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Towards Sustainable Management of Chamo Lake-Wetland Biodiversity Resources: Geospatially Supported Approach

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Presentation outline

- Introduction
- Material and Methods
- Result and Discussion
- Conclusion and Recommendations

Introduction

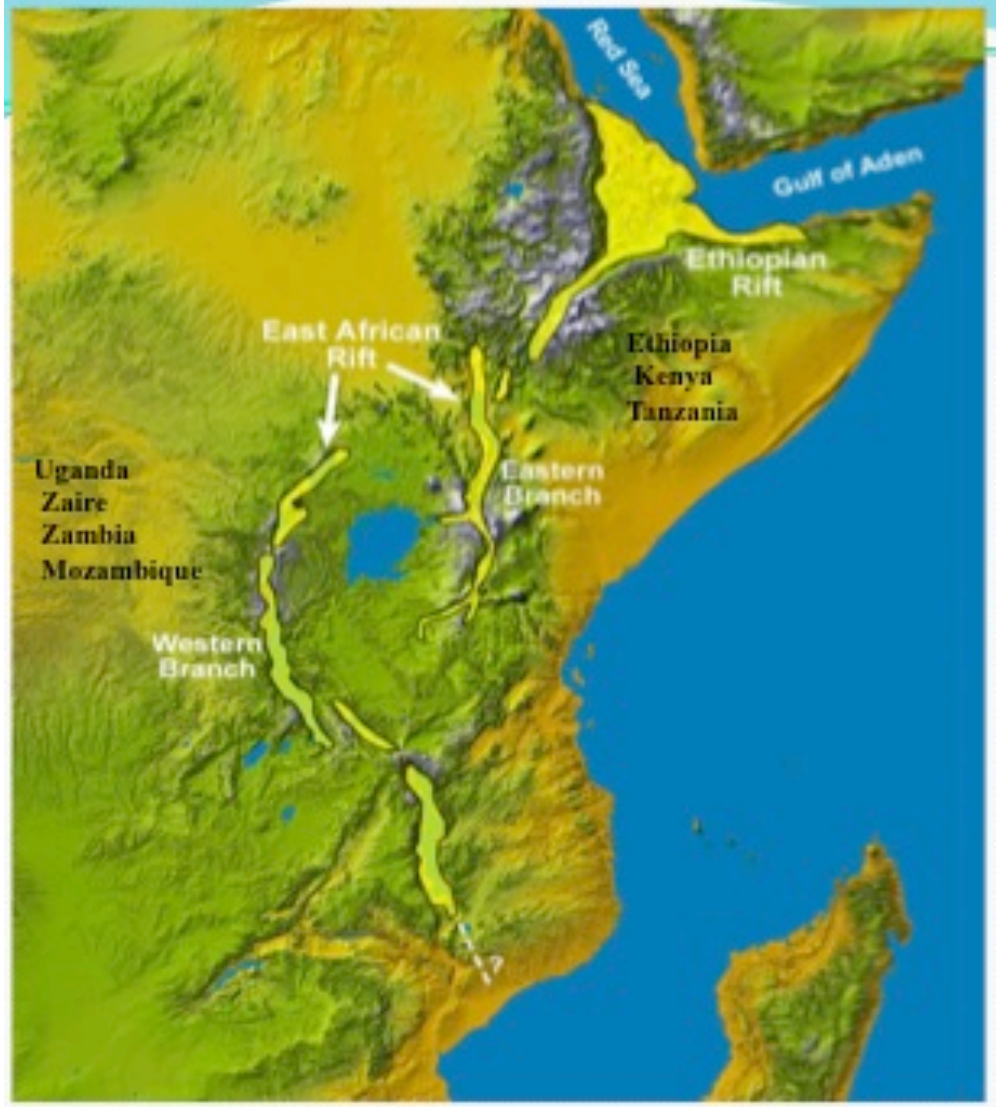
- There are about **5.3 million lakes** in the globe with a size greater than **one hectare**

- **Lakes of the world contain 90 percent of the liquid freshwater on the earth's surface**

- **In Africa, the majority of lakes are concentrated along the great east African rift valley.**

- **The east African rift valley possesses eastern and western arms**

Meybeck 1995; Shiklomanov 1993



- A series of more than thirty lakes are found along the length of NNE to SSW orientation.

- The **Eastern segment** lakes (North to south):

Assal, Afrera, Abhe, Afambo, Gemari, Yardi, Beseka, Koka, Zuway, Langano, Abyata, Shalla, Awassa, Abaya, **Chamo,** ChewBahir, Turkana, Baringo, annington, Nakuru, Elmeneteita, Naivasha, Magadi, Natron, Manyara and Eyasi.

- The **western wing** of rift valley include:

Albert, Edward, Kivu, Tanganyka, and Malawi

Nilsson 1940; Wood and Talling 1988; Hallemichael 2000; Alemayehu et al. 2006; Ayalew 2009).

Figure 1. Eastern and western segments of the east African rift (general) ,
(Source: http://geology.com/articles/east-africa-rift.shtml),

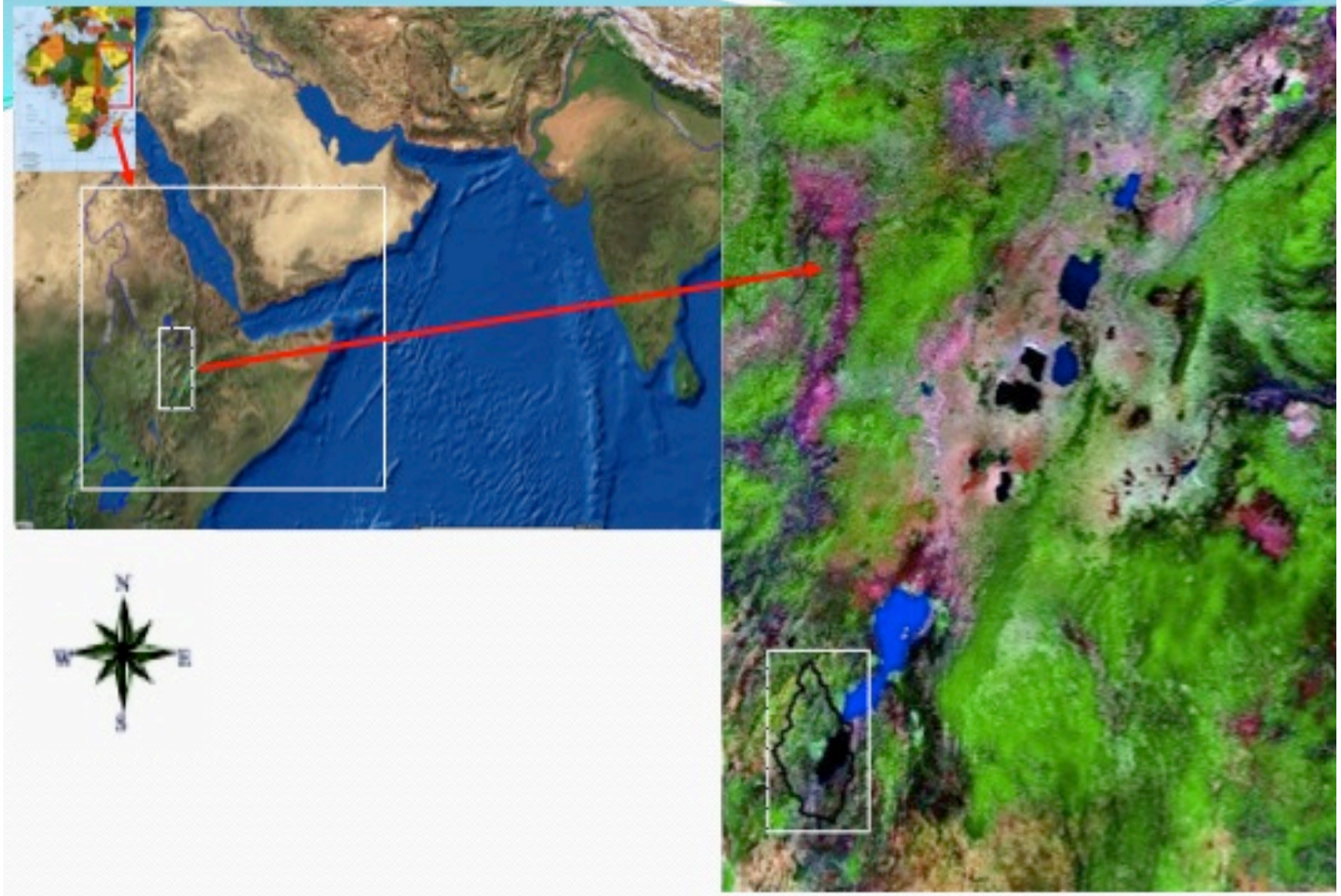


Figure 2. Chains of lakes along the Ethiopian rift valley (from mosaiced satellite image)

- Lake Chamo is among diversified, productive and economically important lakes of Ethiopian rift valley.

- The lake is known for its **hospitality** to maintain and preserve nilotic species that were supposed to be remained at the time of connected river network of **Abaya-Chamo-Chew Bahir-Turkana-Nile basin**

- Nevertheless, the lake-wetland ecosystem is in peril because of human induced local and global effects

Objectives

- Analyze long-term lake level changes and its repercussions on water chemistry, productivity and overall lake-wetland ecosystem
- Examine the floristic composition and role of the existing wetland, riverine and terrestrial vegetation cover under natural and impacted condition.
- Explore threats of lake-wetland ecosystem utilization traditions
- Suggest an environmentally friendly spatially oriented environmental planning for sustainable utilization and maintenance of biodiversity resource.

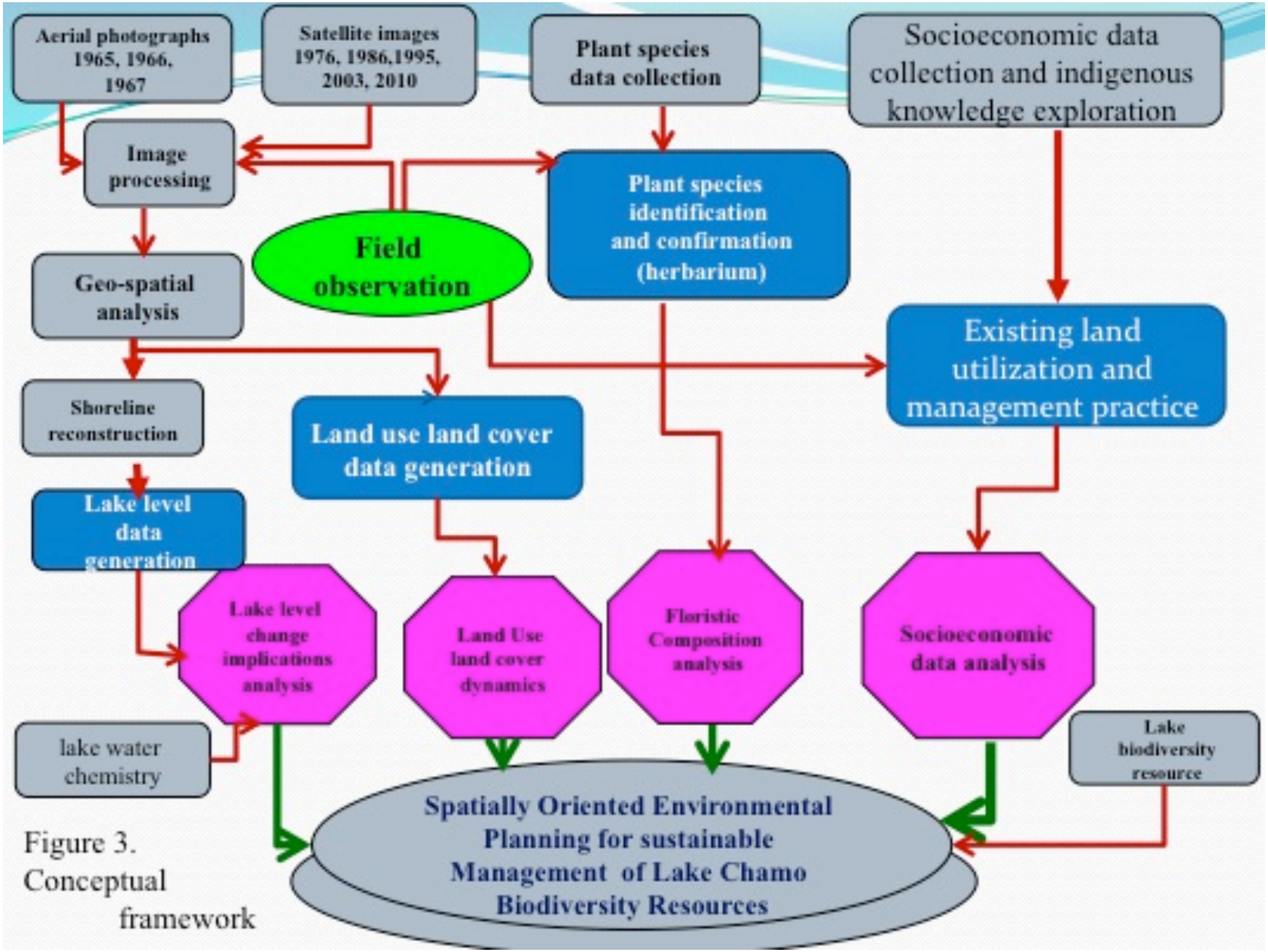


Figure 3. Conceptual framework

2. Material and Methods

The study area location and relief profile

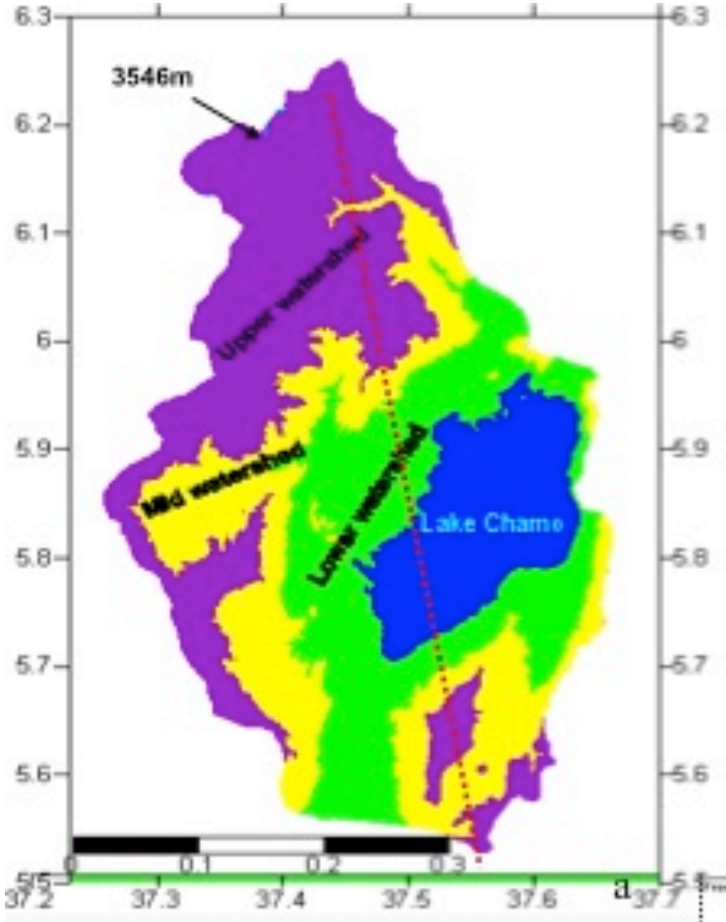
❖It covers an area of about 2205 sq. km with 80 km length and 50 km width.

❖The GPS coordinates for the watershed

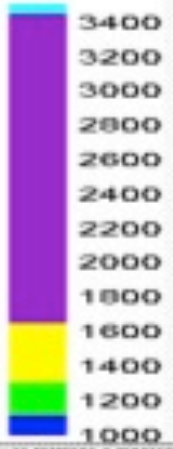
- 37°13' 18E to 37°40' E longitude
- 05°32' N to 06°55' N latitude.

❖The lake watershed is situated at an altitude ranging:

- 1,105 m ASL (lake level)
- 3,546 m ASL (tip of Gamo Highlands



3546m asl
1105 asl
2441m
39 km



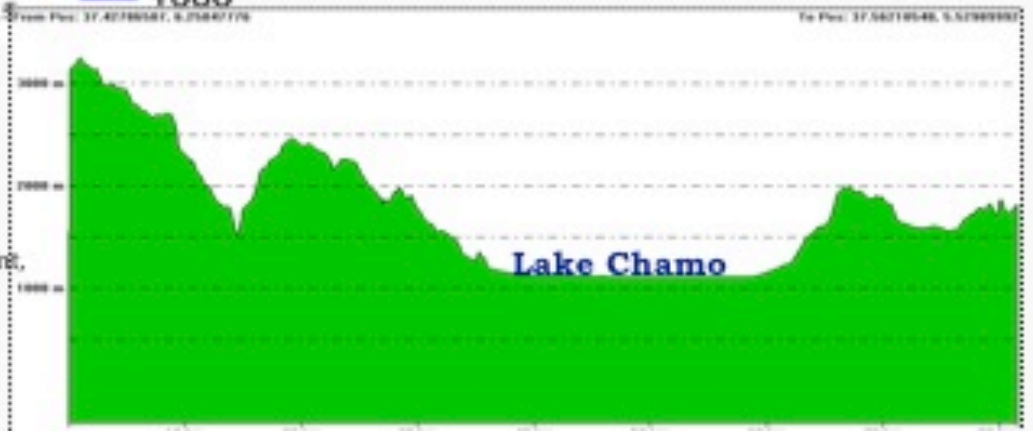


Figure 4

a. Lake Chamo watershed zones along altitudinal gradient,

b. Relief profile of lake Chamo watershed

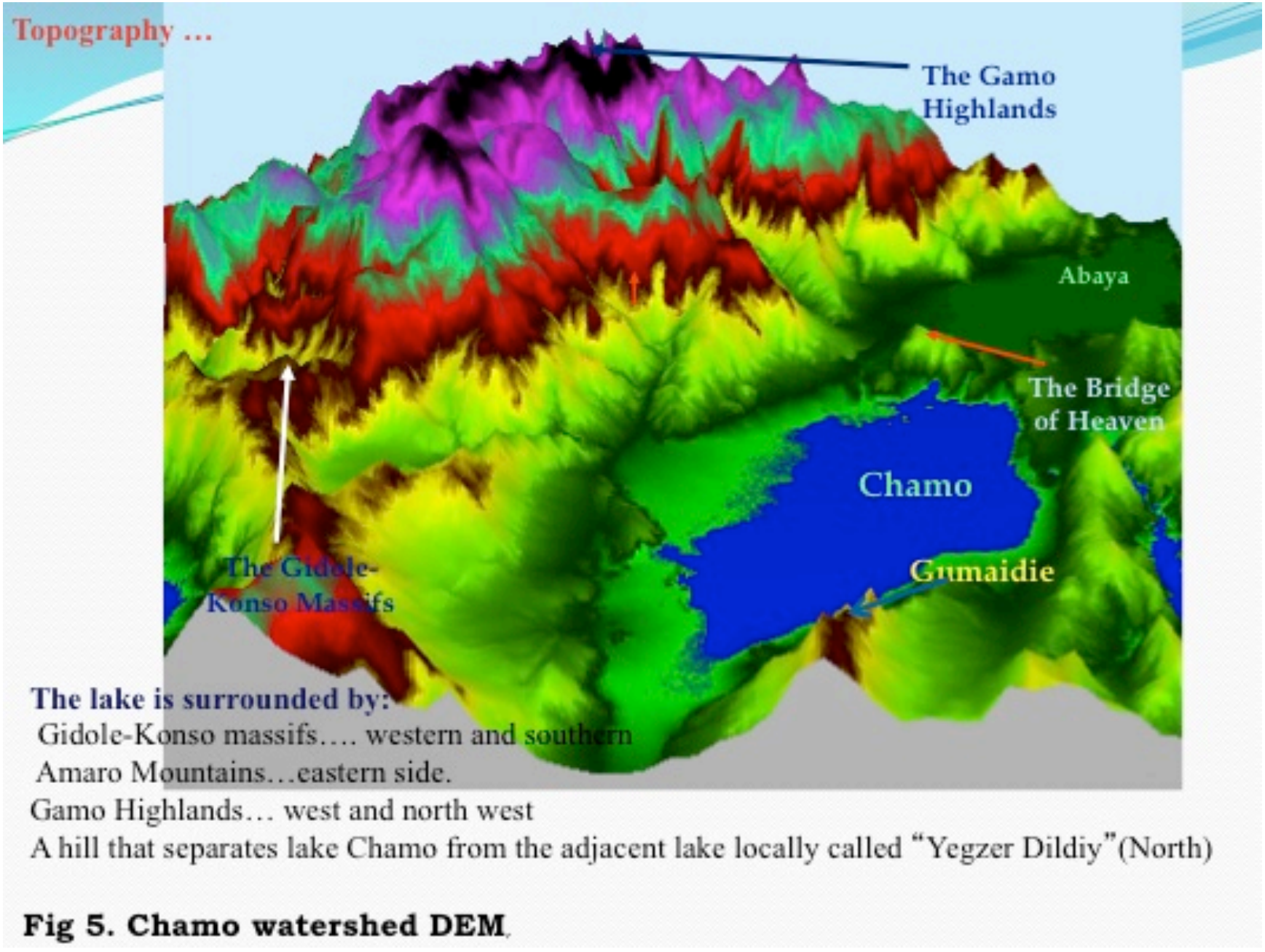
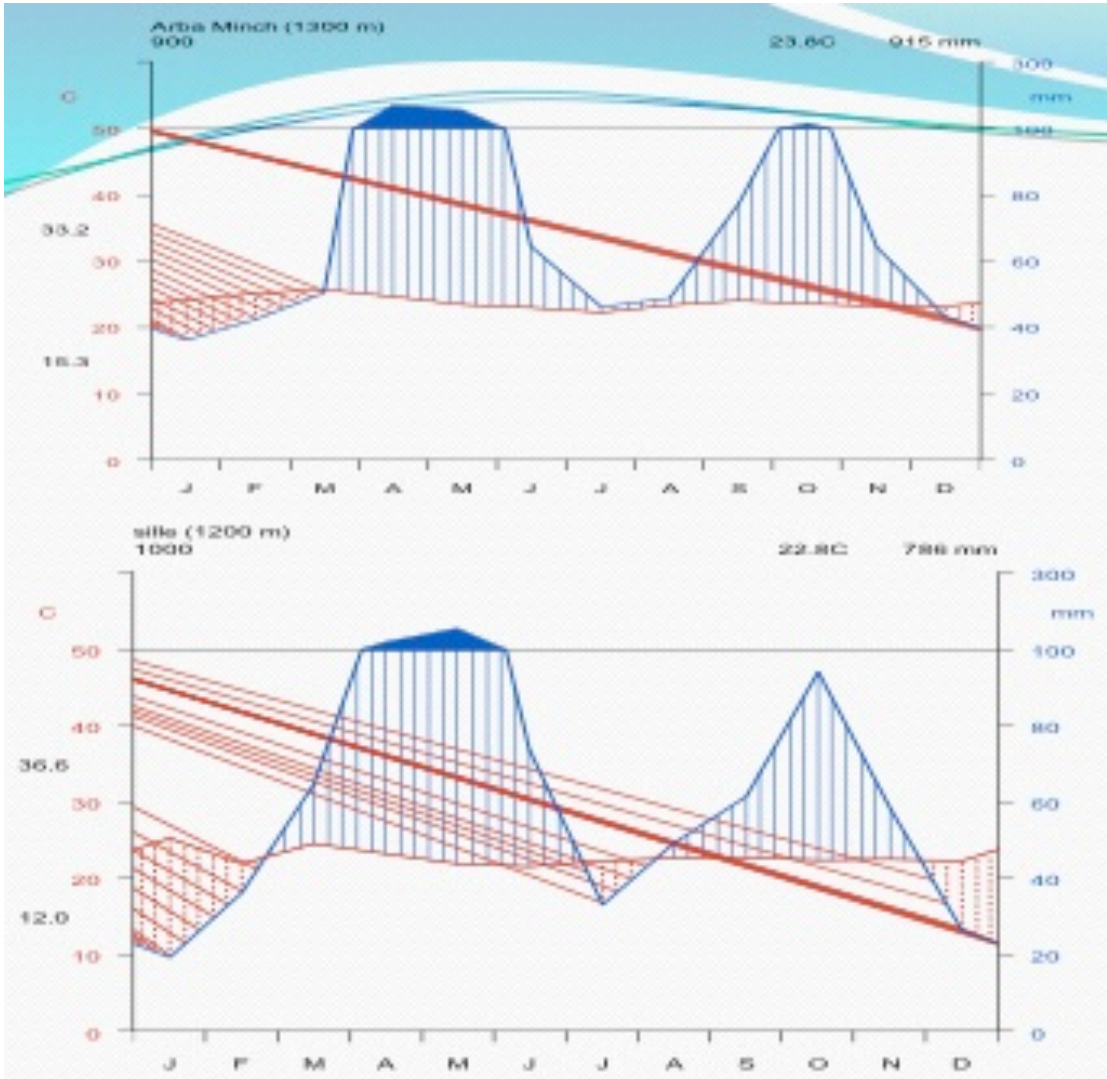


Fig 5. Chamo watershed DEM



Climate ....

- In lake Chamo watershed, the climate type varies from semi-arid to afro-alpine.
- The rainfall varies along the altitudinal gradient.
- Rainfall pattern **is bimodal** type characterized by two peak rainy seasons
- April-May and September-October

Figure 6 aClimate diagram of lake Chamo region a. Arba Minch station (ENMSA), b. Sille station (ENMSA)

Soil …

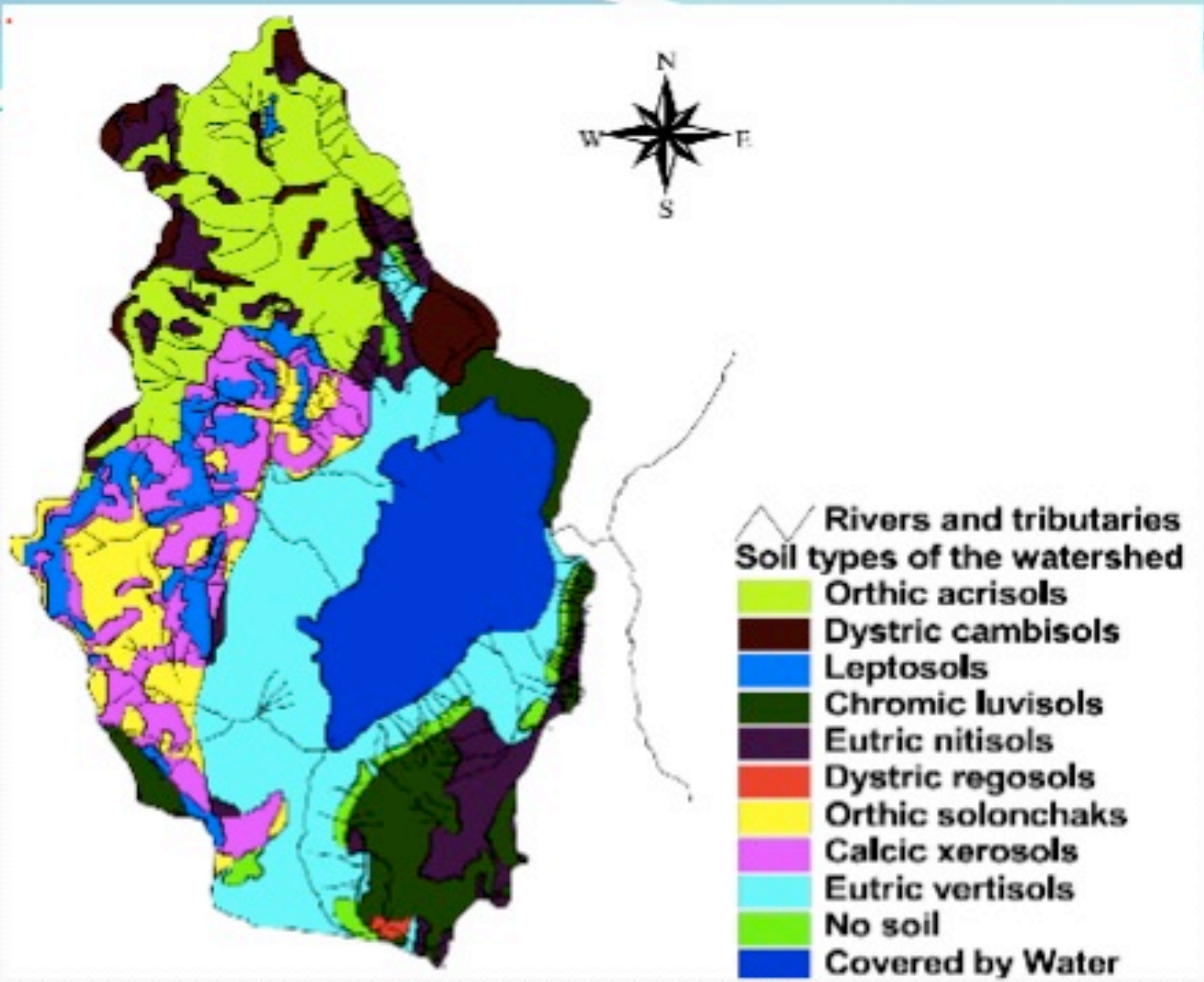
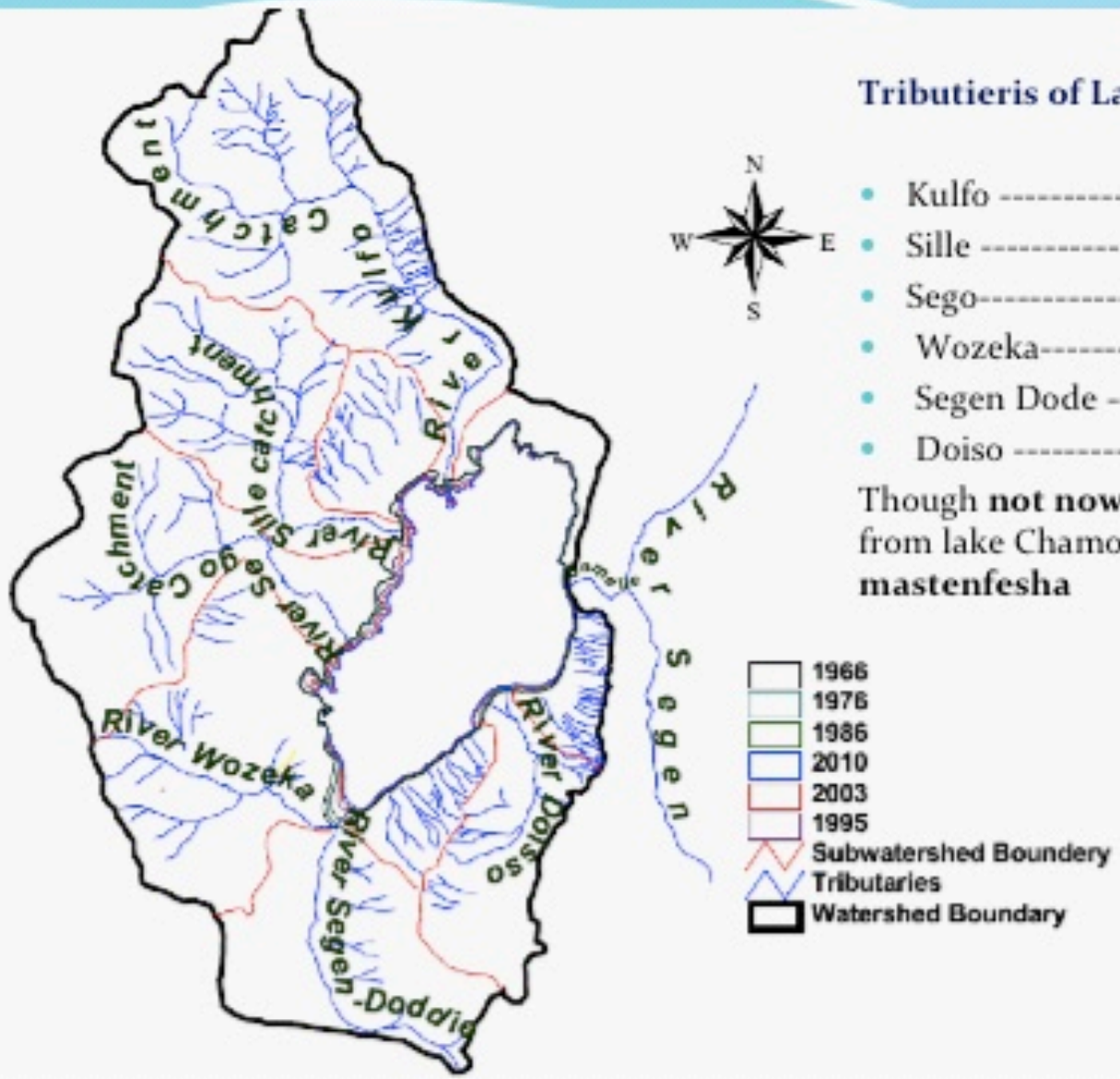


Figure 7. Soil map of lake Chamo watershed mapped from Core ETHIO-GIS Data Sets



Tributieris of Lake chamo

- Kulfo ----------Gamo highlands.
- Sille ---------- Bonke.
- Sego---------- Zeysie and Geresse
- Wozeka----------Gidole
- Segen Dode -----Gumaide
- Doiso ----------Gumaide and Abulo

Though **not now**, there was outflow from lake Chamo to Segan river through **mastenfesha**

Figure 8. Hydrological network and catchments of lake Chamo watershed

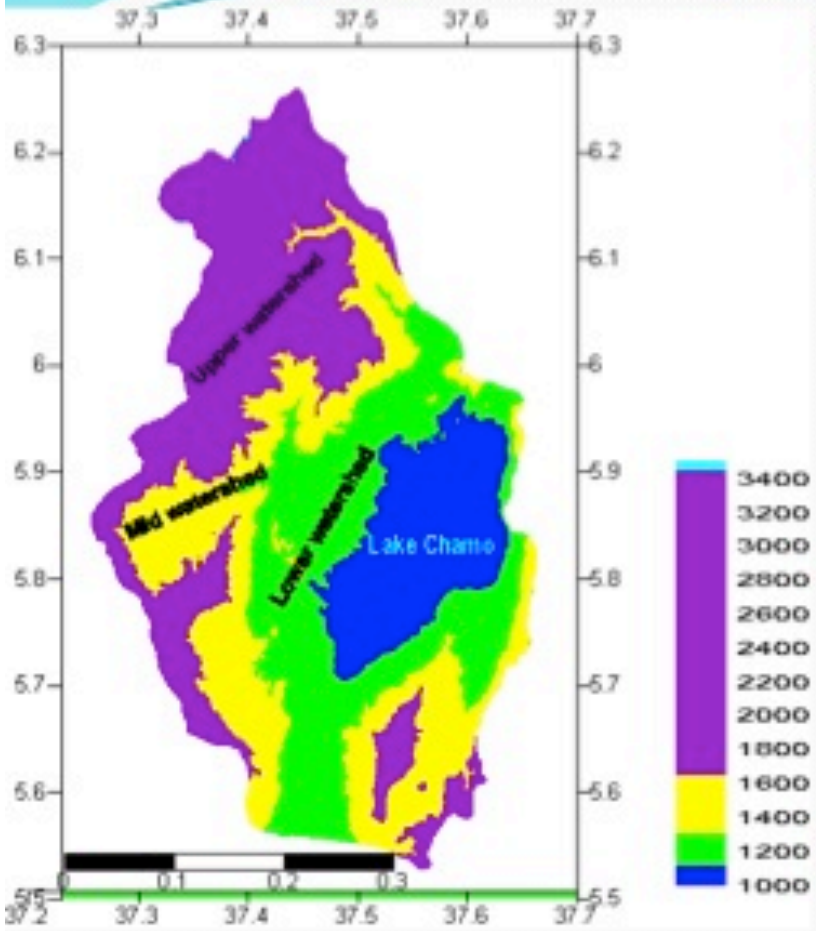


Figure 9. Lake Chamo watershed zones along altitudinal gradient

Farming practices:

- Altitude and resource availability determines the farming practice of the community
- The lower watershed zone community
  - densely populated and intensive agriculture is practiced.
  - Cotton, maize, banana plantations dominate the area
  - The state farms of AM, Sille, Elgo and Wozeka in the plain area adjacent to the lake are irrigable
- In the mid watershed zone(worm transition zone)
  - crops like maize, *teff* and sorghum are widely grown.
  - Cash crop plantations like Chat and Coffee are grown.
- The upper watershed zone community
  - grows barley and wheat among cereals and potato from tubers.
  - *Enset* (*Ensete ventricosum)* is commonly grown in this zone.

Biodiversity resources of the lake watershed

- **Aquatic biodiversity and faunal resources:**

Lake Chamo is typically **eutrophic.**

It is known for its diversified ichthyofauna of about **18 fish species** (Golubtsov and Habteselassie 2010).

The **commercially important fish species** of the Chamo lake include *Lates niloticus Oreochromis niloticus, Clarias gariepinus, Labeo horie* and *Barbus* sp.

- The lake-wetland is a place where **thousands** of *Crocodylus niloticus* and **hundreds of** *Hippopotamus amphibious* and a **variety of birds live in harmony**

Table 16 biodiversity resources of lake chamo

[a]Phytoplankton	[b]Zooplankton and Zoobenthos	[c]Fish	[d]Reptiles	[e]Birds	[f]Mammals
Cyanophyta *Anabaena* *Microcystis* *Oscillatoria* *Lyngbya* *Merismopedia* *Chrococcus* *Spirulina* *Anabaenopsis* *Aphanizomenon* Chlorophyta *Cosmarium* *Scenedesmus* *Chlorella* *Tetraaedron* *Oocystis* *Coelost* *Ankistrodesmu* *Cosmarium* Bacillariophyta *Navicula* *Nitzschia* *Cyclotella* *Pennularia* *Melosira* *Rhopaldi* *Cymbella*	Copepoda *Thermocyclops* sp. *Eucyclops* sp. Cladocera *Moinamicrura* *Ceripdaphnia* sp. *Daphnia magna* Rotifera *Brachionus calyciflorus* *B. caudatus* *B.urceolaris* *Filinia opoliensis* *F. terminalis* *Anureopsis fissa* *Polyarthra vulgaris* Zoobenthos Chironomidae Coleptera Hydroptilidae Odonata Zygoptera Anisoptera Hemiptera Notonectidae Corixidae	*Lates niloticus* *Oreochromis niloticus* *Clarias gariepinus* *Bagrus docmak* *Mormyrus caschive* *Hydrocynus forskahlii* *Barbus kerstenii* *Barbus stigmatopygus* *Barbus* sp. *Garra hirticeps* *G. quadrimaculata* *Labeo cylindricus* *L. horie* *L. niloticus* *Labeobarbus bynni* *L. intermedius* *Synodontis schall* *Aplocheilichthys antinorii*	*Crocodylus niloticus*	*Leptoptilus ruminiferous* *Pelicanus onocrotalus* *Phalacrocorax carbo* *Threskiornis aetiopicus* *Haliaetus vocifer* *Alopochus aegyptica.*	*Hippopotamus amphibious*

Figure 22. Lake Chamo resources a. *Lates niloticus,* b. *Oreochromis niloticus,* c. *Bargus docmak,* d. *Barbus intermedius,*

Figure 23 a. *Crocodylus niloticus, b.Pelicanus onocrotalus c. Hippopotamus amphibious, d. Equus burchellii, e. Gazella granti*

2.2 Methodology

1. Lake level (Surface area coverage)

- Aerial photographs and satellite imageries were used to assess the long-term *(last 45 years)* trend of Chamo lake level changes. (EMA)
- The aerial photographs were scanned in 600 DPI.
- Following digitization, the soft copies were geo-referenced and clipped for suitable mosaicing.
- Finally, the image was processed using appropriate software ERDAS imagine for the required information.

- Multi-temporal satellite images of the lake Chamo region for the period from **1972 to 2010** were obtained from **NASA through GLCF.**

- For consistency of information
  - **All same season (almost January)** to avoid biases associated with seasonal fluctuation

  - **Cloud free satellite images-** to avoid haze effect.

- The area of lake surface coverage was measured using utility measurement tool in **ERDAS imagine 9.1.**

3. Geo-spatial analysis of lake level changes

Table 3. Satellite imageries used for land use and land cover dynamics analysis

Date of record	Sensor	Raw and path	Image ID
January1965,1966 and 1967	Aerial photo		R-144 (4), R-173(3), R-206(6), R-207(1),R-255(2), R-365(2)
December 8, 1972	MSS	181-56	LM1181056197234 3AAA04
January 25 , 1976	MSS	181-56	LM2181056197602 5AAA05
December 8, 1984	MSS	181-56	LM5169056198434 3AAA03
January 28, 1986	TM	169-56	LT5169056198602 8XXX03
December 14, 1989	TM	169-56	LM4169056198934 8AAA03
January 21, 1995	TM	169-56	LT5169056199502 1XXX02
January 27, 2000	ETM+ on	169-56	LE7169056200002 7EDC00
February 4, 2003	ETM+ on	169-56	LE7169056200303 5SGS00
January 26, 2005	ETM+ off	169-56	LE7169056200536 0ASN00
January 6, 2008	ETM+ off	169-56	LE7169056201000 6ASN00
January 30, 2010	TM	169-56	LT5169056201003 0MLK00

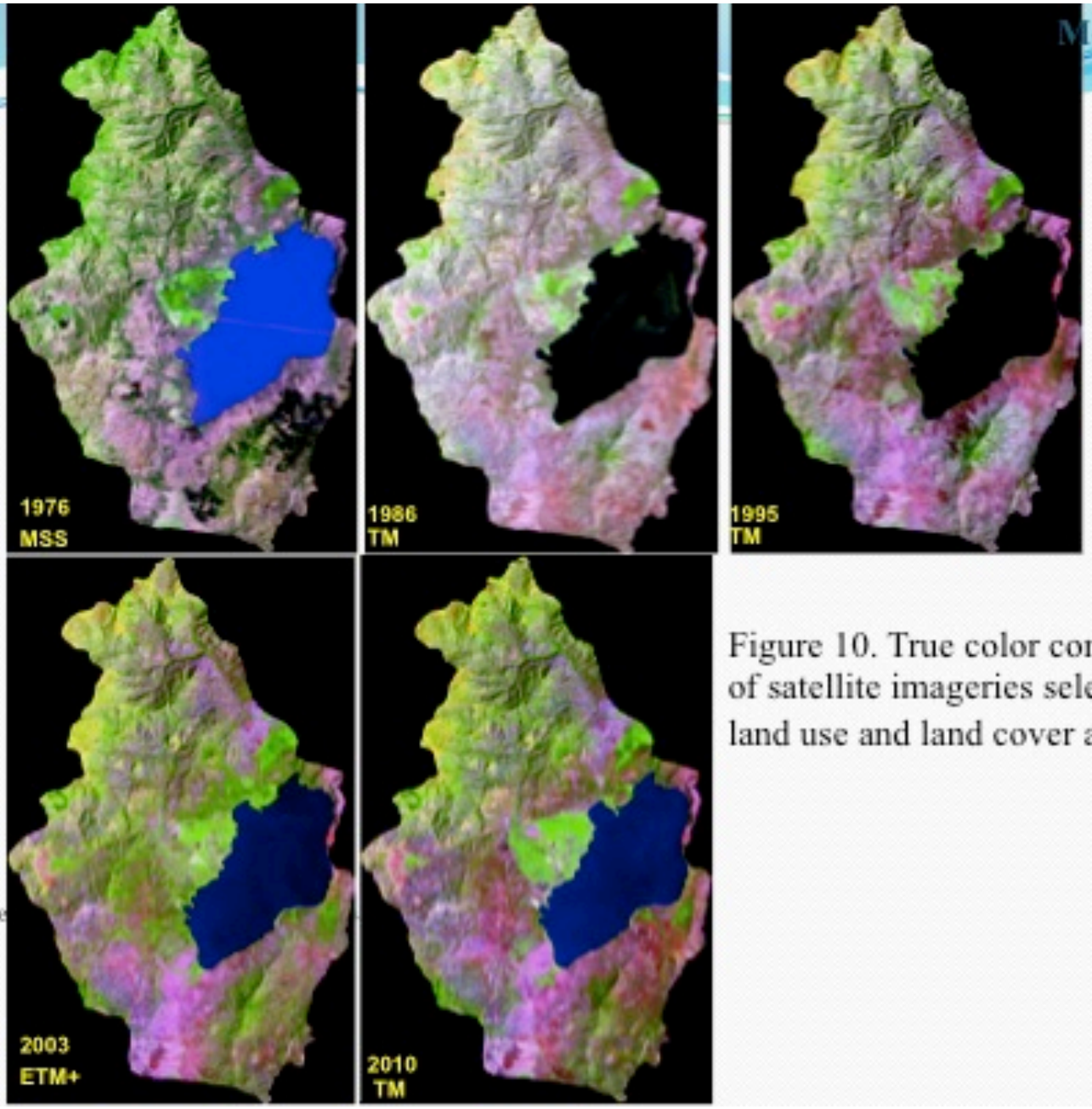


Figure 10. True color composite of satellite imageries selected for land use and land cover analysis.

2. **Lake water chemistry**:

- **Multi-temporal secondary data** were collected from **1938 to 2010.**
- The collection was made exhaustibly to address most remote back environmental conditions of the lake limnology
  - physico-chemical
  - biological aspects of the aquatic environs.

Floristic Composition Analysis

- A reconnaissance was made to select **representative vegetation of the lake outskirt.**
- Two pairs of transects were selected
- Each pair contains riverine vegetation and vegetation consisting wetland and terrestrial species.
- The rivers selected for this purpose were
- Kulfo (untouched/protected portion of the sampling process)
- Sille. (encroached/impacted portion of the sampling process)

- In both the cases, **20 meters by 20 meters (400 sq. m)** **quadrants** were laid every 100 meter distance(from the lake margin (shore).
- **Best samples** of **leaves, flowers, and fruits** of plant species were collected for identification
- The samples were **pressed on-site using** standard plant press with ample information
- Finally, the samples were transported to **Arba Minch University** for identification and to **Addis Ababa university** herbarium for further confirmation.

Figure 11. Sample collection and on-site pressing process for vegetation composition analysis

3. Result and Discussions

3.1 Spatio-temporal analysis of lake level changes

- The maximum recorded surface area coverage of lake Chamo cited in many research works is **551 sq. km**

(Grove et. al. 1975; Kebede et. al. 1994; Gebremariam 2002; Bekele 2006).

- Considering the above lake aerial coverage, the present study indicates that the lake size shrunk **by 46.02%.**

- **The level of lake Chamo for the last 45 years was found to be significant.**

- **The study showed that Chamo has shrunk by 14.42% (50.12 sq. km) of the lake surface area that was in 1965.**

Table 6. Result showing temporal lake level changes

Date of record	Sensor	Image ID	Lake area In sq. km	Perimeter in km	Max length in km	Max width in km
Unknown	Topo Sheet 2,3	DOS 1:250,000 rift valley lakes basin project planning map.	551	-	26	22
January1965,1966 and 1967	Aerial photo	R-144 (4), R-173(3), R-206(6), R-207 (1),R-255(2), R-365(2)	347.57	102.55	30.791	20.99
December 8, 1972	MSS	LM1810561972343AAA04	338.36	102.30	30.69	20.79
January 25 , 1976	MSS	LM2181056197602 5AAA05	339.49	102.88	30.72	20.92
December 8, 1984	MSS	LM5169056198434 3AAA03	333.22	105.82	30.57	20.77
January 28, 1986	TM	LT5169056198602 8XXX03	331.79	108.03	30.27	20.72
December 14, 1989	TM	LM4169056198934 8AAA03	322.40	14.76	29.91	20.52
January 21, 1995	TM	LT5169056199502 1XXX02	314.28	105.17	29.67	20.46
January 27, 2000	ETM+ on	LE7169056200002 7EDC00	313.49	105.78	29.66	20.39
February 4, 2003	ETM+ on	LE7169056200303 5SGS00	304.44	100.55	29.46	19.92
January 26, 2005	ETM+ off	LE7169056200536 0ASN00	298.56	97.3	29.86	19.33
January 6, 2008	ETM+ off	LE7169056201000 6ASN00	299.61	97	29.3	19.2
January 30, 2010	TM	LT5169056201003 0MLK00	297.45	97.74	29.29	19.41