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# TULU MOYE GEOTHERMAL PROJECT RAPID BIODIVERSITY STUDY REPORT

*Prepared for*



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*Prepared by*



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## LIST OF ACRONYMS

|                     |   |
|---------------------|---|
| <b>AZE</b>          | Alliance for zero extinction                            |
| <b>CBD</b>          | Convention on Biological Diversity                      |
| <b>CITES</b>        | Convention on international trade in endangered species |
| <b>GIS</b>          | Global Information System                               |
| <b>GN</b>           | General Notes   |
| <b>GPS</b>          | Global positioning System                               |
| <b>Herpetofauna</b> | Reptiles and Amphibians                                 |
| <b>IBA</b>          | Important Bird area                                     |
| <b>IFC</b>          | International Finance corporation                       |
| <b>IUCN</b>         | International union for conservation of nature          |
| <b>KBA</b>          | Key Biodiversity Area                                   |
| <b>RG</b>           | Reykjavik Geothermal                                    |
| <b>MWe</b>          | Megawatt energy   |

## EXECUTIVE SUMMARY

This study focused on the wet-season (July to end of August 2017) and cover species of wet season as well as species not found in the original baseline study on biological environment of the dry season that was done by GIBB International Consulting, Design and Management. To get the full list of Biological environment, it is advisable to refer to both dry and wet season reports.

The wet season rapid biodiversity assessment records: out of 120 totally identified plant species - 77 plant species, that were not recorded during the dry season assessment, are now added in the records of the Tulu Moye area. Most of these new records are herbaceous plants, ferns and grasses. A good number of woody plants are also newly recorded. In case of Mammals, 39 large and small mammals that are grouped in 20 families are recorded. Out of these 39 species, 17 of them are new records of the wet season survey. In birds, a total of 96 bird species have been recorded. Out of 96 bird species, 18 species are the new records of the wet season. In case of Herpetofauna (Reptiles and Amphibians) survey, 41 species have been recorded. Out of these species, one new amphibian species was listed during wet season.

In case of conservation of the ecosystem of Tulu Moye project site, establishment of buffer zone between the natural habitat (forest) and modified habitat (farm and grazing field) could reduce the impact of human disturbance on the natural habitat. This study recommends participatory forest management approach which has been tested for their effectiveness in various parts of the country. Free grazing and timber cutting should be restricted.

Although critical habitat has not been identified at the Tulu Moye geothermal project area, care should be taken by the project management to prohibit forest resource utilization from the natural habitat and to reduce soil erosion that might come due to road and project site construction.

In general, the actual impact of the envisaged project on the mammals and birds of the area is minimal. This can be explained by the absence of any endemic mammals and birds' species. The assessment in terms to IUCN Red data list, except the critically endangered one species (Leopard) of mammals, there are no critically endangered species around the project area. However, four species occurring within the Project area are listed in Class B of the African Convention on the Conservation of Nature and Natural Resources (The Algiers Convention). This means they are totally protected, but may be hunted, killed, captured or collected under special authorization granted by the competent Authority in contracting states.

Wildlife sport hunting and bush meat eating behaviour didn't exist in the project area according to the study team discussion with local communities. However, during field work it was observed that, as a result of the farming activities expansion up to the wildlife habitat, some crop was eaten by a large group of Anubis baboon and warthog. Both wild animals were considered as pest or enemy of the community which in turn put the mammals in danger of being hunted. There is no buffer zone between the natural forest and the local community settlement areas.

Therefore, Hitosa Woreda environment, forest and climate change office and Hitosa Woreda administration and relevant offices have to take immediate measure to control expansion of farming activities at the expense of destroying the natural forest and displacing wild animals.

Regarding bird species, White-backed Vulture, Hooded Vulture and Ruppell's Vulture which are categorized as critically endangered, Lappet-faced Vulture which is categorized as endangered and Pallid Harrier which is categorized as near threatened bird species - were not all seen during the study period but confirmed as residents of the project area through secondary sources. 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. These bird species are also not a concern to Ethiopia. The African vultures as a whole are in good status in Ethiopia despite their threat concern in many parts of Africa.

Even though Gnaro Lava Field may be a candidate as an Important Bird Area (IBA) with a total of 18 records of biome affiliated birds it is not significant number and there is no restricted range species or congregations of any sort of migratory birds that provides the site more focus to qualify as an IBA.

The current survey in Herpetofauna has enabled to recognize the occurrence of at least a few species of amphibians and reptiles at Tulu Moye area. Potential occurrence of more species of herps is very likely, as snakes and other reptiles in particular could be less active during the relatively cold rainy season. Endemics, 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.



## 1 INTRODUCTION

### 1.1 Study Background

Ethiopia has identified several sites in the rift valley area that have great potential for the production of geothermal energy. Over the last decade geothermal energy development projects have started exploration and production in East Arsi zone. Reykjavik Geothermal, an Iceland based company, is developing geothermal energy in Oromia region, Arsi zone, Hitosa Woreda (district), Tulu Moye area based on an agreement made with the Government of Ethiopia. Up to 3-500 MWe power installation is planned within the Tulu Moye geothermal area (the Project). The Project will be developed in two phases: the first phase will include exploration drilling, production drilling, well/drill pads, access road(s), water supply, quarries, pipeline(s), and up to a 100 MWe power installation. The second phase will involve expansion of power installation from 100 MWe up to 300 MWe, with potential of 500 MWe.

Energy exploration in many parts of the world has resulted in environmental changes, with significant local and regional impacts. Biodiversity is one of the environmental sector that could be affected by energy extraction projects. The impacts could be due to habitat loss and degradation, habitat fragmentation, loss of species, impairment of ecological processes, and introduction of alien invasive species.

Geothermal development activities mostly affect vegetation by gaseous emissions, physical removal of vegetation to pave way for roads, drilling pads, and buildings and hot or cold geothermal brine flowing on the surface (Jennifer 2010).

### 1.2 Project Location

The Tulu Moye geothermal prospect is located about 100 km south east of Addis Ababa, with Lake Koka to the north and Lake Ziway to the south. The initial location of exploration wells is about 40 km south of Adama City, about 24 km north of Assela and about 11 km from the town of Iteya.

### 1.3 Scope of works

Baseline biodiversity study has been conducted on the larger Project area. The Rapid (follow-up) biodiversity study focused only on the Gnaro lava field and surrounding areas and will attempt to update the survey findings of the original baseline study. It also gives emphasis to investigate and cover species possibly not found in the original baseline study on biological environment.

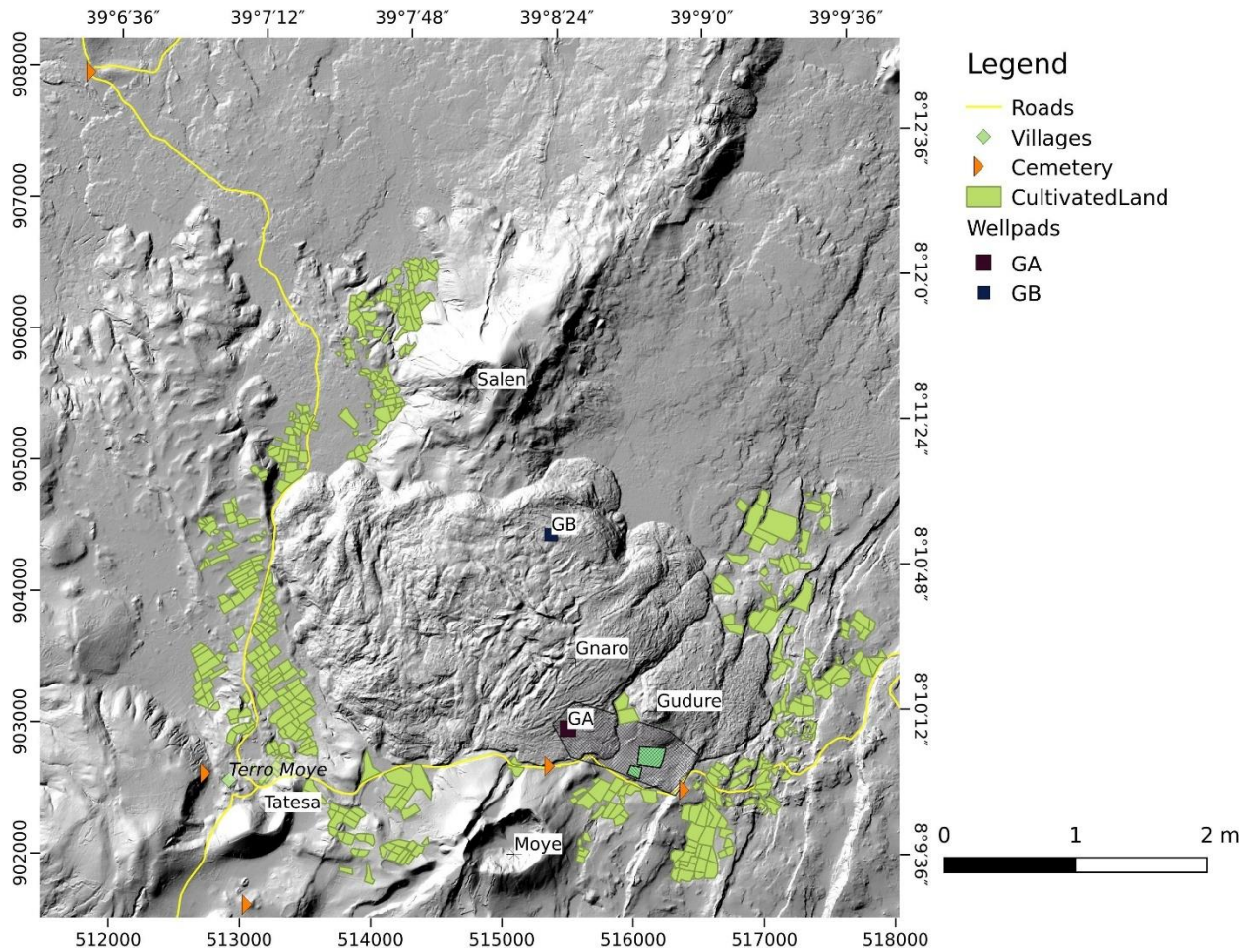
The Gnaro lava field lies mostly within the Tulu Moye kebele (also referred to as Tero Moye kebele). North of Gnaro lies Tero Desta kebele and Anole kebele to the east.

#### 1.4 Objective of the rapid biodiversity study

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 Gnaro lava field during the wet-season.



*Figure 1-1: Project location.*



**Figure 1-2:** The Gnaro lava field, tentative location of well pads GA and GB. Power station and lay-down area (dark-green squares) in south part of older lava part called Gudure

## 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 applicable period considered as wet season, if at all possible the wet season sampling should follow rains fairly closely in order to highlight ephemerals for the area;
- 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.

## 2.1 Specific Methods for Plants

The rapid plant diversity assessment of Tulu Moye Geothermal project site follows first the identification of natural and modified habitats. The International Finance Corporation (IFC) 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.

Hierarchical cluster analysis using Euclidean distances and Ward's method of hierarchical grouping was performed to identify plant community groups using PC-ORD software (McCune and Mefford, 1999). Input data are species presence/absence.

The vertical structure of both natural and modified habits was described based on such variables as (i) number of vertical layers (ii) maximum vegetation height and (iii) maximum vegetation cover.

The provision of ecosystem services both by the natural and modified ecosystems has been assessed using expert elucidation and key informant discussion methods. Discussion was made with experts of the Hitosa district Department of Environment and Forest and farmers at Tulu Moye /Tero Moye kebele.

Biodiversity sensitivity assessment was done for the different habitat types identified. 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, forest grazing) and land degradation were observed and recorded.

## 2.2 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 selecting representative vantage points in five observations zones. Walking along transects lines was also applied. In case of, indirect observation, main emphasis has been given for identifying mammals sign, like analysing 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 both 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. For Rodents and Insectivores; searching under fallen logs for runs where tiny feet have left a distinct path, as well as for signs of discarded food remains or fecal pellets were sampled. Other indirect signs of small mammals' presence include observation of their teeth, skull and other skeletal remains.

### **2.3 Specific Methods for Birds**

Birds were recorded along six line transects measuring 1–4 km (mean= c.2.12 km), systematically selected to sample all major habitats along altitudinal gradients.

Two line transects were taken at the Drillpad\_Area1 center point measuring 1 and 1.5 km radius respectively and one line transect at the Drillpad\_Area2 center point measuring a distance of 1.48 km. Another one line transect was taken in the middle of the bushland habitat and two line transects in areas which are occupied by cultivated land and settlements surrounding the project impact area. Transects were 200–250 m apart and were visited on different days. All bird species seen or heard were recorded as present, irrespective of their distance from transects.

As the primary objective of the study was to record the species present in the area, quantitative data, such as the number of individuals or the frequency of occurrence along each transect, were not collected.

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:  $(T_i/T_n) \times 100$ ; 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.

#### **2.4 Specific Methods for Herpetofauna (Reptiles and Amphibians)**

The survey on the herpetofauna was conducted at different micro-habitats during the day and in the evening. Open grasslands, on and under rocks, on piles of boulders, in flood pools, earthen holes, on tree branches, under mosses, under leaf litter and rotting logs. Vocal sound produced by frog calls was used to triangulate specimens for close observation and to take photos. GPS records 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 digital camera.

### 3 RAPID BIODIVERSITY ASSESSMENT OF THE PROJECT AREA

#### 3.1 Vegetation

The natural vegetation of Ethiopia is used to identify and describe the ecosystems of Ethiopia. The vegetation of Ethiopia has been classified by different authorities. The most recent one is the "Atlas of Potential Vegetation of Ethiopia" (Friis et al, 2010). According to this book, the natural vegetation of Tulu Moye area belongs to the "dry evergreen Afromontane forest and grassland complex", and most specifically "the Afromontane woodland, wooded grassland and grassland subtype".

This vegetation type includes the primary and secondary woodlands, wooded grasslands and grasslands of the highlands. *Juniperus procera*, *Olea europaea* subsp *cuspidata*, *Podocarpus falcatus*, *Prunus africana*, *Ekebergia capensis*, and *Celtis africana* are the characteristic tree of this vegetation type. Shrubs include *Carissa spinarum*, *Rosa abyssinica*, *Euclea divinorum*, and *Dodonaea angustifolia*.

The naturally occurring vegetation that covers the mountains and hills of Tulu Moye is evergreen scrubland. The vegetation has two layers, the shrub layer and the ground layer. Isolated trees of *Juniperus procera* and *Olea europaea* subsp *cuspidata* are found without forming canopy.

#### 3.2 Conservation priority

The IFC Performance Standard 6 requires an understanding of conservation initiatives in the areas surrounding the Study Area of influence. Understanding these conservation activities can have an influence on the classification of Modified, Natural and Critical Habitats.

The critical habitat definition presented in paragraph 16 of Performance Standard 6 is in line with criteria captured from a wide range of definitions of priority habitat for biodiversity conservation in use by the conservation community and incorporated in related governmental legislation and regulations. Critical habitats are areas of high biodiversity value that may include at least one or more of the five values specified in paragraph 16 of Performance Standard 6 and/or other recognized high biodiversity values. For ease of reference, these values are referred to as critical habitat criteria for the remainder of this document. Each criterion is described in detail in paragraphs GN71–GN97. Critical habitat criteria are as follows and should form the basis of any critical habitat assessment:

- Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species
- Criterion 2: Endemic and/or restricted-range species
- Criterion 3: Migratory and/or congregator species
- Criterion 4: Highly threatened and/or unique ecosystems
- Criterion 5: Key evolutionary processes



In general, internationally and/or nationally recognized areas of high biodiversity value will likely qualify as critical habitat; examples include the following:

Areas that meet the criteria of the IUCN’s Protected Area Management Categories Ia, Ib and II, although areas that meet criteria for Management Categories III-VI may also qualify depending on the biodiversity values inherent to those sites.

This project area as well as within 10 km radius of it, there are no protected areas i.e. any National Parks, Wildlife /Game Reserves, and wildlife sanctuaries. However, Lake Koka and Lake Ziway found close to the Project area (more than 10 km distance from Drilling area) are listed as Important Bird Areas (IBAs).

The endemic plant, *Impatiens rothii* is not listed in the IUCN red list. The socio-economic study of the study area did not reveal any specific ecosystem that the local community wanted to be protected for their cultural and economic importance. Therefore, the study team could not recognize critical habitat at Tulu Moye area.

**Following IFC Performance Standard 6 and general note 57 (GN 57), the project area has been evaluated whether there is critical habitat or not. As the result indicated that (Table 3.1), there is no critical habitat around the project area. Following the result, the project area is divided in to as natural and modified habitats.**

**Table 3.1:** Qualifying Critical Habitat based on GN 57

| No. | Criteria   | Present/Absent   | Project Impact and recommended action                                    |
|-----|--|--|--|
| 1   | Presence or absence of <b>IBA site</b>   | Absent (at more than 10 km distance Lake Zeway and Koka IBA sites) | Precautionary principle to apply   |
| 2   | <b>Presence or absence of Protected Areas</b> (National park, Game reserves, wildlife sanctuaries) | Absent   | None   |
| 3   | Presence or absence of <b>Ramsar wetlands site</b>   | Absent   | None (No Ramsar site in Ethiopia)  |
| 4   | Presence or absence of <b>Alliance for zero extinction (AZE) site</b>                              | Absent   | None   |
| 5   | Presence or absence of <b>Horn of Africa Biodiversity Hot spot</b>                                 | Absent   | Precautionary principle to apply. (The site is in the Great Rift Valley) |
| 6   | Potential species of conservation concern  | Absent   | None   |

### 3.3 Terrestrial Habitat

Based on evaluation of IFC Performance Standard 6 and Guidance Note 57 (GN 57), the habitat of the study areas was classified into natural and modified Table 3.2 and Figure 3.1 respectively.

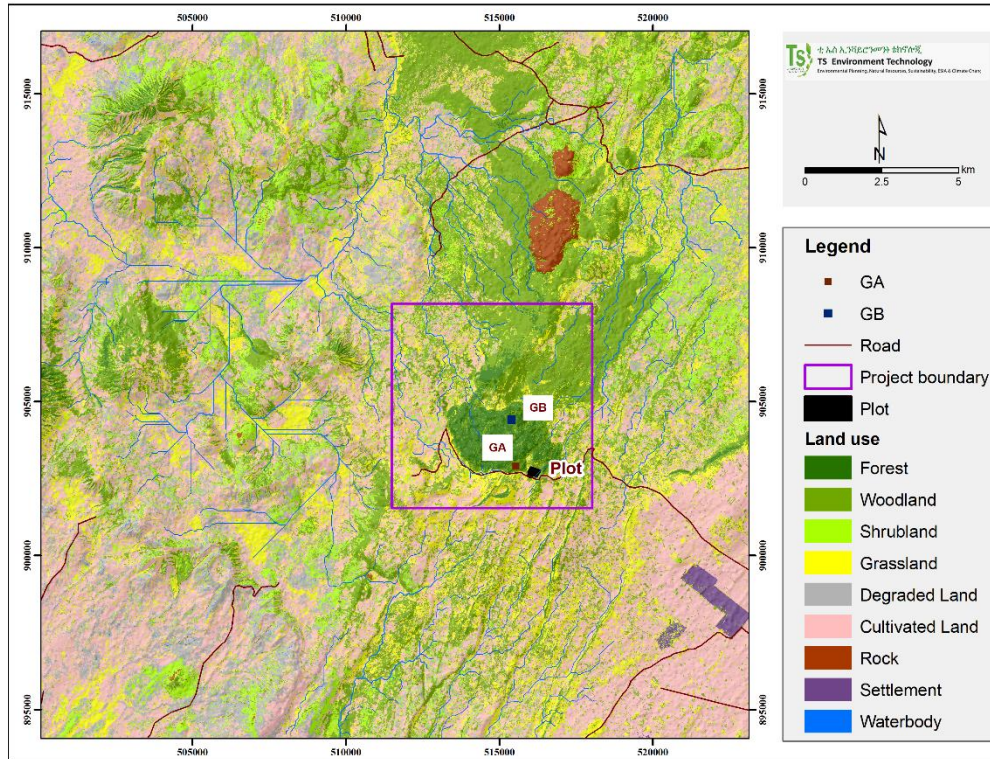
Natural habitat is where the land is covered with natural vegetation and anthropogenic influence is minimal. Modified habitat is one with the original natural vegetation cover has been converted into non-natural vegetation (e.g. Eucalyptus plantation) or non-vegetated land cover (e.g. agricultural land) or converted into other land cover (e.g. forestland converted into grassland).

The vegetation in the Study Area has been separated into the following broad terrestrial habitats.

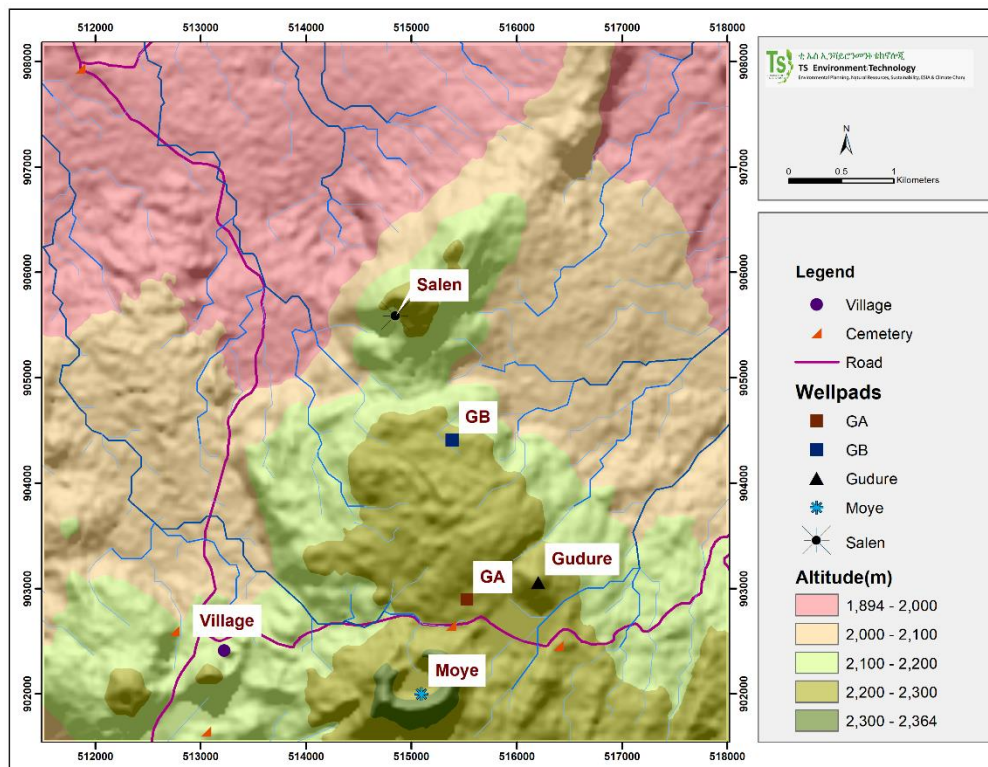
- Regenerating Land
- Natural Forest
- Scrubland
- Grazing Land
- Cultivated Land
- Settlement

**Table 3.2:** Area statistics of habitat types at Tulu Moye

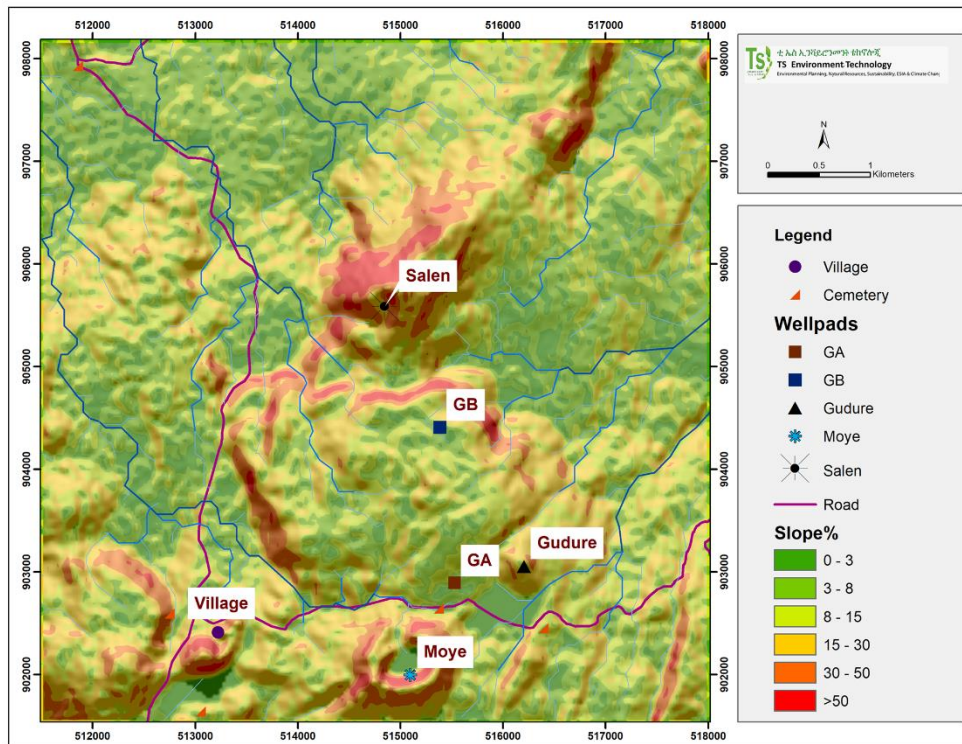
|   | Habitat Type      | Area (ha.) | Percent |
|---|-------------------|------------|---------|
| 1 | Regenerating Land | 743.27     | 20.13   |
| 2 | Natural Forest    | 708.43     | 19.19   |
| 3 | Scrubland         | 115.71     | 3.13    |
| 4 | Grazing Land      | 538.02     | 14.57   |
| 5 | Cultivated Land   | 1559.79    | 42.25   |
| 6 | Settlement        | 26.24      | 0.71    |



**Figure 3-1:**  
*Habitat type identification in the study area of Tulu Moyer, Gnaro lava field area.*



**Figure 3-2:**  
*Altitude map of Tulu Moyer, Gnaro lava field and omega.*



**Figure 3-3:**  
Slope map of  
Tulu Moye,  
Gnaro lava field  
and omega.

### 3.3.1 Natural Habitat

The natural habitat at Tulu Moye includes the natural forest and scrubland vegetation. Natural forest is found at altitudes from 2100 to 2300 m and with slope of up to 30% in the southern part of the study area. It covers 19% of the study area. The natural forest has only one stratum of tree which is dominated by *Olea europaea* subsp *cuspidata* and *Juniperus procera*. The shrub layer is dominated by *Rhus retinorrhoea*, *Olinia rochetiana*, *Maytenus arbutifolia*, *Euclea schimperi*, *Clutia abyssinica* and *Erica arborea*. The herb *Commelina forskaolii* dominates the ground layer.



Forest vegetation grown in the slopy mountain

Scrubland (natural habitat)

**Figure 3-4:** Natural Habitat at Tulu Moye

The scrubland vegetation is found on the escarpments and valleys of Tulu Moye at altitudes between 2100 and 2300, and with slope of above 30% in the northern part of Tulu Moye. It covers 3% of the study area. The vegetation has got two vertical strata; the shrub stratum composed of *Euclea schimperi*, *Clusia abyssinica*, *Rhus retinorrhoea*, *Rhus vulgaris*, *Calpurnia aurea*, *Carissa spinarum*, *Dovyalis verrucosa*, *Erica arborea*, and *Rumex nepalensis*. The ground layer is dominated by grass species including *Melinis repens*, *Pennisetum sp.*, *Eragrostis sp.* and *Cyanodon dactylon*.

### 3.3.2 Modified Habitat

Generally, there are three types of modified habitats: regenerating forest, grazing land and farm land.

**Regenerating woodland:** - In many parts of the Gnaro area of Tulu Moye, the tree *Juniperus procera* is regenerating and is in secondary stage of development (see Figure 3.5). About 20% of the study area is covered with such type of regenerating woodland. The area was deforested and rehabilitation of the mountain through area closure has been practiced over the last three decades, resulting in the development of patches of *Juniperus procera*. In between the *Juniper* trees and patches grasses belonging to the genus *Festuca* were found growing. If the area is kept out of human and livestock influence, it is most probable that secondary forest could develop once again.



Regenerating wood land

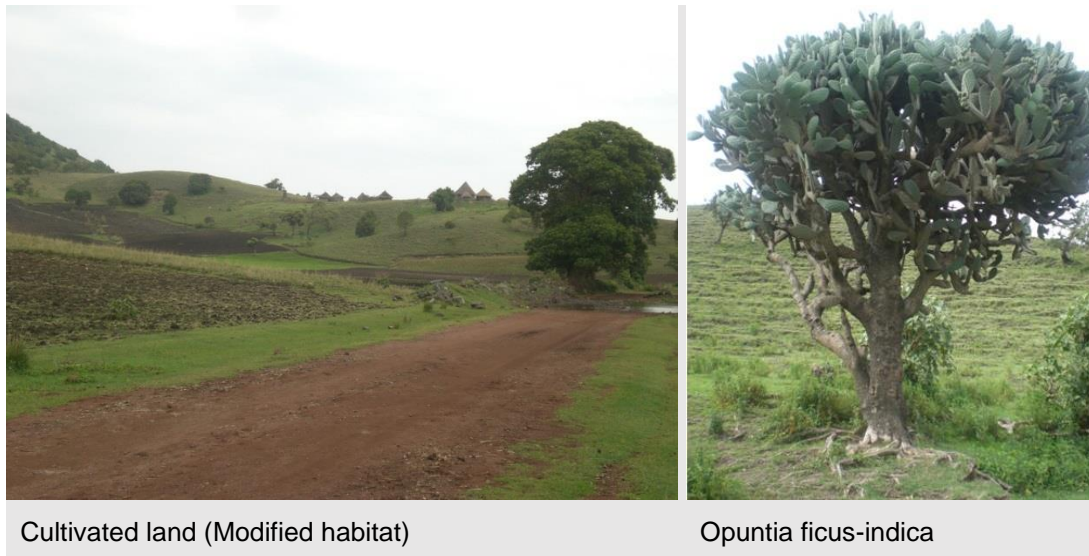
Grazing land (Modified habitat)

**Figure 3-5:** Modified Habitat at Tulu Moye

**Grazing land.** - This habitat is being used for livestock grazing (Figure 3.5). The land is covered with short grasses and herbs (e.g. *Cyanodon dactylon*, *Eragrostis sp.*, *Festuca sp.*, *Pennisetum sp.*, *Cyperus dichroostachyus*) and the herb *Chamaecrista mimosoides*. In some area, grazing land is found adjacent to scrubland vegetation (see Figure 3.5), in which case livestock could

get into the forest vegetation and graze the ground vegetation thereby affecting seedling and saplings, which are the raw materials for the future survival of the forests.

**Cultivated land:** - Crop is the dominant land cover during growing season (June to December), otherwise the land remains bare for the rest of the months. The fact that natural vegetation is found adjacent to cultivated land (Figure 3.6) and the presence of isolated trees on farm land (Figure 3.6) indicate that the farm land developed through conversion of the scrubland. *Olea europaea* subsp *cuspidata*, *Acacia abyssinica*, *Acacia seyal* are some of the trees seen on farm land. Farmers plant *Agave sisalana* (Agavaceae) as live fence around their compound. *Opuntia ficus-indica* (Cactaceae) is planted by some farmers on their crop field (see Figure 3.6).



Cultivated land (Modified habitat)

Opuntia ficus-indica

**Figure 3-6:** Modified Habitat at Tulu Moye

### 3.3.3 Plant communities

Based on hierarchical cluster analysis, three plant communities were recognized. Plant community 1 is named *Croton macrostachyus-Calpurnia aurea* after the two species which were found in more than 80% of the sample plots constituting the community type. This community type represents modified habitats (farmland and grazing land) of Tulu Moye area. 54 plant species are represented in this plant community. Since trees and shrubs are found widely scattered, there is no vertical stratification into tree and shrub layer. Less than 10% of the ground is covered by woody species. The ground layer is dominated by the grass *Cyanodon dactylon* which is the main nutritious grass for livestock.

Plant community 2 is named *Osyris quadripartita-Commelina forskoolii* after the two species that are found in all the sample plots constituting the plant community. *Jasminum grandiflorum* (climber), *Olea europaea* subsp *cuspidata*, *Rhus retinorrhoea* and *Senecio lyratus* are other species that are present in all sample plots. This plant community contains plant species from the modified and natural habitats. 56 plant species are included in this plant community. Aerial cover of the vegetation varies between 10% and 60%

*Juniperus procera-Clerodendron myricoides* is the third plant community. The community type is represented in the natural vegetation of the study area. This community type differs from the other two plant communities by the abundance of *Juniperus procera*, *Clerodendron myricoides*, *Erica arborea*, *Asparagus racemosus*, *Clematis hirsuta*, *Euclea schimperi* and *Pittosporum viridiflorum*. In general, 88 plant species are represented in this plant community. The vegetation structure contains three vertical strata: the tree layer reaching up to 15 m in height; the shrub layer is generally reach a height of 4 to 6 meters. The ground herbaceous layer is generally lower than 0.5 m. The aerial vegetation cover is generally more than 70%.

### 3.3.4 Ecosystem services

Discussion with key informant indicated the community's understanding of multiple ecosystem services provided by the natural ecosystem of Tulu Moye. Provisioning ecosystem services are those that are mostly enjoyed by the local people daily. These services are dependent on annual crop production as well as goods collected from the natural ecosystem. Table 3.3 presents the provisional ecosystem services mentioned by local people.

**Table 3.3:** Provisional ecosystem services provided by the ecosystem of Tulu Moye area

| Plants used for livestock feed | For treatment of human and livestock disease | Fuel source          | For House construction        | Food source          |
|--------------------------------|--|----------------------|-------------------------------|----------------------|
| Calpurnia aurea,               | Calpurnia aurea,                             | Acacia etbaica       | Croton macrostachyus          | Carissa spinarum     |
| Cyanodon dactylon              | Aloe sp.                                     | Acacia seyal         | Ehretia cymosa                | Ficus ovate          |
| Hyoestes forskaollii           | Clerodendron myricoides                      | Croton macrostachyus | Ficus ovata                   | Rhus vulgaris        |
| Maytenus arbutifolia           | Kalanchoe quartiniana                        | Rhus retinorrhoea    | Olea europaea subsp cuspidata | Opuntia ficus-indica |
| Senna didymobotrya             | Heteromorpha arborescens                     | Rhus vulgaris        | Juniperus procera             |                      |
|                                | Myrsine africana                             |                      | Rhus retinorrhoea             |                      |
|                                |  |                      | Schefflera volkensii          |                      |
|                                |  |                      | Euphorbia tirucalii           |                      |

*Acacia abyssinica* (Fabaceae) is used for providing shed both for people and livestock. *Acacia abyssinica*, *Acacia etbaica* (Fabaceae), *Acacia persiciflora* (Fabaceae), *Acacia seyal*

(Fabaceae), *Balanites aegyptica* (Fabaceae), are used for improving soil fertility on farm land. The hairy leaves of the climber *Clematis hirsuta* (Ulmaceae) (Figure 3.7) is used to rid lice from the hairs of children.



**Figure 3-7:** *The leaves and fruits of Clematis hirsuta.*

The vegetation cover of mountains and hills provide flood regulation, carbon sequestration, local temperature regulation, and water purification. It is a common practice in the Oromo tradition to gather under the shed of Ficus tree and discuss social issues. This tradition has helped the maintenance of such trees on farm and grazing lands. Local people are enjoying the naturally occurring steam bath (locally called Artu) at Tulu Moye both for physical relaxation and for treating neuro-muscular problems.

As the provision of some ecosystem services might be affected when the geothermal project is implemented, the IFC Guidance Note 6 Biodiversity Conservation and Sustainable Management of Living Natural Resources was used to review the likelihood impact of the project on the provision of ecosystem services, the relevance of the impact on local community, and the degree of management control on the impacts. The result is presented in Table 3.4.



**Table 3.4: Ecosystem service review for Tulu Moye area**

| Ecosystem services                     | Degree of impact (Type I) | Degree of dependence community (Type II) | Relevance to affected community (Type I) | Degree of management control (Type I/II) |
|--|---------------------------|--|--|--|
| <b>PROVISIONING</b>                    |                           |  |  |  |
| Crops                                  | Medium                    | NO                                       | High                                     | Low                                      |
| Livestock                              | Low                       | NO                                       | High                                     | Low                                      |
| Capture fisheries                      | -                         | NO                                       | -  | -  |
| Aquaculture                            | -                         | NO                                       | -  | -  |
| Wild foods                             | Low                       | NO                                       | Very low                                 | -  |
| Timber & wood products                 | Medium                    | NO                                       | Medium                                   | Low                                      |
| Biomass fuel                           | Medium                    | NO                                       | High                                     | Low                                      |
| Freshwater                             | Medium                    | High                                     | High                                     | Low                                      |
| Genetic resources                      | No data                   | NO                                       | No data                                  | -  |
| Medicines, biochemical                 | No data                   | NO                                       | No data                                  | -  |
| <b>REGULATING</b>                      |                           |  |  |  |
| Air quality control                    | Medium                    | NO                                       | Low                                      | High                                     |
| Global climate regulation              | -                         | NO                                       | -  | -  |
| Regional/local climate regulation      | -                         | NO                                       | -  | -  |
| Water regulation                       | High                      | HIGH                                     | High                                     | Low                                      |
| Erosion regulation                     | High                      | LOW                                      | High                                     | Medium                                   |
| Water purification and waste treatment | No data                   | LOW                                      | No data                                  | Low                                      |
| Pest and disease regulation            | No data                   | NO                                       | No data                                  | Medium                                   |
| Pollination                            | High                      | NO                                       | High                                     | Low                                      |
| Flood regulation                       | High                      | HIGH                                     | High                                     | Low                                      |
| <b>CULTURAL</b>                        |                           |  |  |  |
| Sacred or spiritual purposes           | -                         | NO                                       | -  | Low                                      |
| Areas used for religious purposes      | -                         | NO                                       | -  | Low                                      |
| <b>SUPPORTING</b>                      |                           |  |  |  |
| Nutrient capture and recycling         | No data                   | High                                     | No data                                  | Low                                      |
| Primary production                     | Low                       | NO                                       | High                                     | Low                                      |
| Pathways for genetic exchange          | No data                   | NO                                       | No data                                  | Low                                      |

### 3.3.5 Human Disturbance

Tree cutting for construction, fuel and charcoal making are the major types of disturbance recorded in the study area (see Figure 3.8 & 3.9).

Although, such activities are illegal, farmers are continually exploiting the scrubland for fuel wood sources. Charcoal production is threatening the woody plant diversity of the study area.

Some of the common woods selected for charcoal making are *Acacia etbaica*, *Acacia seyal*, *Croton macrostachyus*, and *Rhus vulgaris*. Livestock were found grazing inside the scrubland. Seedlings and saplings could be damaged by grazing and trampling, thereby affecting the regeneration capacity of the vegetation.



Fuel wood collected from the forest and Illegal charcoal making at Tulu Moye

**Figure 3-8:** Modified Habitat at Tulu Moye



Illegal cutting at the natural forest

**Figure 3-9:** Modified Habitat at Tulu Moye

### 3.3.6 Biodiversity sensitivity

In general, the biodiversity sensitivity assessment of the different habitats at Tulu Moye project area shows that the natural habitat has medium sensitivity because of higher species diversity and the endemic *Impatiens rothii*. The regenerating forest land has also medium sensitivity because of its location on mountain slope, its early seral development stage and the presence

of *Juniperus procera* which is one of the economically and environmentally important tree species. Plant species diversity on grazing land and farm land is low and very low respectively and thus their biodiversity sensitivity is low for grazing land and very low for farm land.

### 3.3.7 Biodiversity sensitivity assessment

The sensitivity of all identified habitats to biodiversity conservation has been evaluated with the aim to determine the location and extent of all sensitive habitats that must be protected from converting into other non-compatible land uses. The biodiversity sensitivity rank of Tulu Moye is presented in Table 3.5.

There are areas with very low, low, medium and high sensitivity. In general, most areas (58%) of Tulu Moye are less sensitive. The cultivated land, grazing land and natural forest have medium to low sensitivity. The regenerating woodland and scrubland vegetation are highly sensitive.

**Table 3.5:** Area statistics of biodiversity sensitivity rank

| Biodiversity sensitivity Rank | Area (ha) | Percent |
|-------------------------------|-----------|---------|
| High                          | 858.98    | 23.27   |
| Medium                        | 708.43    | 19.19   |
| Low                           | 538.02    | 14.57   |
| Very Low                      | 1586.03   | 42.96   |

### 3.3.8 Floral of the project area

Both the natural and modified habitats of Tulu Moye provide several ecosystem services. Crops are the major ecosystem services obtained from the modified habitat. Medicinal plants, wild fruit, and wood are important ecosystem service obtained from the natural habitat. For enhancing agricultural productivity, soil and water conservation measures should be taken to reduce the problem of erosion. Incorporating indigenous trees, especially leguminous trees, into the agricultural system tremendously improves soil fertility and thus agricultural production. Planting fast growing trees around homestead could reduce the pressure on the natural forest.

Currently the major threat to the natural habitat of Tulu Moye is agricultural expansion and tree cutting for fuel wood, charcoal and construction. Cattle grazing inside the forest also affect the regeneration capacity of some woody species. Absence of buffer area between farm land and forest area could make farmers to easily expand their farm land into the forest.

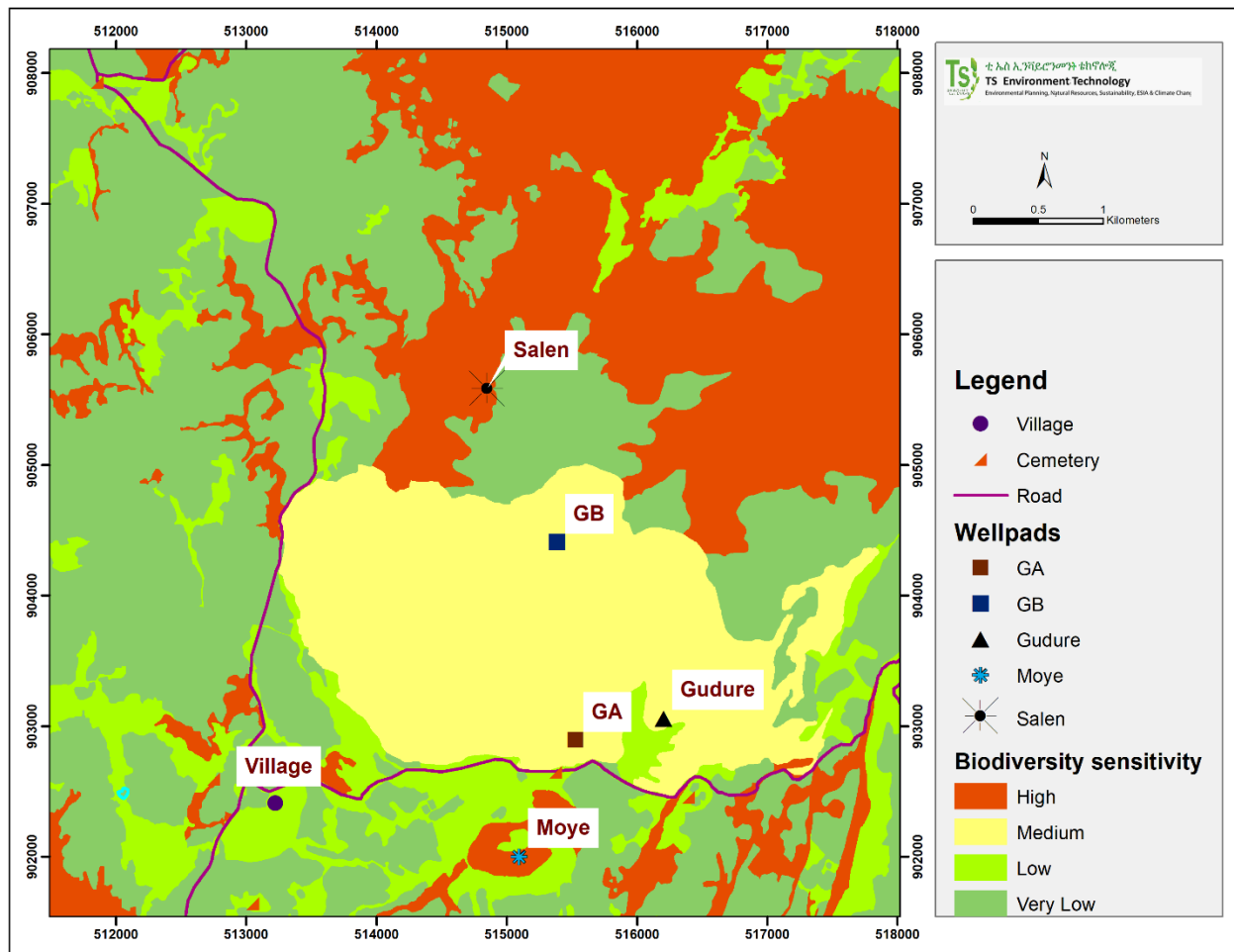


Figure 3-10: Biodiversity sensitivity map for Tulu Moye, Gnaro lava field area

### 3.3.9 Plant species composition

In general, 120 species belonging to 63 families were recorded both from the modified and disturbed habitats (Annex 1.). Out of these, 96 species were recorded from the natural habitat and 81 from the modified habitat. 59 species were found both in the modified and natural habitats and the remaining 60 species were recorded either from the modified or natural habits. Fabaceae is the most dominant family represented by 15 species, followed by Asteraceae with 11 species, Poaceae with 8 species, and Euphorbiaceae with 5 species. The families Anacardiaceae, Apiaceae, Apocymaceae, Commelinaceae, Rubiaceae, and Pteridaceae each contain 3 species. The remaining families contain 1 or 2 species each. *Impatiens rothii* (Figure 3.11), belonging to the family Balsaminaceae is the only endemic species recorded from the study area. In terms of growth habit 34 species are trees, 20 shrubs, 43 herbs, 8 grasses, 6 ferns, 2 sedges and 7 climbers. *Juniperus procera*, *Olea europaea subsp cuspidata*, *Rhus retinorrhoea*, *Olinia rochetiana*, and *Pittosporum viridiflorum* are the tree species most

frequently recorded from the study area. *Clutia abyssinica*, *Myrsine africana*, *Maytenus arbutifolia*, *Clerodendron myricoides*, *Osyris quadripartita* and *Euclea schimperi* are the common shrubs. *Erica arborea* is found on slopes at higher altitude. *Commelina forskaolii* and *Senecio lyratus* and the grasses *Cyanodon dactylon*, *Aristida adscensionis*, *Melinis repens*, *Festuca abyssinica* are mostly found covering the ground layer. *Clematis hirusuta* and *Jasminum grandiflorum* are the most commonly climber species.



**Figure 3-11:** *Impatiens rothii* (endemic) at 37 N 05116156, 0903026

### 3.3.10 Plant diversity

During the dry season assessment, 83 plant species belonging to 43 families were recorded from Tulu Moye, Tero Desta, Amude, Bite Daba, Hula Arba, Bite and Boka project area. In the present assessment, 77 plant species which were not recorded during the dry season assessment were recorded only from the Tulu Moye area. Most of these new records are herbaceous plants ferns and grasses. A good number of woody plants are also newly recorded.

*Osyris lanceolata*, *Ritygynia parvifolia*, and *Newtonia hildbrandii* which were reported in the dry season assessment are not recorded in the Flora of Ethiopia and Eritrea. The genus *Ritygynia* is only represented by *Ritygynia neglecta*. *Argemone mexecana* which was reported in the dry season assessment was not seen in the present during the present assessment. This species is in fact most conspicuous during the dry season (Table 3.6).

**Table 3.6:** Plant species not recorded during dry season assessment

| No. | Species                          | Family          |
|-----|----------------------------------|-----------------|
| 1   | <i>Acanthus polystachius</i>     | Acanthaceae     |
| 2   | <i>Hypoestes forskaolii</i>      | Acanthaceae     |
| 3   | <i>Amaranthus sp.</i>            | Amaranthaceae   |
| 4   | <i>Agrocharis schimperi</i>      | Apiaceae        |
| 5   | <i>Foeniculum vulgare</i>        | Apiaceae        |
| 6   | <i>Heteromorpha arborescens</i>  | Apiaceae        |
| 7   | <i>Cadaba sp.</i>                | Apocynaceae     |
| 8   | <i>Tylophora heterophylla</i>    | Apocynaceae     |
| 9   | <i>Gomphocarpus purpurascens</i> | Asclepiadaceae  |
| 10  | <i>Periploca linearifolia</i>    | Asclepiadaceae  |
| 11  | <i>Asparagus racemosus</i>       | Asparagaceae    |
| 12  | <i>Kniphofia thomsonii</i>       | Asphodelaceae   |
| 13  | <i>Asplenium aethiopicum</i>     | Aspleniaceae    |
| 14  | <i>Bidens pilosa</i>             | Asteraceae      |
| 15  | <i>Conyza hypoleuca</i>          | Asteraceae      |
| 16  | <i>Crepis rueppellii</i>         | Asteraceae      |
| 17  | <i>Galinsoga quadriradiata</i>   | Asteraceae      |
| 18  | <i>Helichrysum schimperi</i>     | Asteraceae      |
| 19  | <i>Senecio lyratus</i>           | Asteraceae      |
| 20  | <i>Tageta minota</i>             | Asteraceae      |
| 21  | <i>Vernonia hochestteri</i>      | Asteraceae      |
| 22  | <i>Xanthium spinosum</i>         | Asteraceae      |
| 23  | <i>Impatiens rothii</i>          | Balsaminaceae   |
| 24  | <i>Cynoglossum amplifolium</i>   | Boraginaceae    |
| 25  | <i>Canarina eminii</i>           | Campanulaceae   |
| 26  | <i>Spergula arvensis</i>         | Caryophyllaceae |
| 27  | <i>Chenopodium ambrosioides</i>  | Chenopodiaceae  |
| 28  | <i>Commelina Africana</i>        | Commelinaceae   |
| 29  | <i>Commelina forskaolii</i>      | Commelinaceae   |
| 30  | <i>Cyanotis barbata</i>          | Commelinaceae   |
| 31  | <i>Kalanchoe quartiniana</i>     | Crassulaceae    |
| 32  | <i>Kalanchoe sp.</i>             | Crassulaceae    |
| 33  | <i>Cyperus dichroostachyus</i>   | Cyperaceae      |
| 34  | <i>Fimbristylis longiculmis</i>  | Cyperaceae      |
| 35  | <i>Dioscorea alata</i>           | Dioscoreaceae   |
| 36  | <i>Euclea schimperi</i>          | Ebenaceae       |
| 37  | <i>Euphorbia hirta</i>           | Euphorbiaceae   |

| No. | Species                         | Family           |
|-----|---------------------------------|------------------|
| 38  | <i>Acacia etbaica</i>           | Fabaceae         |
| 39  | <i>Acacia persiciflora</i>      | Fabaceae         |
| 40  | <i>Calpurnia aurea</i>          | Fabaceae         |
| 41  | <i>Chamaecrista mimosoides</i>  | Fabaceae         |
| 42  | <i>Taverniera abyssinica</i>    | Fabaceae         |
| 43  | <i>Vermifrux abyssinica</i>     | Fabaceae         |
| 44  | <i>Geranium arabicum</i>        | Geraniaceae      |
| 45  | <i>Trichocladus ellipticus</i>  | Hamamelidaceae   |
| 46  | <i>Clerodendron myricoides</i>  | Lamiaceae        |
| 47  | <i>Premna schimperi</i>         | Lamiaceae        |
| 48  | <i>Satureja punctata</i>        | Lamiaceae        |
| 49  | <i>Sida schimperiana</i>        | Malvaceae        |
| 50  | <i>Bersama abyssinica</i>       | Melanthaceae     |
| 51  | <i>Mollugo nudicaulis</i>       | Molluginaceae    |
| 52  | <i>Maesa lanceolata</i>         | Myrsinaceae      |
| 53  | <i>Myrsine Africana</i>         | Myrsinaceae      |
| 54  | <i>Jasminum grandiflorum</i>    | Oleaceae         |
| 55  | <i>Pittosporum viridiflorum</i> | Pittosporaceae   |
| 56  | <i>Plantago lanceolata</i>      | Plantaginaceae   |
| 57  | <i>Aristida adscensionis</i>    | Poaceae          |
| 58  | <i>Cyanodon dactylon</i>        | Poaceae          |
| 59  | <i>Dactyloctenium aegyptium</i> | Poaceae          |
| 60  | <i>Eragrostis sp.</i>           | Poaceae          |
| 61  | <i>Harpachne schimperi</i>      | Poaceae          |
| 62  | <i>Melinis repens</i>           | Poaceae          |
| 63  | <i>Portulaca oleracea</i>       | Portulacaceae    |
| 64  | <i>Adiantum poiretii</i>        | Pteridaceae      |
| 65  | <i>Pallaea calomelanos</i>      | Pteridaceae      |
| 66  | <i>Cassipourea malosana</i>     | Rhizophoraceae   |
| 67  | <i>Canthium oligocarpum</i>     | Rubiaceae        |
| 68  | <i>Pavetta abyssinica</i>       | Rubiaceae        |
| 69  | <i>Psydrax schimperiana</i>     | Rubiaceae        |
| 70  | <i>Casimiroa edulis</i>         | Rutaceae         |
| 71  | <i>Salvadora persica</i>        | Salvadoraceae    |
| 72  | <i>Craterostigma pumilum</i>    | Scrophulariaceae |
| 73  | <i>Cheilanthes farinose</i>     | Sinopteriacae    |
| 74  | <i>Datura stramonium</i>        | Solanaceae       |
| 75  | <i>Clematis hirsuta</i>         | Ulmaceae         |
| 76  | <i>Urera hypselodendron</i>     | Urticaceae       |
| 77  | <i>Cyphostemma niveum</i>       | Vitaceae         |

### 3.3.11 Conservation

*Impatiens rothii* (Balsaminaceae) is the only endemic plant species recorded from the Tulu Moye area. According to the Flora of Ethiopia and Eritrea (Edwards et al. 2000), the species is common throughout the central plateau of Ethiopia in damp, open or shaded areas in montane forests, ravines, forest margins, stream margins, margins of marshland, wet fallow fields and grasslands, and moist evergreen shrub.

*Osyris lanceolata* which was described in the dry season biodiversity report as cited in the CITES appendix, is a synonym of *Osyris quadripartita*. Because of the extreme variability of the leaf and size of the species, some of the former collections were recognized as separate species (Hedberg and Edwards, 1989). However, *Osyris quadripartita* is the only species of the genus *Osyris* known to occur in the Flora of Ethiopia. In Ethiopia, *Osyris quadripartita* is common in gallery forest, *Juniperus*, *Podocarpus*, *Combretum* and *Dodonea* woodland, *Erica* scrub, *Commiphora* scrub, on rocky slopes, degraded woodland and scrub, at altitudes 1600-2900 m (Hedberg and Edwards, 1989)

*Senna didymobotrya*, *Dodonaea angustifolia*, *Opuntia ficus-indica* have been mentioned as invasive species in the dry season biodiversity assessment report. However, the Floras of Ethiopia and Eritrea considered these species as the natural component of the vegetation of Ethiopia. *Senna didymobotrya* is found in the montane wooded grassland, evergreen thicket and bushland, riparian or in disturbed places in Wollega, Wello, Shewa, Arsi and Sidamo area.

*Dodonaea angustifolia* is the natural component of upland forest and bushland and grassland, secondary forest and scrub. However, it has also the potential to invade recently cleared forest area and overgrazed land.

Although *Opuntia ficus-indica* is an introduced species it has widely naturalized in Ethiopia. In some areas (e.g. in tigray) farmers plant it for its edible fruit. The flowers are important source of nectars for honey production.

### 3.3.12 Conservation status

According to the IUCN red list category, all the plant species recorded in this study, including the endemic *Impatiens rothii*, are least concern (LC) species. Although *Nicotiana glauca* was not recorded from Tulu Moye in the present study, the dry season assessment has demonstrated the existence of the plant, perhaps cultivated around homesteads or growing along roadside. Accidental introduction of this species into the forest could affect the plant diversity of the natural habitat.



### **3.4 Fauna of the project area**

#### **3.4.1 Mammals**

Regardless of the project area being subject to diverse human activities such as farming, grazing and cutting of trees for fuel wood and charcoal, 39 species of mammals within 20 families were recorded. The species are recorded either by direct observation of the animal or by analyzing animals' signs like foot prints, fecal material, burrows, dens and caves. Moreover, literature review was also used to list the mammals (Figure 3.12 up to 3.16).

Out of these, only one mammal species recorded as threatened species by IUCN Red Data List of 2016. This species is Leopard which is listed as a critically endangered species and it exists throughout the project area. Four species occurring within the Project area are listed in Class B of the African Convention on the Conservation of Nature and Natural Resources (The Algiers Convention). This means they are totally protected, but may be hunted, killed, captured or collected under special authorization granted by the competent Authority in contracting states. These include Klipspringer, Oribi, Grivet monkey and Aardvark.

The Aardvark is recognized by Ethiopian Wildlife Development, Conservation and Utilization, Council of Ministers Regulations, as a Protected Species. According to these regulations females and juveniles of all species are protected species.

ANNEX II provides detailed species list of mammal species, their conservation status and occurrence patterns within the Project area. Out of listed mammals' species, 17 of them are new record for wet season survey (Table 3.7).

##### **3.4.1.1 Wildlife Corridor at the Project Impact area**

A wildlife corridor is a link of wildlife habitat, generally native vegetation, which joins two or more larger areas of similar wildlife habitat. Basically, corridors are critical for the maintenance of ecological processes including allowing for the movement of animals and the continuation of viable populations. The presence of wildlife corridor is of paramount importance where there are wildlife resources in areas of legally protected status or good population status of different wildlife species irrespective of the presence of any protected area. However, the availability of a wildlife corridor in this particular case is not an issue as the wildlife population is scarce and there are no any protected areas, like National parks, Game reserves, Wildlife sanctuaries and Controlled hunting areas, nearby which triggers the movement of wild animals from one place to another either in search of food or watering point. On the other hand, the distribution of the existing wild animals is not directly related to the project impact area. Olive Baboons (*Papio anubis*) could be the only wild animal that can be mentioned in relation to a wildlife corridor. But this animal is highly adaptable primate that roams every habitat available including cultivated fields and settlement areas. The listed mammal species are found only in very small resident populations that tend to be sedentary.



**Figure 3-12:** Fecal of Spotted Hyena



**Figure 3-13:** Droppings of Greater Kudu



**Figure 3-14:** Leopard cave



**Figure 3-15:** Aardvark burrows



**Figure 3-16:** Klipspringer

**Table 3.7:** List of Mammals that were exclusively recorded during Wet season

| No. | Family Name    | Common Name                       | Scientific Name          | IUCN/AC, EW |
|-----|----------------|-----------------------------------|--------------------------|-------------|
| 1   | Felidae        | Serval cat                        | Leptailurus seval        | LC          |
| 2   | Felidae        | Leopard*                          | Panthera pardus          | CE          |
| 3   | Bovidae        | Greater kudu*                     | Tragelaphus strepsiceros | LC          |
| 4   | Bovidae        | Bush buck*                        | Tragelaphus scriptus     | LC          |
| 5   | Bovidae        | Grey duicker*                     | Sylvicapra grimmia       | LC          |
| 6   | Bovidae        | Bohor reed buck                   | Redunca redunca          | LC          |
| 7   | Procavilade    | Bush hyrax*                       | Heterohyrax brucei       | LC          |
| 8   | Pteropodidae   | Straw colored fruit bat           | Eldon helvum             | LC          |
| 9   | Pteropodidae   | Ethiopian Epauletted Fruit Bat    | Epomophorus labiatus     | LC          |
| 10  | Pteropodidae   | East-African Epauletted Fruit Bat | Epomophorus minimus      | LC          |
| 11  | Pteropodidae   | Long-haired Rousette              | Rousettus lanosus        | LC          |
| 12  | Minopteridae   | Long fingered bat                 | Minoptera spp            | LC          |
| 13  | Rhinopomatidae | Rufous Mouse-eared Bat            | Myotis bocagii           | LC          |
| 14  | Leporidae      | African Savanna Hare              | Lepus victoriae          | LC          |
| 15  | Leporidae      | Scrub Hare *                      | Lepus saxatiis           | LC          |
| 16  | Muridae        | Abyssinian Grass Rat*             | Arvicanthis abyssinicus  | LC          |
| 17  | Muridae        | Acacia rat *                      | Thallomys paedulus       | LC          |

\*) Species observed in the field

### 3.4.2 Avian fauna (Birds)

The bird study result at Tulu Moye Geothermal exploration and harvesting power plant area shows that a total of 81 bird species have been identified and recorded within the four days intensive survey. From the total 81 bird species, all of them are categorized as Least Concern according to the 2016 IUCN Red List category. Regarding their status two bird species Barn swallow and Eurasian Hoopoe are palearctic migrants, two other bird species are Intra-African migrants and the remaining 77 species are residents. Wattled Ibis, Abyssinian Slaty Flycatcher, White-winged Cliff Chat, Ethiopian Oriole and Black winged Lovebird are five bird species which are near endemic (endemic to Ethiopia and Eritrea) and Ruppell's Weaver is North East African endemic found in Ethiopia, Eritrea, Northern Somalia and Djibouti. No bird species was found as endemic status.

Other 15 species of birds (which makes the total list of birds of the area to 96) that are obtained from secondary data and are believed to occur in the area are either palaerctic migrants visiting the area during the European winter or residents which move from one place to another locally and were not seen during the study period. Of these 7 species of birds extracted from secondary sources: Black Kite, Common Kestrel, Tawny Eagle, Pied Wheatear, Isabeline

Wheatear and Grey Wagtail are palearctic migrants and are Least Concern in the IUCN Red List Category.

The remaining three raptor species of birds namely White-backed Vulture, Hooded Vulture and Ruppell's Vulture are residents but are treated as Critically Endangered in the IUCN Red List Category.

One vulture species which is the Lappet-faced Vulture is an endangered species and Pallid Harrier is a near threatened species. 18 bird species which are in the Afro-tropical Biome assemblage have been recorded. This can be one criterion for the site to be a candidate as an Important Bird Area (IBA) as the area is not yet recognized as an important bird area.

Overall a number of palaerctic migrants in the area are very small with a total record of eight bird species. One species was recorded from direct observation and the remaining seven species gathered from recent secondary sources. This is an indication that migratory birds are not using this route during their migration in autumn and spring (See Annex III).

According to a measurement of an abundance of birds of the area most of the birds recorded were common and fairly common; some uncommon and rare abundance were also indicated for a few bird species (See Annex III).

18 Bird species are exclusively wet season new records (Table 3.8). Whereas, 24 bird species which were assumed to occur in the project impact area by the survey team during the dry season are not actually occurring in the area. They are neither recorded in the country nor they are outside their distribution range (See Annex III).

When taking into account the migration route of the birds, the actual project impact area is far from the regular migration route in the rift valley where north south migration of birds and vice-versa is a regular seasonal movement. The rift valley migratory route allows tens of thousands of migratory birds from western palaeartic to cross the rift valley, travelling southwards into East Africa and beyond. In this particular case the bird migration is usually taking place along the Important Bird Areas of Lake Koka and Lake Zeway which are 14.15km and 21.83km respectively farther from the actual project impact area.



**Figure 3-17:** *The two near-endemic birds that are frequently encountered at Tulu Moye*



**Figure 3-18:** The common bird Baglafaecht Weaver and occasionally seen Eurasian Hoopoe at Tulu Moye

**Table 3.8:** Bird Species which were exclusively wet season recorded

| Ser. No. | Common Name                  | Scientific Name                 | Remarks                                       |
|----------|------------------------------|---------------------------------|---|
| 1.       | African Harrier Hawk         | <i>Polyboroides typus</i>       | Observed in the drill pad surrounding         |
| 2.       | Scaly Francolin              | <i>Pternistis squamatus</i>     | Heard inside the drilling area                |
| 3.       | Jacobin Cuckoo               | <i>Clamator jacobinus</i>       | Observed inside the drilling area             |
| 4.       | African Emerald Cuckoo       | <i>Chrosococcyx capreus</i>     | Heard outside the drilling area               |
| 5.       | White-rumped Swift           | <i>Apus caffer</i>              | Observed inside the drilling area             |
| 6.       | Yellow-fronted Tinkerbird    | <i>Pogoniulus chrysoconus</i>   | Observed inside and outside the drilling area |
| 7.       | Red-shouldered Cuckoo Shrike | <i>Campephaga phoenicea</i>     | Observed outside the drilling area.           |
| 8.       | Yellow-bellied Eremomela     | <i>Eremomela icteropygialis</i> | Heard outside the drilling area               |
| 9.       | Buff-bellied Warbler         | <i>Phyllolais pulchella</i>     | Observed outside the drilling area            |
| 10.      | Brown woodland Warbler       | <i>Phylloscopus umbrovirens</i> | Observed inside the drilling area             |
| 11.      | Stout Cisticola              | <i>Cisticola robustuss</i>      | Observed in the drill pad surrounding         |
| 12.      | Tacazze Sunbird              | <i>Nectarinia tacazze</i>       | Observed outside the drilling area            |
| 13.      | Slate-coloured Boubou        | <i>Laniarius funebris</i>       | Observed inside the drilling area             |
| 14.      | Abyssinian Oriole            | <i>Oriolus larvatus</i>         | Observed inside the drilling area             |
| 15.      | Swainson's Sparrow           | <i>Passer swinsonii</i>         | Observed inside and outside the drilling area |
| 16.      | Yellow-spotted Petronia      | <i>Petronia pyrgita</i>         | Observed outside the drilling area            |
| 17.      | Fan-tailed Widowbird         | <i>Euplectes axillaris</i>      | Observed outside the drilling area.           |
| 18.      | Yellow-bellied Waxbill       | <i>Coccopygia quartinia</i>     | Observed inside the drilling area.            |

### 3.4.3 Herpetofauna (reptiles and amphibians)

Within the project area, a total of 41 species in the herpetofauna groups were recorded. These, includes; 12 species of frogs, 12 species of lizards, 15 species of snakes and 2 species of Terrapins and Tortoises.

Out of the listed frog species, 3 of them are Ethiopian endemic and 8 species were exclusively wet season records. In case of Lizards, out of 12 species, 6 of them wet season records. Similarly, out of 15 species of snakes, 10 of them are exclusively wet season records. In case of Terrapins and tortoises, both species are wet season records.

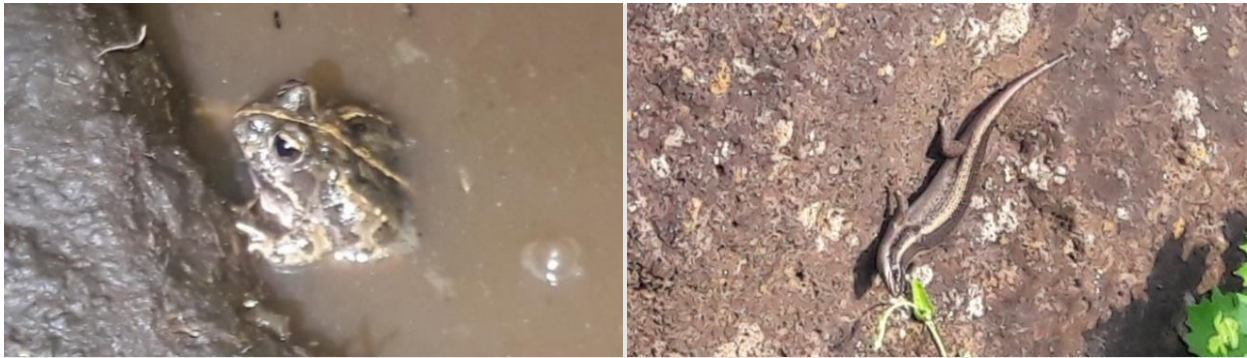
Regarding IUCN status, out of the total 41 species, 2 species of frogs, are threatened (1 species is vulnerable and 1 species is near threatened). 7 species of Lizards, 11 species of snakes and 1 species of tortoise, have an unknown conservation status due to several reasons (Annex 4). The rest species are not listed in the IUCN red list.

The diversity of herpetofauna encountered in the study area during the rainy season was very low. This can be attributed to three points. First, the absence of water bodies and moist habitats can limit the availability of amphibians; second, most of the reptiles can be hibernating during the relatively cold rainy season; and third, the very low insect diversity can indirectly mean prey species are scarcely available.

Under the above considerations and with considerable amount of time spent searching for amphibians and reptiles, only one frog species and three species of lizards were encountered in the study area. The frog inhabits the road-side flood pools, while the lizards were seen on large boulders. The cryptic nature of the lizards and the rough rock piles and crevices made it difficult to capture specimens for proper identification. Close observation of the pictures of the specimens enabled us to identify the frog, and two of the lizards; the third lizard was recorded as unidentified species in the Genus *Trachylepis*.

**Table 3.9:** List of amphibian and reptile species encountered at Tulu Moye during the wet season in July 2017

| Common name           | Scientific name                | Conservation status (IUCN), and CITES status |
|-----------------------|--------------------------------|--|
| Kachowski's sand frog | <i>Tomopterna kachowskii</i>   | LC, Not in CITES                             |
| African striped skink | <i>Trachylepis striata</i>     | LC, Not in CITES                             |
| Eritrean Rock Agama   | <i>Acanthocercus annectens</i> | LC, Not in CITES                             |
| Unidentified lizard   | -----                          | ----   |



A) Kachowski's sand frog

B) African striped skink

**Figure 3-19:** Two of the species amphibians and reptiles encountered at the surveyed area.

Discussion with the local people, including elders, students and women who collect fuel wood from the wild, indicated that there are two types of snakes (one black and one pale coloured) in the Project area. However, literatures from previous studies indicate the potential occurrence of other species of amphibians and reptiles in the broader project area.

As the project area comprises a combination of the Rift Valley and the edge of the Eastern Rift, we expect the presence of more species at lower altitudes that are outside of the current survey area. The list of twelve amphibians, twelve lizards, fifteen snakes and two terrapins/tortoises that have been recorded at earlier years and mainly documented in Largen and Spawls (2010) are listed in Annex IV. The listing in Annex IV has been extracted based on geographic proximity and habitat similarity of the historic records to the broader project area at mid- and lower altitudes as far as Lake Ziway and Koka; and this listing can't be considered as definitive and confirmed information of occurrence of these species. Three of the listed species of amphibians are Ethiopian endemics, of which, the IUCN conservation status of Lake Zwai snout-burrower is "LC" (least concern), Kouni Valley striped frog is "VU" (vulnerable), and Erlanger's grass frog is "NT" (near threatened). Species that have been listed in reports of both the dry- and rainy season are marked in Annex IV.

#### 4 CONCLUSION & RECOMMENDATION

The natural vegetation (natural habitat) at Tulu Moye exists in a matrix of agricultural land. Population pressure is expected to put pressure on the forest vegetation for expanding farm land and to collect wood for construction and fuel. Conservation of this vegetation type is necessary for the sustainable provision of ecosystem services for the local community. It is thus utmost important that the Hitosa Woreda administration or any other relevant government organization should demarcate the forest and put in place participatory forest management strategy for the conservation and sustainable utilization of the forest resource. The establishment of buffer zone between the NATURAL HABITAT (forest) and MODIFIED HABITAT (farm and grazing field) could reduce the impact of human disturbance on the natural habitat. This study recommends participatory forest management approach which has been tested for their effectiveness in various parts of the country. Free grazing and timber cutting should be restricted. Collection of dried branches could be allowed as source of firewood. The cutting of *Acacia* trees for charcoal making should specifically be prohibited. Fast growing and locally adapted trees could be planted around homestead and outside the natural habitat to provide wood for construction and fuel.

Although CRITICAL HABITAT has not been identified at the Tulu Moye geothermal project area, care should be taken by the project management to prohibit forest resource utilization from the NATURAL HABITAT and to reduce soil erosion that might come due to road and project site construction. Additionally, cutting of *Acacia* and *Ficus* trees from the farmland and grazing land should not be done as these species have environmental, economic and cultural importance.

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. Regarding IUCN Red data list, except the critically endangered one species (Leopard) of mammals, there is no critically endangered species around the project area. However, four species occurring within the Project area are listed in Class B of the African Convention on the Conservation of Nature and Natural Resources (The Algiers Convention). This means they are totally protected, but may be hunted, killed, captured or collected under special authorization granted by the competent Authority in contracting states. These include Klipspringer, Oribi, Grivet monkey and Aardvark.

During discussion made with local communities, the community stressed that there is no problem of sport hunting practice on wildlife and bush meat eating behavior around the local communities. However, during field work it has been observed that farming activities are expanded up to the wildlife habitat. Hence; whenever crops are eaten by a large group of Anubis baboon and warthog, the local community consider both these wild animals as pest or enemy of the community. There is no buffer zone between the natural forest and the local community settlement areas. To control the problem of pest animals, the community uses scarecrow and screaming in unison and throwing stones. If things continue as usual, this might exacerbate to throwing spears, putting hunting trap and even to killing directly using guns.



Therefore, Hitosa Woreda environment, forest and climate change office and Hitosa Woreda administration and relevant offices have to take immediate measure to control expansion of farming activities at the expense of destroying the natural forest and displacing wild animals.

Regarding bird species, White-backed Vulture, Hooded Vulture and Ruppell's Vulture which are categorized as critically endangered, Lappet-faced Vulture which is categorized as endangered and Pallid Harrier which is categorized as near threatened bird species but which were not all seen during the study period are either opportunistic scavengers or flying across the area and are not utilizing the area permanently for food, shelter and as breeding ground. These bird species are not also a concern to Ethiopia. The African vultures as a whole are in good status in Ethiopia despite their threat concern in many parts of Africa.

Even though Gnaro Lava Field may be a candidate as an Important Bird Area (IBA) with a total of 18 records of biome affiliated birds it is not significant number and there is no restricted range species or congregations of any sort of migratory birds that provides the site more focus to qualify as an IBA.

The current survey in Herpetofauna has enabled to recognize the occurrence of at least a few species of amphibians and reptiles at Tulu Moye area. Potential occurrence of more species of herps is very likely, as snakes and other reptiles in particular could be less active during the relatively cold rainy season. Endemics, 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.

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## ANNEX I

List of plant species recorded from modified and natural habitats

(1 = present, 0 = absent)

|    | Species                         | Family         | Habit | Habitat type |         | IUCN Status |
|----|---------------------------------|----------------|-------|--------------|---------|-------------|
|    |                                 |                |       | Modified     | Natural |             |
| 1  | <i>Acacia abyssinica</i>        | Fabaceae       | Tree  | 0            | 1       | LC          |
| 2  | <i>Acacia albida</i>            | Fabaceae       | Tree  | 1            | 0       | LC          |
| 3  | <i>Acacia brevispica</i>        | Fabaceae       | Tree  | 1            | 1       | LC          |
| 4  | <i>Acacia etbaica</i>           | Fabaceae       | Tree  | 0            | 1       | LC          |
| 5  | <i>Acacia persiciflora</i>      | Fabaceae       | Tree  | 1            | 0       | LC          |
| 6  | <i>Acacia seyal</i>             | Fabaceae       | Tree  | 1            | 1       | LC          |
| 7  | <i>Acanthus polystachius</i>    | Acanthaceae    | Shrub | 0            | 1       | LC          |
| 8  | <i>Adiantum poiretii</i>        | Pteridaceae    | Fern  | 1            | 1       | LC          |
| 9  | <i>Aloe macrocarpa</i>          | Aloaceae       | Herb  | 1            | 1       | LC          |
| 10 | <i>Amaranthus sp.</i>           | Amaranthaceae  | Herb  | 0            | 1       | LC          |
| 11 | <i>Aristida adscensionis</i>    | Poaceae        | Grass | 1            | 1       | LC          |
| 12 | <i>Asparagus racemosus</i>      | Asparagaceae   | Herb  | 1            | 1       | LC          |
| 13 | <i>Asplenium aethiopicum</i>    | Aspleniaceae   | Fern  | 1            | 1       | LC          |
| 14 | <i>Asplenium sp.</i>            | Aspleniaceae   | Fern  | 0            | 1       | LC          |
| 15 | <i>Balanites aegyptica</i>      | Balanitaceae   | Tree  | 1            | 0       | LC          |
| 16 | <i>Bersama abyssinica</i>       | Melanthaceae   | Tree  | 0            | 1       | LC          |
| 17 | <i>Bidens pilosa</i>            | Asteraceae     | Herb  | 1            | 0       | LC          |
| 18 | <i>Buddleja polystachya</i>     | Apocynaceae    | Tree  | 1            | 1       | LC          |
| 19 | <i>Cadaba sp.</i>               | Apocynaceae    | Shrub | 0            | 1       | LC          |
| 20 | <i>Calpurnia aurea</i>          | Fabaceae       | Shrub | 1            | 1       | LC          |
| 21 | <i>Canarina eminii</i>          | Campanulaceae  | Herb  | 0            | 1       | LC          |
| 22 | <i>Canthium oligocarpum</i>     | Rubiaceae      | Tree  | 0            | 1       | LC          |
| 23 | <i>Carissa spinarum</i>         | Apocynaceae    | Shrub | 1            | 1       | LC          |
| 24 | <i>Casimiroa edulis</i>         | Rutaceae       | Herb  | 1            | 0       | LC          |
| 25 | <i>Cassipourea malosana</i>     | Rhizophoraceae | Tree  | 1            | 0       | LC          |
| 26 | <i>Celtis africana</i>          | Ulmaceae       | Tree  | 1            | 1       | LC          |
| 27 | <i>Chamaecrista mimosoides</i>  | Fabaceae       | Herb  | 0            | 1       | LC          |
| 28 | <i>Cheilanthes farinosa</i>     | Sinopteriaceae | Herb  | 1            | 1       | LC          |
| 29 | <i>Chenopodium ambrosioides</i> | Chenopodiaceae | Fern  | 0            | 1       | LC          |

|    | Species                         | Family           | Habit   | Habitat type |         | IUCN Status |
|----|---------------------------------|------------------|---------|--------------|---------|-------------|
|    |                                 |                  |         | Modified     | Natural |             |
| 30 | <i>Clematis hirsuta</i>         | Ulmaceae         | Climber | 1            | 1       | LC          |
| 31 | <i>Clerodendron myricoides</i>  | Lamaceae         | Shrub   | 1            | 1       | LC          |
| 32 | <i>Clutia abyssinica</i>        | Euphorbiaceae    | Shrub   | 1            | 1       | LC          |
| 33 | <i>Combretum molle</i>          | Combretaceae     | Tree    | 1            | 1       | LC          |
| 34 | <i>Commelina africana</i>       | Commelinaceae    | Herb    | 1            | 1       | LC          |
| 35 | <i>Commelina forskalii</i>      | Commelinaceae    | Herb    | 1            | 1       | LC          |
| 36 | <i>Conyza hypoleuca</i>         | Asteraceae       | Herb    | 1            | 1       | LC          |
| 37 | <i>Craterostigma pumilum</i>    | Scrophulariaceae | Herb    | 1            | 0       | LC          |
| 38 | <i>Crepis rueppellii</i>        | Asteraceae       | Herb    | 0            | 1       | LC          |
| 39 | <i>Crotolaria sp.</i>           | Fabaceae         | Herb    | 0            | 1       | LC          |
| 40 | <i>Croton macrostachyus</i>     | Euphorbiaceae    | Tree    | 1            | 1       | LC          |
| 41 | <i>Cyanodon dactylon</i>        | Poaceae          | Grass   | 1            | 1       | LC          |
| 42 | <i>Cyanotis barbata</i>         | Commelinaceae    | Herb    | 1            | 1       | LC          |
| 43 | <i>Cynoglossum amplifolium</i>  | Boraginaceae     | Herb    | 0            | 1       | LC          |
| 44 | <i>Cyperus dichroostachyus</i>  | Cyperaceae       | Sedge   | 1            | 0       | LC          |
| 45 | <i>Cyphostemma niveum</i>       | Vitaceae         | Climber | 1            | 0       | LC          |
| 46 | <i>Dactyloctenium aegyptium</i> | Poaceae          | Grass   | 0            | 1       | LC          |
| 47 | <i>Datura stramonium</i>        | Solanaceae       | Herb    | 0            | 1       | LC          |
| 48 | <i>Dioscorea alata</i>          | Dioscoreaceae    | Climber | 1            | 0       | LC          |
| 49 | <i>Dovyalis abyssinica</i>      | Flacourtiaceae   | Shrub   | 1            | 1       | LC          |
| 50 | <i>Ehretia cymosa</i>           | Boraginaceae     | Tree    | 1            | 1       | LC          |
| 51 | <i>Ekebergia capensis</i>       | Meliaceae        | Tree    | 1            | 1       | LC          |
| 52 | <i>Entada abyssinica</i>        | Fabaceae         | Tree    | 1            | 1       | LC          |
| 53 | <i>Eragrostis sp.</i>           | Poaceae          | Grass   | 0            | 1       | LC          |
| 54 | <i>Erica arborea</i>            | Ericaceae        | Shrub   | 0            | 1       | LC          |
| 55 | <i>Euclea schimperi</i>         | Ebenaceae        | Shrub   | 1            | 1       | LC          |
| 56 | <i>Euphorbia hirta</i>          | Euphorbiaceae    | Herb    | 0            | 1       | LC          |
| 57 | <i>Euphorbia sp.</i>            | Euphorbiaceae    | Herb    | 1            | 0       | LC          |
| 58 | <i>Euphorbia tirucalli</i>      | Euphorbiaceae    | Herb    | 1            | 0       | LC          |
| 59 | <i>Festuca abyssinica</i>       | Poaceae          | Grass   | 0            | 1       | LC          |
| 60 | <i>Ficus ovata</i>              | Moraceae         | Tree    | 1            | 1       | LC          |
| 61 | <i>Ficus vasta</i>              | Moraceae         | Tree    | 1            | 1       | LC          |
| 62 | <i>Fimbristylis longiculmis</i> | Cyperaceae       | Sedge   | 0            | 1       | LC          |

|    | Species  | Family         | Habit   | Habitat type |         | IUCN Status |
|----|--|----------------|---------|--------------|---------|-------------|
|    |  |                |         | Modified     | Natural |             |
| 63 | <i>Foeniculum vulgare</i>                      | Apiaceae       | Herb    | 1            | 1       | LC          |
| 64 | <i>Galinsoga quadriradiata</i>                 | Asteraceae     | Herb    | 1            | 0       | LC          |
| 65 | <i>Geranium arabicum</i>                       | Geraniaceae    | Herb    | 1            | 0       | LC          |
| 66 | <i>Gomphocarpus purpurascens</i>               | Asclepiadaceae | Herb    | 1            | 1       | LC          |
| 67 | <i>Grewia ferruginea</i>                       | Tiliaceae      | Shrub   | 0            | 1       | LC          |
| 68 | <i>Harpachne schimperi</i>                     | Poaceae        | Grass   | 1            | 0       | LC          |
| 69 | <i>Helichrysum schimperi</i>                   | Asteraceae     | Herb    | 1            | 1       | LC          |
| 70 | <i>Heteromorpha arborescens</i>                | Apiaceae       | Herb    | 1            | 1       | LC          |
| 71 | <i>Hypoestes forskollii</i>                    | Acanthaceae    | Herb    | 1            | 1       | LC          |
| 72 | <i>Impatiens rothii</i>                        | Balsaminaceae  | Herb    | 0            | 1       | LC          |
| 73 | <i>Jasminum grandiflorum</i>                   | Oleaceae       | Climber | 1            | 1       | LC          |
| 74 | <i>Juniperus procera</i>                       | Cupressaceae   | Tree    | 1            | 1       | LC          |
| 75 | <i>Kalanchoe quartiniana</i>                   | Crassulaceae   | Herb    | 1            | 0       | LC          |
| 76 | <i>Kalanchoe sp.</i>                           | Crassulaceae   | Herb    | 0            | 1       | LC          |
| 77 | <i>Kniphofia thomsonii</i>                     | Asphodelaceae  | Herb    | 0            | 1       | LC          |
| 78 | <i>Maesa lanceolata</i>                        | Myrsinaceae    | Shrub   | 1            | 1       | LC          |
| 79 | <i>Maytenus arbutifolia</i>                    | Celasteraceae  | Shrub   | 1            | 1       | LC          |
| 80 | <i>Maytenus senegalensis</i>                   | Celasteraceae  | Shrub   | 1            | 1       | LC          |
| 81 | <i>Melinis repens</i>                          | Poaceae        | Grass   | 1            | 1       | LC          |
| 82 | <i>Mollugo nudicaulis</i>                      | Molluginaceae  | Herb    | 0            | 1       | LC          |
| 83 | <i>Myrsine africana</i>                        | Myrsinaceae    | Shrub   | 1            | 1       | LC          |
| 84 | <i>Nuxia congesta</i>                          | Loganiaceae    | Tree    | 1            | 1       | LC          |
| 85 | <i>Olea europaea</i> subsp<br><i>cuspidata</i> | Oleaceae       | Tree    | 1            | 1       | LC          |
| 86 | <i>Olinia rochetiana</i>                       | Oliniaceae     | Tree    | 1            | 1       | LC          |
| 87 | <i>Opuntia ficus-indica</i>                    | Cactaceae      | Tree    | 1            | 0       | LC          |
| 88 | <i>Osyris quadripartita</i>                    | Santalaceae    | Tree    | 1            | 1       | LC          |
| 89 | <i>Ozoroa insignis</i>                         | Anacardiaceae  | Tree    | 1            | 0       | LC          |
| 90 | <i>Pallaea calomelanos</i>                     | Pteridaceae    | Fern    | 0            | 1       | LC          |
| 91 | <i>Pavetta abyssinica</i>                      | Rubiaceae      | Tree    | 1            | 1       | LC          |
| 92 | <i>Pennisetum sp.</i>                          | Poaceae        | Grass   | 1            | 1       | LC          |
| 93 | <i>Periploca linearifolia</i>                  | Asclepiadaceae | Climber | 0            | 1       | LC          |



|     | Species                         | Family         | Habit   | Habitat type |         | IUCN Status |
|-----|---------------------------------|----------------|---------|--------------|---------|-------------|
|     |                                 |                |         | Modified     | Natural |             |
| 94  | <i>Pittosporum viridiflorum</i> | Pittosporaceae | Tree    | 1            | 1       | LC          |
| 95  | <i>Plantago lanceolata</i>      | Plantaginaceae | Herb    | 1            | 1       | LC          |
| 96  | <i>Portulaca oleracea</i>       | Portulacaceae  | Herb    | 0            | 1       | LC          |
| 97  | <i>Premna schimperi</i>         | Lamiaceae      | Tree    | 1            | 1       | LC          |
| 98  | <i>Psydrax schimperiana</i>     | Rubiaceae      | Tree    | 0            | 1       | LC          |
| 99  | <i>Pteris sp.</i>               | Pteridaceae    | Fern    | 1            | 1       | LC          |
| 100 | <i>Rhus retinorrhoea</i>        | Anacardiaceae  | Tree    | 1            | 1       | LC          |
| 101 | <i>Rhus vulgaris</i>            | Anacardiaceae  | Tree    | 1            | 1       | LC          |
| 102 | <i>Rumex nepalensis</i>         | Polygonaceae   | Herb    | 1            | 1       | LC          |
| 103 | <i>Salvadora persica</i>        | Salvadoraceae  | Tree    | 1            | 0       | LC          |
| 104 | <i>Satureja punctata</i>        | Lamiaceae      | Herb    | 0            | 1       | LC          |
| 105 | <i>Schefflera abyssinica</i>    | Araliaceae     | Tree    | 1            | 1       | LC          |
| 106 | <i>Senecio lyratus</i>          | Asteraceae     | Herb    | 1            | 1       | LC          |
| 107 | <i>Senna didymobotrya</i>       | Fabaceae       | Shrub   | 1            | 0       | LC          |
| 108 | <i>Sida schimperiana</i>        | Malvaceae      | Shrub   | 1            | 0       | LC          |
| 109 | <i>Solanum anguivi</i>          | Solanaceae     | Herb    | 0            | 1       | LC          |
| 110 | <i>Tageta minota</i>            | Asteraceae     | Herb    | 0            | 1       | LC          |
| 111 | <i>Taverniera abyssinica</i>    | Fabaceae       | Herb    | 1            | 1       | LC          |
| 112 | <i>Trichocladus ellipticus</i>  | Hamamelidaceae | Shrub   | 1            | 0       | LC          |
| 113 | <i>Tylophora heterophylla</i>   | Apocynaceae    | Climber | 1            | 0       | LC          |
| 114 | <i>Ureia hypselodendron</i>     | Urticaceae     | Climber | 1            | 0       | LC          |
| 115 | <i>Vermifruax abyssinica</i>    | Fabaceae       | Herb    | 0            | 1       | LC          |
| 116 | <i>Vernonia hochestteri</i>     | Asteraceae     | Shrub   | 0            | 1       | LC          |
| 117 | <i>Vernonia sp.1</i>            | Asteraceae     | Shrub   | 0            | 1       | LC          |
| 118 | <i>Vernonia sp.2</i>            | Asteraceae     | Shrub   | 0            | 1       | LC          |
| 119 | <i>Vigna sp.</i>                | Fabaceae       | Herb    | 1            | 1       | LC          |
| 120 | <i>Xanthium spinosum</i>        | Asteraceae     | Herb    | 0            | 1       | LC          |

## ANNEX II

Mammals Species List Geothermal Exploration and Harvesting Power Plan at Gnaro Lava Field.

Conservation status and distribution within the project area. Including IUCN status, African convention status and Ethiopian protection status.

NB: LC= Least concern; AC =African convention on the conservation of natural resources; B= Class B species totally protected, but may be hunted, killed, captured or collected under special authorization granted by the competent authority in contracting state, EW= Ethiopian wildlife conservation and utilization council of ministers regulations, PS= Protected species, \* = Species observed in the field, others are based on literature and key local informants

Geothermal Exploration and Harvesting Power Plan at Gnaro Lava Field. Mammals survey Result

|    | Family Name     | Common Name                       | Scientific Name          | IUCN/AC, EW | Tulu Moyo |
|----|-----------------|-----------------------------------|--------------------------|-------------|-----------|
| 1  | Felidae         | Serval cat                        | Leptailurus seval        | LC          | 1         |
| 2  | Felidae         | Leopard*                          | Panthera pardus          | CE          | 1         |
| 3  | Hyenidae        | Spotted Hyena*                    | Crocuta crocuta          | LC          | 1         |
| 4  | Canidae         | Common Jackal*                    | Canis aureus             | LC          | 1         |
| 5  | Viverridae      | Common Genet                      | Genetta genetta          | LC          | 1         |
| 6  | Viverridae      | African Civet*                    | Civettictis civetta      | LC          | 1         |
| 7  | Mustelidae      | Honey Badger (Ratel)              | Melivora capensis        | LC          | 1         |
| 8  | Herpestriidae   | White tailed mongoose*            | Ichneumia albicauda      | LC          | 1         |
| 9  | Suidae          | Common Warthog*                   | Phacocoerus africanus    | LC          | 1         |
| 10 | Bovidae         | Greater kudu*                     | Tragelaphus strepsiceros | LC          | 1         |
| 11 | Bovidae         | Bush buck*                        | Tragelaphus scriptus     | LC          | 1         |
| 12 | Bovidae         | Grey duicker*                     | Sylvicapra grimmia       | LC          | 1         |
| 13 | Bovidae         | Oribi                             | Ourebia ourebi           | LC, B       | 1         |
| 14 | Bovidae         | Klipspringer*                     | Oreotragus oreotragus    | LC, B       | 1         |
| 15 | Bovidae         | Bohor reed buck                   | Redunca redunca          | LC          | 1         |
| 16 | Procavilidae    | Ethiopian Rock hyrax*             | Procavia habessinica     | LC          | 1         |
| 17 | Procavilade     | Bush hyrax*                       | Heterohyrax brucei       | LC          | 1         |
| 18 | Orycteropodidae | Aardvark*                         | Orycteropus afer         | LC, B, PS   | 1         |
| 19 | Cercopithecidae | Grivet monkey*                    | Cercopithecus aethiopsis | LC          | 1         |
| 20 | Cercopithecidae | Anubis (Savanna) baboon*          | Papio Anubis             | LC          | 1         |
| 21 | Scuiridae       | Stripped Ground squirrel*         | Euxerus erythropus       | LC          | 1         |
| 22 | Pteropodidae    | Straw colored fruit bat           | Eldon helvum             | LC          | 1         |
| 23 | Pteropodidae    | Ethiopian Epauletted Fruit Bat    | Epomophorus labiatus     | LC          | 1         |
| 24 | Pteropodidae    | East-African Epauletted Fruit Bat | Epomophorus minimus      | LC          | 1         |

|    | Family Name    | Common Name            | Scientific Name             | IUCN/AC, EW | Tulu Moye |
|----|----------------|------------------------|-----------------------------|-------------|-----------|
| 25 | Pteropodidae   | Egyptian fruit bat     | Rousettus aegyptiacus       | LC          | 1         |
| 26 | Pteropodidae   | Long-haired Rousette   | Rousettus lanosus           | LC          | 1         |
| 27 | Minopterae     | Long fingered bat      | Minoptera spp               | LC          | 1         |
| 28 | Megadermatidae | Heart nosed bat        | Cardioderma cor             | LC          | 1         |
| 29 | Rhinopomatidae | Rufous Mouse-eared Bat | Myotis bocagii              | LC          | 1         |
| 30 | Leporidae      | African Savanna Hare   | Lepus victoriae             | LC          | 1         |
| 31 | Leporidae      | Scrub Hare *           | Lepus saxatiis              | LC          | 1         |
| 32 | Hystricidae    | Crested Porcupine*     | Hystrix cristata            | LC          | 1         |
| 33 | Bathyergidae   | Necked mole rat*       | Hetrocephalus glaber        | LC          | 1         |
| 34 | Murinae        | Unstriped Grass rat*   | Arvicanthis cf.abbyssinicus | LC          | 1         |
| 35 | Murinae        | Multimammate rat       | Mastomys natalensis         | LC          | 1         |
| 36 | Murinae        | Common mice*           | Mus spp                     | LC          | 1         |
| 37 | Muridae        | Abyssinian Grass Rat*  | Arvicanthis abyssinicus     | LC          | 1         |
| 38 | Muridae        | Multimammate Mouse     | Mastomys natalensis         | LC          | 1         |
| 39 | Muridae        | Acacia rat *           | Thallomys paeuducus         | LC          | 1         |

### ANNEX III

List of Birds of Tulu Moye Geothermal Exploration and Harvesting Power Plan at Gnaro Lava Field.

| Ser. No | Common Name                | Scientific Name                  | Abundance | Regional Status | IUCN Red List Category | Biome Affiliation |
|---------|----------------------------|----------------------------------|-----------|-----------------|------------------------|-------------------|
| 1       | Black-headed heron*        | <i>Ardea melanocephala</i>       | -         | R               | LC                     | -                 |
| 2       | Hammerkop*                 | <i>Scopus umbretta</i>           | -         | R               | LC                     |                   |
| 3       | Wattled Ibis               | <i>Bostrychia carunculata</i>    | U         | R, NE           | LC                     | AH                |
| 4       | Black Kite*                | <i>Milvus migrans</i>            | -         | PM              | LC                     | -                 |
| 5       | Hooded Vulture*            | <i>Necrosyrtes monachus</i>      | -         | R               | EN                     | -                 |
| 6       | Lappet-face Vulture*       | <i>Torgos trachiolotus</i>       | -         | R               | CE                     | -                 |
| 7       | White-backed Vulture*      | <i>Gyps africanus</i>            | -         | R               | CE                     | -                 |
| 8       | Ruppell's Griffon Vulture* | <i>Gyps Rueppellii</i>           | -         | R               | CE                     | -                 |
| 9       | Pallid Harrier*            | <i>Circus macrourus</i>          | -         | PM              | NT                     | -                 |
| 10      | Dark Chanting Goshawk*     | <i>Melierax metabates</i>        | -         | R               | LC                     | -                 |
| 11      | Augur Buzzard*             | <i>Buteo augur</i>               | -         | R               | LC                     | -                 |
| 12      | Tawny Eagle*               | <i>Aquila rapax</i>              | -         | R, PM           | LC                     | -                 |
| 13      | African Harrier Hawk       | <i>Polyboroides typus</i>        | r         | R               | LC                     | -                 |
| 14      | Common Kestrel*            | <i>Falco tinunnculus</i>         | -         | PM              | LC                     | -                 |
| 15      | Helmeted Guineafowl        | <i>Numida meleagris</i>          | f         | R               | LC                     | -                 |
| 16      | Scaly Francolin            | <i>Pternistis squamatus</i>      | r         | R               | LC                     | -                 |
| 17      | Blue Spotted Wood Dove     | <i>Turtur afer</i>               | f         | R               | LC                     | -                 |
| 18      | Speckled Pigeon            | <i>Columba quinea</i>            | f         | R               | LC                     | -                 |
| 19      | Red-eyed Dove              | <i>Streptopelia semitorquata</i> | c         | R               | LC                     | -                 |
| 20      | Ring-necked Dove           | <i>Streptopelia capicola</i>     | u         | R               | LC                     | -                 |
| 21      | Dusky Turtle Dove          | <i>Streptopelia lugens</i>       | f         | R               | LC                     | AH                |
| 22      | Laughing Dove              | <i>Streptopelia senegalensis</i> | u         | R               | LC                     | -                 |
| 23      | Black-winged Lovebird      | <i>Agapornis taranta</i>         | c         | R,NE            | LC                     | AH                |

| Ser. No | Common Name                  | Scientific Name                     | Abundance | Regional Status | IUCN Red List Category | Biome Affiliation |
|---------|------------------------------|-------------------------------------|-----------|-----------------|------------------------|-------------------|
| 24      | White-cheeked Turaco         | <i>Tauraco leucotis</i>             | r         | R               | LC                     | AH                |
| 25      | Jacobin Cuckoo               | <i>Clamator jacobinus</i>           | u         | AM              | LC                     | -                 |
| 26      | Red-chested Cuckoo           | <i>Cuculus solitarius</i>           | f         | R               | LC                     | -                 |
| 27      | African Emerald Cuckoo       | <i>Chrosococcyx capreus</i>         | r         | R               | LC                     | -                 |
| 28      | Klaas's Cuckoo               | <i>Chrosococcyx klaas</i>           | r         | R               | LC                     | -                 |
| 29      | Diederick Cuckoo             | <i>Chrysococcyx cuprius</i>         | r         | AM              | LC                     | -                 |
| 30      | White-rumped Swift           | <i>Apus caffer</i>                  | r         | R               | LC                     | -                 |
| 31      | Speckled Mousebird           | <i>Colius striatus</i>              | f         | R               | LC                     | -                 |
| 32      | Blue-breasted Bee Eater      | <i>Merops variegatus</i>            | u         | R               | LC                     | -                 |
| 33      | Eurasian Hoopoe              | <i>Upupa epops</i>                  | r         | R               | LC                     | -                 |
| 34      | Yellow-fronted Tinkerbird    | <i>Pogoniulus chrysoconus</i>       | c         | R               | LC                     | -                 |
| 35      | Cardinal Woodpecker          | <i>Dendropicus fuscescens</i>       | r         | R               | LC                     | -                 |
| 36      | Black Saw-Wing               | <i>Psalidoprocne pristoptera</i>    | f         | R               | LC                     | -                 |
| 37      | Barn Swallow                 | <i>Hirundo rustica</i>              | u         | PM              | LC                     | -                 |
| 38      | Grey Wagtail*                | <i>Motacila cinerea</i>             | -         | PM              | LC                     | -                 |
| 39      | Long-billed Pipit            | <i>Anthus similis</i>               | u         | R               | LC                     | -                 |
| 40      | Red-shouldered Cuckoo Shrike | <i>Campephaga phoenicea</i>         | r         | R               | LC                     | -                 |
| 41      | Common Bulbul                | <i>Pycnonotus barbatus</i>          | c         | R               | LC                     | -                 |
| 42      | Ruppell's Robin Chat         | <i>Cossypha semirufa</i>            | f         | R               | LC                     | AH                |
| 43      | Pied Wheatear*               | <i>Oenanthe pleschanka</i>          | -         | PM              | LC                     | -                 |
| 44      | Abyssinian Wheatear          | <i>Oenathus lugens</i>              | f         | R               | LC                     | -                 |
| 45      | Isabelline Wheatear*         | <i>Oenanthe isabellina</i>          | -         | PM              | LC                     | -                 |
| 46      | Mocking Cliffchat            | <i>Thamnolaea cinnamomeiventris</i> | u         | R               | LC                     | -                 |
| 47      | White-winged Cliffchat       | <i>Thamnolaea semirufa</i>          | f         | R               | LC                     | AH                |

| Ser. No | Common Name                  | Scientific Name                   | Abundance | Regional Status | IUCN Red List Category | Biome Affiliation |
|---------|------------------------------|-----------------------------------|-----------|-----------------|------------------------|-------------------|
| 48      | Little Rock Thrush           | <i>Monticola rufocenerius</i>     | f         | R               | LC                     | AH                |
| 49      | Ground Scraper Thrush        | <i>Psophocichla litsitsirupa</i>  | r         | R               | LC                     | -                 |
| 50      | African Thrush               | <i>Turdus pelios</i>              | c         | R               | LC                     | -                 |
| 51      | Buff-bellied Warbler         | <i>Phyllolais pulchella</i>       | r         | R               | LC                     | -                 |
| 52      | Yellow-bellied Eremomela     | <i>Eremomela icteropygialis</i>   | r         | R               | LC                     | -                 |
| 53      | Brown Woodland Warbler       | <i>Phylloscopus umbrovirens</i>   | f         | R               | LC                     | AH                |
| 54      | Rattling Cisticola           | <i>Cisticola chiniana</i>         | r         | R               | LC                     | -                 |
| 55      | Stout Cisticola              | <i>Cisticola robustus</i>         | f         | R               | LC                     | -                 |
| 56      | Tawny-flanked Prinia         | <i>Prinia subflava</i>            | f         | R               | LC                     | -                 |
| 57      | Grey-backed Camaroptera      | <i>Camaroptera brachura</i>       | c         | R               | LC                     | -                 |
| 58      | Abyssinian Slaty Flycatcher  | <i>Melaenornis chocolatinus</i>   | f         | R, NE           | LC                     | AH                |
| 59      | Northern Black Flycatcher    | <i>Melaenornis edolioides</i>     | r         | R               | LC                     | -                 |
| 60      | African Paradise Flycatcher  | <i>Terpsiphone viridis</i>        | f         | R               | LC                     | -                 |
| 61      | Black-headed Batis           | <i>Batis minor</i>                | f         | R               | LC                     | -                 |
| 62      | White-rumped Babbler         | <i>Turdoides leucopygia</i>       | f         | R               | LC                     | AH                |
| 63      | White-winged Black Tit       | <i>Parus leucomelas</i>           | u         | R               | LC                     | -                 |
| 64      | Scarlet-chested Sunbird      | <i>Chalcomitra senegalensis</i>   | r         | R               | LC                     | -                 |
| 65      | Tacazze Sunbird              | <i>Nectarinia tacazze</i>         | u         | R               | LC                     | AH                |
| 66      | Variable Sunbird             | <i>Cinnyris venustus</i>          | c         | R               | LC                     | -                 |
| 67      | Common Fiscal                | <i>Laniusc collaris</i>           | r         | R               | LC                     | -                 |
| 68      | Sulphur-breasted Bush Shrike | <i>Telophorus sulphureopectus</i> | u         | R               | LC                     | -                 |
| 69      | Black Crowned Tchagra        | <i>Tchagra senegalus</i>          | f         | R               | LC                     | -                 |
| 70      | Northern Puffback            | <i>Dryoscopus gambensis</i>       | u         | R               | LC                     | -                 |
| 71      | Slate-colored Boubou         | <i>Laniarius funebris</i>         | r         | R               | LC                     | -                 |
| 72      | Ethiopian Boubou             | <i>Laniarius aethiopicus</i>      | c         | R               | LC                     | -                 |
| 73      | Ethiopian oriole             | <i>Oriolus monacha</i>            | u         | R,NE            | LC                     | AH                |

| Ser. No | Common Name                        | Scientific Name                 | Abundance | Regional Status | IUCN Red List Category | Biome Affiliation |
|---------|------------------------------------|---------------------------------|-----------|-----------------|------------------------|-------------------|
| 74      | Fork-tailed Drongo                 | <i>Dicrurus adsimilis</i>       | r         | R               | LC                     | -                 |
| 75      | Fan-tailed Raven                   | <i>Corvus rhipidurus</i>        | u         | R               | LC                     | -                 |
| 76      | Red-winged Starling                | <i>Chychognathus morio</i>      | u         | R               | LC                     | -                 |
| 77      | Greater Blue-eared Glossy Starling | <i>Lamprotornis chalybaetus</i> | f         | R               | LC                     | -                 |
| 78      | Red-billed Oxpecker                | <i>Buphagus erythrohynchus</i>  | u         | R               | LC                     | -                 |
| 79      | Swainson's Sparrow                 | <i>Passer swainsonii</i>        | f         | R               | LC                     | AH                |
| 80      | Yellow-spotted Petronia            | <i>Petronia pyrgita</i>         | r         | R               | LC                     | -                 |
| 81      | White-browed Sparrow Weaver        | <i>Plocepasser mahali</i>       | r         | R               | LC                     | -                 |
| 82      | Baglafaecht Weaver                 | <i>Ploceus baglafaecht</i>      | u         | R               | LC                     | AH                |
| 83      | Ruppell's Weaver                   | <i>Ploceus galbula</i>          | c         | R               | LC                     | -                 |
| 84      | Village Weaver                     | <i>Ploceus cucullatus</i>       | f         | R               | LC                     | -                 |
| 85      | Northern Red Bishop                | <i>Euplectes franciscanus</i>   | f         | R               | LC                     | -                 |
| 86      | Red-collared Widowbird             | <i>Euplectes ardens</i>         | f         | R               | LC                     | -                 |
| 87      | Fan-tailed Widowbird               | <i>Euplectes axillaris</i>      | r         | R               | LC                     | -                 |
| 88      | Yellow-bellied Waxbill             | <i>Coccopygia quartinia</i>     | u         | R               | LC                     | -                 |
| 89      | Red-checked Cordon Bleu            | <i>Uraeginthus bengalus</i>     | f         | R               | LC                     | -                 |
| 90      | Red-billed Firefinch               | <i>Lagonosticta senegala</i>    | f         | R               | LC                     | -                 |
| 91      | Village Indigobird                 | <i>Viduata chalybeata</i>       | r         | R               | LC                     | -                 |
| 92      | African Citril                     | <i>Serinus citrinelloides</i>   | f         | R               | LC                     | AH                |
| 93      | Reichenow's Seed Eater             | <i>Serinus reichenowi</i>       | f         | R               | LC                     | -                 |
| 94      | Streaky Seed Eater                 | <i>Serinus strialatus</i>       | f         | R               | LC                     | AH                |
| 95      | Brown Rumped Seed Eater            | <i>Serinus tristriatus</i>      | u         | R               | LC                     | AH                |
| 96      | Cinnamon-breasted Bunting          | <i>Emberiza tahapisi</i>        | c         | R               | LC                     |                   |

Sequence and taxonomy follow Dowsett *et al.* (2014).

**Relative frequency:** c = common; f = frequent (fairly common); u = uncommon; r = rare.

**Status** (Redman *et al.* 2009, Dowsett *et al.* 2014): R = Resident; PM = Palearctic migrant; NE = Near- endemic, NEAE=North East African endemic

**IUCN Red List category** (IUCN Red List 2016): CE, Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened, LC= Least Concern

**Biome:** AH = Afro tropical highlands biome affiliation (EWNHS 1996).

\* Bird species obtained from secondary data either recorded during the study of the wider project area or from other sources of previous studies



## ANNEX V

Bird Species not occurring in the Project impact Area at Tulu Moye but reported during the dry season Survey.

| Ser. No | Common Name                | Species Name                      | Remarks  |
|---------|----------------------------|-----------------------------------|--|
| 1       | Shoebill                   | <i>Balaeniceps rex</i>            | This bird is at Gambela National Park and not at Lake Ziway.           |
| 2       | Water Thicknee             | <i>Burhinus vermiculatus</i>      | The distribution range of this bird is not in or around Tulu Moye.     |
| 3       | White-bellied Go-away Bird | <i>Corythaixoides leucogaster</i> | This is a low land speceise and very unlikely at Tulu Moye             |
| 4       | Square-tailed Nightjar     | <i>Caprimulgus fossii</i>         | This bird species does not occur in Ethiopia.                          |
| 5       | African Grey Hornbill      | <i>Tochus nasulus</i>             | This bird is a low land species and very unlikely at Tulu Moye.        |
| 6       | Von der Decken's Hornbill  | <i>Tockus deckeni</i>             | This bird is a low land species and very unlikely at Tulu Moye.        |
| 7       | Spot-flanked Barbet        | <i>Tricholaema lacrymosa</i>      | This bird species does not occur in Ethiopia.                          |
| 8       | Chin Spot Batis            | <i>Batis molitor</i>              | This bird species does not occur in Ethiopia.                          |
| 9       | Brown-crowned Tchagra      | <i>Tchagra australis</i>          | This bird species does not occur in Ethiopia.                          |
| 10      | Rosy-patched Bush Shrike   | <i>Rhodophoneus cruentus</i>      | Distribution range is unlikely in the project area at Tulu Moye.       |
| 11      | White-necked Raven         | <i>Corvus albicollis</i>          | This bird species does not occur in Ethiopia                           |
| 12      | Black-headed Apalis        | <i>Apalis melanocephala</i>       | This bird species does not occur in Ethiopia                           |
| 13      | Pale Prinia                | <i>Prinia somalica</i>            | Distribution range of this bird species is not in the project area.    |
| 14      | Yellow-breasted Apalis     | <i>Apalis flavicta</i>            | Distribution range of this bird species is not in the project area.    |
| 15      | Banded Parisoma            | <i>Parisoma boehmi</i>            | Distribution range is in the south and never in the project area.      |
| 16      | Brown-tailed Rock Thrush   | <i>Cercomela scotocerca</i>       | This bird species does not occur in Ethiopia                           |
| 17      | Spotted Palm Thrush        | <i>Cichladusa guttata</i>         | Distribution range is unlikely in the project area at Tulu Moye.       |
| 18      | White-browed Scrub Robin   | <i>Cerchotrichas leucophrs</i>    | Distribution range is unlikely in the project area at Tulu Moye.       |
| 19      | Amethyst Sunbird           | <i>Chalcomitra amethystina</i>    | This bird species does not exist in Ethiopia                           |
| 20      | Bush Petronia              | <i>Petronia dentata</i>           | Distribution range is very unlikely in the project area at Tulu Moye.  |
| 21      | Grey-headed Sparrow        | <i>Passer griseus</i>             | The distribution of this bird is in north western Ethiopia.            |
| 22      | Heuglin's Masked Weaver    | <i>Ploceus heuglini</i>           | This bird species does not exist in Ethiopia                           |
| 23      | Yellow-mantled Widow Bird  | <i>Euplectes macrora</i>          | The distribution range of this bird species is west of the Rift Valley |
| 24      | Yellow fronted Canary      | <i>Crithagra mozambica</i>        | This is a lowland species in western Ethiopia                          |

## ANNEX V

### Bird Survey Transects at Tulu Moye Geothermal Exploration and Harvesting Power Plan project area

| Transect Code                        | UTM co-ordinates                   | Latitude/Longitude  | Altitude       | Transect Length |
|--------------------------------------|------------------------------------|---|----------------|-----------------|
| Drill Surrounding-Drill Surrounding1 | X516198 Y902433<br>X514565 Y902660 | N 8° 9'50.4" E39°7'49.2"<br>N 8° 9'57.9" E39°7'56.0"        | 2208m<br>2159m | 1.67 km         |
| Artu Shako-Tero Desta                | X514253 Y902665<br>X513280 Y904463 | N8°9'58.032" E39°7'48.8"<br>N8°10'56.59" E39°7'14.03"       | 2157m<br>2046m | 3.10 km         |
| Gnaro5-Gnaro9                        | X513439 Y904472<br>X514339 Y902756 | N8° 10'56.9" E39°7'59.2"<br>N8° 10' 01.0" E39°7'48.6"       | 2067m<br>2173m | 4.0 km          |
| Drill Pad11-Drill Pad12              | X516113 Y902720<br>X516150 Y903172 | N 8° 9'59.8" E39 8'46.6"<br>N 8°10'14.5" E39°8'47.8"        | 2216m<br>2265m | 1 km            |
| Drill Pad13-Drill Pad14              | X516151 Y902742<br>X516270 Y903451 | N8° 10' 00.5" E39° 8' 47.9"<br>N 8° 10' 23.6" E39° 8' 51.7" | 215m<br>2200m  | 1.5 km          |
| Drill Pad 21-Drill Pad 24            | X515990 Y902603<br>X514522 Y902776 | N 8° 9'55.9" E39°8'42.5"<br>N 8° 10'01.7" 39°7'54.6"        | 2209m<br>2186m | 1.48 km         |

## ANNEX VI

### List of all GPS co-ordinates taken for the Rapid Biodiversity Study at Tulu Moye Geothermal Exploration and Harvesting Power Plan

| Ser.No. | UTM co-ordinates | Latitude/Longitude           | Altitude |
|---------|------------------|------------------------------|----------|
| 1       | X516198 Y902433  | N 8° 9' 50.4" E39°7'49.2"    | 2208m    |
|         | X514565 Y902660  | N 8° 9' 57.9" E39°7'56.0"    | 2159m    |
| 2       | X514253 Y902665  | N8°9'58.032" E39°7'48.8"     | 2157m    |
|         | X513280 Y904463  | N8°10'56.59" E39°7'14.03"    | 2046m    |
| 3       | X513439 Y904472  | N8° 10' 56.9" E39°7'59.2"    | 2067m    |
|         | X514339 Y902756  | N8° 10' 01.0" E39°7'48.6"    | 2173m    |
| 4       | X516113/Y902720  | N 8° 9' 59.8" E39 8' 46.6"   | 2216m    |
|         | X516150/Y903172  | N 8° 10' 14.5" E39°8'47.8"   | 2265m    |
| 5       | X516151 Y902742  | N8° 10' 00.5" E39° 8' 47.9"  | 2215m    |
|         | X516270 Y903451  | N 8° 10' 23.6" E39° 8' 51.7" | 2200m    |
| 6       | X515990 Y902603  | N 8° 9' 55.9" E39°8'42.5"    | 2209m    |
|         | X514522 Y902776  | N 8° 10' 01.7" 39°7'54.6"    | 2186m    |
| 7       | X515445/Y903397  | N8°10' 21.9" E39° 8' 24.8"   | 2255m    |
| 8       | X514991 Y903345  | N8° 10' 20.2" E39°8'09.9"    | 2209m    |
| 9       | X513549 Y904579  | N8° 11' 00.3" E39°7'22.8"    | 2044m    |
| 10      | X514049 Y904127  | N8°10' 45.6" 39°7'39.2"      | 2143m    |
| 11      | X514440 Y903573  | N8° 10' 27.6" E39°7'51.9"    | 2185m    |
| 12      | X513943 Y902538  | N8° 9' 53.9"/E 39° 7' 35.68" | 2162m    |
| 13      | X513045 Y902878  | N8° 10' 4.98" E39° 7' 6.33"  | 2104m    |
| 14      | X516068 Y903166  | N 8° 10' 14.3" E39° 8' 45.1" | 2256m    |
| 15      | X515445 Y903397  | 8°10'21.9" E39°8'24.8"       | 2255m    |
| 16      | X514991 Y903345  | N8° 10'20.2" E39° 8' 09.9"   | 2229m    |
| 17      | X516026 Y902858  | N 8° 10'4.3" E39° 8' 43.7"   |          |
|         | X516298 Y902751  | N 8° 10'0.8" E39° 8' 52.6"   |          |
|         | X516187 Y902574  | N8° 9'55.05" E39° 8' 49.0"   |          |
|         | X515927 Y902694  | N8° 9'58.9"/ E 39° 8' 40.5"  |          |
| 18      | X515970 Y902661  | N 8° 9' 57.88" E 39°8'41.9"  |          |
|         | X516063 Y902619  | N8° 9' 56.52" E39°8'44.96"   |          |
|         | X516011 Y902539  | N8° 9' 55 24" E39° 8'40.03"  |          |
|         |                  | N8° 9' 53.91" E39° 8'43.26"  |          |
| 19      | X516112          | N 8° 9' 59.8" E39° 8' 46.6"  |          |
|         | Y902719          |                              |          |
| 20      | X 515989         | N8° 10'21.9" E 39° 8' 24.8"  |          |
|         | Y902599          |                              |          |

## ANNEX VII

List of Herpetofauna (Amphibians and Reptiles) that are thought to potentially occur at and around Tulu Moye at mid- and low-altitudes (data extracted from Largen and Spawls, 2010).

**NB. LC=** List concern, **VU =**Vulnerable, **NT =** Near threatened

| S.N.           | Common name                                 | Scientific name                    | IUCN status |
|----------------|---|------------------------------------|-------------|
| <b>Frogs</b>   |   |                                    |             |
| 1              | Egyptian square-marked toad <sup>3</sup>    | <i>Sclerophrys regularis</i>       | LC          |
| 2              | Asmara toad <sup>3</sup>                    | <i>Sclerophrys asmarae</i>         | LC          |
| 3              | Keith's toad <sup>3</sup>                   | <i>Sclerophrys kerinyagae</i>      | LC          |
| 4              | Lake Zwai snout burrower <sup>4</sup>       | <i>Hemismus microscephus</i>       | LC          |
| 5              | Kachowski's sand frog <sup>1</sup>          | <i>Tomopterna kachowskii</i>       | LC          |
| 6              | Common reed frog <sup>3</sup>               | <i>Hyperolius viridiflavus</i>     | LC          |
| 7              | Kouni Valley striped frog <sup>4</sup>      | <i>Paracassina kounhiensis</i>     | VU          |
| 8              | Peracca's clawed frog <sup>3</sup>          | <i>Xenopus clivii</i>              | LC          |
| 9              | Angola river frog <sup>3</sup>              | <i>Amietia angolensis</i>          | LC          |
| 10             | Mascarene grass frog <sup>3</sup>           | <i>Ptychadena mascareniensis</i>   | LC          |
| 11             | Erlanger's grass frog <sup>4</sup>          | <i>Ptychadena erlangeri</i>        | NT          |
| 12             | Natal dwarf puddle frog <sup>3</sup>        | <i>Phrynobatrachus natalensis</i>  | LC          |
| <b>Lizards</b> |   |                                    |             |
| 1              | Black-necked ridgeback agama <sup>1,2</sup> | <i>Acanthocercus atricollis</i>    | LC          |
| 2              | Eritrean rock agama <sup>2</sup>            | <i>Acanthocercus annectens</i>     | LC          |
| 3              | Side-striped chameleon <sup>3</sup>         | <i>Trioceros bitaeniatus</i>       | LC          |
| 4              | Gracile chameleon <sup>2</sup>              | <i>Chamaeleo gracilis</i>          | LC          |
| 5              | Kenya dwarf gecko <sup>3</sup>              | <i>Lygodactylus keniensis</i>      | LC          |
| 6              | Common long-tailed lizard <sup>2</sup>      | <i>Latastia longicaudata</i>       | Unknown     |
| 7              | Peters' writhing skink <sup>3</sup>         | <i>Lygosoma afrum</i>              | Unknown     |
| 8              | Ragazzi's bronze skink <sup>3</sup>         | <i>Lygosoma ragazzii</i>           | Unknown     |
| 9              | Long-tailed skink <sup>3</sup>              | <i>Trachylepis megalura</i>        | Unknown     |
| 10             | Five-lined skink <sup>3</sup>               | <i>Trachylepis quinquetaeniata</i> | Unknown     |
| 11             | African striped skink <sup>1,2</sup>        | <i>Trachylepis striata</i>         | Unknown     |
| 12             | Nile monitor <sup>2</sup>                   | <i>Varanus niloticus</i>           | Unknown     |
| <b>Snakes</b>  |   |                                    |             |
| 1              | African rock python <sup>2</sup>            | <i>Python sebae</i>                | Unknown     |
| 2              | Brown house snake <sup>3</sup>              | <i>Lamprophis fuliginosus</i>      | Unknown     |
| 3              | Striped Ethiopian snake <sup>3</sup>        | <i>Pseudoboodon lemniscatus</i>    | Unknown     |
| 4              | Sandford's Ethiopian snake <sup>3</sup>     | <i>Pseudoboodon sandfordorum</i>   | Unknown     |
| 5              | Cape file snake <sup>3</sup>                | <i>Gonionotophis capensis</i>      | LC          |

| S.N.                           | Common name                             | Scientific name                  | IUCN status |
|--------------------------------|---|----------------------------------|-------------|
| 6                              | Geoffroy's racer <sup>3</sup>           | <i>Platyceps florulentus</i>     | LC          |
| 7                              | Ethiopian hook-nosed snake <sup>3</sup> | <i>Scaphiophis raffreyi</i>      | Unknown     |
| 8                              | White-lipped herald snake <sup>2</sup>  | <i>Crotaphopeltis hotamboeia</i> | Unknown     |
| 9                              | Boomslang <sup>2</sup>                  | <i>Dispholidus typus</i>         | Unknown     |
| 10                             | Hissing sand snake <sup>3</sup>         | <i>Psammophis sibilans</i>       | Unknown     |
| 11                             | Grey-billed skaapsteker <sup>3</sup>    | <i>Psammophylax variabilis</i>   | Unknown     |
| 12                             | Black mamba <sup>2</sup>                | <i>Dendroaspis polylepis</i>     | LC          |
| 13                             | Egyptian cobra <sup>3</sup>             | <i>Naja haje</i>                 | LC          |
| 14                             | Rhombic night adder <sup>3</sup>        | <i>Causus rhombeatus</i>         | Unknown     |
| 15                             | Puff adder <sup>2</sup>                 | <i>Bitis arietans</i>            | Unknown     |
| <b>Terrapins and Tortoises</b> |   |                                  |             |
| 1                              | Helmeted terrapin <sup>3</sup>          | <i>Pelomedusa subrufa</i>        | Unknown     |
| 2                              | Leopard tortoise <sup>3</sup>           | <i>Stigmochelys pardalis</i>     | LC          |

<sup>1</sup> Species that were encountered during the rainy season at Tulu Moye area

<sup>2</sup> Species that were reported for the dry season for the whole project area and also reported in the current survey as potentially occurring in the project area

<sup>3</sup> Species that was not listed during dry season survey and based on literature review that are potentially occur at the project area

<sup>4</sup>Ethiopian endemic

Unknown These are species for which either assessment of conservation status or taxonomic revision is underway, or information is not available on IUCN Red List website