

CHARACTERIZATION AND MAPPING OF SOILS OF FARTA WOREDA

DRAFT REPORT

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1. INTRODUCTION

1.1 Background

CASCAPE has entered into a collaborative agreement with the Government of Ethiopia (MoA/ATA) to assist the Ethiopian Soils Information System (EthioSIS) in various ways including detailed characterization and classification of major agricultural soils in all CASCAPE intervention Woredas across the country. In its first phase (20-- to 2015?), CASCAPE has been engaged in characterization and mapping of soils in 30 intervention Woredas and delivered reports and soil-landscape maps at a scale of 1:250,000. In the current second phase (2016 - 2019), CASCAPE is engaged in characterizing and mapping of 65 Woredas of which 10 are categorized as high intensity Woredas. A Woreda level soil-landscape maps have been prepared for eight out of ten high intensity Woredas. The two Woredas that a soil-landscape mapping to be conducted were Farta (under Bahir Dar cluster) and Kafta Humera (under Mekelle cluster).

This particular study was, therefore, to characterize and map soils of Farta Woreda in South Gondar zone of the Amhara Regional State of Ethiopia. The CASCAPE project works in four kebeles (Awzet Azawre, Heruy Aregawi, Atta Sifatra and Wowo) of the Woreda. The overall aim of the study is to characterize and map soils of the four kebeles at 1:250000 scale, solicit legacy data on all of the Woreda and to carry out geo-spatial analysis (Random Forest Machine model) to produce Woreda level soil-landscape map and an accompanying report.

1.2 General Objectives

The overall objectives of the study was to characterize the major agricultural soils of the Woreda to classify and understand their characteristics (physical, chemical and morphological characteristics) with respect to agricultural use and map their distribution. This will serve as a basis for developing site-specific and functional soil information to help land users to make soil fertility management decisions, scaling up and extrapolation of researched best practices to enhance agricultural production and productivity of the country.

1.3 Specific Objectives

The specific objectives of the study were:-

- To characterize the soils of four kebeles (Awzet, Hiruy, Atta and Wowa) based on the soil mapping units derived by a combination of slope, drainage, landform and geological information.
- To collect and compile legacy soil information in the kebeles and the whole Woreda.
- To prepare soil-landscape map of the Woreda at 1:250,000 scale based on auger and profile data using Random Forest Machine (RFM) model.
- To conduct field validation of the soil-landscape maps with check-augers to prepare final soil-landscape map and a report

1.4 Scope of the Study

- The scope of this study was to characterize soils of 4 kebeles in Farta Woreda of south Gondar Zone of the Amhara Regional State (Ethiopia) and prepare soil-landscape map of the Woreda using the soil information of the four kebeles and legacy soil information in the Woreda. The geo-spatial analysis of the soil information by RFM model will be carried out by ISRIC, whereas the soil characterization and validation of the map will be carried out by Dr. Abayneh Esayas. This draft report is intended to present preliminary findings of the study pending final field verification after issuing of woreda soil-landscape relationship map by ISRIC.

2. DESCRIPTION OF THE STUDY AREA

2.1 Location

Farta Woreda is located in south Gondar Administrative Zone of the Amhara National Regional State, Ethiopia (Figure 1). It is at about 100km north of the Regional Capital- Bahir Dar and 660 km north of the Addis Ababa. The total area of the Woreda is 109,925 hectares (CSA, 2007). According to CSA (2007), there are 36 kebles in total.

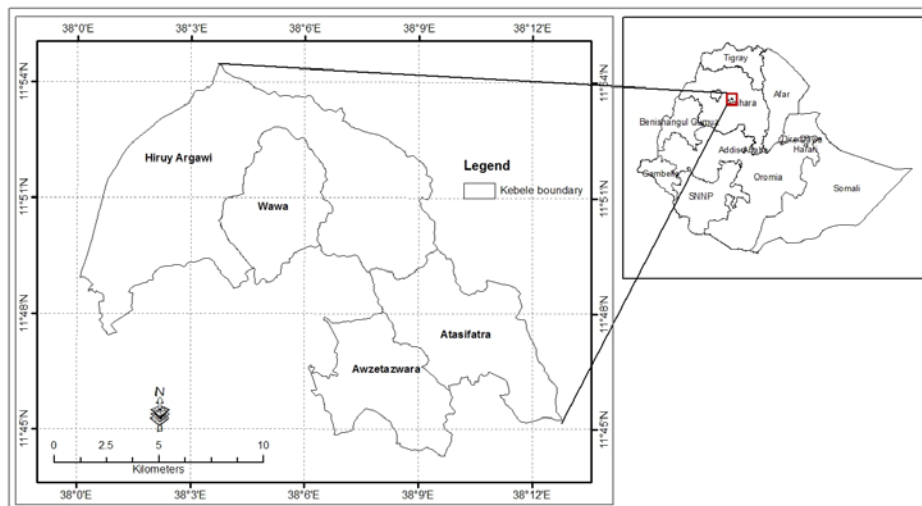


Figure 1: Location map of the study area.

2.2 Geology

The surface geology of the study area is dominated by volcanic rocks of the Recent Era (EGS, 2010). The most dominant geological units are basalt intercalated with trachyte and pyroclastics. Pumiceous tuff dominate on the higher altitudes (that forms part of Guna Mountain). In terms of soil parent material, the soils of the study area are derived from basalt, pyroclastics (tuff) and pumice. Localized recent alluvial deposits and colluviums also exist as parent material.

2.3 Topography

The topography of the study area is mountainous to foot plains with an altitude range of 2600 to 3100 meters above sea level. There are seasonal and perennial streams draining through the study area. At present, due to deforestation of the original vegetation cover for cereal based farming, most of the mountainous area is subject to erosion. The mid-altitude (2600 to 2800 meters above sea level) areas are gently sloping and insitu soil weathering process under well draining condition dominate. At bottom plains depositional and insitu soil forming processes under moist to wet moisture regime dominate.

2.4 Land Cover and Land Use

The major current land cover and land use types in Farta Woreda are crop land, spares forest, open grassland, open shrubland, bare soil, closed shrubland, wetland, water body and

settlement. Annual cropland accounts for 67% of the surface area, whereas, spares forest for 14%, open grassland for 12%, open shrubland for 5.8%. The rest of the land cover and land use types account for less than 1% each. The Land use and land cover statistics of the four kebeles are given in Table 1 to 4 below.

Table 1. Land cover and land use types in Atta Sifatra kebele

Land_Cover	Count	Area_Ha	Area_%
Annual Cropland	27675	2491	73.79
Open Grassland	5688	512	15.17
Sparse Forest	2872	258	7.66
Open Shrubland	907	82	2.42
Closed Shrubland	167	15	0.45
Wetland	133	12	0.35
Bare Soil	63	6	0.17
Total		3375	100.00

Table 2. Land cover and land use types in Awzet Azawre Kebele

Land_Cover	Count	Area_Ha	Area_%
Annual Cropland	24901	2241.09	88.6
Open Grassland	2497	224.73	8.9
Sparse Forest	404	36.36	1.4
Closed Shrubland	229	20.61	0.8
Open Shrubland	57	5.13	0.2
Bare Soil	32	2.88	0.1
Total		2530.8	100

Table 3: Land cover and land use types in Wawa Kebelle

Land_Cover	Count	Area_Ha	Area_%
Annual Cropland	16932	1523.88	65.99
Sparse Forest	4297	386.73	16.75
Open Grassland	2693	242.37	10.50
Open Shrubland	1214	109.26	4.73
Closed Shrubland	252	22.68	0.98
Bare Soil	199	17.91	0.78
Wetland	70	6.30	0.27
Total		2309.13	100.00

Table 4. Land cover and land use types in Hiruy Aregawi kebele

Land_Cover	Count	Area_Ha	Area_%
Annual Cropland	28479	2563.11	73.30
Open Grassland	7300	657.00	18.79
Sparse Forest	1048	94.32	2.70
Open Shrubland	925	83.25	2.38
Closed Shrubland	794	71.46	2.04
Bare Soil	281	25.29	0.72
Wetland	25	2.25	0.06
Total		3496.68	100.00

2.5 Climate

The nearest meteorological station to the study area was located in Debre Tabor town. Average rainfall and temperature data from 30 years (1980 to 2009) records are presented in Table 5. May to October are the major rainy months of the year. February to May are the hottest months of the year and September to January are the coldest months of the year.

Table 5. Climatic data of the study area

Attribute	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Max T ⁰ C	22	23	23	23	23	22	19	19	20	21	21	22	21
Min T ⁰ C	9	10	11	11	11	11	10	10	9	9	8	8	10
RF (mm)	7.4	5.0	26.0	41.4	85.8	150.3	367.7	364.5	172.8	67.7	26.3	10.7	1326

The average annual amount of the rainfall is relatively high and it indicates that there is enough amount of moisture to penetrate down the soil profile on stable plain to gently sloping areas. On steeper slopes, with the current sparse land cover, it can generate erosion and sediment deposition on low relief locations. On depressed areas, aquic moisture regime could possible dominate. The temperature of the area is greater than 8⁰C throughout the year and one can assume moderate rate of weathering and percolation of suspended particles

3. MATERIALS AND METHODS

3.1 Approach

The overall approach to the study was in three steps; pre-fieldwork, field soil sampling and post-fieldwork. Details of activities in each step are described in the following sections. The soil data for the four Kebeles and the entire Woreda was acquired from two sources. The kebele data was from the current soil studies (primary data) and from previous soil studies (legacy data). The soil data for the rest of the Kebeles were from legacy data.

3.2 Pre-fieldwork

The activities carried out before conducting the actual field soil survey and sampling were preparation of base map for the four kebeles and identification and mining of legacy data. Details of both activities are described in the subsequent sections.

3.2.1 Base-map Preparation

For the preparation of the Base-map of the Kebeles, the following maps were use:- Digital Elevation Model (DEM) of SRTM (90 meter resolution), Woreda and Kebele administrative boundary maps (CSA, 2015), geological map of Debre Tabor area at 1:250,000 scale (EGS, 2010) and 1:50,000 scale soil map of the Tekeze and Tana sub-Basin (ARWWDSA, 2014. Slope, degree of dissection and curvature of the topography were determined from the DEM map using ArcGIS 10.3 software. For the preparation of preliminary soil mapping (SMU), the geological map, soil unit map and slope map were superimposed on the administrative map using the GIS software. Based on the variability of mosaic of SMUs, preliminary sampling locations were indicated. This constituted Base-map of the Kebeles (1:50,000 scale).

3.2.2 Legacy Data Acquisition

In order to increase the number of data points to ensure accurate extrapolation of soil-landscape relationships, legacy data on the study area were collected and used. Different maps (as indicated in section 3.2.1) and soil profile and auger data were acquired from different sources. Soil profile and auger observations were mined from two major sources, namely Tana sub-Basin and Tekeze sub-Basin soil survey carried out in 2014 by the Amhara Region's Water Works Design and Supervisions Authority (ARWWDSA, 2014). A total of 39 auger observations in Microsoft Excel format and 20 profile descriptions (from both studies) that fall within the study area were collected. Out of the 20 profile descriptions, 2 profile descriptions were from Tekeze sub-basin study in Microsoft Word format and 18 profile descriptions were from Tana sub-Basin study and they were in Microsoft Excel format.

3.3 Fieldwork

The field soil investigation was carried out at 1:250,000 scale and followed a free survey approach along transects that cut-across different mapping units. The field investigation started with auger observations along the different transects to a depth of 1.2 meter depth unless obstructed by hard layer. The auger descriptions were made according to the guidelines of FAO, 2006. On each kebele, once the soil auger observations were carried out - soil variability assessment was carried out to locate representative soil profile sites to conduct profile descriptions and soil sampling. The soil profiles were located along topo-sequence (to a depth of 2 meter unless obstructed by hard rock) to be able to study centenary (soil-landscape relationship). The soil profile descriptions were made according to the guidelines of FAO, 2006 and soil samples were collected from each identified layers for laboratory analysis. A total of 21 profile descriptions and 46 auger observations were made in this study.

3.4 Post-fieldwork

The major activities after the fieldwork were rectification of the SMUs based on the field observation, submission of soil samples for laboratory analysis, soil classification and preparation of this report and accompanying maps.

The soil samples were analyzed at Horicoop Ethiopia PLC's Soil and Water Analysis Laboratory through the CASCAPE project office. A total of 59 samples were collected and analyzed for

physical (texture, bulk density) and chemical properties (pH, Available phosphorus, total nitrogen, organic carbon, exchangeable acidity (H & Al), exchangeable bases (Ca, Mg, K & Na), cation exchange capacity (CEC) and available micronutrients (Cu, Zn, Fe, Mn & B) following the standard laboratory procedures.

Once the soil laboratory analysis result was made available by the project to the consultant, field soil classification was reviewed and it was according to WRB 2014 (updated in 2015). The legacy soil classification was according to the previous versions and in order to harmonize with the current study, all legacy data soil classifications were updated according to the current classification. Lack of some data (such as exchangeable acidity) has limited the reclassification of the legacy data.

The SMUs were revised based on the final soil classification (after acquisition of soil laboratory data) and geology of the parent material based on field observation. A total of ----- SMUs were identified in the four Kebeles. The primary and legacy auger and profile descriptions were compiled in Microsoft Excel format for the purpose of soil-landscape relations analysis by ISRIC. Annexes to be appended to this report were also compiled in this phase. Field verification of the soil-landscape relationship map for the entire Woreda to be produced by ISRIC will be verified due course and this draft report will be reviewed to produce a final version.

3.5 Soil Map Legend

The soil mapping units (SMU) were generated by using the geology, slope and soil units as identifying criteria. The legend describes these three attributes separated by a slash. For example **B/3/LVvr**. The first character (B) denotes the geology (pyroclastics) and the second (3) denotes slope class (2-5% slope) and the last (LVvr) denotes soil unit according to WRB 2014 - Vertic (vr) Luvisols (LV).

4. RESULT AND DISCUSSION

4.1 Soils of Awzet Azawre Kebele

A total of 46 soil mapping units (SMU) were identified using the three selected distinguishing criteria (geology, slope and soil unit). Mainly slope and soil units account for the existence of so many different SMUs in the Kebele. This indicates that the topography (slope) accounted more than the geology of the area for the formation of different soil groups in the Kebele. There were seven Soil Reference Groups (SRG) identified in the Kebele according to WRB 2014 soil classification system updated in 2015. The SRGs are Alisols, Nitisols, Luvisols, Vertisols, Cambisols, Regosols and Leptosols (Figure 2).

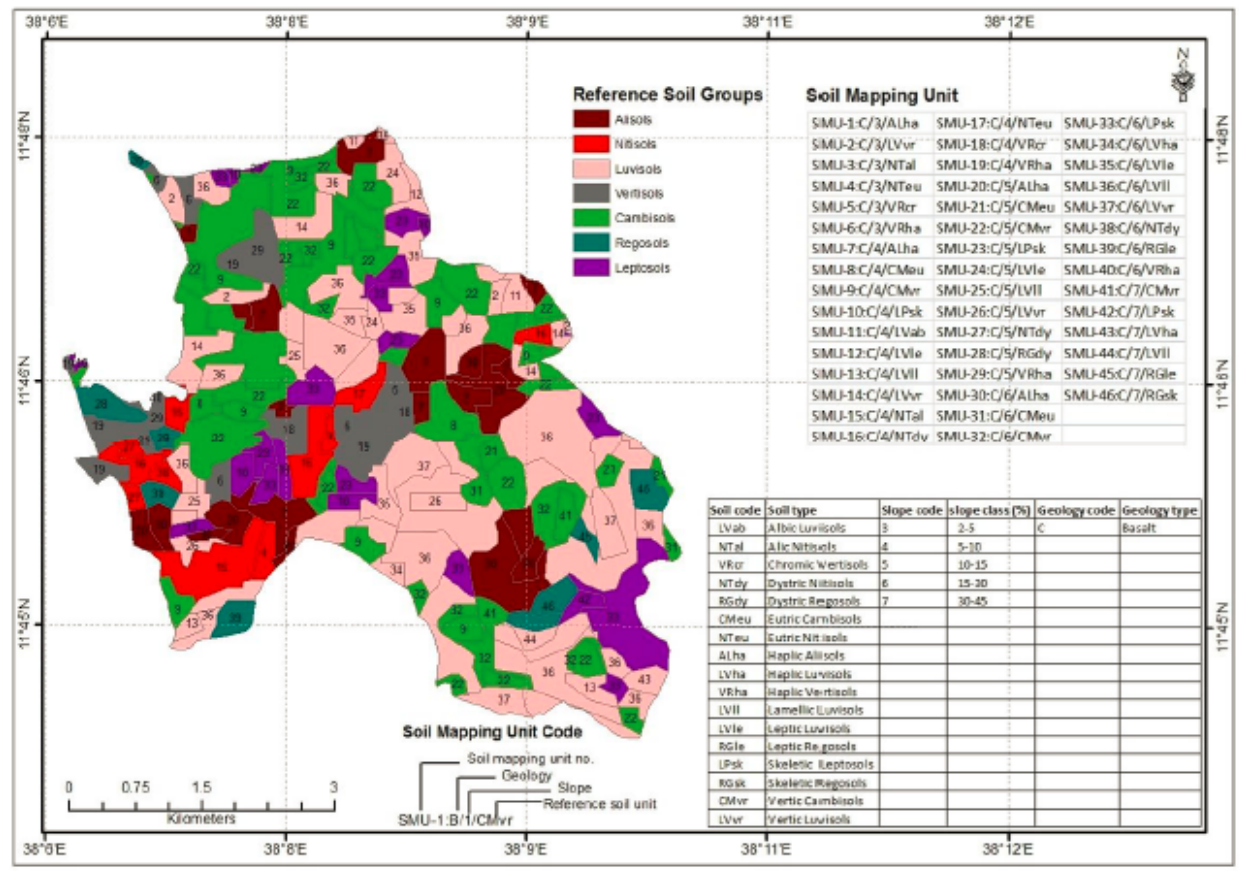


Figure 2. Soil landscape map of Awzet Azawre kebele

4.2 Soils of Hiruy Aregawi Kebele

A total of 65 soil mapping units (SMU) were identified using the three selected distinguishing criteria (geology, slope and soil unit). Mainly slope and soil units account for the existence of so many different SMUs in the Kebele. This indicates that the topography (slope) accounted more than the geology of the area for the formation of different soil groups in the Kebele. There were seven Soil Reference Groups (SRG) identified in the Kebele according to WRB 2014 soil classification system updated in 2015. The SRGs are Alisols, Nitisols, Luvisols, Vertisols, Cambisols, Regosols and Leptosols (Figure 3).

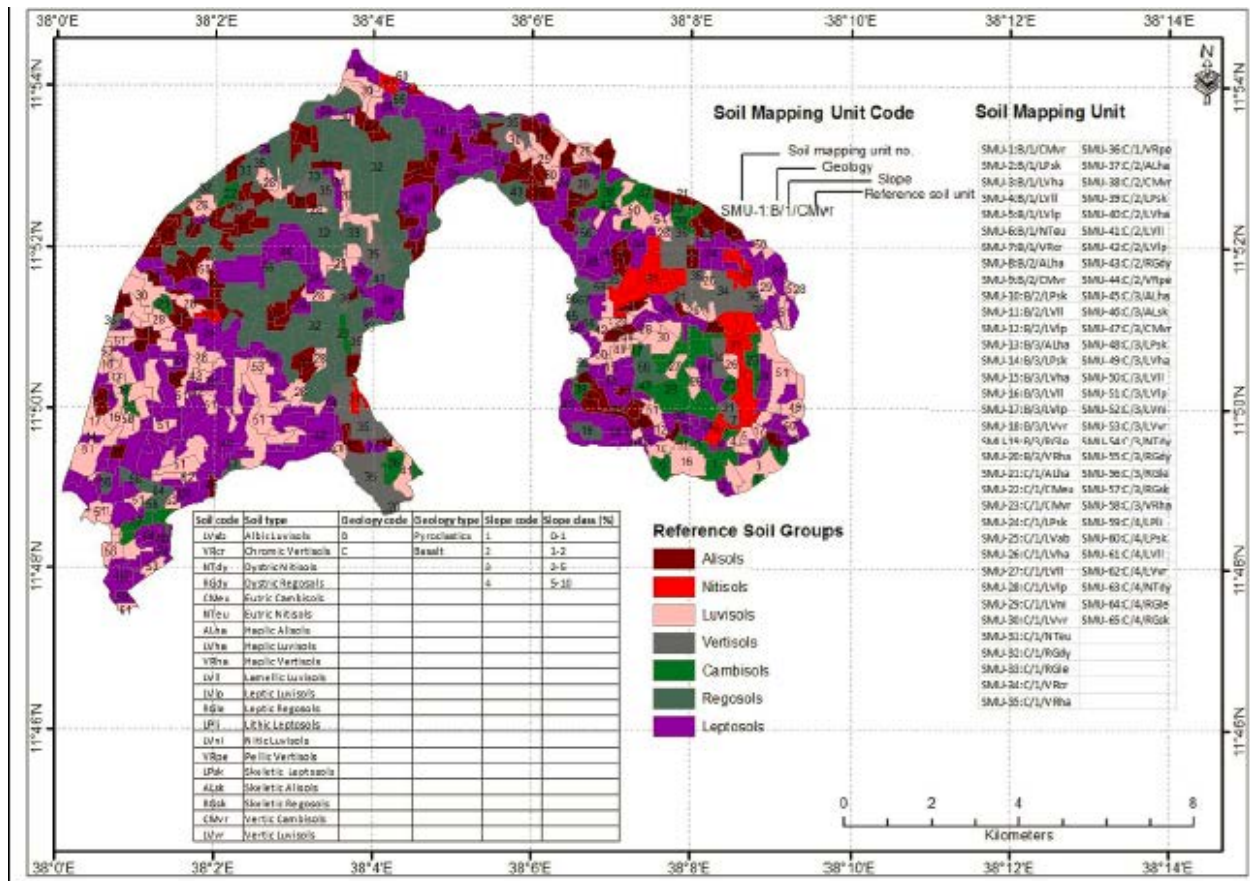


Figure 3. Soil landscape map of Hiruy Aregawi Kebele

4.3 Soils of Atta Sifatra Kebelle

A total of 61 soil mapping units (SMU) were identified using the three selected distinguishing criteria (geology, slope and soil unit). Mainly slope and soil units account for the existence of so many different SMUs in the Kebelle. This indicates that the topography (slope) accounted more than the geology of the area for the formation of different soil groups in the Kebelle. There were seven Soil Reference Groups (SRG) identified in the Kebelle according to WRB 2014 soil classification system updated in 2015. The SRGs are Alisols, Nitisols, Luvisols, Vertisols, Cambisols, Regosols and Leptosols (Figure 4).

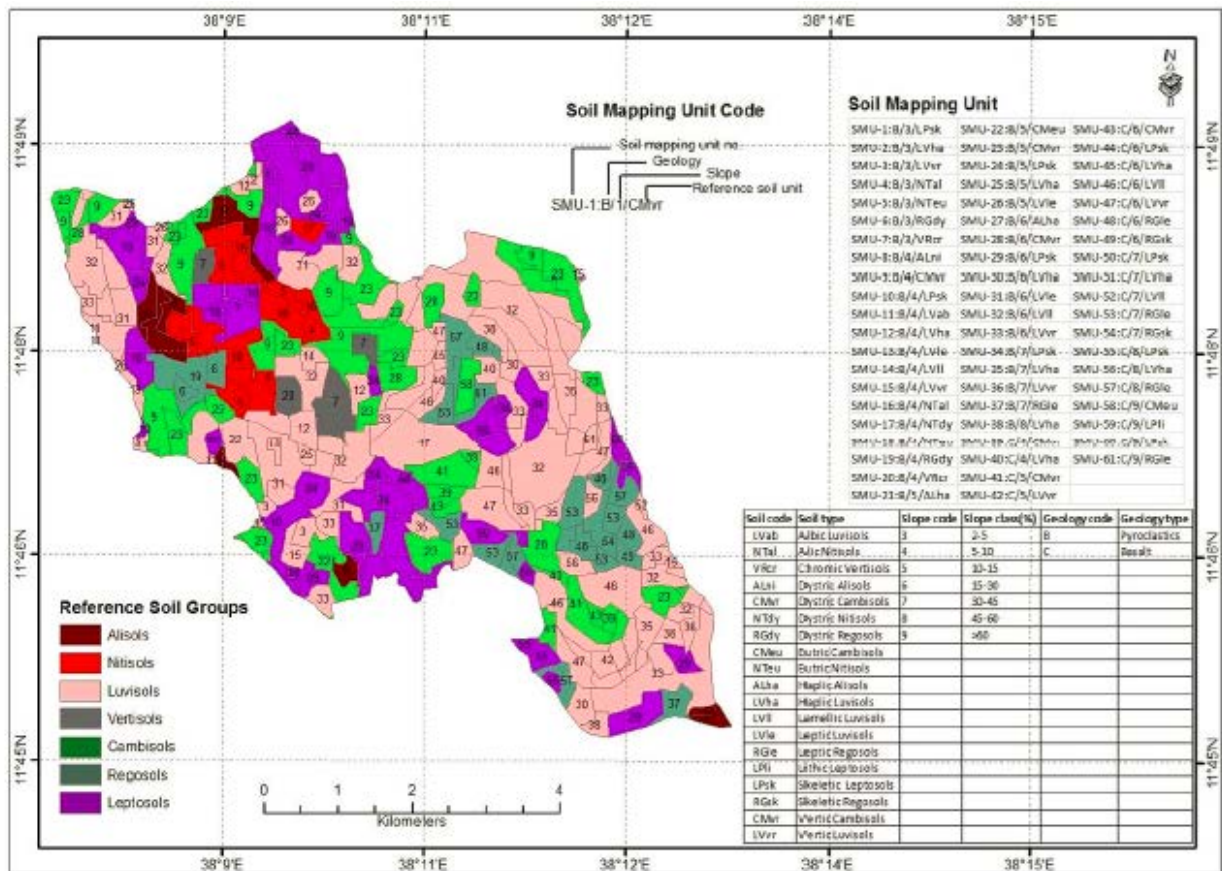


Figure 4. Soil landscape map of Atta Sifatra Kebelle

4.4 Soils of Wawa Kebelle

A total of 42 soil mapping units (SMU) were identified using the three selected distinguishing criteria (geology, slope and soil unit). Mainly slope and soil units account for the existence of so many different SMUs in the Kebelle. This indicates that the topography (slope) accounted more than the geology of the area for the formation of different soil groups in the Kebelle. There were seven Soil Reference Groups (SRG) identified in the Kebelle according to WRB 2014 soil classification system updated in 2015. The SRGs are Alisols, Nitisols, Luvisols, Vertisols, Cambisols, Regosols and Leptosols (Figure 5).

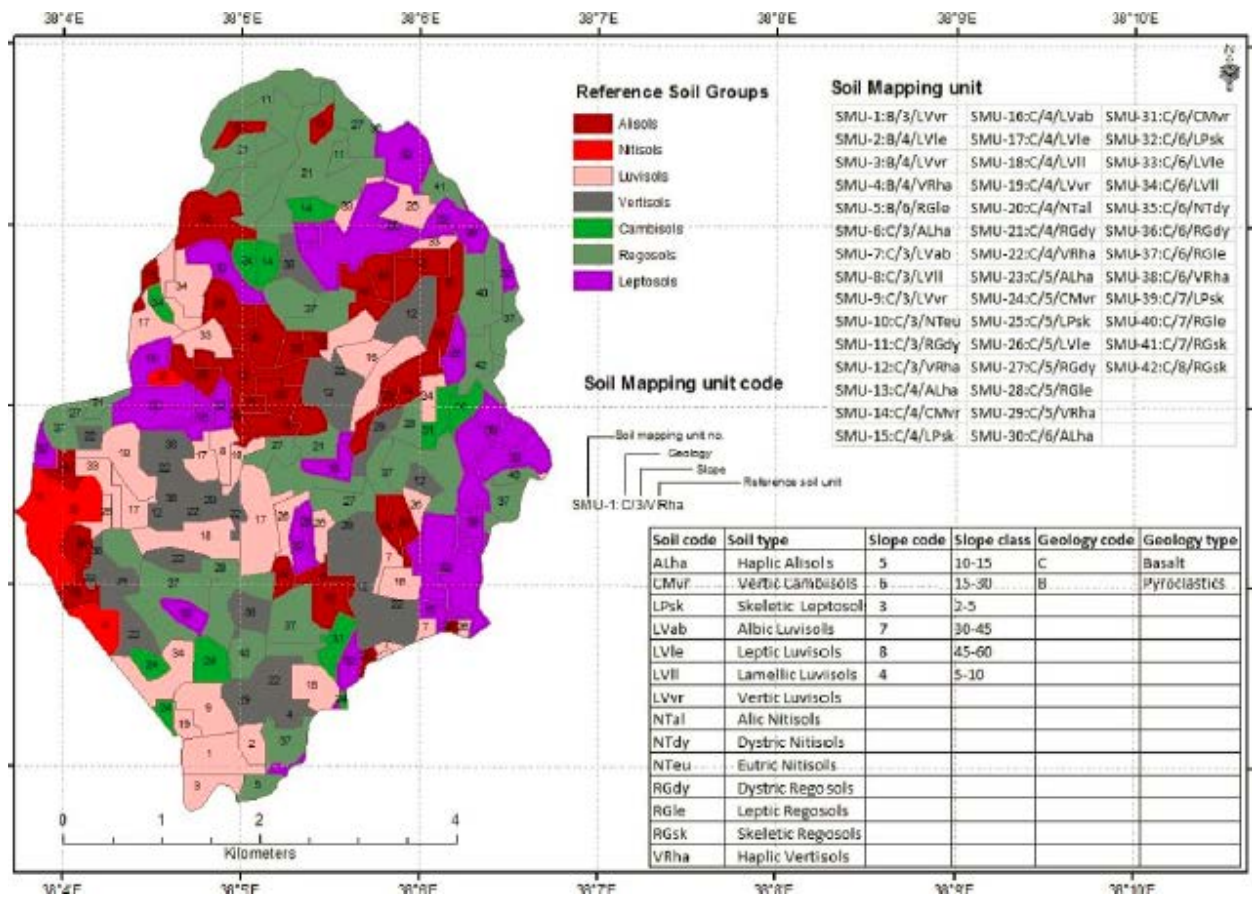


Figure 5. Soil landscape map of Wawa Kebelle

5. CONCLUSIONS

The combination of geology, slope and soil units were found to be best criteria to identify different mapping units that conforms with the actual ground land unit mosaic in the study area. Moreover, the variability of soil units with slope demonstrates that the soil distribution in the area has a strong association with the landscape of the area. This implies that the use of these criteria is best option for soil-landscape association extrapolation.

From pedogenic point of view, despite few types of parent material, the existence of seven Reference Soil Groups and more than 20 soil units clearly indicates that topography and associated geomorphic processes and moisture regime difference played a role in the formation of different soil types in the area.

Appendix A. Description of Profile Description

Profile number: FF1 **Date:** 05/09/2017
Soil classification (FAO): Stagnic Fluvisols **Profile description status:** Routine profile description
(USDA): **coordinate (WSG84) N :**1304772
E :405742

Location: Atta Sifatira Kebelle, about 1.5km north of awuzet village
Author(s): Gebeyehu Belay **Map sheet:**
Land form: Plain **Elevation (asl):** 2732m
Micro topography: None **Depth to bedrock:** >150cm
Slope gradient: 2.5% **Rock out crops:** None
Slope class: 3 **Surface cracks:** None
Slope form: Straight **Sealing/capping:** None
Position: Lower slope **Bleached sand:** None
Slope aspect: West to east **Flooding frequency:** None
Parent material: Pyroclastic **Flooding duration:** None
Human influence: Grazing **Permeability:** Slow
Salt status: None **Surface stones & boulders:** None
Effective soil depth: >150cm **Surface coarse fragments:** None
Moisture status: Wet throughout
Drainage class: Moderately well drained
External Drainage: Slow runoff
Land cover: Grass land
Land use: Pasture
Fertilizer: None
Erosion status: a. Site: None
b. Surrounding: None

PROFILE DESCRIPTION

AP 0-10cm Dark brown (7.5YR 3/2) moist; clay loam; weak fine sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine and medium roots; many medium pores; non biological activities; clear and smooth boundary.

1A 10-20cm Very dark brown (7.5YR 2.5/2) moist; silty loam; moderate medium sub angular .blocky; non mottles; non sticky and non plastic wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; non mineral concretions; none calcareous; few medium roots; few medium pores; clear and smooth boundary.

2A 20-36cm Very dark gray (10YR3/1); clay loam; moderate medium sub angular blocky; few fine

distinct mottles; slightly sticky and slightly plastic wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; few fine black hard manganese mineral concretions; none calcareous; many fine roots; very few low pores; abrupt and smooth boundary.

3A 36-60cm Very dark grayish brown (10YR 3/2) moist; silty clay loam; moderate medium sub angular blocky; few fine distinct mottles; non sticky and non plastic wet, friable when moist; none surface cracks; none rock fragments; non-cemented and non-compacted; common medium hard black colored manganese mineral concretions; none calcareous; common fine roots; common medium size pores; clear and smooth boundary.

A1 60-80cm Very dark brown (10YR 2/2) moist; clay; strong coarse medium angular blocky; few fine distinct mottles; sticky and plastic wet, friable when moist; common distinct cutans; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concretions; none calcareous; few fine roots; many medium size pores; abrupt and smooth boundary.

A2 80-130+cm Black (10YR 2/1) moist; heavy clay; strong medium angular blocky; few fine faint mottles; very sticky and very plastic wet, friable when moist; common distinct cutans; none surface cracks; none rock fragments; non-cemented and non-compacted; none manganese mineral concretions; none calcareous; few fine roots; many medium size pores.

Profile number: FF2
Soil classification (FAO): Dystric Leptosols

(USDA):

Date: 05/09/2017

Profile description status: Routine profile description

coordinate (WSG84) N: 1304887

E: 410591

Location: Atta Sifatira Kebelle, about 2km north of awuzet village

Author(s): Gebeyehu Belay

Land form: Mountainous

Micro topography: None

Slope gradient: 48%

Slope class: 8

Slope form: Irregular

Position: Middle slope

Slope aspect: North to south

Parent material: Pyroclastic

Human influence: PLantation

Salt status: None

Effective soil depth: 20cm

Moisture status: Moist throughout

Drainage class: Excessively drained

External Drainage: Rapid runoff

Land cover: Plantation

Land use: Eucalyptus plantation

Fertilizer: None

Erosion status: a. **Site:** Severe sheet and rill erosion

b. **Surrounding:** Severe sheet and rill erosion

Map sheet:

Elevation (asl): 2976m

Depth to bedrock: >20cm

Rock out crops: Common coarse gravels

Surface cracks: None

Sealing/capping: None

Bleached sand: None

Flooding frequency: None

Flooding duration: None

Permeability: Rapid

Surface stones & boulders: Many

Surface coarse fragments: None

PROFILE DESCRIPTION

AP 0-20cm Dark brown (7.5YR 3/2) moist; sandy clay loam; moderate medium crumb; non-mottles; non sticky and non plastic when wet, very friable when moist; none surface cracks none; few medium irregular shaped fresh rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; common fine roots; many medium size interstitial pores; non biological activities; clear and smooth boundary.

Profile number: FF3
Soil classification (FAO): Dystric Leptosols

(USDA):

Location: Atta sifatra kebele
Author(s): Gebeyehu Belay
Land form: Valley side slope
Micro topography: Terrace
Slope gradient: 8%
Slope class: 4
Slope form: Straight
Position: Upper slope
Slope aspect: South west to north east
Parent material: Pyroclastic
Human influence: Ploughing
Salt status: None
Surface stones & boulders: Many stones and few boulders
Effective soil depth: 40cm
Surface coarse fragments: many coarse gravels
Moisture status: Moist throughout
Drainage class: Excessively drained
External Drainage: Rapid runoff
Land cover: Cultivation of barley
Land use: Cultivated land
Fertilizer: None
Erosion status: a. **Site:** Severe sheet and rill erosion
b. **Surrounding:** Severe sheet and rill erosion

Date: 05/09/2017
Profile description status: Routine profile description
coordinate (WSG84) N: 1305006
E: 409042

Map sheet:
Elevation (asl): 2768m
Depth to bedrock: >40cm
Rock out crops: Common
Surface cracks: None
Sealing/capping: None
Bleached sand: None
Flooding frequency: None
Flooding duration: None
Permeability: rapid

PROFILE DESCRIPTION

AP 0-40cm Black (10YR 2/1) moist; sandy loam; weak fine granular; non-mottles; non sticky and non plastic when wet, friable when moist; none surface cracks none; few medium irregular shaped weathered rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many medium size interstitial pores; non biological activities; abrupt and smooth boundary.

Profile number: FF4
Soil classification (FAO): Haplic Luvisols
(USDA):

Date: 05/09/2017
Profile description status: Routine profile description
coordinate (WSG84) N: 1305207
E: 407933

Location: Atta sifatra kebele
Author(s): Gebeyehu Belay
Land form: Plain
Micro topography: None
Slope gradient: 4%
Slope class: 3
Slope form: Straight
Position: Upper slope
Slope aspect: South east to north west
Parent material: Pyroclastic
Human influence: Ploughing
Salt status: None
Surface stones & boulders: few stones
Effective soil depth: 100cm
Surface coarse fragments: Few gravels
Moisture status: Moist throughout
Drainage class: Poorly drained
External Drainage: Slow runoff
Land cover: Cultivation of barley
Land use: Cultivated land
Fertilizer: None
Erosion status: a. Site: Severe sheet and rill erosion
b. Surrounding: Severe sheet and rill erosion

Map sheet:
Elevation (asl): 2804m
Depth to bedrock: >100cm
Rock out crops: Common
Surface cracks: None
Sealing/capping: None
Bleached sand: None
Flooding frequency: None
Flooding duration: None
Permeability: Slow

PROFILE DESCRIPTION

AP 0-20cm Dark brown (7.5YR 3/3) moist; clay; moderate medium granular; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; common medium size interstitial pores; non biological activities; diffuse and smooth boundary.

A 20-40cm Dark brown (5YR 3/2) moist; silty clay; moderate medium granular; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; few fine roots; many medium size interstitial pores; non biological activities; diffuse and smooth boundary

BC 40-100cm Dark gray (10YR4/1) moist; sandy clay; strong medium sub angular blocky; common medium reddish prominent mottles; non sticky and non plastic when wet, friable when

moist; none surface cracks none; few medium irregular shaped weathered rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many medium size interstitial pores; non biological activities.

Profile number: FF5
Soil classification (FAO): Dystric Leptosols

(USDA):

Location: Atta sifatra kebele
Author(s): Gebeyehu Belay
Land form: high gradient hills
Micro topography: Terrace
Slope gradient: 13%
Slope class: 5
Slope form: Convex
Position: Upper slope
Slope aspect: North to south
Parent material: Pyroclastic
Human influence: Ploughing
Salt status: None
Surface stones & boulders: Many stones and few boulders
Effective soil depth: 20cm
Surface coarse fragments: many coarse types of gravel
Moisture status: Moist throughout
Drainage class: Excessively drained
External Drainage: Rapid runoff
Land cover: Cultivation of barley
Land use: Cultivated land
Fertilizer: None
Erosion status: a. **Site:** Severe sheet and rill erosion
b. **Surrounding:** Severe sheet and rill erosion

Date: 05/09/2017

Profile description status: Routine profile description

coordinate (WSG84) N: 1304621
E: 409091

Map sheet:

Elevation (asl): 2851m

Depth to bedrock: 20cm

Rock out crops: Few

Surface cracks: None

Sealing/capping: None

Bleached sand: None

Flooding frequency: None

Flooding duration: None

Permeability: Rapid

PROFILE DESCRIPTION

AP 0-20cm Dark grayish brown (10YR 4/2) moist; sandy loam; weak fine crumb; non-mottles; non sticky and non plastic when wet, friable when moist; none surface cracks none; common fine and medium irregular shaped weathered rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many medium size interstitial pores; non biological activities; abrupt and smooth boundary.

Profile number: FA1
Soil classification (FAO): Umbric Andosols
(USDA):

Date: 31/08/2017
Profile description status: Routine profile description
coordinate (WSG84) N: 1298239
E: 408200

Location: Awuzet Azawurie kebele, Shimamo village

Author(s): Gebeyehu Belay

Land form: Plateau

Micro topography: None

Slope gradient: 18%

Slope class: 6

Slope form: Irregular

Position: Upper slope

Slope aspect: South to north

Parent material: Pyroclastic

Human influence: Grazing

Salt status: None

Effective soil depth: 40cm

Moisture status: wet throughout

Drainage class: Somewhat excessively drained

External Drainage: rapid runoff

Land cover: Grass land

Land use: Grazing land

Fertilizer: None

Erosion status: a. Site: Moderate sheet and rill erosion

b. Surrounding: Moderate sheet and rill erosion

Map sheet:

Elevation (asl): 3288m

Depth to bedrock: >40cm

Rock out crops: None

Surface cracks: None

Sealing/capping: None

Bleached sand: None

Flooding frequency: None

Flooding duration: None

Permeability: Moderate

Surface stones & boulders: None

Surface coarse fragments: None

PROFILE DESCRIPTION

AP 0-20cm Black (10YR 2/1) moist; sandy loam; moderate medium crumb; non-mottles; non sticky and non plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine and medium roots; many fine interstitial pores; non biological activities; clear and smooth boundary.

AC 20-40cm Dark brown (10YR 3/3) moist; silty clay loam; moderate fine sub angular .blocky; non-mottles; non sticky and non plastic wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concretions; none calcareous; few medium and many fine roots; many fine interstitial pores; clear and smooth boundary.

Profile number: FA2
Soil classification (FAO): Dystric Leptosols

(USDA):

Date: 31/08/2017

Profile description status: Routine profile description

coordinate (WSG84) N: 1298715

E: 407330

Location: Awuzet Azawurie kebele, west of Shimamo village

Author(s): Gebeyehu Belay

Land form: Mountainous

Micro topography: None

Slope gradient: 54%

Slope class: 9

Slope form: Irregular

Position: Upper slope

Slope aspect: South to north

Parent material: Pyroclastic

Human influence: Grazing and browsing

Salt status: None

Effective soil depth: 20cm

Moisture status: wet throughout

Drainage class: Excessively drained

External Drainage: rapid runoff

Land cover: Plantation

Land use: Eucalyptus plantation

Fertilizer: None

Erosion status: a. **Site:** Slight sheet and rill erosion

b. **Surrounding:** Slight sheet and rill erosion

Map sheet:

Elevation (asl): 3228m

Depth to bedrock: >20cm

Rock out crops: Common

Surface cracks: None

Sealing/capping: None

Bleached sand: None

Flooding frequency: None

Flooding duration: None

Permeability: rapid

Surface stones & boulders: Many

Surface coarse fragments: None

PROFILE DESCRIPTION

AP 0-20cm Black (10YR 2/1) moist; clay loam; weak coarse crumb; non-mottles; non sticky and non plastic when wet, friable when moist; none surface cracks none; few medium irregular shaped fresh rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many fine interstitial pores; non biological activities; abrupt and smooth boundary.

Profile number: FA3
Soil classification (FAO): Dystric Regosols

(USDA):

Location: Awuzet Azawurie kebele, Mahl gult village

Author(s): Gebeyehu Belay

Land form: Mountain

Micro topography: Terrace

Slope gradient: 25%

Slope class: 6

Slope form: Irregular

Position: Middle slope

Slope aspect: North to south

Parent material: Pyroclastic

Human influence: Ploughing

Salt status: None

Effective soil depth: 20cm

Moisture status: wet throughout

Drainage class: Excessively drained

External Drainage: rapid runoff

Land cover: Cultivated land of potato

Land use: Cultivation of lentil, potato, wheat and legumes

Fertilizer: None

Erosion status: a. **Site:** Severe sheet and rill erosion and slight gully

b. **Surrounding:** Severe sheet and rill erosion and slight gully

Date: 31/08/2017

Profile description status: Routine profile description

coordinate (WSG84) N: 1300696

E: 407415

Map sheet:

Elevation (asl): 3221m

Depth to bedrock: >20cm

Rock out crops: Few

Surface cracks: None

Sealing/capping: None

Bleached sand: None

Flooding frequency: None

Flooding duration: None

Permeability: Rapid

Surface stones & boulders: Common

Surface coarse fragments: Few

PROFILE DESCRIPTION

AP 0-20cm Dark grayish brown (10YR 4/2) moist; sandy clay loam; weak medium sub angular blocky; non-mottles; non sticky and non plastic when wet, friable when moist; none surface cracks none; common fine irregular shaped weathered rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many fine interstitial pores; non biological activities; abrupt and smooth boundary.

Profile number: FA4
Soil classification (FAO): Haplic Luvisols/Alisols
(USDA):

Date: 01/09/2017
Profile description status: Routine profile description
coordinate (WSG84) N: 1300840
E: 406761

Location: Awuzet Azawurie kebele, Tabot maderia village

Author(s): Gebeyehu Belay

Land form: Valley bottom

Micro topography: None

Slope gradient: 13%

Slope class: 5

Slope form: Irregular

Position: Middle slope

Slope aspect: East to west

Parent material: Pyroclastic

Human influence: Ploughing

Salt status: None

Effective soil depth: 95cm

Moisture status: Moist throughout

Drainage class: Well drained

External Drainage: Moderate runoff

Land cover: Cultivation of vegetables and cereals

Land use: Cultivated land of potato

Fertilizer: 150kg DAP and 200kg Urea and compost

Erosion status: a. **Site:** Severe sheet & rill, and slight gully erosion

b. **Surrounding:** Severe sheet & rill, and slight gully erosion

* Water seepage at 80cm depth

PROFILE DESCRIPTION

AP 0-12cm Dark brown (7.5YR 3/3) moist; clay loam; moderate medium sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many fine interstitial pores; non biological activities; clear and smooth boundary.

Bt₁ 12-40cm Dark brown (7.5YR 3/2) moist; clay; moderate medium sub angular blocky; common medium distinct and clear reddish mottles; sticky and plastic wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; few fine rounded shaped manganese mineral concretions; none calcareous; many fine roots; many fine and medium interstitial pores; clear and smooth boundary.

Bt₂ 40-65cm Black (7.5YR 2.5/2) moist; clay; moderate medium angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; common fine rounded shaped manganese mineral concretions; none calcareous; common fine roots; many fine and medium interstitial pores; non biological activities; clear and smooth boundary.

BC 65-95cm Brown (7.5Y 4/3) moist; clay; weak fine angular .blocky; non-mottles; non sticky and non plastic wet, friable when moist; none surface cracks none; common fine & medium irregular shaped weathered rock fragments; non-cemented and non-compacted; common fine rounded shaped manganese mineral concretions; none calcareous; few fine roots; many fine interstitial pores.

Profile number: FA5
Soil classification (FAO): Haplic Luvisols/Alisols
(USDA):

Date: 01/09/2017
Profile description status: Routine profile description
coordinate (WSG84) N: 1301302
E: 405668

Location: Awuzet Azawurie kebele, Awuzet village

Author(s): Gebeyehu Belay

Land form: Valley bottom

Micro topography: None

Slope gradient: 1.5%

Slope class: 2

Slope form: Straight

Position: Middle slope

Slope aspect: East to west

Parent material: Pyroclastic

Human influence: Grazing

Salt status: None

Effective soil depth: 200cm

Moisture status: Moist throughout

Drainage class: Moderately well drained

External Drainage: Slow runoff

Land cover: Grass

Land use: Grazing land

Fertilizer: None

Erosion status: a. Site: None

b. Surrounding: None

* Water seepage at 80cm depth

PROFILE DESCRIPTION

AP 0-40cm Brown (7.5YR 4/3) moist; clay; weak medium granular; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine and few medium roots; common fine interstitial pores; non biological activities; clear and smooth boundary.

B 40-90cm Brown (7.5YR 5/2) moist; silty clay; moderate medium sub angular .blocky; slightly sticky and slightly plastic wet, friable when moist; none surface cracks none; none rock

fragments; non-cemented and non-compacted; few fine rounded shaped manganese mineral concretions; none calcareous; common fine roots; common fine interstitial pores; clear and smooth boundary.

BC 90-200cm Brown (7.5YR 4/2) moist; silty clay; strong coarse angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; few fine rounded shaped manganese mineral concretions; none calcareous; few fine roots; very few fine interstitial pores; non biological activities.

Profile number: FA6
Soil classification (FAO): Eutric Leptosols

(USDA):

Date: 01/09/2017

Profile description status: Routine profile description

coordinate (WSG84) N: 1301690

E: 405171

Location: Awuzet Azawurie kebele, 1km of west of Awuzet village

Author(s): Yirdaw Mekonen

Land form: High gradient hills

Micro topography: Terrace

Slope gradient: 30%

Slope class: 6

Slope form: Convex

Position: Middle slope

Slope aspect: Northeast to South west

Parent material: Pyroclastic

Human influence: Grazing and browsing

Salt status: None

Effective soil depth: 25cm

Moisture status: Moist throughout

Drainage class: Excessively drained

External Drainage: rapid runoff

Land cover: Plantation

Land use: Eucalyptus plantation

Fertilizer: None

Erosion status: a. Site: Severe sheet and rill erosion

b. Surrounding: Severe sheet and rill erosion

Map sheet:

Elevation (asl): 2934m

Depth to bedrock: >25cm

Rock out crops: Abundant

Surface cracks: None

Sealing/capping: None

Bleached sand: None

Flooding frequency: None

Flooding duration: None

Permeability: rapid

Surface stones & boulders: Many

Surface coarse fragments: None

PROFILE DESCRIPTION

AP 0-25cm Very dark (5YR 3/1) moist; sandy clay; weak fine granular; non-mottles; non sticky and non plastic when wet, friable when moist; none surface cracks none; few fine irregular shaped fresh rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; few fine roots; many fine interstitial pores; non biological activities; clear and smooth boundary.

Profile number: FW1
Soil classification (FAO): Vertic Luvisols
(USDA):

Date: 02/09/2017
Profile description status: Routine profile description
coordinate (WSG84) N: 1309984
E: 400670

Location: Wowa Mgera kebele,
about 1.5km east of Magera mariyam church

Author(s): Gebeyehu Belay

Land form: Valley bottom

Micro topography: Terrace

Slope gradient: 9%

Slope class: 4

Slope form: Straight

Position: Upper slope

Slope aspect: East to west

Parent material: Basalt

Human influence: Ploughing

Salt status: None

Effective soil depth: >165cm

Moisture status: Moist throughout

Drainage class: Well drained

External Drainage: Slow runoff

Land cover: Cultivated land of barley

Land use: Cultivated land

Fertilizer: None

Erosion status: a. **Site:** Severe sheet& rill and slight gully

b. **Surrounding:** Severe sheet& rill and slight gully

PROFILE DESCRIPTION

AP 0-20cm Dark brown (7.5YR 3/3) moist; clay loam; strong coarse sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine, common medium and few coarse roots; many medium size interstitial pores; non biological activities; clear and smooth boundary.

B 20-60cm Dark brown (7.5YR 3/2) moist; clay; strong coarse sub angular blocky; sticky and plastic wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concretions; none calcareous; many fine and few coarse roots; common fine interstitial pores; clear and smooth boundary.

Bt1 60-100cm Dark brown (7.5YR 3/2) moist; clay; strong coarse sub angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; few fine rounded shaped hard black colored manganese mineral concretions; none calcareous; few fine roots; very few fine interstitial pores; non biological activities.

Bt1 100-165+cm Very dark reddish brown (7.5YR 2.5/2) moist; clay; strong coarse angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; few fine rounded shaped hard black colored manganese mineral concretions; none calcareous; few fine roots; very few fine interstitial pores; non biological activities.

Profile number: FW2

Date: 07/09/2017

Soil classification (FAO): Dystric Regosols

Profile description status: Routine profile description

(USDA):

coordinate (WSG84) N: 1307904

E: 399799

Location: Wama Magera kebele,
about 200km east of magera Arsema church

Author(s): Gebeyehu Belay

Map sheet:

Land form: High gradient hills

Elevation (asl): 2675m

Micro topography: Terrace

Depth to bedrock: >25cm

Slope gradient: 23%

Rock out crops: Abundant

Slope class: 6

Surface cracks: None

Slope form: Irregular

Sealing/capping: None

Position: Middle slope

Bleached sand: None

Slope aspect: Northeast to South west

Flooding frequency: None

Parent material: Basalt

Flooding duration: None

Human influence: PLoughing

Permeability: rapid

Salt status: None

Surface stones & boulders: common

Effective soil depth: 25cm

Surface coarse fragments: None

Moisture status: Moist throughout

Drainage class: Excessively drained

External Drainage: Rapid runoff

Land cover: Cultivated field fo barley

Land use: Cultivated land

Fertilizer: None

Erosion status: a. **Site:** Severe sheet and rill erosion

b. **Surrounding:** Severe sheet and rill erosion

PROFILE DESCRIPTION

AP 0-25cm Dark reddish brown (5YR 3/2) moist; clay loam; moderate medium sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; few fine irregular shaped fresh rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many low size interstitial pores; non biological activities; Abrupt and smooth boundary.

Profile number: FW3
Soil classification (FAO): Haplic Luvisols/Alisols
(USDA):

Date: 06/09/2017
Profile description status: Routine profile description
coordinate (WSG84) N: 1308464
E: 399901

Location: Wawa Magera kebele, about 600m north of Arseima church

Author(s): Gebeyehu Belay

Land form: Ridge summit

Micro topography: Terrace

Slope gradient: 8%

Slope class: 4

Slope form: Irregular

Position: Middle slope

Slope aspect: West to east

Parent material: Pyroclastic

Human influence: Ploughing

Salt status: None

Effective soil depth: 60cm

Moisture status: Moist throughout

Drainage class: Well drained

External Drainage: Rapid runoff

Land cover: Harvested field of barley

Land use: Cultivated land

Fertilizer: None

Erosion status: a. Site: Severe sheet and rill erosion

b. Surrounding: Severe sheet and rill erosion

* Water seepage at 80cm depth

PROFILE DESCRIPTION

AP 0-40cm Dark brown (7.5YR 3/2) moist; clay loam; strong medium sub granular; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; common fine size interstitial pores; non biological activities; clear and smooth boundary.

Bt 40-40cm Dark brown (7.5YR 3/3) moist; clay; strong medium angular .blocky; sticky and plastic wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concretions; none calcareous; common fine roots; common fine size interstitial pores; clear and smooth boundary.

BC 40-60cm Brown (7.5YR 4/4) moist; clay loam; moderate medium sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; few coarse irregular shaped hard gravels; non-cemented and non-compacted; none mineral concretions; none calcareous; common fine roots; very few fine size interstitial pores; non biological activities.

Profile number: FW4
Soil classification (FAO): Eutric Fluvisols
(USDA):

Date: 06/09/2017
Profile description status: Routine profile description
coordinate (WSG84) N: 1309441
E: 399932

Location: Wawa magera kebele,
Near Debre Tabor University ground water well
Author(s): Gebeyehu Belay
Land form: Valley bottom
Micro topography: Terrace
Slope gradient: 6%
Slope class: 4
Slope form: Straight
Position: Middle slope
Slope aspect: East to west
Parent material: Alluvial deposit of Pyroclastic
Human influence: Grazing
Salt status: None
Effective soil depth: 140cm
Moisture status: Moist throughout
Drainage class: Moderately drained
External Drainage: Slow runoff
Land cover: Grazing and eucalyptus around homestead
Land use: Grass land
Fertilizer: None
Erosion status: a. Site: None
b. Surrounding: None

Map sheet:
Elevation (asl): 2557m
Depth to bedrock: >140cm
Rock out crops: Abundant
Surface cracks: None
Sealing/capping: None
Bleached sand: None
Flooding frequency: None
Flooding duration: None
Permeability: Slow
Surface stones & boulders: None
Surface coarse fragments: None

PROFILE DESCRIPTION

AP 0-20cm Very dark gray (7.5YR 3/1) moist clay; moderate medium sub angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many fine size interstitial pores; non biological activities; abrupt and smooth boundary.

1A 20-40cm Very dark gray (10YR 3/1) moist sandy clay; weak medium sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, very friable when moist; none surface cracks none; common medium rounded shaped fresh rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; common coarse size interstitial pores; non biological activities; clear and smooth boundary.

2A 40-60cm Dark brown (7.5YR 3/2) moist sandy loam; weak medium sub angular blocky; non-

mottles; non sticky and non plastic when wet, loose when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; common fine roots; common coarse size interstitial pores; high biological (termites) activities; abrupt and smooth boundary.

3A 60-90cm Very dark gray (10YR 3/1) moist clay; moderate medium angular blocky; non-mottles; sticky and plastic when wet, friable when moist; few distinct clay cutans; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; few fine roots; common coarse size interstitial pores; high biological (termites) activities; abrupt and smooth boundary.

4A 90-100cm Very dark gray (7.5YR 3/1) moist sandy loam; weak fine crumb; non-mottles; non sticky and non plastic when wet, very friable when moist; none surface cracks none; common fine and medium irregular shaped fresh rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; very few fine roots; common coarse size interstitial pores; non biological activities; clear and smooth boundary.

A10 0-140cm Dark brown (10YR 3/2) moist clay; moderate medium angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine size interstitial pores; non biological activities; abrupt and smooth boundary.

Profile number: FW5
Soil classification (FAO): Haplic Vertisols

(USDA):

Date: 06/09/2017

Profile description status: Routine profile description

coordinate (WSG84) N: 1311937

E: 399924

Location: Wawa magera kebele, wawa village

Author(s): Gebeyehu Belay

Land form: Plain

Micro topography: Gilgai

Slope gradient: 9%

Slope class: 4

Slope form: Straight

Position: Middle slope

Slope aspect: South to north

Parent material: Basalt

Human influence: Ploughing and grazing

Salt status: None

Effective soil depth: 105cm

Surface coarse fragments: Common CaCO₃

Moisture status: Moist throughout

Drainage class: Poorly drained

External Drainage: Slow runoff

Land cover: Grass

Land use: Grazing land

Fertilizer: None

Erosion status: a. Site: Severe gully

b. Surrounding: Severe sheet and rill and moderate gully

Map sheet:

Elevation (asl): 2498m

Depth to bedrock: >105cm

Rock out crops: None

Surface cracks: None

Sealing/capping: None

Bleached sand: None

Flooding frequency: None

Flooding duration: None

Permeability: Slow

Surface stones & boulders: None

PROFILE DESCRIPTION

AP 0-20cm Dark brown (7.5YR 3/3) moist; clay; strong medium sub angular blocky; non-common medium distinct mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many fine size interstitial pores; non biological activities; clear and smooth boundary.

A1 20-50cm Black (10YR 2/1) moist; heavy clay; strong medium sub angular .blocky; svery sticky and very plastic wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; few fine rounded sfte manganese nodules; none calcareous; common fine roots; many fine size interstitial pores; clear and smooth boundary.

A2 50-105cm Black (10YR 2/1) moist; heavy clay; strong medium angular blocky; non-mottles; very sticky and very plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concretions; none calcareous; very few fine roots; common fine size interstitial pores; non biological

activities.

Profile number: FH1
Soil classification (FAO): Haplic Luvisols/Alisols
(USDA):

Date: 07/09/2017
Profile description status: Routine profile description
coordinate (WSG84) N: 1310089
E: 397096

Location: Hiruy Aba aregawi kebele,
about 200m south of Hiruy giyorgis church

Author(s): Gebeyehu Belay

Land form: Plain

Micro topography: Terrace

Slope gradient: 4%

Slope class: 3

Slope form: Straight

Position: Middle slope

Slope aspect: Northeast to South west

Parent material: Pyroclastic

Human influence: Grazing and browsing

Salt status: None

Effective soil depth: 165cm

Moisture status: Moist throughout

Drainage class: Well drained

External Drainage: Slow runoff

Land cover: Grass land

Land use: Grazing

Fertilizer: None

Erosion status: a. Site: None

b. Surrounding: None

Map sheet:

Elevation (asl): 2622m

Depth to bedrock: 165cm

Rock out crops: None

Surface cracks: None

Sealing/capping: None

Bleached sand: None

Flooding frequency: None

Flooding duration: None

Permeability: moderate

Surface stones & boulders: None

Surface coarse fragments: None

PROFILE DESCRIPTION

AP 0-15cm Dark brown (7.5YR 3/2) moist; clay loam; strong medium sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many fine size interstitial pores; non biological activities; clear and smooth boundary.

A 15-45cm Dark brown (7.5YR 3/3) moist; clay loam; strong medium sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; common fine roots; many fine size interstitial pores; non biological activities; clear and smooth boundary.

Bt 45-65cm Dark brown (7.5YR 3/4) moist; clay; strong medium sub angular blocky; non-mottles;

sticky and plastic when wet, friable when moist; none surface cracks none; few distinct clay cutans; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; few fine roots; many fine size interstitial pores; non biological activities; clear and smooth boundary.

B 65-90cm Brown (7.5YR 4/4) moist; clay; strong medium sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; few medium rounded and black hard manganese mineral concentrations; none calcareous; common fine roots; many fine size interstitial pores; non biological activities; clear and smooth boundary.

BC1 90-128cm Dark brown (7.5YR 3/2) moist; clay; moderate fine and medium angular blocky; non-mottles sticky and slightly plastic when wet, friable when moist; few fine irregular shaped weathered rock fragments; none surface cracks; none; non-cemented and non-compacted; few medium rounded and black hard manganese mineral concentrations; none calcareous; common fine size interstitial pores; non biological activities; clear and smooth boundary.

BC2 128-165cm Very dark brown (7.5YR 2.5/2) moist; clay; weak medium angular blocky; non-mottles; sticky and slightly plastic when wet, friable when moist; none surface cracks none; few fine irregular shaped weathered rock fragments; non-cemented and non-compacted; few medium rounded and black hard manganese mineral concentrations; none calcareous; common fine size interstitial pores; non biological activities; clear and smooth boundary.

Profile number: FH2
Soil classification (FAO): Haplic Alisols

(USDA):

Date: 07/09/2017

Profile description status: Routine profile description

coordinate (WSG84) N: 1308009

E: 395785

Location: Hiruy Aba aregawi kebele,
about 500m south east of Aba aregawi church

Author(s): Gebeyehu Belay

Land form: Plain

Micro topography: Terrace

Slope gradient: 7%

Slope class: 4

Slope form: Irregular

Position: Middle slope

Slope aspect: South to north

Parent material: Basalt

Human influence: Ploughing

Salt status: None

Effective soil depth: 65cm

Moisture status: Moist throughout

Drainage class: Well drained

External Drainage: Moderate runoff

Land cover: cultivated land of beans

Land use: Cultivated land

Fertilizer: None

Erosion status: a. Site: Slight sheet and rill erosion

b. Surrounding: Slight sheet and rill erosion

*Soil profile digging stopped at 65cm because of stones and boulders.

PROFILE DESCRIPTION

AP 0-15cm Dark reddish brown (5YR 3/2) moist; clay; strong medium crumb; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; abundant stones and boulders; non-cemented and non-compacted; none mineral concentrations; none calcareous; common fine roots; many fine size interstitial pores; non biological activities; clear and smooth boundary.

Bt 15-65cm Dark brown (7.5YR 3/2) moist; clay; strong medium sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; abundant stones and boulders; non-cemented and non-compacted; none mineral concentrations; none calcareous; few fine roots; many fine size interstitial pores; non biological activities.

Profile number: FH3
Soil classification (FAO): Haplic Luvisols/Alisols
(USDA):

Date: 07/09/2017
Profile description status: Routine profile description
coordinate (WSG84) N: 1308218
E: 396046

Location: Hiruy Aba aregawi kebele,
about 300m south of Abune Aregawi church

Author(s): Gebeyehu Belay

Land form: Plateau

Micro topography: Terrace

Slope gradient: 12%

Slope class: 5

Slope form: Convex

Position: Upper slope

Slope aspect: West to east

Parent material: Basalt

Human influence: Ploughing

Salt status: None

Surface stones & boulders: Common stones & boulders **Surface coarse fragments:** None

Effective soil depth: 130cm

Moisture status: Moist throughout

Drainage class: Well drained

External Drainage: moderate runoff

Land cover: cultivated land of barley

Land use: cultivated land

Fertilizer: None

Erosion status: a. Site: Severe sheet and moderate rill erosion

b. Surrounding: Severe sheet and moderate rill erosion

Map sheet:

Elevation (asl): 2634m

Depth to bedrock: 130cm

Rock out crops: Few

Surface cracks: None

Sealing/capping: None

Bleached sand: None

Flooding frequency: None

Flooding duration: None

Permeability: moderate

PROFILE DESCRIPTION

AP 0-15cm Dark brown (7.5YR 3/3) moist; clay loam; strong medium sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many fine size interstitial pores; non biological activities; clear and smooth boundary.

A 15-45cm Dark brown (7.5YR 3/4) moist; clay; strong medium sub angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; common fine roots; many fine size interstitial pores; non biological activities;

gradual and smooth boundary.

- Bt₁ 45-75cm Brown (7.5YR 4/4) moist; clay; strong medium angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; few faint clay cutans; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; few fine roots; many fine size interstitial pores; non biological activities; clear and smooth boundary.
- Bt₂ 75-100cm Dark brown (7.5YR 3/4) moist; clay; strong medium sub angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; common distinct clay cutans; few medium irregular shaped weather gravels; non-cemented and non-compacted; none mineral concentrations; none calcareous; common fine roots; many fine size interstitial pores; non biological activities; clear and smooth boundary.
- BC100-130cm Dark brown (7.5YR 3/3) moist; clay loam; moderate fine and medium angular blocky; non-mottles sticky and plastic when wet, friable when moist; common medium irregular shaped weathered rock fragments; none surface cracks; none; non-cemented and non-compacted; few medium rounded and black hard manganese mineral concentrations; none calcareous; common fine size interstitial pores; non biological activities.

Profile number: FH4
Soil classification (FAO): Skeletic Leptosols

(USDA):

Location: Hiruy Aba aregawi kebele,
about 600m west of Abune Aregawi church

Author(s): Gebeyehu Belay

Land form: Plateau

Micro topography: Terrace

Slope gradient: 18%

Slope class: 6

Slope form: Convex

Position: Upper slope

Slope aspect: West to east

Parent material: Basalt

Human influence: Ploughing

Salt status: None

Surface stones & boulders: Common stones & boulders

Surface coarse fragments: common coarse gravels

Effective soil depth: 18cm

Moisture status: Moist throughout

Drainage class: Excessively drained

External Drainage: Rapid runoff

Land cover: Cultivated land of barley

Land use: cultivated land of wheat

Fertilizer: None

Erosion status: a. **Site:** Severe sheet and moderate rill erosion

b. **Surrounding:** Severe sheet and moderate rill erosion

Date: 07/09/2017

Profile description status: Routine profile
description

coordinate (WSG84) N: 1309251

E: 394178

Map sheet:

Elevation (asl): 2659m

Depth to bedrock: 18cm

Rock out crops: Few

Surface cracks: None

Sealing/capping: None

Bleached sand: None

Flooding frequency: None

Flooding duration: None

Permeability: Rapid

PROFILE DESCRIPTION

AP 0-18cm Dark brown (7.5YR 3/2) moist; clay loam; strong medium sub angular blocky; non-mottles slightly sticky and slightly plastic when wet, friable when moist; common medium size irregular shaped fresh stones and many fine to coarse irregular shaped fresh gravels; none surface cracks; none; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine pores; many fine size interstitial pores; non biological activities.

Profile number: FH5
Soil classification (FAO): Vertic Luvisols
(USDA):

Date: 07/09/2017
Profile description status: Routine profile description
coordinate (WSG84) N: 1312855
E: 396640

Location: Hiruy Aba aregawi kebele,
about 150m south of Gafat (Tewodros Gafat engineering site)

Author(s): Gebeyehu Belay

Land form: Plateau

Micro topography: Terrace

Slope gradient: 8%

Slope class: 4

Slope form: Straight

Position: Upper slope

Slope aspect: North to south

Parent material: Basalt

Human influence: Ploughing

Salt status: None

Surface stones & boulders: None

Effective soil depth: 110cm

Moisture status: Moist throughout

Drainage class: Well drained

External Drainage: moderate runoff

Land cover: cultivated land of barley

Land use: cultivated land

Fertilizer: None

Erosion status: a. **Site:** Severe sheet and moderate rill erosion

b. **Surrounding:** Severe sheet and rill erosion

Map sheet:

Elevation (asl): 2516m

Depth to bedrock: 110cm

Rock out crops: None

Surface cracks: None

Sealing/capping: None

Bleached sand: None

Flooding frequency: None

Flooding duration: None

Permeability: moderate

Surface coarse fragments: None

PROFILE DESCRIPTION

AP 0-12cm Dark brown (7.5YR 3/2) moist; clay loam; strong medium sub angular blocky; non-mottles; slightly sticky and slightly plastic when wet, friable when moist; none surface cracks none; few medium irregular shaped fresh stones; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many fine size interstitial pores; non biological activities; clear and smooth boundary.

AB 12-40cm Dark brown (7.5YR 3/3) moist; clay; strong medium sub angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; many fine roots; many fine size interstitial pores; non biological activities; clear and smooth boundary.

Bt₁ 40-60cm Dark brown (5YR 3/3) moist; clay; strong medium angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; common distinct clay cutans; none rock fragments; non-cemented and non-compacted; none mineral concentrations; none calcareous; few fine roots; many fine size interstitial pores; non biological activities; gradual and smooth boundary.

Bt₂ 60-110cm Brown (7.5YR 4/4) moist; clay; strong medium angular blocky; non-mottles; sticky and plastic when wet, friable when moist; none surface cracks none; few distinct clay cutans; few fine irregular shaped weather gravels; non-cemented and non-compacted; none mineral concentrations; none calcareous; few fine roots; many fine size interstitial pores; non biological activities; abrupt and smooth boundary.

Appendix B. Description of Augur Observation

AugerID	Kebele	X_LonDD	Y_LatDD	Z_Alti	SlpPosit	PM	Drain	D to BR	Rtbl D	LocalCls	WRBrsg	WRBpre1
AMSGGB_20170829.001	Atta sifatira	1305794	407687	2784	LS	IP1	SE	50	S	Chirecha	Regosol	Dystric
AMSGGB_20170829.002	Atta sifatira	1307496	407966	2740	MS	IP1	E	50	S	Chirecha	Regosol	Dystric
AMSGGB_20170829.003	Atta sifatira	1305289	408089	2783	MS	IP1	E	50	S	Chirecha	Regosol	Dystric
AMSGGB_20170829.004	Atta sifatira	1305121	408011	2800	MS	IP1	E	60	S	Chirecha	Regosol	Dystric
AMSGGB_20170829.005	Atta sifatira	1303914	409110	2821	UP	IP1	M	100	M	Debay afer	Fluvisol	Eutric
AMSGGB_20170829.006	Atta sifatira	1306814	408180	2784	UP	IP1	E	30	VS	Chirecha	Regosol	Eutric
AMSGGB_20170829.007	Atta sifatira	1306423	407497	2800	MS	IP1	SE	40	S	Key Afer	Luvisols	Haplic
AMSGGB_20170829.008	Atta sifatira	1306216	407618	2783	MS	IP1	I	>110	D	Key Afer	Luvisols	Vertic
AMSGGB_20170829.009	Atta sifatira	1304439	410147	2947	UP	IP1	E	10	VS	Chirecha	Leptosol	Lithic
AMSGGB_20170829.010	Atta sifatira	1304769	410392	2916	LS	IP1	E	10	VS	Chirecha	Leptosol	Lithic
AMSGGB_20170830.001	Atta sifatira	1301732	403976	2963	UP	IP1	E	25	VS	Chirecha	Regosol	Dystric
AMSGGB_20170830.002	Atta sifatira	1304074	409304	2852	MS	IP1	M	40	S	Key Afer	Luvisol	Haplic
AMSGGB_20170830.003	Atta sifatira	1301612	408433	2925	LS	IP1	W	100	M	Key Afer	Luvisol	Haplic
AMSGGB_20170830.004	Atta sifatira	1301719	409181	2958	MS	IP1	E	25	VS	Chirecha	Regosol	Dystric
AMSGGB_20170830.005	Atta sifatira	1301653	409059	2678	MS	IP1	I	120+	D	Key Afer	Luvisol	Vertic
AMSGGB_20170830.006	Atta sifatira	1301655	408895	2942	MS	IP1	E	25	VS	Chirecha	Regosol	Dystric
AMSGGB_20170831.001	Atta sifatira	1302357	408545	2885	MS	IP1	M	60	M	Key Afer	Luvisol	Haplic
AMSGGB_20170831.002	Awuzet Azawurie	1301073	405705	2893	MS	IP1	W	>120	D	Key Afer	Luvisol	Haplic
AMSGGB_20170831.003	Awuzet Azawurie	1301612	405302	2893	LS	IP1	M	>120	D	Tikur Afer	Gleysol	Eutric
AMSGGB_20170831.004	Awuzet Azawurie	1301860	405340	2921	LS	IP1	W	>120	D	Bunie Afer	Cambisol	Dystric
AMSGGB_20170831.005	Awuzet Azawurie	1301556	405580	2879	LS	IP1	M	>120	D	Debay afer	Fluvisol	Eutric
AMSGGB_20170831.006	Awuzet Azawurie	1300033	405803	2975	MS	IP1	W	>120	D	Bunie Afer	Cambisol	Eutric
AMSGGB_20170831.007	Awuzet Azawurie	1300693	405867	2926	UP	IP1	W	>120	D	Bunie Afer	Cambisol	Eutric
AMSGGB_20170831.008	Awuzet Azawurie	1301868	405241	2949	UP	IP1	E	15	VS	Chirecha	Leptosol	Dystric
AMSGGB_20170831.009	Awuzet Azawurie	1301507	408495	2948	UP	IP1	M	110	D	Key Afer	Luvisol	Vertic

AMSGGB_20170831.010	Awuzet Azawurie	1301631	407801	2955	MS	IP1	W	110	D	Key Afer	Alisols	Haplic
AMSGGB_20170831.011	Awuzet Azawurie	1300151	407299	2984	UP	IP1	W	65	M	Key Afer	Alisols	Haplic
AMSGGB_20170831.012	Awuzet Azawurie	1299343	407058	3093	MS	IP1	W	55	M	Bunie Afer	Cambisol	Luvic
AMSGGB_20170831.013	Awuzet Azawurie	1299719	407178	3029	MS	IP1	W	110	D	Key Afer	Luvisol	Vertic
AMSGFA_20170902.001	Wawa Magera	1307844	399760	2649	MS	IP1	E	30	VS	Chirecha	Regosol	Dystric
AMSGFA_20170902.002	Wawa Magera	1308268	399814	2598	UP	IP1	M	70	M	Bunie Afer	Cambisol	Eutric
AMSGFA_20170902.003	Wawa Magera	1309068	399933	2567	MS	IP1	P	>120	D	Tikur Afer	Vertisol	Pellic
AMSGFA_20170902.004	Wawa Magera				UP	IP1	SE	80	M	Bunie Afer	Cambisol	Eutric
AMSGFA_20170902.005	Wawa Magera	1311277	401890	2654	MS	IP1	P	70		Key Afer	Luvisol	Haplic
AMSGFA_20170902.006	Wawa Magera	1310569	401006	2613	MS	IP1	W	110		Key Afer	Luvisol	Vertic
AMSGFA_20170906.001	Wawa Magera	1308921	397893	2621	MS	IP1	P	>120	D	Tikur Afer	Vertisol	Haplic
AMSGFA_20170906.002	Hiruy Aba Aregawi	1309187	397364	2623	MS	IP1	P	>120	D	Tikur Afer	Vertisol	Haplic
AMSGFA_20170906.003	Hiruy Aba Aregawi	1309580	397632	2649	UP	IP1	E	25	VS	Chirecha	Leptosol	Dystric
AMSGFA_20170906.004	Hiruy Aba Aregawi	1310027	397772	2625	MS	IP1	W	80	m	Key Afer	Luvisol	Haplic

