# Introduction

## 1.1 Study Background

## 1.2 About Senkelle Swaen’s Hartebeest Sanctuary

## 1.3 Scope of works

## 1.4 Objective of the Rapid Biodiversity Study

### 1.4.1 Specific Objectives

# Approach and Study Methods


## 2.2 Specific Methods for Plants

## 2.3 Specific Methods for Mammals

## 2.4 Specific Methods for Birds

## 2.5 Specific Methods for Herpetofauna (Reptiles and Amphibians)

## 2.6 Specific Methods for Invertebrates

# Rapid Biodiversity Assessment of the Project Area

## 3.1 Vegetation

## 3.2 Conservation Priority

## 3.3 Terrestrial Habitat

### 3.3.1 Natural Habitat

### 3.3.2 Modified Habitat

## 3.3.3 Plant Communities

## 3.3.4 Ecosystem Services

## 3.3.5 Biodiversity Sensitivity
3.3.6 Biodiversity Sensitivity Assessment

3.3.7 Floral of the Project Area

3.3.8 Plant Species Composition

3.3.9 Conservation

3.4 Fauna of the Project Area

3.4.1 Mammals

3.4.2 Wildlife Corridor at the Project Impact area

3.4.3 Avian Fauna (Birds)

3.4.4 Herpetofauna (Reptiles and Amphibians)

3.4.5 Invertebrates

3.5 Stakeholder consultation

3.5.1 Notes from stakeholder consultation

4 CONCLUSION & RECOMMENDATION

5 REFERENCES

5.1 References of Plants Survey

5.2 References of Mammals Survey

Baseline Biodiversity, Air and Hydrology Study Report
5.3 References of Birds Survey

Bookmark not defined.

5.4 References of Herpeto-Fauna Survey

Bookmark not defined.

5.5 References of Herpeto-Fauna Survey

Bookmark not defined.

6 List of Annexes

Bookmark not defined.

Annex I.- Corbetti Geothermal Project List Of Plant Species With IUCN Status

Bookmark not defined.

Annex 1.1.- Natural Forest Dominant Species

Bookmark not defined.

Annex 1.2.- Shrub Land Dominant Species

Bookmark not defined.

Annex 1.3.- Modified Habitat Dominant Species (Farmland Remnant Trees)

Bookmark not defined.

Annex 1.4.- Herb and Grass Dominant Species

Bookmark not defined.

Annex 1.5.- Scrubland Dominant Species

Bookmark not defined.

Annex 1.6.- Shrub and Tree Species around Settlements Areas

Bookmark not defined.

Annex 1.7.- Habitat Class per each Well Pad

Bookmark not defined.

7 Annex II. Corbetti Geothermal Project Mammals Biodiversity List (Well Pad A-K) and beyond the well pads

Bookmark not defined.

8 ANNEX III.- Checklist of Birds found around Corbetti Geothermal Project

Bookmark not defined.

9 ANNEX IV.- List of Amphibians and Reptiles that are thought to potentially occur at Corbetti area

Bookmark not defined.
Annex V - The case of New Electric Transmission Line along the proposed well pads

*Bookmark not defined.*
LIST OF TABLES

Table 1: Planned Development Phases ................................................................. 9
Table 2: List of Expected Services for the Consultant ............................................ 14
Table 3: Qualifying Critical Habitat Based on IFC PS 6 and GN 57 .........................
Table 4: Area Statistics of Habitat Types at Corbetti ..............................
Table 5: Provisional Ecosystem Services Provided by the Ecosystem of Corbetti Area  
Table 6: Ecosystem Service Review for Corbetti Area .....................
Table 7: Area statistics of Biodiversity Sensitivity Rank .............................

LIST OF FIGURES

Figure 1: Site Location Map .................................................................................. 8
Figure 2: Projects Geographical Context ............................................................ 10
Figure 3: Location map of the project ................................................................. 11
Figure 4: Location map of the Senkelle Swaen’s Hartebeest Sanctuary ............. 14
Figure 5: CGC Project Location .......................................................................... 17
Figure 6: Habitat type in the project area ....................................................... 29
Figure 7: Habitat Type Identification in the Study Area of Corbetti Geothermal Project
Figure 8: Altitude map of Corbetti Geothermal Project ..............................
Figure 9: Slope map of Corbetti Geothermal Project ..............................
Figure 10: Erica Arborea Dominated Woodland ....................................... 28
Figure 11: Showing Evergreen Scrubland Vegetation ............................
Figure 12: Showing Farmland with remnant trees ....................................
Figure 13: Showing Herbs with Grassland Vegetation 

Error! Bookmark not defined.

Figure 14: Showing Shrub and Trees around Settlement area ............................
Figure 15: Showing Shrub and Trees around Settlement area ............................
Figure 16: Biodiversity Sensitivity Map for Corbetti Area .............................. 28
Figure 17: Endemic Plant, Aloe gilbertii Sebsebe & Brandham subsp. gilbertii  

Error! Bookmark not defined.
Figure 18: Endemic plant, Cussonia osti Nikki Chiov ..........Error! Bookmark not defined.
Figure 19: Some Of Commonly Found Wildlife Species At Corbetti Project Area (Anubis Baboon (Left) And Common Warthog (Right) .....Error! Bookmark not defined.
Figure 20: Wildlife migration route between Senkelle Swayne’s Hartebeest Sanctuary and Corbetti Kebele (Urgi village) (around well pad “C”) ..Error! Bookmark not defined.
Figure 21: Ruppel Vulture ................................Error! Bookmark not defined.
Figure 22: Lappet – faced Vulture ................................Error! Bookmark not defined.
Figure 23: Yellow wagtail ........................................Error! Bookmark not defined.
Figure 24: Montane White Eye ....................................Error! Bookmark not defined.
Figure 25: African Dusky Fly catcher..............................Error! Bookmark not defined.
Figure 26: Tacazze Sunbird .........................................Error! Bookmark not defined.
Figure 27: Augur Buzzard ..........................................Error! Bookmark not defined.
Figure 28: Thick-billed Raven ......................................Error! Bookmark not defined.
Figure 29: Map Of Corbetti Locality And Surveyed Area (Orange Tracks) For Herpetofaunal Occurrence Around Well Pads A To L ......Error! Bookmark not defined.
Figure 30: Presumed White-spotted wall gecko (inside the red circle) hanging on the wall in a gorge at Corbetti area. (Photo credit: Abebe Ameha Mengistu)Error! Bookmark not defined.
Figure 31: Black-necked ridgeback agama on thatched roof (top)Error! Bookmark not defined.
Figure 32: Black-necked ridgeback agama on thatched roof (top) and on dead and live trees at Corbetti area. (Photo credit: top: Meron Adefris; bottom: Abebe Ameha Mengistu) ..........................................................Error! Bookmark not defined.
Figure 33: African Striped Skink Basking On The Outside Wooden Wall Of A Hut At Corbetti Area. (Photo Credit: Abebe Ameha Mengistu)....Error! Bookmark not defined.
Figure 34: Corbetti Mosque (Near Pad A) igure 3.2.Danshe Mosque (Near Pad D)Error! Bookmark not defined.
Figure 35 Hulla Mosque (Near Corbetti water tanker)......Error! Bookmark not defined.
Figure 36 Ansewe Mosque (Near Pad D).........................Error! Bookmark not defined.
Figure 37:Willy Mosque and Baema Mosque.................Error! Bookmark not defined.
## LIST OF ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AZE</td>
<td>Alliance for zero extinction</td>
</tr>
<tr>
<td>CBD</td>
<td>Convention on Biological Diversity</td>
</tr>
<tr>
<td>CITIRES</td>
<td>Convention on international trade in endangered species</td>
</tr>
<tr>
<td>GIS</td>
<td>Global Information System</td>
</tr>
<tr>
<td>GN</td>
<td>General Notes</td>
</tr>
<tr>
<td>GPS</td>
<td>Global positioning System</td>
</tr>
<tr>
<td>Herpetofauna</td>
<td>Reptiles and Amphibians</td>
</tr>
<tr>
<td>IBA</td>
<td>Important Bird area</td>
</tr>
<tr>
<td>IFC</td>
<td>International Finance corporation</td>
</tr>
<tr>
<td>IUCN</td>
<td>International union for conservation of nature</td>
</tr>
<tr>
<td>KBA</td>
<td>Key Biodiversity Area</td>
</tr>
<tr>
<td>MWe</td>
<td>Megawatt energy</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

This study covered the species of dry season (December 2017) as well as species not found in the original baseline study on biological environment that was done by Beles Engineering Pvt. Ltd. Company. To get the full list of biological environments, it is advisable to refer both dry and wet season reports.

The Dry season rapid biodiversity assessment has been done at around 12 well pads of Corbetti Geothermal project, 203 totally identified plant species of the dry season assessment, are now added in the records of the Corbetti area. A good number of woody plants are also newly recorded. In case of Mammals, 35 large and small mammals that are grouped in 21 families are recorded. In birds, a total of 125 bird species, in Herpetofauna (Reptiles and Amphibians) a total of 21 species, in case of Invertebrates, a total of 44 species have been recorded.

In general, the actual impact of the envisaged project on the mammals and birds of the area is minimal. This can be explained with regard to the absence of any endemic mammals and birds species. The assessment in regard to IUCN Red data list of mammals, except the critically endangered one species (Leopard) of mammals, there are no critically endangered species around the project area.

In case of bird species, White-backed Vulture, Hooded Vulture, Lappet-faced Vulture and Ruppell’s Vulture which are categorized as critically endangered. However, these vultures are either opportunistic scavengers or flying across the area and are not utilizing the area permanently for food, shelter and as breeding ground.

The current survey in Herpetofauna has enabled to recognize the occurrence of at least a few species of amphibians and reptiles at Corbetti area. Potential occurrence of more species of herps is very likely, as amphibians, snakes and other reptiles in particular could be less active during the dry season. Threatened species or illegally traded frogs and reptiles were not recorded in the study area. However, the planned development of the area for geothermal use will have to consider availability of safe micro-habitats for breeding of amphibians (that are less mobile and highly sensitive for dehydration) and less agile species of reptiles.
Invertebrate diversity around the project area was relatively poor in all well pads and consisted of restricted species. Beetle diversity and abundance was relatively higher. The composition and abundance of butterflies and ants depended on the type of host plants in the area.

The dry season study revealed that no invertebrate found in the Corbetti area fell in IUCN category of Red List, and was not of endemic and local importance. All of the invertebrates collected in this study were found commonly in similar ecosystems of the *Acacia Commiphora* ecosystem type in Ethiopia. It can thus be concluded that no serious threat to invertebrate biodiversity exists if drilling for geothermal energy proceeds in all the concession areas and pads surveyed in this study. However, another survey during the wet season is required to fully understand the biodiversity status of the Corbetti area.
1 Introduction

1.1 Study Background

Corbetti Geothermal PLC (CGC) is currently developing a geothermal project in Corbetti (Southern Ethiopia). The Project is located within the Corbetti Caldera 250 km south of Addis Ababa, next to Lake Hawassa, near the town of Hawassa in southern Ethiopia. The Corbetti caldera geothermal resource covers an area of 155 km² of extensive young volcanism, the resource estimated to be in the order of 1,000 MW and steam temperatures in excess of 250°C. The development requires construction of access roads to well pads, construction of well pads, a water supply line and assembly of rig and rig equipment and finally construction and operation of power plants. The company plans to develop geothermal power in phases; starting with modular wellhead units of 10-20MW capacity and increasing to 50-100MW units up to a maximum of 500 MWe of power.

Figure 1: Site Location Map
CGC has obtained an exploration licence and will agree various commercial contracts with the Government of Ethiopia including a power purchase agreement (PPA) with Ethiopian Electric Power (EEP), the government owned entity which will purchase the power. The project will be operated for 25 years from the commercial operation date (COD) of the final phase and is proposed for development in up to five phases, with progress to each phase dependent on the success of the previous phase. The development phases are summarised in Table below.

**Table 1: Planned Development Phases**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Capacity (MW)</th>
<th>COD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit</td>
<td>Cumulative</td>
</tr>
<tr>
<td>1</td>
<td>Up to 4x5</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>1x50</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>1x50</td>
<td>120</td>
</tr>
<tr>
<td>4</td>
<td>3x50</td>
<td>270</td>
</tr>
<tr>
<td>5</td>
<td>5x50</td>
<td>520</td>
</tr>
</tbody>
</table>

In addition to the COD milestones in Table 1, construction works have already started and a significant part of the access road is partially complete – up to the ‘T’ junction where the road splits to the well pads. Phase 1 comprises drilling of between 5 and 7 wells from two, three or four well pads (Well pads A, B, C and D) and then installing up to 4x5MW relocatable atmospheric exhaust steam turbines placed at two of the exploration well pads. Phase 2 is a permanently installed 1x50MW axial exhaust condensing steam turbine power plant. Eight to twelve additional production wells and one reinjection well from several further well pads are planned for Phase 2, along with associated steam field infrastructure. The Phase 1 power plant will be on the first well pad that finds steam.

An ESIA for Phase 1 has been completed and approved by the Ethiopian Ministry of Mines. However, CG is planning to update the ESIA throughout the development phases with the increasing availability of information about the geothermal resource (fluid / steam characteristics) and as the infrastructure for each phase is confirmed.
In addition to the Phase 1 and Phase 2 generation components, 15km of new transmission line and a new sub-station are required to export the power into the existing national grid. This will be constructed for Phase 1 and will comprise 10 km of 132kV transmission line and 5km of 15kV transmission line. CGC has responsibility for building the 15kV line; 132kV substation and a 15kV to 132 kV step up transformer while EEP has responsibility for building and connecting the 132kV transmission line, which will be connected into the existing Alaba to Shashemene 132kV transmission line.

As part of the Phase 1 works the substation will consist of a 15kV switchboard and a 132kV switch yard which will connect to the individual well-heads via 15 kV overhead lines (OHLs) and a 24MVA 132/15 kV transformer. The grid connection point will be at the 132kV side of this transformer. As part of the Phase 2 works the Developer will install a 60MVA 132/15kV transformer adjacent to the 50MW unit and supply and install a 132kV OHL from the 132kV substation to this new transformer. The connection point between the power plant and the transmission system will be at the 132kV circuit breaker in the substation. The infrastructure layout for Phase 1 is presented in Figure 2 below. Figure presents the surrounding context.

Figure 2: Projects Geographical Context
The Corbetti Geothermal Project located about 280 km south east of Addis Ababa, with Lake Hawassa to the south. The initial location of exploration wells is about 20 km North of Hawassa and about 35 km South west of Shashemene City.

![Location map of the project](image)

**Figure 3: Location map of the project**

### 1.2 About Senkelle Swaen’s Hartebeest Sanctuary

The Senkelle Swayne’s Hartebeest Sanctuary (SSHS) is one of the protected areas managed by the Ethiopian Wildlife Conservation Authority (EWCA), and it is the smallest protected area in the country. It contains the endemic (only found in Ethiopia) and endangered (low in number) subspecies of hartebeest that called Swayne’s Hartebeest. The Sanctuary was established in 1971G.C (1964 E.C) and it is among
Baseline Biodiversity, Air and Hydrology Study Report

the gazetted protected areas found in Ethiopia.

The SSHS occurs between Oromiya and Southern Nation Nationalities and People Regional States (SNNPRS) and covers an area of 54 km². It is found at 320 km from Addis Ababa in the western side of the Great Ethiopian Rift Valley, along Shashemene - ArbaMinich road. The sanctuary is one of the principal wildlife Conservation areas of Ethiopia.

Geographically, it is found between 7° 7’15” to 7°12’45” N latitude and 38°5’15” to 38°20’15” E longitude with the altitude ranges varying from 2000 to 2100 m a.s.l.

Vegetation types in the sanctuary are divided into savanna woodland, valley complex and grassland. The average rainfall at Senkele, measured over four years (1991 to 1994) is 1,116 mm. It has a moderately bimodal pattern of rainfall typical of the Woinadega’ agro-ecological zone of Ethiopia. The three-month dry season, from November to January is followed by the ‘Belg’ rains, from March to April. During the dry season, cloud cover is at a minimum and wind speeds are at their annual maximum contributing to the high levels of evapo-transpiration associated with tropical climate patterns.

The Senkele Swayne’s Hartebeest Sanctuary (SSHBS) was established in 1971 to save the most viable population of the Swayne’s Hartebeest (SH), an endemic and endangered larger antelope of Ethiopia. The Swayne’s Hartebeest (Alcelaphus Buselaphus Swaynei), once extremely numerous in Somalia is now believed to survive only in two localities (Senkelle SHBS and Mazie National Park) in Ethiopia, and is classed as critically endangered. However, the establishment of this protected is being contributing a lot on the protection and management other life forms that dwelled within it, as well as the entire ecosystem existed in the area and that could be vanished due to anthropogenic effects.

The sanctuary is about 10Km west of the CGC proposed well pad and in addition to the distance geographically separated by ground divided. This can concluded the proposed CGC project area is located outside the sanctuary influence area (Figure 4). Hence this biodiversity does not include require


The details of the Sanctuary described under Article as follows;

**Article 4. Boundaries of the Sanctuary.**
The Sanctuary is found in Siraro woreda of West Arsi zone and Hawassa woreda of Sidama zone within the following demarcation Points:

**SIRARO WOREDA of WEST ARSI ZONE**

a) Commencing at beacon number 1, from the area known as Oda Seder, around Qite Tesisa at 07°12’21” Latitude North and 38°18’40” Longitude East.

b) Thence, following the road from east to west direction up to beacon number 2, at 07°12’42” Latitude North and 38°17’36” Longitude, East around Qite Tessisa.

c) Thence, up to beacon number 3, lying between Qite Tessisa and Senbete Lecho at 07°12’20” Latitude North and 38°16’03” Longitude East.

d) Thence, turning to southward up to beacon number 4, at 07°11’33” Latitude North and 38°16’19” Longitude East, at around Senbete Lencho.

e) Thence, turning to westward up to beacon number 5, at 07°11’23” Latitude North and 36°15’12” Longitude East at around Loke Sifo;

f) Thence, turning to Southward up to beacon number 6, at 07°09’18” Latitude North and 36°15’32” Longitude East at around Loke Sifo;

g) Thence turning to south eastern direction up to beacon number 7, at 07°08’50” Latitude North and 38°16’31” Longitude East around Kela Lalima;

h) Thence up to beacon number 8, at 07°08’23” Latitude North and 38°16’12” Longitude East on the rear side of Bekela camp.

i) Thence up to beacon number 9, at 07°08’12” Latitude North and 38°17’04” longitude east at around Bekela Lalima;

**SIDAMA ZONE, HAWASSA WOREDA**

a) Up to beacon number 10, at 07°07’22” Latitude North and 38°17’02” Longitude East at place called Hadesso.

b) Thence, excluding the Tatessa land and passing through Anole and Meti and following the edges of Goda Hare gorge joins the initial beacon number one.
1.3 Scope of works

The scope of the work is to carry out the Environmental Baseline study for Baseline Environmental Study Corbetti Geothermal Project, Phase 1 Operations as shown in Location map (Fig. 2). The Environmental Baseline Study is required to meet the International Finance Institutions (IFIs) and will fill the gaps in the existing Baseline Environmental data.

Hence TS Environment will provide competent personnel, adequate equipment and supplies for the delivery of the services to assist CGC meet its legal, environmental and social obligations during it operations to include, but not be limited to the activities provided in table 2 below.

Table 2: List of Expected Services for the Consultant

<table>
<thead>
<tr>
<th>Area of Review</th>
<th>Actions/Tasks</th>
<th>Delivery time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecology</td>
<td>• Undertake ecology desk study at well pad A, B, C and D to consider invertebrates, birds, reptiles / amphibians and smaller mammals, and collect further information on the fauna.</td>
<td>Final Report 4 months from contracting</td>
</tr>
<tr>
<td>Area of Review</td>
<td>Actions/Tasks</td>
<td>Delivery time</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td>• Make a thorough field study on the micro-flora of the site. Where necessary desktop research may be needed to provide additional information such as the potential need for multi-season surveys.</td>
<td>consultant</td>
</tr>
<tr>
<td></td>
<td>• Identify threatened species according to IUCN Red list</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Consult with local communities and the Senkelle Sanctuary regarding sensitive/culturally significant flora or potential for movements of wildlife from Senkelle within the Corbetti area and the risk of Invasive species.</td>
<td></td>
</tr>
<tr>
<td>Air Quality</td>
<td>• Undertake baseline air quality monitoring at sensitive receptors around all Phase 1 well pads (A, B, C and D) and infrastructure using Standard Operational Procedures, this will include installation of automated weather stations and measurement of dust, particulate matter and gases (CO$_2$, H$_2$S, SoX, NoX).</td>
<td>Final Report 4 months from contracting consultant</td>
</tr>
<tr>
<td></td>
<td>• Update air quality impact assessment based on new baseline data and undertake modelling if required to consider the potential health/nuisance impacts on the nearest residential receptors.</td>
<td></td>
</tr>
<tr>
<td>Surface and Ground Water Quality</td>
<td>• Reassess the sensitivity of Lake Hawasa as a potential water source as part of ongoing water supply feasibility studies, through the collection of baseline data on water quality and availability.</td>
<td>Final Report 4 months from contracting consultant</td>
</tr>
<tr>
<td></td>
<td>• Carry out a ground water quality assessment and availability of resource to the project.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Assessment of the impact on Lake Hawassa and groundwater of Phase 1 of the project</td>
<td></td>
</tr>
</tbody>
</table>
2 Study Objectives

2.1 Biodiversity

To carry out follow-up rapid Biodiversity Study on plants, mammals, birds, and Herpetofauna (reptiles and amphibians) around recently defined drilling area in and around the Corbett proposed drill field.

2.1.1 Specific Objectives

- To fill the Phase I baseline survey gaps in Biodiversity (Amphibians, Reptiles, Invertebrates) and revitalize the mammals, bats and Birds baseline survey and identify local wildlife migration route (migration corridor).
- To undertake consultation with local communities regarding sensitive/culturally significant flora and fauna.
- To consult Senkelle sanctuary regarding the status of the sanctuary and obtain information on its history including human use prior to its creation and human encroachments subsequent to this, potential for movements from Senkelle within Corbetti area and risk of invasive species.
- To collect information on the newly installed EEP transmission line in case this ultimately forms part of the project
- To collect further information on the flora and fauna (including relevant information coming from consultation activities) to determine the ultimate requirement for additional survey, the potential for multi-season assessment and whether a rapid update to the impact assessment/determination of mitigations is required
- To identify baseline conditions and assessment endpoints that are important for making assessment of the environmental impacts of the project on the components of the ecosystem; and provide mitigation and environmental management plans during and after the completion of the project activities.
Figure 5: CGC Project Location
2.1.2 Approach and Study Methods
Both flora and fauna ecological characteristics were collected through quantitative (field sampling) and quantitative study (desk review and other secondary information) methods. The general approach includes:

- Field investigation, survey and observations
- Discussion with local key informants
- Use of GPS, binoculars and GIS digital and analytical technology
- Desk review of published and unpublished documents
- Consultation with relevant government institutions heads and experts
- Discussion using semi-structured interviews

In order to conduct the rapid biodiversity studies in agreement with accepted standards and regulations in the field, TS Environment have undertaken the following:

- Undertake sampling for the specialist studies during the study period;
- Conduct the field studies in accordance with relevant national regulations and restrictions (legal or religious), but also ensuring compliance with international standards, policies, laws and regulations;
- Evaluate implications of results in terms of relevant legislation, guidelines and standards applicable to the protection and/or management of that environment in Ethiopia and according to IFC PS6:
  - Provide a description of the existing environment and habitat parameters in the study area considered (baseline conditions) and define their diversity and quality;
  - Provide a description of key species and species groups occurrence within the habitats defined in the study area considered and define the potential of the area in terms of diversity and quality based on usual sources of classification (IUCN red list, CITES, PROTA) by identifying threatened, rare and/or endemic species or subspecies;
  - Moreover, depending on supporting literature existence, provide background trends for the species and indicate how this may be affected by the project development;
  - Indicate the value and/or conservation importance of each component of the environment;
  - Identify biodiversity contribution to the sustained delivery and maintenance of ecosystem services and map this distribution in the landscape of relevance;
During biodiversity baseline studies, identify local values and uses attached to life forms sampled and integrate this information to highlight ecosystem services hotspots from a human use point of view in order to contribute to the natural resources use studies;

Provide comprehensive description to the existing environment in the study area to enable a standardized assessment of the sensitivity of the study area and define modified, natural and critical habitat zones.


- trends in species population and distribution;
- rates of potential colonization by new species and habitats;
- ecological processes, such as succession;
- likely changes in agricultural practice, including agro-environment schemes;
- expected outcomes from current and predicted management practices;
- trends in habitat quality e.g. resulting from pollution or pollution control;
- environmental trends e.g. climate change;
- management plans and conservation objectives for designated sites; and
- the effects of other projects (see 3.7 and Box 12).

The baseline conditions for each ecological feature should be described clearly, objectively and succinctly within the EcIA, using figures and plans where necessary. Where an extensive amount of survey data has been generated, this can be provided as appendices.

In some cases, other development projects (besides the one being assessed) can influence the baseline and need to be taken into account. This will be the case in circumstances where another development has been consented or recently constructed and is predicted to have an impact on an ecological feature being considered as part of the EcIA. The baseline may also be affected where another development has an ongoing incremental ‘operational’ phase effect. An example of this is given in Box 1. Impacts arising from other developments will, in some cases, need to be considered as cumulative impacts. Information on cumulative impact assessment is given in paragraphs 5.20 to 5.23.

Box 1: Establishing the baseline: consideration of other development projects

The scenario

An EIA is being carried out for a proposed wind farm in the uplands. The proposal includes 20 turbines and associated permanent infrastructure, and a temporary works area during
The wind farm adjoins a nationally designated site for nature conservation. Construction of another wind farm within the same range of hills is already underway.

**Predicting the baseline**

The approach to establishing the baseline should be agreed after discussion between the competent authority, the statutory nature conservation organisation and any other relevant agencies. It is likely to include consideration of:

- ecological and other trends affecting the baseline condition of upland habitats and their bird populations e.g. grazing pressure, afforestation, peat extraction, climate change, anticipated changes in the level of disturbance caused by the public;
- predicted impacts arising from the wind farm under construction, as reported in the Environmental (Impact) Statement; and
- predicted (but yet to occur) impacts of other completed, in-construction and consented projects e.g. the operational impacts of other wind farms elsewhere in the uplands

---

**2.1.4 Specific Methods for Plants**

The rapid plant diversity assessment of CGC project site follows first the identification of natural and modified habitats. The International Finance Corporation (IFC) and UK Chartered Institute of Ecology and Environmental Management (CIEEM) Guidelines for Ecological Impact Assessment in the United Kingdom (2006) approach was followed for the identification of natural, modified and critical habitats.

Natural habitats are those with large natural vegetation cover and with little anthropogenic disturbances. Vegetation is the typical land cover of natural habitats. Modified habitats are those highly modified and converted to non-vegetated land uses. Agricultural land, grazing land, plantation forest, mined area, and so forth - are examples of modified habitats.

Within each natural and modified habitat, sample plots of 20 m X 20 m were laid along altitudinal gradient. Within each sample plot all woody species (trees, shrubs) were recorded. Herbaceous and graminoid species were recorded in a 2 m X 2 m subplot laid within the larger plot. Some of the plant species were identified on site. Plant specimens were collected for those which were difficult to identify for later identification using the Floras of Ethiopia and Eritrea.

The provision of ecosystem services both by the natural and modified ecosystems has been assessed using expert elucidation and key informant discussion methods. Some of the plant species were identified
on site. Plant specimens were collected for those which were difficult to identify for later identification using the Floras of Ethiopia and Eritrea.

Biodiversity sensitivity assessment was done for the different identified habitat types. Landscape feature, plant species richness, vegetation structure and presence of endemic plant species were the criteria for the assessment. The assessment varies from 1 (very low sensitivity) to 5 (very high sensitivity). Presence of signs of anthropogenic disturbance (tree cutting, charcoal making, grazing) and land degradation were observed and recorded.

2.1.5 Specific Methods for Mammals

For Mammals rapid assessment, both direct and indirect faunal survey methodologies were employed. By direct observation, rapid survey of the wildlife resource of the area has been assessed by using binocular and GPS by selecting representative vantage points. Walking along transects lines was also applied. In case of indirect observation, main emphasis has been given for identifying mammals sign, like analyzing the animals foot print, burrows, skeleton, fecal materials, hairs, horn etc. and visiting the dens, caves, sleeping sites. Since most mammals are secretive or nocturnal, they are seldom seen by the casual observer. But their presence is often revealed by tracks, burrows, nests, evidence of feeding and its residues, foot prints, tail markings, fecal material or scats.

Community elders (key informant) were utilized as secondary sources after a thorough discussion to supplement literature review.

Survey walks along transect lines and observation on suitable vantage points mainly applied for large and medium mammals. The surveys were conducted at early morning and late afternoon until dusks (when the animals were active).

In addition to the field survey, discussions were conducted with the local communities that lived for more than ten years around the project site. The discussions were conducted using semi-structured questionnaire and utilization of field guides, photos (illustrations) and demonstration of the colour, behaviour, sound, and the possible habitat of the animal. During the discussion time, long discussion time was given to exhaustively list out all animals that live around their locality.

For Small Mammals, like for Bats, dusk-time walks near forest streams, potential roosting sites (e.g. caves) and fruiting/flowering trees provide an indication of presence of bats and abundance. In addition to the direct observation, caves, hollow trees and fallen logs were visited. Other indirect signs of small mammals’
presence include observation of their teeth, skull and other skeletal remains. Moreover, the 2016 IUCN Red List category was checked to determine the current conservation status of mammals of the study area status.

2.1.6 Specific Methods for Birds

For bird’s identification, transects walk has been done along the 12 well pads as well as review of secondary data. All the birds seen or heard along each transect were recorded irrespective of their distance from the observer. Each bird species and the list of the different bird species existing in the area with complete information was recorded. The 2016 IUCN Red List category was checked to determine the current conservation status of birds of the study area and their regional status. Birds were identified using binoculars close observations and a field guide (Redman et al. 2011).

GPS apparatus was used to measure the transect distances and altitude of sampling habitats. The surveys were conducted early in the morning 09:30–12.30 am. In addition to this, birds observed opportunistically in the forest and surrounding agricultural areas were also noted.

Birds were identified using binoculars and a field guide (Redman et al. 2011). Each transect was visited twice; thus, c.12.75 km was covered. The surveys were conducted early in the morning 09:30–12.30 hrs. In addition, birds observed opportunistically in the forest and surrounding agricultural areas were also noted. As a broad guide to a species’ local abundance, relative frequency of occurrence was calculated using a simple formula: \((\frac{T_i}{T_n}) \times 100\); where, \(T_i\) = number of transects along which a species was recorded, and \(T_n\) = the total number of transects surveyed. Species were then classified as common (observed along at least five, or 75%, of six transects), frequent or fairly common (observed on 50–74% of transects), uncommon (25–49%) or rare (<25%). In addition to determining the relative abundance of each bird species of the project impact sites the 2016 IUCN Red List status of birds was used to determine the current threat status of birds of the study area.

2.1.7 Specific Methods for Herpetofauna (Reptiles and Amphibians)

The survey on the herpetofauna was conducted at different micro-habits during the day; although evening survey was in the plan, for safety reasons, the local people recommended to cancel evening survey in the area. Search was made by walking through bushes, on grasslands, valleys, and plains covering on average 6.7 km every day for subsequent three days.
The search was made in open fields, earthen holes, on tree branches, under leaf litter and rotting logs, and on walls and ceilings of houses. GPS tracks were taken to outline the area covered during the field survey, and to show specific points where specimens were encountered. Specimens were neither treated in inhumane manner, nor killed during the survey. Photos were taken using Nikon D3300 digital camera and SAMSUNG-GALAXY-S7 phone.

Consultation was also made with the Wildlife Department of Wondo Genet College (Hawassa University) to check if any previous study was conducted on the amphibians and reptiles of Corbetti area. Unfortunately, we found out that there was no such study conducted so far by the College. Local guides were employed to obtain information on the occurrence of amphibians and reptiles at the study area.

2.1.8 Specific Methods for Invertebrates

Collection of samples was made from around 10:030 to 12:00 am every day, when most insects were active and flying around.

Materials used in the present study included; Butterfly nets, beating clothes, Aspirators, vials, killing jars, spreading board, collection boxes, pins (different size), GPS, Camera, Paper boxes and Styro-Foams. 70% Chloroform and Ethyl acetate were used as killing agents.

The sampling spots included:

(i) Thick forests along gulley and ridges sampled using beating clothes (Plate 1),

(ii) Butterfly sweep nets were used to collect butterflies and flying insects in the grassland and open fields, and edges of the thick forests;

(iii) Aspirators were used to collect small invertebrates from the beating cloth, ground holes and crevices, open ground, etc. Soil dwelling insects were also collected by sorting/observing visually with the aspirator. Specimens were transferred to a killing jar soaked with 70% Chloroform. Butterflies were transferred and mounted dry with ventral side up in pinning boxes. All collected and sorted out invertebrates were brought to the laboratory and identified to family level using available taxonomic keys, texts, reference specimens and in comparison, with voucher specimens present in the Zoological Natural History Museum of the Addis Ababa University.
2.2 Hydrology

2.2.1 Desk Study

Detail literature review was conducted before and after the field investigation. Several works with regard to hydrology, ecology and biology have been conducted in Hawassa Basin. The general hydrological and hydrogeological description by Jica, 2012, Nedaw 1997, and Tadesse et. al 2003 deals with characterizing the Hawassa Catchment with regard to hydrology and hydrogeology. Specific studies focused on surface water ground water interaction, engineering geology and other related topics were studied focusing Lake Hawassa catchment by several authors. Specific study in the project area mainly focuses on the geothermal prospect and associated environmental studies. The environmental base line study carried by Beles engineering presents a detail account of the broader area giving reasonably detailed detail description of all main topics in baseline study. A paper on surface exploration for geothermal prospect tried to model the geology of the area with respect to geothermal prospect (Gestur Gislason, et.al). The Corbetti social and environmental Gap analysis is also examined as a source for defining the study (Jacobs 2016). In addition to analyzing existing published, unpublished and grey literatures, topographic map, satellite images, SRTM data, meteorological data and hydrological data were processed and analyzed.

2.2.2 Field Investigation and Lab Analysis

A five days field investigation focused on Well pad area has been conducted from December 5 to 9, 2017 to collect water and soil samples, conduct pumping test, to verify the geological, hydrogeological, geomorphological and land use features of the area. Six water samples from Lake Hawassa, Tikur Wuha River, and boreholes were collected after rinsing the sampling bottles twice. All the samples were kept in cool box and they were sent to be analyzed to the lab immediately. A standard procedure was followed to analyze the samples for major cations and anions, and minor constituents. Moreover to make a hydrological analysis a wetSpass model is used. The model is briefly described below.

2.2.3 WetSpass Model

WetSpass is based up on the foundation of time dependent spatially distributed water balance. WetSpass stands for water and energy transfer between soil, plants and atmosphere under quasi-steady state condition. It is a physically based model for estimation of the long term average spatial patterns of the groundwater recharge, surface runoff and evapotranspiration from long term average meteorological data together with land use, soil and groundwater depth maps by employing physical and empirical relationships (Batelaan and Woldeamlak, 2004; De Smedt et al., 2001).
3 Air quality

4 SCOPE THE ASSESSMENT

The scope of this baseline air quality assessment is to:

• Undertake baseline air quality monitoring at sensitive receptors around all Phase 1 sites and infrastructure using Standard Operational Procedures, this will include installation of automated weather stations and measurement of dust, particulate matter (PM10 and PM2.5) and gases (CO₂, H₂S, SOₓ, NOₓ).
• Update air quality impact assessment based on new baseline data and undertake modelling to consider the potential health/nuisance impacts on the nearest residential receptors based upon national and international standards.
• Liaise with Ethiopian Ministry of Environment Forest and Climate Change regarding the air emissions standards for hydrogen sulphide and other pollutants

4.1 Air quality assessment approach and methodology

The study team followed a well-established methodology to conduct this study. In general these are the methodologies used for this study:

• A desk review to discover and synthesize all pertinent information regarding the project and the project area including project documents
• A field visit to the project area along with a baseline survey that extends over 3 weeks
• Air emission inventory of the project area as well as identification of potential receptors
• An air quality impact assessment with the aid of computerized modeling study

The tasks included generally the following approach:

• The determination of applicable air quality limit values, dust nuisance values and associated averaging periods;
• The selection of suitable atmospheric dispersion model or screening tool
• Discussion of meteorological parameters required to establish the atmospheric dispersion potential and other model inputs such as release height, gas exit velocity, gas exit temperature and emission rate
• Defining dimensions of modeling grid and/or location of sensitive receptors;
• Defining background pollutant concentration at receptors
• Simulate the modeling/screening task;
• Compare the model results against the applicable air quality limit values to identify potential air quality impacts

The baseline Air Quality Assessment shall summarize the preliminary findings about the study area and its surrounding. The assessment for the current project included the identification of sensitive receptors, project site atmospheric dispersion potential and a status quo on existing ambient air quality.

In order to understand the dispersion of pollutants to the atmosphere it is important to have a clear understanding of the driving forces, in this case the regional climate and meteorology. The study utilized
seventeen years (2000 – 2016) worth of meteorological data obtained from National Meteorology Agency of Ethiopia, since no on-site meteorological data were available.

Typically, baseline evaluations include the analysis of background ambient concentrations and dust fall rates. Monitoring ambient dust fall data from the existing project area will be included in this regard.

In the evaluation of ambient air quality impacts, reference was made to the national standards and IFC guidelines pertaining to air quality for sources and pollutants relevant to the current study.

The establishment of an emissions inventory forms the basis for subsequent impact assessment. The emissions inventory comprises the identification of sources of emission, and the quantification of each source’s contribution to ambient air pollution concentrations.

The main environmental issue associated with geothermal development here in is the release of hydrogen sulfide gas. Hydrogen sulfide is a colorless gas with a strong odor of rotten eggs, and low temperature volcanic emissions. Direct inhalation of high concentrations of hydrogen sulfide can cause death to humans and animals in a matter of minutes.

Particulate matter may be considered secondary concern from the project’s construction. In the estimation of particulate emissions and the simulation of patterns of dispersion, a distinction is made between thoracic particulates (PM10 - particulate matter with an aerodynamic diameter of less than 10 μm) and respire able particulates (PM2.5 - particulate matter with an aerodynamic diameter of less than 2.5 μm). PM10 and PM2.5 are of concern due to their potential for human health effects.

4.2 Air Quality Assessment Procedure

The Corbetti geothermal development project will emit different pollutants to the atmosphere; significant among these is the discharge of non-condensable gases (NCG). The NCG present in geothermal fluid are a mixture of CO₂, H₂S, H₂, and CH₄. Among all NCG emitted, H₂S is of the greatest important due to its noxious smell in low concentration and also its toxicity in high concentration.

Along with the gaseous releases, dust and particulate matter releases will increase due to the project activity like increased use of project vehicles, clearing of the land for project infrastructures and etc. An emission inventory will be conducted to summarize all potential pollutants.

The monitoring program measures

- Dust fall
- Suspended particulate with diameter less than 10 μm (PM₁₀),
- Suspended particulate with diameter less than 2.5 μm (PM₂.₅),
- Nitrogen dioxide (NO₂),
- Sulphur dioxide (SO₂),
- Hydrogen sulphide (H₂S)
- Carbon dioxide (CO₂) and
4.2.1 Dust fall

As part of the ambient air quality baseline program, a 15 days dust fall measurements were conducted from April 11-26, 2018. The dust fall monitoring program was developed in accordance with ASTM D1739-2010 sampling method.

Each dustfall station consists of a fence post pounded in to the ground, onto which a steel pipe and bracket are fixed. The steel bracket, in which dust fall canisters are inserted, is protected with bird wire to prevent contamination of the samples.

4.2.2 Particulate Matter (PM2.5 and PM10)

The monitoring of particulates mater (PM$_{10}$ and PM$_{2.5}$) configured to monitor concentrations at 15 minute intervals. The monitoring program were in accordance with USEPA (40 CFR Part 53) and EU (2008/50/EC) as applicable. MiniVol portable air sampler manufactured by a US based AIRMETRICS Company is used to collect ambient air samples for PM10 and PM2.5 samples for gravimetric analysis. The monitoring was conducted between April 11 and 26, 2018. The MiniVol's pump draws air at 5 lit/min through a particle size separator and then trough a 47 mm filter. The 10 micron or 2.5 micron particle separation is achieved by impaction.

MiniVol portable air sampler has a size-selective inlet head that limits the particles collected to the desired PM10 size range. When configured for PM2.5, the PQ200 includes a cyclone downstream of the PM10 inlet to further limit the particle sizes. The PQ200 has a standard airflow rate of 16.7 liters per minute (L/min). The PM10 or PM2.5 will be collected on a 47 mm diameter PTFE membrane filter, and the particle mass collected determined gravimetrically.

In addition Aeroqual's 500 portable air quality monitors used for simultaneous concentration measurement of fine (PM2.5) and coarse (PM10) ambient PM during the 1st phase of air quality monitoring in March 2018.

4.2.3 Hydrogen sulphide

Monitoring for hydrogen sulphide (H$_2$S) levels in the ambient air from existing geothermal features at Corbetti project site conducted between April11-26. The monitoring location are identified as near as possible to where people reside and/or areas where there is extensive cultivation.

Hydrogen sulphide monitoring conducted using a portable monitor devise for continuous measurement of H$_2$S at ambient concentrations (less than1 part per million). Monitoring undertaken for 3 days (72hrs) at each location and data recorded at the interval of every 15 minutes.

4.2.4 Study Area

Monitoring sites located in suitable areas that comply with the guidelines set out in Australian Standard AS 3580.1.1:2007: Methods for sampling and analysis of ambient air – Guide to siting air monitoring equipment. The purpose of AS3580 is to ensure that the location of the sampling site is such that the collected data is representative of that location. In addition all sampling equipment was placed at about 2 m above ground level.

The study area of the air quality baseline monitoring program focused on the location of proposed Phase 1: Project infrastructure anticipated to be locations of main site activity and air emissions during the operations.
phase of the Project. The monitoring location are identified as near as possible to where people reside and/or areas where there is extensive cultivation.

To meet the study objective, it is important to select locations that are representative of the project impact region which are likely to yield useful data to establish pollutant concentration. The locations selected to install air quality measuring equipment’s satisfies the project’s air quality study objectives. Criteria used during selection of study locations will include the following parameters:

- Relative location to the nearest population center,
- Distance and the prevailing wind direction from potential emission sources (measuring stations should be located in the downwind of the anthropogenic pollution source),
- Accessibility throughout the study period,
- Security of sampling equipment from unauthorized agents and vandalism, and
- Topography (nearby uniformity of the land).

**Figure XX: Biodiversity Sensitivity Map for Corbetti Area**
**Figure XX: Habitat Type Identification in the Study Area of Corbetti Geothermal Project**

**Figure 6: Air Quality Study Area**
Figure 7: Predicted Highest 24 Hourly H2S Concentrations due to Operational phase