parking or maintenance. (ICAO, 2001)

**Operator:** A person, organization or enterprise engaged in or offering to engage in an aircraft operation. (ICAO, 2001)

**Runway:** A defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft. (ICAO, 2001)

**Taxiing:** Movement of an aircraft on the surface of an aerodrome under its own power, excluding take-off and landing. (ICAO, 2007)

**Wildlife:** Living things neither cultivated nor domesticated. (ECAA, 2015).

**Wildlife hazard:** Potential danger due to wildlife to aircraft. (ECAA, 2014).

**Wildlife attractant:** They are the source of cover, shelter, food and water in the local environment. (ECAA, 2013).

**Wildlife strike:** when wildlife and a moving aircraft collide. (ECAA, 2013).

## **1.9 Organization of the thesis**

This thesis is organized in to six chapters. The present chapter is about the Background, the statement of the problem, the objectives, the research questions, the significance, the study area, the scope, the limitations of the study and organization of the thesis. The second chapter deals with the related literature about wildlife hazard on aircraft operation near airports, policies to protect airports and other related points. The third chapter of this thesis discusses on issues related to the study area and its features.

The fourth chapter of this thesis discusses on points related with data types, Source, the sample size and sampling techniques, the instruments used to collect Data, the method of data analysis and presentation are illustrated. How wildlife activity affects the aircraft operation and data is collected using the instrument is also having a part in this chapter. In chapter five, the analysis of the data is presented. Thus, the data collected through observation, key informant's questionnaire, accident incident database review and document analysis are analyzed, presented and discussed with their findings at last. Finally, in chapter six the conclusion of the study and the recommendation of the researcher is presented.

## **Chapter Two. Related Literature Review**

Wildlife encompasses animals and plants even other forms of life which are living without the direct control of human beings. Wildlife hazard on aircraft refers to a potential danger due to wildlife's (mostly wildlife and mammals) on aircraft operation in and around an aerodrome. The wildlife occurrence on the aerodrome had a negative consequence on aircraft operation (MacKinnon et al.,2001).

### **2.1 Theory of Airports wildlife strikes/accidents**

For this study there is one theory related with air traffic accident and incident related concepts which is Normal accident theory. It is a 1984 book by Charles Perrow which provides a detailed analysis of complex system. It was the first to propose a frame work for characterizing complex technological system such as air traffic ,marine traffic and especially nuclear power plant according to their risk ness .Perrow says that multiple and unexpected failures are built into society complex and tightly coupled systems. Such as accidents are in evitable.

Perrow arguments based on human error, big accidents tend to escalate, and technology is not the problem, the organization are. Normal Accident contributed key concepts to a set of intellectual developments in the 1980s that revolutionized the conception of safety and risk. It made the case for examining technological failures as the product of highly interacting systems and highlighted organizational and management factors as the main causes of failures. Technological disasters could no longer be ascribed to isolated equipment malfunction, operator error or act of God.

Per row identifies three conditions that make a system likely to be susceptible to Normal Accidents. These are:

- The system is Complex
- The system is tightly coupled
- The system has Catastrophic potential

Air traffic by nature fulfill all their conditions identified by Perrow which the system is complex, tightly coupled and it has catastrophic potential.

Calbraith Rodgers on 3 April 1912, was the first man to fly across America, was killed in the first crash resulting from a gull along California (Cleary and Dolbeer, 2005). Despite this tragic event, strikes with wildlife and other wildlife were of little concern for the primary 50 years of aviation.

In fact, only three civil aircraft were destroyed, and two human fatalities were documented worldwide between 1912 and 1959. But in October 1960, a turboprop-powered Lockheed Electra crashed in Boston Harbor, Boston, Massachusetts, USA, shortly after takeoff, following the ingestion of over 200 European starlings (*Sturnus vulgaris*) into the air intakes of three of the aircraft's four engines. Sixty-two people died; a fatality counts which so far remains the very best for a wildlife ~ induced plane crash. During 1960-2010, wildlife and other wildlife strikes destroyed 160 civil aircrafts (ICAO Airport Services Manual, Part 3).

Why numerous Wildlife Strikes? There are multiple reasons for the dramatic increase in wildlife strikes since the 1960s. First, the arrival of turbine powered passenger aircraft within the 1960s revolutionized aviation, but it also magnified the matter of wildlife strikes. Early piston powered were slow and has huge noise from their engine. Wildlife could usually avoid these aircraft, and human intrusion were experienced but it did not amplify that much. whereas, contemporary aircrafts have relatively low sound and swift flight due to this there is limited chance for wildlife to escape from this machine. The aircrafts affecting 9 1.8 kg (4 lb) and thus are more likely than smaller species to cause damage to aircraft when struck and exceed certification standards for many air frame components and engines (Dolbeer and Eschenfelder 2003 & DeVault et al. 2011). Thus, the rise probability of damaging wildlife strikes since the 1960s is primarily associated with the increase in traffic by two-engine, large-inlet, turbine-powered aircraft concurrent with major increases in populations of the many large-bodied wildlife species. Dolbeer, Richard A., (The History of Wildlife Strikes and Management at Airports,2013).

### **Wildlife hazard on aircraft**

Wildlife hazard is a potential danger on aircrafts due to wildlife. Wildlife strikes were a negligible risk in the early days as there were few airlines in the air flying at comparatively low speeds. Damage to aircraft was, consequently, restricted to crushed windshields, smashed leading edges, and some impairment to the fuselage. The price of repairs was minor and airplanes operators and airdrome authorities recognized wildlife strikes as an ordinary hazard of aviation. In time, the swiftness of airplanes amplified, and apparatus sound levels dropped with the development of novel generation turbine engines. Airplanes simply became too swift and too silent for wildlife to sense and escape. Wildlife unintentionally became a grave threat to the safety of aviation as strikes became more common and graver.

### **2.1.1 Direct and Indirect cost of wildlife strike**

Collisions between wildlife and aircraft are known to cause significant negative impact to the aviation industry in direct and indirect costs annually. (John.R,2004). Sometimes it is impossible to get the accurate figure of the cost of wildlife strike due to the commercial airlines system that does not segregate cost incurred by wildlife with other costs and the culture of reporting is not a such developed worldwide. (Cleary et al.,2000). Wildlife strikes force an operator to spend millions of dollars on several direct and indirect costs. Direct costs are costs related with direct expense related with the wildlife strike and Indirect costs are influenced by the degree of danger to the airplane, how far from the operator's nearest maintenance facility, number of flights the airline and the operator's type operation which means either it is international, domestic or both. (Sharing the Sky,2004)

### **2.1.2 Wildlife appealing features at aerodrome**

According to ICAO (International Civil Aviation Organization), Most of the wildlife strike inside the airport. This is because airports provide water (artificial pond, stream, rive, puddle), food (grain, organic waste, insects, worm, grass, vegetation) shelter and cover (patch of vegetation, over grown grass, buildings and structures) as well as tranquil environment.

### **2.1.3 Wildlife accident on aircraft**

There are several major accidents due to wildlife one of the well-known strikes were occurred On October 1960, the deadly wildlife-strike accident occurred when Starlings were ingested into three of the four turboprop engines. The number-one engine had collapsed; numbers two and four lost power. The aircraft lost control and crashed into Boston. Of the 72 persons on board, 62 died and 9 were injured (Sharing the Sky,2008).

one occurrence, for example, a Boeing 747 on take-off developed a huge shaking in the engine. The compressor stuck, and the engine locked down. the airplane, with 270 travelers aboard, made a flat landing at a near airdrome. The body of a Glaucous-winged gull was on the airstrip at the previous airport. Also found were numerous fragments of steel. During inspection of the leaving

airdrome, gull-type remnants were found along with an extensively damaged engine and wing parts. Damage was estimated at U.S.\$1.4 million. (Sharing the Sky,2008).

The inspection of the wildlife leftovers, through the usage of electrophoresis identification, confirmed that it was a Glaucous-winged gull. Damage to airplanes imposed by a wildlife attack is typically negligible; though, some attacks can cause terminated take-offs and cautionary landings and can cause crash. For example, in one case a Herring gull (*Larus argentarius*) was sucked by an engine on an aircraft (a Boeing-737). The damaged engine lost power at which point the pilot decided to cancel the take-off. The captain used the brakes at the last and tried to control the airplane. As a result, the airplane slipped off the runway and descended to a standstill in a marshy place. Travelers were expatriated. The prices of evacuating the airplane out of the sludge and getting it back into service were valued at over U.S.\$1.5 million. The prices of down-time for examination and restoration of airplane subsequent wildlife damage, or supposed wildlife impairment, aborted airlifts, postponement of airplane travelers and air cargo, allocation of travelers to other means of transportation, overnight accommodation at the expenditure of the airplane operator and the deleterious effects on schedules of linking flights can often be very substantial and destructive to carrier operational budgets and public goodwill.(ICAO Bird Control Manual,1991).

#### **2.1.4 Mitigation measure for wildlife hazard**

According to (Edward and Richard,2005) Habitat management including managing the source of water, shelter, cover food is very vital in an airport wildlife hazard management program. In addition to the primary management activity it is pertinent to include active management elements like scaring, dispersing and killing of dangerous/risky wild animals.

wildlife hazard management professionals in the field airport safety recommends much of the wildlife hazard related risks can be eliminated if an airport follow scientific and systematic approach to deal with. Airports are the first line to start managing the hazardous wildlife. The primary activity that must be undertaken are removing attractants and the controlling the movement of wildlife against aircraft operation. (Sharing the Sky,2004).

## **2.2 Airport Wildlife hazard management system**

According to the International civil aviation organization the rules and standards that national regulatory divisions exerted over wildlife hazard management at the airport differs in each nation. Some of the responsible bodies are open-minded and highly organized and structured. On the other hand, other jurisdictions are lenient. Each state civil aviation authority is responsible to ratify proclamation regarding maintain ace and ensuring of airport safety. Based on the ratified regulation each aerodrome regulatory has the responsibility to establish their own airport wildlife hazard management program. Then they are responsible for the implementation, monitoring and evaluation of their program. Each nation civil aviation authorities are responsible for the oversight activities of each airport.

### **2.2.1 World Wildlife Strike Association**

It is an international none profit organization that facilitate and coordinate countries, airlines, airport operators, educational institutions who are interested and has a stake in aviation wildlife strike management related issues. (World wildlife strike association, 2012).

### **2.2.2 Ethiopian wildlife hazard management legal frame work**

According to Ethiopian civil aviation authority proclamation 616/2009, Ethiopian civil aviation authority plays a pivotal role in managing wildlife hazard on the aviation sector within the country. It's established a legal frame work supported by proclamation 616/2009. By using proclamation 616/2009 as a basis the authority prepared and ratified its industry specific regulation which is Ethiopian civil aviation regulation. Therein particular regulation the difficulty of wildlife hazard management is discussed.

According to Ethiopian civil aviation authority proclamation 616/2009 Some of the wildlife hazard management issues on the regulation states that:

- (1) An operator shall, in consultation with the acceptable authority, take necessary Action to regulate wildlife hazards at an aerodrome.
- (2) An operator shall make sure that procedures to affect the danger posed to aircraft Operations by the presence of wildlife and animals within the aerodrome flight pattern or Movement areas are in situ.

(3) The wildlife management plan of an aerodrome shall be approved by the Authority and shall form a part of the aerodrome manual.

In addition to the regulation the authority also prepared guidance material that helps to implement regulations on the aerodrome wildlife hazard management among the guidance materials which were provided to the stake holders:

1. Guide line of wildlife hazard management at airport.
2. Hazardous land use practice in and around airport.
3. Profile of risky wildlife in and around airports in Ethiopia
4. Wildlife and wildlife strike reporting

To ensure the security and appropriate implementation of wildlife hazard management program ECAA has an Inspection and audit program conducted by Aerodrome Safety and Standards and supply non-compliance regarding the Airport's wildlife hazard management activities on yearly basis. ECAA per ECARAS prt.12.7.3 the aerodrome safety and standard Directorate recommend the Airport to determine contemporary airport wildlife hazard management system for all civil airports counting on their local condition.

When an entire assessment is submitted by the airport to the regulator for review and approval. The regulator was also use it to work out if the airport must prepare their plan to deal with their airport wildlife hazard. (ECAA,2013)

The Plan accomplishes this through the identification of hazardous wildlife and their attractants, suitable proactive and reactive management techniques, necessary resources and supplies to successfully implement a wildlife hazard management program and personnel responsibilities and training requirements. Appropriate federal and possible local wildlife control permits should be identified also as a schedule and methodology to gauge and update the Plan that is according to ICAO Airport Services Manual, Part 3.

### 2.3 Conceptual framework

The conceptual framework suggests a rational construction of linked ideas that help provide a picture or visual presentation of how concepts in a study relate to one another within the theoretical framework (Grant & Osanloo, 2014). The following conceptual framework specifies the variables of the study and their association. About the effect of wildlife hazard in Addis Ababa Bole international airport, it is conceptualized that the status of wildlife hazard and aircraft operation in the airport is expanding and the management practice applied did not contribute a lot to keep acceptable level of strike per flight. This leads to more adverse impacts in the aviation industry in general and in Addis Ababa Bole international airport. Therefore, wildlife hazard and aircraft operation /aviation safety should be managed in such a way that proactive approach not the reactive one. to lead towards sustainable development. The conceptual framework below stipulates that key areas of airport wildlife hazard management system and their interaction. There are air traffic movement growth and wildlife hazard management system which are the key factors.

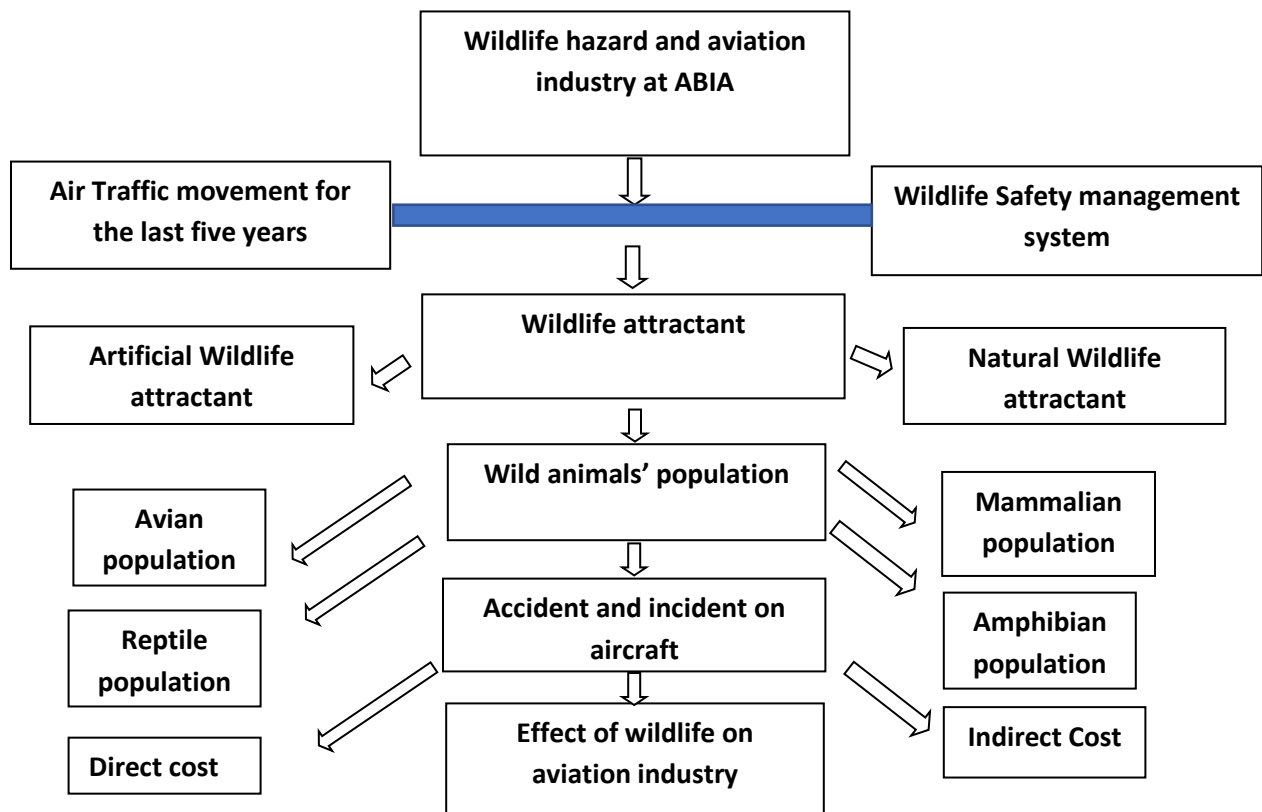


Figure 1 Conceptual framework.

## **Chapter Three. The study area**

### **3.1 Description of the study area**

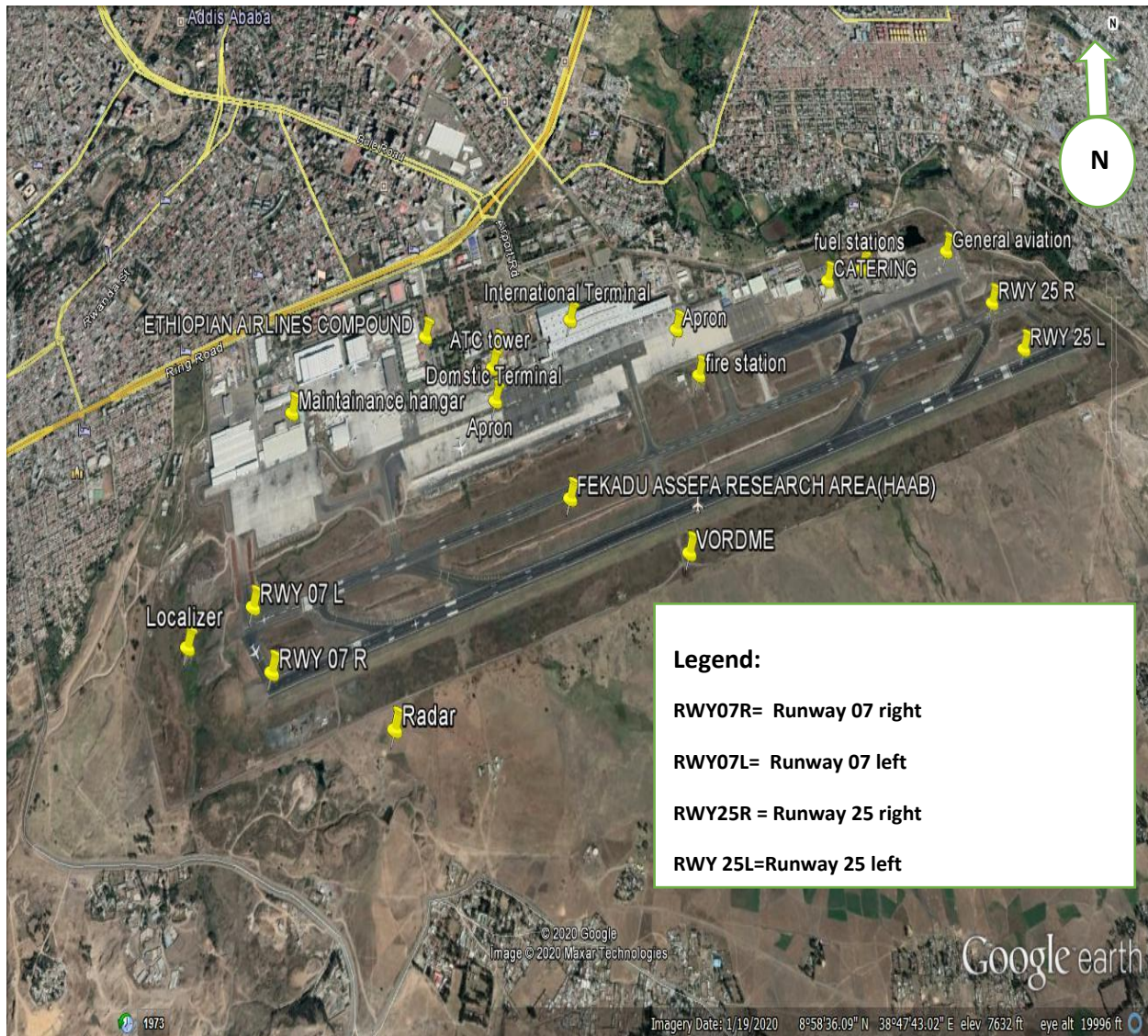
The Addis Ababa Bole International Airport is within the Bole sub city, 6 km south east of the center of Addis Ababa city (The Mayor office) at an elevation of 2400 m (Researcher GPS reading) above water level. Addis Ababa Bole International Airport is in Bole sub-city woreda 01. Headquarters of the EAE, ECAA, EAL, oil depot, the ATC (air traffic control tower), and thus the food Service facilities are among the airport related buildings that exist to the north of the (runway)RWY. The RWY 07/25 lies during a northeast-southwest direction.

It consists of two alternate runways, twelve taxiways connecting the seven runways and two taxiways connecting the old runway with the foremost and repair aprons also as security road which circle the security fence of the airport. Natural habitats within the area include grassland, which is that the dominant feature of the area, wetlands, swampy areas, water bodies, bush lands and woodlands. There are also different species of wildlife and sometimes mammals, reptiles are observed. The study area also includes two big terminal building of the airport which is terminal one and two, civil aviation air navigation office, aviation air navigation, Ethiopian airlines maintenance hangars, old tower for metrological purpose and office firefighting and rescue station, control towers, security and perimeter fences, fuel stations, offices, cafeterias, gardens and other areas with significant Human activities.

The area includes the airport and thus the encompassing residential, crusher plants. It includes the natural habitat like wetlands, the small swampy areas and thus the grassland and thus the man-made environment- the Hangars, the settlement and installed equipment. The study area has different land uses that include the airport environment, Residential area, water bodies, the crusher plants, commercial centers, civic communities, open land. Residential areas are found to the East and West of the airport perimeter.

The Southern a neighborhood of the airport consists of farmland and thus the newly emerging Bole Bulbul residential area. The crusher plants are found to the west and east of the station. The agricultural farm lands are located to the south, west and east of the station. The Water bodies are found to the northeast, south and west of the airport. Commercial Centers occupy the planet north

of the station and thus the civic communities are found altogether Directions. The airport is controlled by the EAE and thus the administration is left to the Addis Ababa Bole International Airport Administration. The distance is approximately 4430m from east to west and 1867m from north to south extent and it covers about 900ha.(Ecaa,2019)



**Figure 2** Location map of the study area with (Source: Satellite image by Google Earth,2020)

### 3.2 Topography

Addis Ababa Bole International Airport is found in southeast of the city having a delegated geographical location of 085830.1470N and 038475.8387E(N.B. This aerodrome point of

reference is 400m from the center line at approximate middle of runway 25R and to the left of runway 25R) at an elevation of 2333.5m above mean water level.



**Figure 3 Master plan map of the Addis Ababa Bole International Airport** (Source: Engineering division of Ethiopian Airport Enterprise)

### 3.2.1 Climate

At Addis Ababa Bole International Airport, the wet season is typically cloudy, the season is partly cloudy, and it's comfortable year-round. Over the course of the year, the temperature typically varies from 49°F to 76°F and isn't below 44°F or above 81°F. (Source: National Meteorological Service Agency, 2019)

### 3.2.2 Temperature

The warm season lasts for 4 months, from February to June, with a mean daily heat above 74°F. the foremost well-liked month of the year is May, with a mean high of 76°F and low of 56°F. The

cool season lasts for 2 months, from July to September, with a mean daily heat below 69°F. The coldest month of the year is December, with a mean low of 49°F and high of 72°F. (Source: National Meteorological Service Agency, 2019)

### **3.2.3 Clouds**

At Addis Ababa Bole International Airport, the standard percentage of the sky covered by clouds experiences significant seasonal variation over the course of the year. The clearer a period of the year at Addis Ababa Bole International Airport begins around August 28 and lasts for 7 months. (Source: National Meteorological Service Agency, 2019)

### **3.2.4 Rainfall**

Addis Ababa Bole International Airport experiences extreme seasonal variation in monthly rainfall. The rainy period of the year lasts for 9.4 months. The foremost rain falls during the 31 days centered on August 3, with a mean total accumulation of 8.3 inches. The rainless period of the year lasts for 2.5 months. (Source: National Meteorological Service Agency, 2019)

### **3.2.5 Sun**

The length of the day at Addis Ababa Bole International Airport doesn't vary substantially over the course of the year. In 2019, the shortest day is December 22, with 11 hours, 36 minutes of daylight; the longest day is June 21, with 12 hours, 39 minutes of daylight. The earliest sunrise is at 6:04 AM on May 28, and thus the newest sunrise is 42 minutes later at 6:46 AM on January 30. The earliest sunset is at 6:00 PM on November 16, and thus the newest sunset is 48 minutes later at 6:48 PM on July 13. (Source: National Meteorological Service Agency, 2019)

## **Chapter Four. Methodology**

### **4.1 Research design**

In this study, Normative descriptive research design was used to know what the present level of wildlife hazard on aircraft operation at Addis Ababa Bole International Airport. Also, a mixed research design of both qualitative and quantitative methods was employed for collecting the essential data on the impact of the wildlife hazard on aircraft, aviation community understanding regarding this aviation safety hazard, the strike database and the ranking of hazardous species.

### **4.2 Research approach, data sources and methods of data collection**

This research used both qualitative and quantitative research approach. Also, the study used both primary and secondary data sources; which complement to each other. A primary source of data was collected by using the following data collection techniques:

### **4.3 Tools and Technique of primary data source**

The primary data was collected using both quantitative and qualitative data collection methods. The quantitative data collection method was ecological survey of wild animals (transect and point counting method). The qualitative data sources were gathered by employing FGDs, Key Informant Interviews and field observation. Questionnaires and checklist/guideline were used to collect relevant data.

### **4.4 Field Observation**

Detailed study was carried out from June 2019 to April 2020. The wet season survey was carried out from June to October 2019 while the remaining months were for dry season investigation. The contribution of local ecosystem meaning the availability of attractants that includes food, water, shelter, and cover sources for different fauna species with air traffic movement were considered. The aircraft operation starting from engine startup, taxiing, take off run, initial climb on, the departure phase on the other hand decent/approach, landing run, taxiing to the gate and parking were observed. The researcher took various descriptive notes of what was happening. Videos and Photographs were taken during field observation. The study was focused on the local ecological components and their relationship with aircraft operation.

## **Transect**

Transect count methods was used to study the presence of wild animals in and around the airport (Tsigereda 2011). Actions, numbers, kinds and places of wild animals were documented. By using transect method the researcher was able to identify the type of fauna and flora species present in the airport vicinity. In addition to that it has provided the data for species density and type.

## **Point counting**

A point count was used during the study period to assess the abundance and distribution of avian and other wildlife's in Addis Ababa Bole international airport. The radius size used was as large as possible to maximize data gathering, but it was not large that wildlife cannot be seen or heard throughout the survey area.

## **4.5 Focus group discussions (FGDs)**

FGD was conducted to understand about Addis Ababa Bole international airport wildlife hazard management system, availability of strike recording database, aviation stake holders' stake on this aviation safety hazard, availability of daily wildlife movement log and legal framework to manage this hazard. One FGD was conducted in per each aviation stake holders meaning (the airport operator, the air navigation service provider, the aircraft operators and civil aviation authority). The total numbers of members in one FGD has 8participants. The FGD participants were selected purposively from Ethiopian airlines three participant, Ethiopian airports three participant and civil aviation authority two participant Each from aviation safety department.

## **4.6 Key Informant Interview (KII)**

The key informant interview used to address the wildlife hazard effect and other wildlife hazard management issues on the aviation sector in Ethiopia specifically to Addis Ababa Bole international airport. Contributing factors for wildlife strike, effectiveness of wildlife hazard management and introduction of contemporary industry specific technologies for managing the hazard& its impacts have explored based on qualitative techniques. Participants of KII were selected purposively from each aviation stake holders (ten ground technicians, five pilots and fifteen safety personnel from aircraft operators. Twenty wildlife scares, Ten grass mowers, Ten safety department personnel from Addis Ababa Bole international airport and five aerodrome inspectors, five air traffic controllers from Ethiopian civil aviation authority.

#### **4.7 Secondary data source**

Secondary data sources were collected from journal articles, books, legal documents (proclamations, regulation and directives), statistical abstracts, study reports, daily log of airport, (ATC) air traffic controllers daily log, pilot report, accident and incident reports database of the civil aviation authority, thesis and dissertations among others. These sources of secondary information were accessed from the database, university libraries, institutions and organizations.

#### **4.8 Sampling techniques**

Addis Ababa Bole international airport is a huge and front line in terms of operation and facility in Ethiopia and repetitively sustained chronic wildlife accidents and incidents. There were several reported incidents due to wildlife. For this reason, the study was selected Addis Ababa Bole international airport purposively among non-probability sampling techniques. Also, for Addis Ababa airport wildlife hazard management case there are airlines company, the airport operator and civil aviation authority which render the air navigation service. Due to this the study selects these specific aviation stake holder's airports purposively among non-probability sampling techniques.

To answer the qualitative question, the study was selected key informant and participants for focus group discussion by purposive sampling technique. In addition, safety officers who have a stake on airport wildlife hazard management system have the responsibility to play their parts in wildlife hazard management system due to this the study select respondents for quantitative approach by using simple random sampling technique. The purposive sampling is selected by some arbitrary method because it is known to be representative of the total population, or it is known that it was produce well matched groups. The Idea is to pick out the sample in relation to some criterion, which is considered important for the study.

Target population is a population to which a researcher wants to generalize the results of the study (Mugenda, 1999). The target population for this study encompassed all aviation stake holders working in and around Addis Ababa Bole international airport. According to Civil aviation authority data the aviation safety-oriented workers is around 100. Therefore, the sample size is the total number of populations which are to be selected as sources for the information to be collected

and analyzed in a research. Sample size was determined according to Yamane, (1967) simplified formula at 95% confidence interval. It is used to determine the number of representative samples that should be included in the survey the sample size of the respondent was selected based on the formula given.  $n = N / 1 + N(e)^2$ , n= Sample Size, N= Total Population and e= Precision level at 95% ( $\alpha=0.05$ ) confident interval for normal distribution data. Therefore, the sample size: N= and e, at  $\alpha=0.05$   $n=100/1+100(0.05)^2$ , n=80. Regarding the distribution of sample respondents proportional to the overall population are from Airport operator 40, from Airlines 30 and from Ethiopian civil aviation authority 10 Total 80 participants were selected for key informant interview.

Furthermore, the researcher purposively selected safety experts, wildlife scares and persons engaged in wildlife hazard management from all stakeholders for Focus Group Discussion with understanding that they have direct relationships with the issue under study. The FGD participants were selected purposively from Ethiopian airlines three participant, Ethiopian airports three participant and civil aviation authority two participants each from aviation safety department.

#### **4.9 Method of data analysis**

The gathered data by the above ways were analyzed to check whether the objectives are met. Since the data collected were qualitative and quantitative in nature, the data analysis of this research depends on both quantitative and qualitative approach. The primary data collected was processed and analyzed by using statistical software's. The survey data was analyzed and interpreted by using descriptive statistics such as Histogram, pie chart, frequency distribution, percentage and matrix. The qualitative data obtained through key informant interview, field observation and focus group discussions were analysed by tabular presentation/matrix, narrative analysis. Regarding the interpretation of wild animals and wildlife attractant observed in the study area the researcher used matrix, pictorial presentation, satellite image and narration. For review of the wildlife strike database pie chart, tables, histograms and photos were used. For the interpretation of data related with the effect of wildlife on aircraft operation histograms, tables photos, pie charts were used.

#### **4.10 Data validity and reliability**

Validity issue in mixed methods research may relate to the type of strategies. These may have related to sample selection, sample size, and follow up on contradictory results, bias in data collection, inadequate procedures, or the use of conflicting research question (Creswell and Plano, 2007). Therefore, the study was given a great focus on accuracy of the mentioned strategies. Finally, both qualitative and quantitative data was have combined each other which the data collected through focus group discussion FGD, key informant interview, field observation and document analysis.

## **Chapter Five: Results and Discussion**

### **5.1 Results**

#### **5.1.1 Wildlife Observed in Addis Ababa Bole international airport**

Wildlife in the study area was detected either throughout the study period or during specific times of the year only. Some were observed completely during the wet season while others only throughout the dry season. There were also wildlife species with high number of individuals at specific times of the study period. These all were due to resources availability and the favorable weather conditions. Food resources are the most important attractant features for the wildlife. Wildlife species richness and abundance in a specific area is influenced by local resource like food, water, cover and shelter availability and vegetation composition.

Wildlife mostly avian are very associated with their environments based on their feeding habit, roosting site preference, sheltering and nesting behavior. Most high-risk wildlife in the airport are grassland generalists. Grassland generalists are those wildlife's that frequently visit the grasslands but are also observed in other habitats as well. Raptors, which mostly depend on preys, prefer high canopy roosting sites (large trees) and other manmade structures.

Scavengers like pied crow, Black Kites and blue-black starling scavenge mainly on wildlife attractant areas like waste disposal areas and food leftovers. Others which moderately create a threat to the airport are mostly frugivorous, nectar feeders and seed eaters; but some of them attract raptors which indirectly induce hazards to the airport operation. Some of them are Speckled pigeons, doves, starlings, weavers, warblers, etc.

The airport harbor vertebrates, insects and other invertebrates. These included vegetation around the airfield. This in turn resulted in the attraction of wildlife or wildlife to the airport. Bees were detected in large numbers after the blooming of Meskel flower (*Biden 's* sp.) during September and October. Grasshoppers were regularly observed flying out of the vegetation of the airfield on to the maneuvering area. Other life forms like Earthworms, caterpillars, spiders, cockroaches and snails bask on the runways following rains. Beetles and butterflies often were observed flying during the study period.

Reptiles like Snakes and lizards were observed inhabiting the airport areas. Amphibians like Frogs and toads were seen within puddles and artificial pond located in the airport, man holes and water ways formed on the runways following the rain during the wet season.

Expert observation and evidences show the presence of vertebrates in the area. These include larger mammals like hyaena, jackal, dogs, cats and hare as well as small mammals like rodents, which were observed directly. Small mammals' evidence like Shed off spines of porcupine were used as indirect indication for their presence in the area. Domestic animals were also detected around the airfield.

In relation to the airport safety, relatively large size wildlife's like spotted hyena pose more impact than the others. Even though spotted hyena was observed by the survey group, unswerving data has been found that hyena still lives in the airport and posed numerous accidents. Hyena is among the bigger mammals and naturally active during the night time and was detected in the airport area as an inhabitant mammal.

Hyena in Bole airport area is attracted by the removal of food leftovers and other putrescible wastes which can be used as food source for the animal. Besides, the vegetation covers of the airport, the sewage lines also serve as an ideal safe place for civet and hyena. In areas located near the runway, droppings and faces of medium sized mammals have been observed. These are the marks of common duiker and jackals. List of species observed is presented in table six.



**Figure 4 Wildlife species recorded from Addis Ababa Bole International Airport (source: Google Earth 2020)**

The above figure is showing some of the wildlife species observed in the study area and their range within the vicinity of the airport. Avian like Black Kite, Pied Crow, Dusky Turtle Dove, Hammer Kop were some of the bird species observed during June to April (20019-2020). Mammalian like Spotted Hyena, Common Ducker and Common Jackal observed during June to April (20019-2020).

The following table list out different life forms which are present in the airport. The identification of this species done via two ways one is direct observation and the other one is indirect observation basically by using the airport species registry daily log computerized data base.

**Table 1 List of wildlife species recorded from Addis Ababa Bole International Airport.**

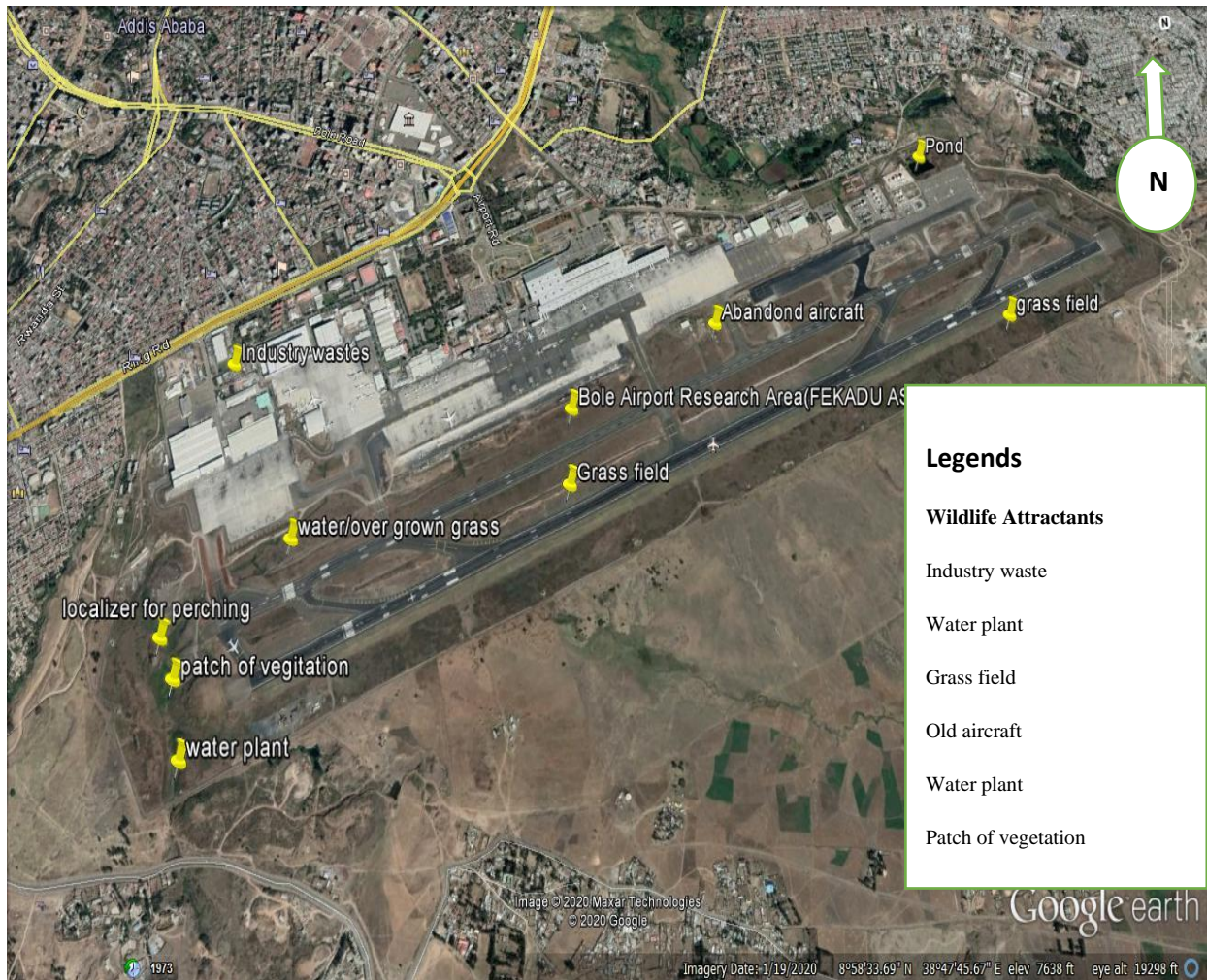
NO.	Birds species	Mammals	Reptiles	Amphibians	Plant
1.	Abdim's Stork	Common ducker	Lizards	Frog	Meskel flower ( <i>Biden's</i> )
2.	Abyssinian Longclaw	Dog	Snake		Acacia spp.
3.	African Citril	Spotted Hyena			Thick grass <i>Hypernia ruffa</i>
4.	African Silver bill	Bat			Water plant
5.	African Fish Eagle	Dog			
6.	African Pied Wagtail	Serval cat			
7.	Augur Buzzard	Common jackal			
8.	Black Headed Heron	Porcupine			
9.	Black Kite	Rat			
10.	Black Shouldered Kite				
11.	Black-Winged Lapwing				
12.	Black-Winged Love wildlife				
13.	Bronze Mannikin				
14.	Brown-Rumped Seed-Eater				
15.	Cape Rook				
16.	Cattle Egret				

<b>17.</b>	Cinnamon-Breasted Bunting
<b>18.</b>	Common Kestrel
<b>19.</b>	Common Moorhen
<b>20.</b>	Common Rock
<b>21.</b>	Crimson-Rumped Waxbill
<b>22.</b>	Dusky Turtle Dove
<b>23.</b>	Egyptian Goose
<b>24.</b>	Ethiopian Swallow
<b>25.</b>	European Bee-Eater
<b>26.</b>	European Swallow
<b>27.</b>	Glossy Ibis
<b>28.</b>	Greater Blue-Eared Starling
<b>29.</b>	Hamer kop
<b>30.</b>	Hooded Vulture
<b>31.</b>	Little Swift
<b>32.</b>	Long-Crested Eagle
<b>33.</b>	Long Tailed Cormorant
<b>34.</b>	Pied Crow
<b>35.</b>	Pied Wheatear
<b>36.</b>	Pin-Tailed Whydah
<b>37.</b>	Red-Billed Firefinch
<b>38.</b>	Red-Eyed Dove
<b>39.</b>	Red-Rumped Swallow

<b>40.</b>	Rougets Rail
<b>41.</b>	Sacred Ibis
<b>42.</b>	Speckled
<b>43.</b>	Speckled Pigeon
<b>44.</b>	Spur-Winged Plover
<b>45.</b>	Streaky Seed-Eater
<b>46.</b>	Tawny Eagle
<b>47.</b>	Thick-Billed Raven
<b>48.</b>	Wattled Ibis
<b>49.</b>	White-Backed Vulture
<b>50.</b>	White-Collared Pigeon
<b>51.</b>	Yellow Wagtail
<b>52.</b>	Yellow-Billed Kite

### 5.1.2 Wildlife attractants inside Addis Ababa Bole international airport.

Addis Ababa Bole international airport environments provide a varied appealing feature and these landscapes are recognized and measured to control the utmost suitable stoppage, barriers, dispersal and obliteration activities. Wildlife attractants broadly classified as natural and artificial. The natural attractants include preferred water, cover, shelter and food. The manmade attractants are mostly created by the socio-economic activities of man such as waste disposal, food processing activities, etc. Therefore, the major wildlife attractant sites inside the airport were assessed. Figure six presented the most common wildlife attractant in the airport.



**Figure 5 Wild life attractant inside AABIA (Source: Google earth 2020)**

#### **Grass and vegetation**

One of the natural attractants of Wildlife in the study area is grass and vegetation the cover of the airport complex. This flora with different sections provides ideal habitat for different species of wildlife; including mammals, wildlife, rodents, reptiles and insects.

The vegetated area of the airport compound favors for mammals and wildlife to reproduce because the area is relatively secured from human interference and there are different types of vegetation ideal for nesting, roosting, resting and feeding at different points of the compound. In addition to that small water bodies (artificial pond located in the airport) and termite mounds around the maneuvering area are the major wildlife attracting features.

Regarding the vegetation cover the thick grass *Hypernia ruffa* has occupied the airport complex. This condition has preferred seed eaters such as Fowl and Francolin, also recognized hiding and laying their eggs throughout the study period. This also favors rodents, other vertebrates and invertebrates to breed and hide during the feeding and breeding session. Figure seven shows the grass field inside the airport during dry season.



The Grassland during the dry season (February 2019; Photo: Fekadu Assefa)  
**Figure 6 Grass land inside the airport**

The existence of different types of plants that flower at different periods of the year, for example, some flower during the dry season, some towards the end of the dry season and some others after the rainy season, are accountable in attracting different species of wildlife's. Most flowering plants can support many nectar feeders and insectivorous wildlife. These phenomena could invite some wildlife of prey to wander around which are risky for aircrafts.



Adey Ababa Tough grass (September 2019; Photo: Fekadu Assefa)

**Figure 7 Adey Ababa Tough grass and other flowering vegetation inside the airport**

Trees which are planted nearest to the airport are the main sites for nesting and hiding opportunity for different wildlife species. Therefore, they're going to increase wildlife attraction.



Patch of vegetation (October 2019; Photo: Fekadu Assefa)

**Figure 8 Patch of vegetation**

### **Water**

Within less than 2 KM distance from the active runway there is a quarry site use for extraction of aggregate material. the site is ideal place for water storage during rainy season. The stored water provide water for different wildlife inside the airport as it is presented in the satellite image.

many open water sites in AABIA, the more complex and frequent the movements of waterfowl are going to be. there's also more activity in the dark than during the day.



Water body (October 2019; Photo: Fekadu Assefa)

**Figure 09 Water way inside the airport**

Wet weather creates puddles that brings different life forms including worms and other invertebrates to the maneuvering areas, making them very available to predators.



Artificial pond (December 2019; Photo: Fekadu Assefa)

**Figure 10 Artificial pond in the airport**

**Food source**

Food leftovers around the apron and other waste disposal sites are also responsible to attract different wildlife particularly large and small mammals, wildlife such as black kites, vultures, crows, marabou stork and other scavengers, pigeons, starlings and sacred ibis. The four species (black kite, vulture, starlings and bee-eaters) are known potential hazards for wildlife strike

problems in the airport. There should be proper strategy to control ramp food leftovers and other unclean conditions inside and near the airport.



Waste disposal site inside the airport (Photo: Fekadu Assefa; January 2020;)

**Figure 11 Waste disposal area in the airport**

In addition, food leftovers generated from cafeterias are one of the major wildlife attractants. The airline cargo and catering area also attracts different wildlife because these areas usually produce putrescible wastes. The temporary waste sorting block is known for its wildlife attracting potential.



Waste collecting bin and sorting area (December 2019; Photo: Fekadu Assefa)

**Figure 12 Garbage handling in the airport**

In Addis Ababa Bole international airport there are variety of food sources in different seasons of the year like: grains, small mammals, termites, insects, worms, rodents, bushes and trees.



Patch of vegetation inside the airport (December 2019; Photo: Fekadu Assefa)

### **Figure 13 Bushes, Trees and other low growing vegetation**

#### **Open Terrain**

Addis Ababa Bole international airport like many airports worldwide has a majority of open terrain which attract different kind of raptors and rodents due to the grass grown for land scape purpose.so this kind of topography attracted wildlife like augur buzzard. And a couple of wildlife,



Airport buildings (March 2019; Photo: Fekadu Assefa)

### **Figure 14 Buildings, Hangars, Towers in the airport.**

as do buildings, lighting structures and other installations like radar towers.



Grass management inside the airport (January 2020; Photo: Fekadu Assefa)

### **Figure 15 Grass management in the airport**

Evidence within the Ethiopia suggests that short grass policy is an ideal solution to mitigate wildlife hazard.



Water way management (December 2019; Photo: Fekadu Assefa)

### **Figure 16 water way management activity in the airport**

The existence of structures like open drainage ditches, ponds and water ways provide ideal attractants like food, water and cover. Parking lot and disabled vehicles in the airport provides shelter and cover for wildlife's.



Water way (December 2019; Photo: Fekadu Assefa)

**Figure 17 Waterways in the airport**

### **Buildings and Structures**

Artificial attractant like ATC tower, terminal building, Telephone lines could be used for resting sites for wildlife of prey. The airport building also contributes for roosting of pigeons and small like rodents and mammals (bats).



Approach light and grass management (February 2020; Photo: Fekadu Assefa)

**Figure 18 Approach light masts in the airport**

Different nesting sites in the airport complex are recorded during the study period. These sites could impose problems particularly during the breeding season.



Signage provide perching opportunity for Raptors (December 2020; Photo: Fekadu Assefa)

**Figure19 Signage (perching opportunity) in the airport.**

Visual aids in the airport like signage, lighting mast and antennas provide ideal vantage point for raptors.



Runway light (June 2019; Photo: Fekadu Assefa)

**Figure 20 Lighting structures**

Lightings attract insect like cockroach in the airport when they light so that insectivorous wildlife attracted to the maneuvering area.



Old aircraft (September 2019; Photo: Fekadu Assefa)

**Figure 21 Old aircrafts**

Old aircrafts and airport infrastructures provide roosting place for pigeons and doves. On the other hand, old and disabled aircrafts provide an ideal hiding place for mammals like Rats and Spotted Hyena.

**Landscaping**

Landscape leveling, and greening activity is currently under progress. This activity has a potential to attract different wildlife species due to the leveling nature and availability of pray because the pray can easily identified under such circumstance.



Runway strip (February 2020; Photo: Fekadu Assefa)

**Figure 22 Landscaping activity in the airport**

### 5.1.3 Addis Ababa Bole international airport wildlife strike.

According to the data gathered from ground technicians, pilots, safety personnel from aircraft operators, bird scares, grass mowers, safety department personnel from AABIAP, aerodrome inspectors, air traffic controllers from Ethiopian civil aviation authority pilots, bird chasers ,maintenance personnel For the last five years the airport sustained wildlife strike most of the strikes were negligible but there were strikes with substantial damage .Table one displays the frequency of wildlife strikes between 2014-2019 Addis Ababa Bole international airport (Table 1).

**Table 2 Wildlife strike data for the period 2014– 2019.**

Year	Number of strikes				Total	
	Morning	Afternoon	Night	Unknown	No.	%
2019	39	25	7	16	87	17
2018	54	16	3	25	98	19
2017	59	19	7	7	92	18
2016	42	19	12	18	91	18
2015	18	5	0	50	73	14
2014	12	4	3	45	64	13
Total	224	88	32	161	505	100

(Source: ECAA wildlife strike database)

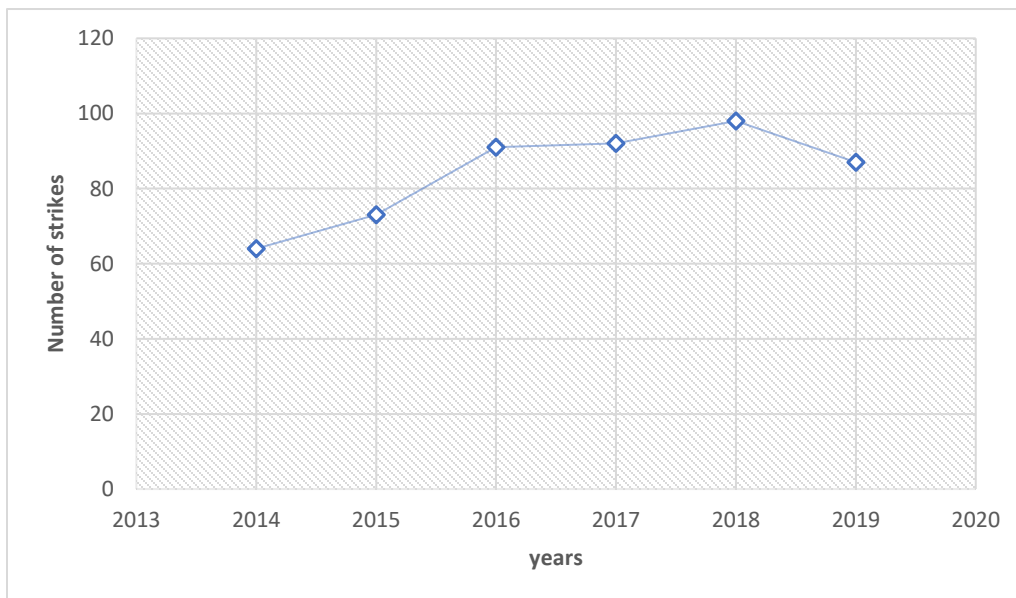
According to the data gathered from ground technicians, pilots, safety personnel from aircraft operators, bird scares, grass mowers, safety department personnel from AABIAP, aerodrome inspectors, air traffic controllers from Ethiopian civil aviation authority pilots, bird chasers ,maintenance personnel and as it is presented in table one-year 2018 records the highest reported wildlife strike in the airport this is due to the growth of reporting culture, the increasing of flight operation and the existence of different wildlife species due to wildlife attractant in the airport.

In 2019 Number of confirmed strikes on the Morning were 39, Number of confirmed strikes on the Afternoon were 25. confirmed strikes on the Night were 7. There are around 16 unknown cases.

The year 2018 Number of confirmed strikes on the Morning were 54, Number of confirmed strikes on the Afternoon were 16. confirmed strikes on the Night were 3. There are around 25 unknown cases. In 2017 Number of confirmed strikes on the Morning were 59, Number of confirmed strikes on the Afternoon were 19. confirmed strikes on the Night were 7.

There are around 7 unknown cases. In 2016 Number of confirmed strikes on the Morning were 42, Number of confirmed strikes on the Afternoon were 19. confirmed strikes on the Night were 12. There are around 18 unknown cases.

In 2015 Number of confirmed strikes on the Morning were 18, Number of confirmed strikes on the Afternoon were 5. confirmed strikes on the Night is 0. There are around 50 unknown cases. In 2014 Number of confirmed strikes on the Morning were 12, Number of confirmed strikes on the Afternoon were 4. confirmed strikes on the Night were 3. There are around 45 unknown cases.



**Figure 10 Number of wildlife strike vs Years (2014– 2019).**

According to the data presented on Fig 04 the number of strike records were increasing from 2014 to 2019. The list number of reported wildlife strike was recorded in 2014 this could be due different reasons for instance during that year there was no responsible department to collect and record wildlife strikes in the airport. And secondly the number of daily flights was to low when it is compared with 2019. But after 2016 there was a massive boost of air traffic movement in the

airport due to this the number of strikes recorded in the airport also dramatically grow with the traffic density, so the concerns also becomes high.

### **Wildlife strike vs aircraft type at AABIA (2014-2019)**

According to the data gathered from ground technicians, pilots, safety personnel from aircraft operators, bird scares, grass mowers, safety department personnel from AABIAP, aerodrome inspectors, air traffic controllers from Ethiopian civil aviation authority pilots, bird chasers, maintenance personnel Different aircrafts have different degree of susceptibility for wildlife strike. Aircrafts with jet engine are more susceptible to wildlife strike than aircraft with propeller engine. This is because the latter aircrafts have high noise from their engine and the earlier one has more quitter engine. On the other hand, unlike avian strike mammalian strike has no variation on different type of aircraft. From 2013 to 2019 there has been many wildlife incidents at Addis Ababa Bole international airport is data are stipulated clearly on the following table. From the next matrix we can clearly understand that which species are more dangerous for the aircraft operation and which type of aircrafts are highly susceptible for wildlife hazard at which phase of flight.

**Table 3 Wildlife strike vs aircraft type at AABIA (2014-2019)**

Aircraft type	Number of strikes						Total
	2014	2015	2016	2017	2018	2019	
Unknown	47	47	69	45	39	26	273
Q-400	2	10	5	13	9	17	56
B-737-800	0	0	6	9	13	8	36
B-787-8	5	2	0	9	5	9	30
B-777-200	2	3	3	5	1	6	20
B-777-300	1	0	4	2	6	3	16
A-330-200	0	0	0	0	14	0	14
B-737-700	3	8	0	1	0	1	13
A-350-900	0	0	0	4	0	9	13
EMBRAER 190	1	0	1	0	6	0	8
B-767-300	0	0	2	0	1	3	6
B-757-200	0	1	0	3	1	0	5
B-787-9	0	0	1	0	2	2	5
B-777F-cargo	0	0	0	0	0	2	2
B-C-17 globe master ill	1	0	0	0	1	0	2
Airbus-330	1	1	0	0	0	0	2
Diamond DA42 Twin star	1	1	0	0	0	0	2

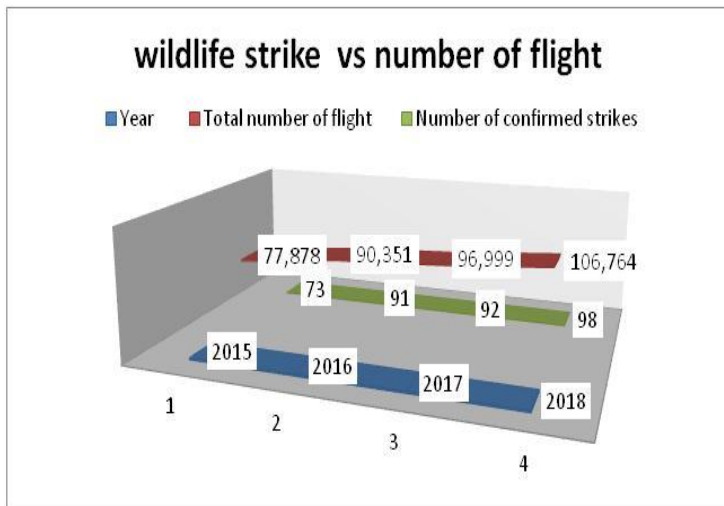
<b>B-737F-cargo</b>	0	0	0	0	0	1	<b>1</b>
<b>Cesena</b>	0	0	0	1	0	0	<b>1</b>
<b>B-747</b>	0	0	0	0	0	0	<b>0</b>
<b>MD-11</b>	0	0	0	0	0	0	<b>0</b>

(Source: ECAA wildlife strike database 2020)

Most of the struck aircrafts type was unknown but the first five most susceptible aircrafts are Q-400, B-737-800, B-787-8, B-737-700 and B-777-200. Jet engine aircrafts are more susceptible for wildlife strike than propeller engine aircraft this is due to their engine is highly exposed or there is no barrier that prevent foreign object from coming in. The above matrix graph shows that the rank of different types of aircrafts that operates at Addis Ababa Bole international airport based on their strike frequency from 2014 to 2019.

### Wildlife strike vs Number of flights

Wildlife strike in the airport was increasing from 73 to 98 this indicates that the number of strike is directly proportional to flight number. As it is stipulated in the graph the air craft traffic volume was increasing from time to time the same is true for the wildlife strike it is increasing from 71 in 2015 to 98 in 2018 which is increasing by fifteen.

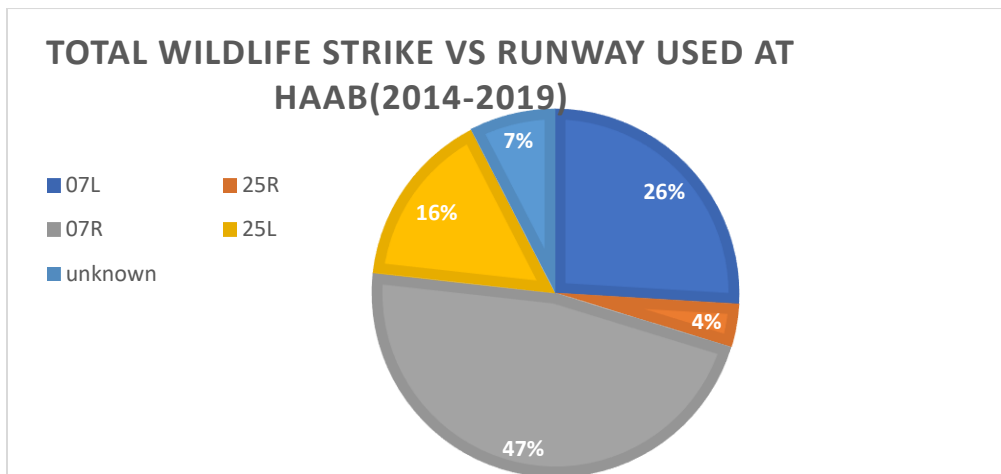


**Figure 23 Wildlife strike vs Number of flights**

### Wildlife strike vs location

According to the data gathered from ground technicians, pilots, safety personnel from aircraft operators, bird scares, grass mowers, safety department personnel from AABIAP, aerodrome

inspectors, air traffic controllers from Ethiopian civil aviation authority pilots, bird chasers ,maintenance personnel most of the strike s were happened via run way 07R this is due to most of landing and takeoff operation served by this active run way. Least strikes were recoded via runway 25R this is due to runway 25R (Runway designation 25 of the right side) is an emergency runway as result it has served less amount of traffic when it is compared with the active runway. Runway 25L (Runway designation 25 of the left side), Runway 07L (Runway designation 07 of the left side), Runway 07R (Runway designation on the left side).



**Figure 24: Wildlife strike vs location**

**Total wildlife strike vs weather at AABIA**

According to the data gathered from ground technicians, pilots, safety personnel from aircraft operators, bird scares, grass mowers, safety department personnel from AABIAP, aerodrome inspectors, air traffic controllers from Ethiopian civil aviation authority pilots, bird chasers ,maintenance personnel most of the wildlife strike were happen during sunny weather this is due to wildlife’s are active by day they can easily access their necessities like food and water. In addition to that cold-blooded animals prefer sunny weather this situation created an ideal opportunity for predators because it eases the access. Cloudy weather also provides an ideal situation for wildlife as a result there were highest wildlife strikes during cloudy weather. The same is true for semi cloud weather there were several recorded wildlife strikes during such weather.

**Table 4 Total wildlife strike vs weather at AABIA (2014-2019)**

Strikes	Number of strikes						Total	
	2014	2015	2016	2017	2018	2019	No.	%
Sunny	27	31	25	50	48	<b>43</b>	224	44
Unknown	12	16	51	9	17	<b>20</b>	125	25
Cloudy	2	6	9	28	20	<b>3</b>	68	13
Sunny/cloudy	11	9	2	5	10	<b>21</b>	58	11
Rainy/ cloudy	8	7	2	0	0	<b>0</b>	17	3
Rainy	4	4	2	0	3	<b>0</b>	13	3
<b>Total</b>	<b>64</b>	<b>73</b>	<b>91</b>	<b>92</b>	<b>98</b>	<b>87</b>	<b>505</b>	<b>100</b>

(Source ECAA wildlife strike database)

According to the data gathered from ground technicians, pilots, safety personnel from aircraft operators, bird scares, grass mowers, safety department personnel from AABIAP, aerodrome inspectors, air traffic controllers from Ethiopian civil aviation authority pilots, bird chasers ,maintenance personnel there was highest number of strikes recorded in November during the period of 2014-2019 there was 75 wildlife strikes in November this is due to during this month there are most of the time plenty of flowering plants, foods and the weather is sunny, and the temperature is optimal, and April is the second month, March is the third highest.

**Table 5 Months of Wildlife strikes at Addis Ababa Bole international airport**

Month	Number of strikes						Total	
	2014	2015	2016	2017	2018	2019	No.	%
<b>NOV</b>	5	19	11	9	18	13	75	15
<b>APR</b>	7	4	17	3	15	13	59	12
<b>MAR</b>	2	3	8	14	9	16	52	10
<b>OCT</b>	2	8	11	13	7	7	48	10
<b>FEB</b>	5	6	7	11	8	10	47	9
<b>DEC</b>	6	17	9	5	4	5	46	9
<b>MAY</b>	6	2	8	12	10	4	42	8
<b>SEP</b>	10	3	4	5	7	8	37	7
<b>AUG</b>	8	6	4	4	8	1	31	6
<b>JAN</b>	4	2	4	6	7	2	25	5
<b>JUN</b>	5	3	3	3	2	6	22	4
<b>JUL</b>	4	0	5	7	3	2	21	4
<b>Total</b>	<b>64</b>	<b>73</b>	<b>91</b>	<b>92</b>	<b>98</b>	<b>87</b>	<b>505</b>	<b>100</b>

(Source: ECAA wildlife strike database 2020)

### **Time of wildlife strike at Addis Ababa Bole international airport**

According to the data gathered from ground technicians, pilots, safety personnel from aircraft operators, bird scares, grass mowers, safety department personnel from AABIAP, aerodrome inspectors, air traffic controllers from Ethiopian civil aviation authority pilots, bird chasers, maintenance personnel In 2015 there are about 19 known case of wildlife strike time and from this data the proportion of timing between morning and afternoon is almost 50% this means nine strike were happened in the morning and around ten strikes were happened during the afternoon. For 2016 year According to the data gathered most of the strike occurred during the morning time and late afternoon there is limited number of strikes during the noon and night time. During 2017 According to the data gathered from aviation safety personnel's and bird chasers most of the strike occurred during the morning time and there is limited number of strikes in the mid-day and late afternoon and night time also. For 2018 there are a total of 27 confirmed wildlife strikes and more than 50% percent of the strike occurred during morning time and the rest of the strike were happened in the afternoon. During 2019 from the total strike around 27 strikes were happened during the time of 02:00-07:00 and around 15 strikes were happened during the afternoon time, so this data indicates that most of almost around 70% percent of the strikes during 2019 were happened before none.

In Addis Ababa Bole international airport there are different wildlife species that impose a hazard on aircraft operation the following matrix states the wildlife strike number and which specious contributed for the incident/accident.

### **Wild animals involved in strikes**

According to the data gathered from ground technicians, pilots, safety personnel from aircraft operators, bird scares, grass mowers, safety department personnel from AABIAP, aerodrome inspectors, air traffic controllers from Ethiopian civil aviation authority pilots, bird chasers, maintenance personnel Various groups of wild animals were involved in aircraft strikes at Bole Airport. These include wildlife like antelopes, Porcupine, Hyena, Jackal, bats, and unknown groups (Table 6).

**Table 6 Wildlife species involved in strike at AABIA (2014-2019)**

Type of species	Number of strikes						Total	
	2014	2015	2015	2016	2016	2019	No.	%
Black kite	6	16	29	47	57	39	194	36.13
Unknown	44	46	20	4	5	3	122	22.72
European beef eater	0	0		5	9	12	26	4.84
Speckled pigeon	1	0	2	2	14	5	24	4.47
Tawny eagle	7	0	5	5	1	1	19	3.54
Dusky turtle dove	2	4	5	3	1	-	15	2.79
Yellow billed kite	0	0	3	9	1	-	13	2.42
Yellow shoulder widow wildlife	0	0	0	0	1	11	12	2.23
White -collared pigeon	1	1	3	6	0	-	11	2.05
Common jackal	1	0	1	1	3	5	11	2.05
Augur buzzard	0	1	2	2	0	4	9	1.68
Cattle egret	0	0	1	0	3	5	9	1.68
Common kestrel	0	0	1	5	2	-	8	1.49
Spotted hyena	1	0	1	0	0	5	7	1.30
Common duiker	0	0	4	2	0	-	6	1.12
Pied crow	0	0	1	5	0	-	6	1.12
Swift	0	0	1	0	0	3	4	0.74
serval cat	0	1	1	0	1	1	4	0.74
Hooded vulture	0	1	0	0	0	3	4	0.74
Slender mongoose	0	0	2	0	2	-	4	0.74
Egyptian goose	0	1	1	1	0	-	3	0.56
Abyssinian hare	0	0	2	1	0	-	3	0.56
African white backed vulture	1	1	0	0	0	1	3	0.56
Spur-winged lapwing	0	0	0	1	1	1	3	0.56
Marabou stork	0	0	0	1	1	1	3	0.56
Porcupine	0	0	1	1	0	-	2	0.37
Owl	0	0	1	1	0	-	2	0.37
Long crested eagle	0	0	1	0	1	-	2	0.37
Dog	0	0	0	1	0	1	2	0.37
Black headed heron	0	0	0	1	1	-	2	0.37
Pallid harrier	0	1		0	0	-	1	0.19
Greater blue-eared starling	0	0	1	0	0	-	1	0.19
Ethiopian swallow	0	0	1	0	0	-	1	0.19
Bat	0	0	1	0	0	-	1	0.19

(Source: ECAA wildlife strike database 2020)

Based on the data recorded from 2014-2019 black kite is the most dangerous wildlife species and most of the species is not identified in post-strike due to lack of facility and human power available in the airport that is according to safety officers.

#### 5.1.4 The Effect of wildlife hazard on aircraft at Addis Ababa Bole international airport.

In Ethiopia, the deadly accident due to wildlife's happened back in September 1988 when Boeing 737 crashed killing 35 people. On another occasion, the airline's DHC-6 aircraft was struck by wildlife off AABIA on October 1995 causing the crew to sustain serious damages and seriously damaging the plane. according to the ECAA database September and October are wildlife seasons when most strikes happen. Wildlife collisions have cost Ethiopian Airlines many million dollars. In recent times, 2019 has registered the highest attack with many incidents.

While many of the attacks happen in Addis Ababa, smaller number happened abroad and in regions and the rests are unrecorded locations. According to Ethiopian airport enterprise from 2013 to 2016 there were huge economical loss due to wildlife strike and it is described in the following table in detail.

**Table 7 Summary of Wild life strike cost at AABIA**

<b>Summary of Wild life strike cost at AABIA</b>			
<b>Year</b>	<b>No of occurrence</b>	<b>Amount in birr</b>	<b>Amount in USD</b>
2013/14	25	40,865,399.30	1192419.66
2014/15	43	14,559,473.37	424833.79
2015/16	40	3,888,300.11	1134574.84
2016/17	36	35,644,696.13	1040083.72
2017/18	18	6,727,756.30	196310.55
2018/19	22	41,363,700.03	1206959.68
Total	184	143,049,325.24	4174064.87

(Source: ECAA wildlife strike database 2020)

The total amount of cost due to wildlife strike I for the last six years is around 143,049,325. It is increasing from time to time and it has a huge impact on the aviation industry and the national economy in general.

The effect of wildlife strikes on aircraft operations is valued mainly in monetary terms. It is not practical to obtain an accurate estimate of the cost of wildlife strikes for aircraft operators and airport operations, let alone the cost of wildlife hazard management.



(Source: sharing the sky, 2009)

**Figure 25 Jet engine damaged by wildlife strike**

The Ethiopian civil aviation authority estimated that the combined cost of aircraft inspections, repairs, cleaning and delays related to wildlife strike events was in millions of dollars annually. This included flight delays, crew alterations, rescheduling flights and accommodation, and injuries. Ethiopian Airlines, the largest domestic carrier, stated that the airline had suffered a huge economic damage due to wildlife strikes and lost over millions of dollars for maintenance and other expenses to fix its aircraft struck by wildlife.

Ethiopian airport enterprise representative was stating that the airport operator and the airlines were bleeding financially to fix damaged engine blades of aircraft and other wildlife hazard related issues due to wildlife strikes at Addis Ababa Bole international airport.

The Director-General, Civil Aviation Authority (ECAA) and the aerodrome safety and standard directorate director of the civil aviation authority of Ethiopia stated that wildlife strikes incident account for a lion share percent of all incidents that occur within Addis Ababa Bole international airport. In fact, industry experts estimate that a single engine blade cost huge amount of dollars and it depends on the aircraft type and the level of damage.

## **5.2 Discussion**

### **5.2.1 Wildlife strike at AABIA**

Now a days the civil aviation sector worldwide faces amplified concerns about aerodrome accountability in the impact of damaging wildlife strikes (Cleary et al., 2005). The same is true for Ethiopian civil aviation sector. In the last five years the air traffic density of the country has increased significantly. At Addis Ababa Bole international airport, the average landing and takeoff has increased significantly. On the other hand, the number of wildlife strike happened in the airport has increased dramatically in the airport.as the aircraft manufacturing technology becomes increasing in the rocket high level and the noise of the engine becomes lesser and lesser this factor contributed to the increasing of wildlife strike in contemporary aircraft like boing 787 and airbus 350 in Addis Ababa Bole international airport.

Wildlife species involved in strikes have significantly amplified in the recent periods. The aircraft traffic volume of increased significantly. The existence of wildlife's near airport maneuvering area and flight pathways cause critical hazards for aircraft operation, particularly during landing, take-off, climb and approaches when the loss of one or more engines, dome, landing gear, fuselage, windshield can jeopardize the safety of flight. Collisions with wildlife have resulted in economic as well as human life losses (Bruderet *al.*, 1997; Elizabeth Yohannes and Afework Bekele, 1998; Dewitt and Langston, 2008). Obviously, safety and financial threat to the civil aviation is inevitable due to the collusion between aircraft and wildlife.

### **5.2.2 Diversity of wildlife in the Airport**

According to the Australian civil aviation authority figures between 1991 and 2001, 87.5 per cent of wildlife strikes involved only one wildlife, which is like ICAO statistics which suggest that 79.1 per cent of recorded wildlife strikes involve only one wildlife (ATSB 2003) whereas in Addis Ababa Bole international airport the cause for wildlife to aircraft collision are more than one species of wildlife.

In an airport environment season and time determine the activity of wildlife. Activity of wildlife is prominent early in the morning and late afternoon hours. Most wildlife in the area crossed runways sidewise to their foraging sites during the morning and to their nesting sites during late

afternoon. Season of the year also affects wildlife. During the study period, wildlife was seen with less significant activities when the weather condition was cold, cloudy and very windy. Resources and weather determined seasonal distribution of wildlife in the study area. As a result, some wildlife were observed throughout the study period while others not (Tsigereda Dessalegn 2011). In the study area scavenger wildlife species like pied crow, raven crow, blue black starling, kites are mostly observed during the morning session and in the afternoon predator wildlife like auger buzzard and swift usually observed when the prey availability is good enough like termite infestation huge number of rats population is existed in the grass field. Hyena and common jackal were observed during the night time. Francolin pigeons and doves were mostly observed during the morning session.

Usually, aircrafts flew at a maximum elevation than travelling wildlife (Jaiye & Vimal Gahlot, 2012). The most hazardous wildlife observed in Addis Ababa Bole international airport are mostly avian and mammal and they are directly contributed to the wildlife to aircraft collision. Reptiles contributes indirectly for wildlife hazard collision. Some of the avian species recorded in the study area are Black Kite, Augur Buzzard, Black Shouldered Kite, pied crow, raven crow, hamerkop, hooded vulture, Egyptian vulture, Blue black starling, speckled pigeon, dusky turtle dove, white collard pigeon, Egyptian geez and tawny eagle are common. There is also some mammal species existed in the airport like Hyena, different Rat species, common jackal common duck, serval cat, different amphibians (mainly frog and toad) and reptiles (snake and lizard) are also inhabited in the airport.

### **5.2.3 Wildlife attractants in the Airport**

Evaluating wildlife hazards to aviation in the airdrome setting is naturally originated by conducting site visit observation (Sharing the Sky, 2009). In the study area wildlife attractant and other appealing features, which makes the airport tranquil, were critically assessed and characterized. Generally, there are water sources like pond and stagnant water, wetlands, cover sources, food sources.

According to The FAA Land-use practices guidance are the key factors defining the wildlife and number of wildlife's that are attracted to airdrome settings. In the study area wildlife attractants

broadly classified as natural and artificial. The natural attractants include preferred water, cover, shelter and food. The manmade attractants are mostly created by the socio-economic activities of man such as waste disposal, food processing activities, etc. Therefore, the major wildlife attractant sites inside the airport were characterized and assessed.

In tropical climates, wastewater management sometimes create marshes and use submergent and developing aquatic vegetation as natural filters. (Cleary, etal,2005). In the study area there are waste water ways and other buildings that serve drainage of the airport used by various species of wildlife's, for nesting, feeding, or roosting.

Water sources ranging from small to large can attract wildlife. (UK CAA,2014). Wetland in the study area is mainly found at the runway end safety areas and runway strips. This is due to the engineering requirement of the surface makes the slope decreased when it is compared with the runway surface. Artificial water body created by extraction of aggregate material also provide ideal source of water for wildlife's.

Wetlands naturally appeal varied species of wildlife, including many dangerous wildlife species. (Cleary, 2005 Due to the availability of water and wetland different water wildlife existed in the study area like heron, cormorant, duck, egrets hamerkop.

Patch of vegetation Provides perfect perching sites for groups of starlings and black birds (Dolbeer,2005). In the study area there are patch of vegetations in different part of the airport environment. The availability trees and different species of plant provided food source, cover source and shelter source for wildlife. landscaping activity in the airport is currently under progress this activity yields ideal hunting opportunity for predator so that it increased their presence.

#### **5.2.4 Effect of wildlife strikes**

Nigerian aircraft operators are liquidating financially to fix damaged parts of airplanes due to wildlife strikes running into billions of dollars. In 2008, Arik Air faced over 34 incidents of wildlife strike attacks on its aircraft, costing the manager over N3.2 billion (US \$20.67 million) to

fix its aircraft struck by wildlife. (Jaiye Jehoshaphat Dukiya1, Vimal Gahlot 2012). In the study area the number of wildlife strike becomes higher in terms of number and critical in terms of safety. In the study area total amount of cost due to wildlife strike for the last six years is around 143,049,325 Birr. It is increasing from time to time and it has incurred a huge economic impact on the aviation industry and the nation economy in general. The effect of wildlife strikes on aircraft operations is valued mainly in monetary terms. It is not practical to obtain an accurate estimate of the cost of wildlife strikes for aircraft operators and airport operations, let alone the cost of wildlife hazard management.

According to FAA's data, airplanes struck wildlife 46 times at Philadelphia International Airport in the first seven months of 2009 during takeoff or landing, or en route, and of the 46, only one was considered "substantial". In that March 21st incident, an Air Wisconsin Airlines pilot reported smelling smoke in the cabin, possibly due to a wildlife sucked into Engine 2. (Jaiye Jehoshaphat Dukiya1, Vimal Gahlot 2012). In the study area for the last five years especially in 2018 and 2019 there are several substantial /significant material damage collisions between wildlife and aircraft. Aborted takeoff, aborted landing and engine ingestion were common one.

ICAO data indicates that 22.8 per cent of wildlife strikes cause some form of damage to the aircraft. The Australian wildlife strike figures between 1991 and 2001 indicate that 13.8 per cent of wildlife strikes results in damage to the aircraft. In the study area Most of the struck aircrafts type was unknown but the first five most susceptible aircrafts are Q-400, B-737-800, B-787-8, B-737-700 and B-777-200. jet engine aircrafts are more susceptible for wildlife strike than propeller engine aircraft this is due to their engine is highly exposed and it has quitter and there is no barrier that prevent foreign object form entering. following graph shows that the rank of different types of aircrafts that operates at Addis Ababa Bole international airport based on their strike frequency from 2014 to 2019.

## **Chapter six-Conclusion and Recommendation**

### **6.1 Conclusion**

The study was focused on Addis Ababa Bole international airport. More emphasis was given to the maneuvering areas (Runways, Taxi ways and Aprons) though the study attempted to cover safety critical parts of the airport. According to the data gathered from ground technicians, pilots, safety personnel, bird scares, grass mowers, aerodrome inspectors and air traffic controllers around 70 species of wildlife including plants were observed and recorded during the study period. The most wildlife attractant sites were categorized as waste disposal sites encompassing, food leftover within the Airport compound, and temporary water reserves. The Airport compound was favorable for wildlife and other animals. It's used as nesting, feeding, breeding and resting sites for a couple of mammals, wildlife, reptiles and amphibians. In Addis Ababa Bole international airport there are several natural and human induced wildlife attractant features. Natural habitats within the study area include grasslands, swampy areas, water body, bushes and trees. among artificial wildlife attractants roofs of buildings, light poles, antennas, cafeterias and other areas with significant human activities. The area possesses favorable places for wildlife's to nest, rest, roost, perch and an honest access to food also as water resources. These and other factors attract sizable amount and various species of wildlife to travel to the planet at different situations and use the airspace as a transient route. The grassland which is that the dominant feature of the planet, harbors seed eating wildlife, rodents, reptiles, insects and other invertebrates. The wetlands, swampy areas and other water bodies were also found to be attractant as water and food resources. Food wastes around different parts of the study area also play a superb role in attracting wildlife's.

The highest number of strikes recorded in November with the quantity of (2014-2019)75 wildlife strikes and during this month there are most of the time many flowering plants, foods and thus the weather is sunny, and thus the temperature is ideal. In the study area the number of wildlife strike becomes higher in terms of number and critical in terms of safety. The total amount of cost incurred because of wildlife strike for the last five years is around 143,049,325 Birr. It is increasing from time to time and it's a huge impact on the aviation industry and thus the national economy generally. The effect of wildlife strikes on aircraft operations was valued mainly in monetary

terms. It isn't practical to urge an accurate estimate of the worth of wildlife strikes for aircraft operators and airport operations, including the worth of wildlife hazard management.

## **6.2 Recommendations**

- Addis Ababa Bole international airport should make a radical review of all wildlife strike data and aim to identify any patterns with regards strike location, species, kind of aircraft and frequency. If any demonstrable patterns are found, the data should be used, in conjunction with off-airfield monitoring data, to inform the wildlife hazard management decision-making process.
- Pilots /other aviation safety personnel should be reminded to conduct a pre-flight inspection.
- Addis Ababa Bole international airport (service provider) and Ethiopian civil aviation authority (the regulator) should establish coordinated arrangement to tackle this aviation challenge with other stakeholders like ministry of education, science and innovation, EWCA, air force etc.....
- It's pertinent to remain records of other preventative management actions which cannot be a neighborhood of the daily routine of wildlife control.
- Timely revision of the Daily Wildlife Control Activities
- Giving training for personnel who are responsible for wildlife hazard management periodically is significant.
- Habitat management, dispersal, removal, and repellent techniques are the best lines of action.

- Addis Ababa Bole international airport possesses two land cruiser four-wheel vehicles which are very convenient for wildlife hazard management inside the airport, but the airport has lack wildlife repellent, dispersal equipment and removal equipment.
- The airport administration should establish coordination with research and academic center and possesses to possess current information of the airport ecology.

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**Questionnaire distributed for Key informants**

Dear respondents, saying many thanks beforehand, you're kindly requested to fill and answer this questionnaire. this is often prepared to urge reliable information on the problem related wildlife hazard and aircraft operation Ababa Bole International Airport. the knowledge you're going to give will help me to assess and make analysis on the issues related to wildlife hazard, their effects and thus the possible solutions about safe operation of the aviation industry and thus the security of the nearby society.

Be confident for your answer that it's kept and used for the case understudy only.

1. Reports of wildlife movement you're receiving daily?

a. 1-5

b. b. 5-10

c. >10

2. do you log all quite wildlife hazard movement and strike report at your office?

If yes, what percentage of the reports get appropriate answer and what actions are taken for the reports?

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3. are you ready to list down the wildlife frequently observed/reported at AABIA/Bole

International Airport?

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4. What factors are often mentioned for the occurrence and movement of wildlife

Hazard at or near the airport?

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5. What factors are associated with the society living near AABIA that contributes for the wildlife hazard?

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6. How can wildlife hazard deter and influence the growing aviation industry?

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7. what's getting to be the effect of wildlife hazard in endangering the safety of the aircraft operation?

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8. What are the possible effects of A/C-wildlife strike?

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9. What are the possible solutions for the matter associated with wildlife hazard expected from the society living within the vicinity/ at or near the airport?

10. have you ever assessed wildlife attracting sites within the vicinity/at or near the airport? If yes, state the interval of inventory period\_\_\_\_\_ If no, why it is?

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11. Are the On-airport sites or off-airport sites are considered/ observed more Hazardous for the safe operation of aircrafts?

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12. do I have a daily discussion with concerned authorities and native community regarding wildlife hazardous movement?

a. Yes

b. No

With best regards,

Fekadu Assefa

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Dear respondents, saying many thanks beforehand, you're kindly requested to fill and answer this questionnaire. this is often prepared to urge reliable information on the problem related wildlife hazard and aircraft operation Ababa Bole International Airport. the knowledge you're going to give will help me to assess and make analysis on the issues related to wildlife hazard, their effects and thus the possible solutions about safe operation of the aviation industry and thus the security of the nearby society.

Be confident for your answer that it's kept and used for the case understudy only.

1. reports of wildlife movement you're receiving daily?

2. are you ready to mention the wildlife frequently observed/reported at AABIA/Bole International Airport?

3. What factors are often mentioned for the occurrence and movement of wildlife Hazard at or near the airport?

4. Do you log all quite wildlife hazard movement and strike report at your office?

---

---

6. what's getting to be the effect of wildlife hazard in endangering the safety of the society within the vicinity?

---

7. What are the possible effects of A/C-wildlife strike?

---

---

8. What are the possible solutions for the matter associated with wildlife hazard expected from the society living within the vicinity/ at or near the airport?

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9. Who is responsible to reduce the effect of wildlife hazard on the safety of the aviation industry and thus the security of the society within the vicinity?

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With best regards,

Fekadu Assefa

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**Focus conference with aviation safety personnel.**

- i. Do you know what wildlife exists here?
- ii. Why the wildlife's/wildlife exist here?
- iii. Is there any water, food, cover and shelter source for wildlife inside your airport?
- iv. what quite plantation/vegetable/crop cultivated inside the airport?
- v. what quite tame animal lives inside the airport? And why they're there?
- vi. How you dispose wastes inside the airport?
- vii. How the wildlife presence affects the aircraft operation?
- viii. What quite aircraft frequently struck?
- ix. Which wildlife species frequently observed and when where?

## Appendix



Addis Ababa airport traffic movement and grass management. (Fekadu Assefa, December 2019)



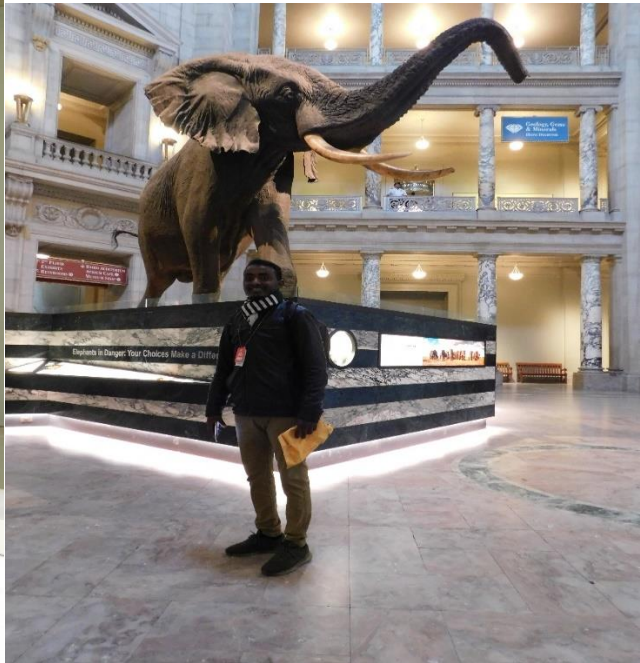
Wildlife control unit vehicle and aircraft running for takeoff.(Fekadu Assefa, December 2019)



Researcher in the middle and two safety officers from the civil aviation authority. .(Fekadu Assefa, December 2019)



Bole airport land scape management. (Fekadu Assefa, December 2019)



Researcher (Mr. Fekadu Assefa) educational visit about wildlife hazard and aviation industry during the study in Smithsonian museum of natural history and Ronald Reagan Airport in Washington DC, USA. (Fekadu Assefa, October 2019).