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Species diversity, distribution, and composition of wetland plants in North Shewa Zone of Oromia region, Ethiopia

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Research Article

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Abstract

Wetland species diversity, distribution, and composition greatly varied from time to time and from one place to another. Plant species diversity and distribution of wetlands were studied in four areas of the North Shewa zone of Oromia region, Ethiopia, to assess plant species diversity, distribution, and community composition of the study wetlands. Four wetland sites were surveyed using quadrats along transects in each wetland to estimate the total coverage of each plant species. The obtained data of 12 Transects (three transects/site) and 120 quadrats (30 quadrats/site) were arranged in MS Excel for the analyses. Vegetation data analysis, statistical tools, diversity indices, Cluster analysis, and parametric tests were done. Among the total of 60 plant species identified, the most dominant and diverse family of the studied wetland plant was Poaceae, contributing about 11, 10, 10, and 13 species in Chancho, Sululta, Holeta, and Sendafa sites, respectively. The next families considered as co-dominant were Asteraceae, Cyperaceae, Lamiaceae, and Fabaceae families in Chancho, Sululta, Holeta, and Sendafa sites, respectively. The diversity (richness) of 120 total quadrats from all the studied wetlands was 60. The species richness distribution of the five vegetation communities of 120 total quadrats of the study area was ranged from 43 (24.29%) species in each 40 quadrats, 40 (22.60%) species in each 27 quadrats, 27 (15.25%) species in each 21 quadrats, 37 (20.90%) species in each 19 quadrats, and 30 (16.95%) species in each 12 quad rats. Similarly, the highest percentage of plant diversity was recorded for Sendafa and Holeta, which shows the presence of 46 (31.08%) and 36 (24.33%) plant species, followed by Chancho and Sululta sites, that shows the presence of 35 (23.65%) and 31 (20.95%) species respectively. Out of the five wetland vegetation communities, about two groups, one that is wholly dominated by Cyperus rigidifolius Steud, and the other group is dominated by Schoenus nigricans L. The third group is dominated by Eleocharis marginulata Hochst. ex A. Steud. Followed by Festuca simensis Hochst. ex A. Richand Heliotropium ceylanicum (Burm f.) Lam as a fourth and fifth dominating species, respectively. The species diversity, richness, and evenness of the Sendafa and Holeta sites were higher than those of the Chancho and Sululta sites. Therefore, the characteristic species, or the species found only in the Chancho site, were two, in the Holeta site was one, and in the Sendafa site were four species. Thus, in total, seven plant species were the characteristic species of the four studied sites. As to Sorenson's similarity coefficient, Sululta and Holeta, as well as Chancho and Sululta sites, have quite a bit of overlap or similarity, while the lowest similarity was observed between Chancho, Sendafa (49%), and Holeta, Sendafa sites (49%). The current work presents a comprehensive and field-based detailed assessment of wetland species diversity and distribution in the region in general, filling knowledge gaps in study areas in particular, and having broader implications for wetland management policy and practice; thus, these wetlands need proper attention and effective protection.

Introduction

Wetlands are the links between land and water and are areas where water is the primary factor controlling the environment and associated plant and animal life (Seid, 2017). They are important features in the landscape that provide numerous beneficial services for people and for fish and wildlife

(Unbushe, 2024). Ramsar convention defined wetlands as "areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (Ramsar., 2018). While they can be highly variable in their appearance and species composition, water inundation is their shared characteristic, and it is the primary factor in controlling the wetland environment and associated plant and animal life (Johnson & Johnson, 2012). Wetlands provide vital ecological services and they are regulators of water regimes and sources of biodiversity at all levels; species, genetic and ecosystem, and are sources of varieties of plant species used as pasture or grazing, drinking water (Seid, 2017). They constitute a resource of great economic, scientific, cultural, and recreational value for the community, and their ability to recycle nutrients makes them critical in the overall functioning of the Earth. Due to the periodic inflow of nutrients, the wetland ecosystem is considered more productive than the adjacent area. Their productivity is comparable to rainforests and coral reefs (Costanza et al., 2014).

Wetland ecosystems are vital in conserving wetland-dependent biodiversity and in delivering important and vital services for human well-being, plus ecological, socio-economic, and recreational benefits to humans (Moges, 2021). African wetlands have long been recognized as playing a critical role in supporting the livelihoods of people in marginal areas through their provision of a range of ecosystem services, providing an important source of water and nutrients needed for the biological productivity and survival of humans (MEA, 2005). Ethiopian wetlands have long been used by local people to derive their livelihood benefits as they usually provide grazing resources for cattle, medicinal plants, craft making, construction material, and water for domestic consumption (Dixon, 2021).

Many Ethiopian wetlands provide a major contribution to local people, largely being a major source of water for irrigation, fish, livestock, human drinking, and cleaning, as sources of grasses and fodders (Moges, 2021). They provide various benefits to local communities and are vital sources of water and fodder, chiefly during the dry season and in times of drought, to both domestic and wild animals (Tadessse & Solomon, 2014). Wetlands are vital sources of food, fuel wood, and raw materials for making household furniture (Unbushe, 2024). Despite their multiple services and values, they are treated as 'wastelands' without value by many groups, and this view has negatively impacted proper wetlands management and led to overexploitation and conversion, thereby causing degradation and loss (Tadessse & Solomon, 2014)

Continuous changes in natural environmental conditions and increased human activity (livestock, agriculture) would contribute to an accelerated change in vegetation that can have far-reaching implications for ecosystem services and lead to reduced biodiversity and livelihood (Andrew et al., 2012).

Similarly, the continuous conversion of wetlands into crop and grazing land, overfishing, drainage, eutrophication, and siltation threaten biodiversity, impair the environmental functions of the wetlands, and affect people's livelihoods (Gebresllassie et al., 2014). Although they are among the most productive

ecosystems on earth, and protection of threatened natural wetlands and preservation of their biodiversity has received increasing attention globally, wetlands and their resources in Ethiopia are still facing many problems (Unbushe, 2024). Natural wetlands are in lasting decline around the world. Between 1970 and 2015, inland and marine or coastal, both declined by nearly 35% where data are available, 3 times the rate of forest loss plus in the 20th and early 21st centuries, there was a much faster rate of loss with 64–71% decline in extent and their loss and degradation continue globally (Gardner et al., 2015).

Ethiopian wetlands are ranked amongst a highly threatened ecosystem; unfortunately, their degradation and loss are continuing (Gebresllassie et al., 2014). During the last two centuries, wetland losses and their natural resources have steadily increased, calling for urgent measures to restore and conserve the remaining wetland systems (MEA, 2005). Few scholars study many factors (spatial, natural, and human disturbance) and their interaction effects on plant species composition and functional structure (Andrew et al., 2012). Some scholars study multiple factors like overutilization, over-collection, overexploitation, habitat degradation, overharvesting, deforestation, population explosion, and overgrazing that are conspicuous biotic stresses that severely threaten the flora of any area, which affect population sustainability on the Earth's crust (Ibrahim et al., 2019). It is vital to gain as full an understanding as possible of the main factors affecting wetland plant communities in terms of their conservation status to prescribe the management recommendations (Li et al., 2017). Plant communities play key roles in maintaining wetland functions; knowing the ecology of these communities is an important component of wetland conservation, plus understanding how wetland vegetation community composition is controlled is important for conservation and biodiversity management (Zheng et al., 2019).

Floristic studies are essential in providing information on plant biodiversity in an ecosystem and are fundamental in drawing the attention of stakeholders to understand the ecosystem services of the biodiversity assemblage and undertake appropriate conservation measures (Nodza et al., 2021). Despite their importance to the maintenance of biodiversity, wetlands and their resources (vegetation in particular) in Ethiopia have been barely investigated, and their previous documentation was extremely limited. The vegetation ecology, species composition, and diversity of wetlands in Ethiopia have not yet been studied in the detail they deserve (Unbushe, 2024). For countries like Ethiopia, it is vital to learn success histories from other countries and certain ongoing projects in some parts of the country to rehabilitate the degraded habitats, ecosystems, and biodiversity loss (Kassa et al., 2016). Though the study wetlands are among the known wetlands of Ethiopia found in the Oromia region, they are facing various threats since there is a limited data on the contribution of these wetlands for the livelihood improvement of the local people and there is no relevant information on study area's wetland plants species distribution, diversity and composition. Former studies in the study areas have focused on wetland ecosystem status, the effects of land use changes on ecosystem services, and land use dynamics.

However, no research work is available on plant species richness and their spatial distribution in areas that are not stated and are still poorly understood. This is due to capacity limitations such as a lack of

skilled labor, finance, and neglect by the government and researchers. Wetland-focused training programs are very scarce in higher learning institutions in the country. Programs are not implemented to fill this gap nationally. As a result, there is a shortage of wetland specialists (Unbushe, 2024).

Furthermore, the major problems in the present study areas are agricultural practices like hay harvesting, small farming, livestock grazing, and the extraction of water for micro irrigation. So, the most direct and effective way of evaluating wetland biological conditions is to directly monitor their biological component through the bio assessment that can help to diagnose the cause of degradation and provide data to make informed management decisions and/or prioritize wetlands being restored (Moges, 2021). Therefore, the main objective was to investigate plant species diversity, distribution, and community composition of the study wetlands and to recommend some corrective measures for sustainable management. It is hoped that this research can provide baseline information for further studies, and the issues raised and recommendations given in the study areas will apply to the other wetlands in Ethiopia. Moreover, it was aimed to analyze the floristic composition, detect the taxonomic identification, and document them, and finally offer relevant information on the composition, distribution, and diversity of species of four wetlands in North Shewa zone, Oromia region in general, and Chancho, Sululta, Holeta, and Sendafa in particular.

Methodology

The study sites for this specific research project were the wetlands of Sululta plain and Chancho area (25km north of Addis Ababa), Holeta-Muger (29km west of Addis Ababa), and Sendafa area (39km northeast of Addis Ababa), North Shewa zone, Oromia region, Ethiopia. The first two sites comprising natural wetlands are found stretching from Sululta town to Chancho town along the Fiche road segment while the second two sites encompassing natural wetlands are located a little bit far away from their respective towns (12 km to the north of Holeta town and 20 km to the south of Sendafa town) respectively. The range of altitudes of the first two sites is 2532 to 2559 meters, but the range of altitudes of the second two sites is 2465 to 2480 meters, respectively. Both Sululta and Chancho sites had hay fields, grazing lands, and human settlements or urban houses, one cement factory, dairy and poultry farms, water or highland factory, and a leather factory. Both the Holeta and Sendafa sites had similar activities to those of both the Sululta and Chancho sites; they had irrigable lands cultivated with different vegetables, sedges, grasses, hays, and cereal crops two to three times.

Survey site selection

The survey sites were selected due to their socio-economic services that they provide to the local people, wetland characteristics, surrounding landscape uses, wetland conversion problems (agricultural and grazing lands, house buildings), topographic features, etc., that lead to wetland reduction and degradation. A detailed and extensive literature survey on location, size, hydrology, ecological condition, land ownership, and accessibility of study wetlands was done. With this, altitudinal range, distribution range, over-exploitation, grazing, and habitat degradation of the study wetlands were observed in all

sites, too. As to my observation and informal evidence from local people living around the study areas, all wetlands and their surroundings are characterized by agriculture, hay, or grass harvesting, overgrazing of wetlands by cattle, and expanded human settlement activities. High water extraction for micro irrigation (vegetable and hay grass irrigation), livestock watering, drinking water for families and cattle, grazing, grass harvesting, and using as aesthetic areas for musicians and agricultural farming were the main activities performed in and around the study site. However, now, the continuous conversion of these wetlands into irrigation lands, agricultural and grazing lands, overexpansion of investments, alarmingly increasing human settlements, and bad habit of land grabbing, high livestock rearing, and overgrazing of land leads to the reduction of the wetland's size. Similarly, due to the high practice of irrigating grasses and vegetables, high water use for home consumption, and watering cattle (huge water consumption), leads to wetland degradation. Generally, overgrazing, grass harvesting, agricultural activities, investments, increasing settlements, land grabbing, and water harvesting for irrigation were the main activities performed in and around the sites.

Survey design and sampling procedures

To familiarize ourselves with the changes in plants and ecological conditions in the study sites and finally, determine the sampling design that would be used in surveying flora in the field, a systematic exploration was conducted in selected wetlands for collecting the floristic data. Therefore, a systematic sampling design was used for laying out the quadrats on line transects in all sites using quantitative ecological techniques (quadrat method) to take plant specimens for identifying their botanical names and determining the diversity indices (Shannon and Wiener, 1949).

Floristic data were collected from each of the four selected sites using the three-line transects of 200m long laid at each site positioned within the east-west direction along the longest axis of each wetland, following transect lines situated in homogenous areas of the study sites. It was done starting at a 20m distance from the water source and 20m distance from each other in regular intervals at all sites, in which the 20m distance between the two consecutive quadrats was used to minimize the dependence of data. Since almost all plants in the study sites were herbaceous, 2*2m quadrat sizes were fixed along all the 200m long transect lines at all sites. Lastly, in each of the three 200m long transect lines of all four study sites, 10 quadrats were placed at a 20m interval (30 quadrats/site) of 2*2m, resulting in 120 sampled quadrats per all sites. Geographical coordinates and altitudes of all quadrats surveyed were recorded in a Garmin GPS and in a notebook by using UTM and WGS 84.

Data collection

Frequent study trips to the research areas started from November 2019 at all four selected areas to obtain all wetland plant species covering the wetland environments under the study. To collect different plant species specimens, field trips were planned throughout the entire vegetation season, waiting for the good flowering period of most plants. The data collection included the collector's name, collection date, code, number, and site. Accordingly, the presence and estimated percentage crown cover of each plant species were determined in a 2*2m quadrat placed at 20m intervals along the 200m line transects

situated in homogeneous areas of each wetland site. All plants present in sampling quadrats were recorded, and specimens of all plant species in each quadrat were collected following the standard procedures from the various wetland environments of the research areas. Next, according to the standard technique, the wetland plant specimens collected in the field were pressed, dried, and well preserved. The information recorded at each site for all quadrats was altitude, Latitudes, longitudes, abundance, etc.

Next, the whole specimens collected were deposited at the National Herbarium, Addis Ababa University (ETH), Ethiopia, on standard herbarium sheets of 28*11.5 cm for preservation. Finally, the species have been identified using Flora of Ethiopia and Eritrea (Edwards et al., 1995; 1997; 2000; Hedberg et al., 1989; 2003; 2006; 2009, Phillips, 1995; Tadesse, 2004). Lastly, all plant specimens encountered were identified to the species level, and their specimens were placed there.

Data analysis

The obtained data of 12 Transects (3 transects/site) and 120 quadrats (30 quadrats/site) were arranged in MS Excel for the analyses. Vegetation data analysis, statistical tools, diversity indices, cluster analysis, and parametric tests were done using IBM and R software. The data obtained on plant species within the studied areas were analyzed as follows. The diversity of the wetland plants was analyzed and measured by using species richness (S), diversity (H'), evenness (J), and Sørensen's similarity coefficient (SSC) indices of Shannon and Wiener (1949). Species richness is a biologically appropriate measure of alpha (α) diversity and is usually expressed as the number of species per sample unit. The Shannon diversity (H') and evenness (E') indices were determined as a measure to incorporate both species richness and evenness (Kent, 2012).

a**) The Shannon diversity index (H') was calculated from the equation**:

$H' = -\sum_{i}^{S} {}_{=1}$ pilnpi **(Eq. 1)**

Where pi is the proportion of individuals found in the ith species. The value of the Shannon diversity index is usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5 (Kent, 2012).

b) The Shannon evenness index (J) calculated from the ratio of observed diversity to maximum diversity by using the following equation:

J = (H')/ (H'max) = (H')/ln S **(Eq. 2)**

Where H'max is the maximum level of diversity possible within a given population, which equals ln S (species number), ln = log base 10, J is normal between zero and one, and with one representing a situation in which all species are equally abundant. Sorensen similarity index used for community comparison as it gives more weight to the species that are common to all sites than to the unique species to either of the wetlands.

c) The Sorensen similarity index calculated from the equation:

SSC = 2C/ (a + b) $\frac{2a}{2a+b+c}$ **(Eq. 3)**

Where SSC = Sorensen similarity coefficient, the number of species common to all sites, a = the number of species present in one of the sites to be compared, and b = the number of species present in the other site. Often, 100 to give a percentage similarity, multiply the SSC. The SSC values range from zero (complete dissimilarity) to one (total similarity). For hypothesis testing of the ecological data, a nonparametric test is recommended since the uniformity of the data distribution might not be achieved..

Results

Table 1
The distribution of all families and number of plant species identified in 4 studied wetlands.

Family Name	Chancho site	Sululta site	Holeta site	Sendafa site
Acanthaceae	Hygrophila schulli (*Hamilt.*) *M. R. & S. M.*	Hygrophila schulli (*Hamilt.*) *M. R. & S. M.*	Hygrophila schulli (*Hamilt.*) *M. R. & S. M.*	Hygrophila schulli (*Hamilt.*) *M. R. & S. M.*
Alismataceae				Alisma plantago-aquatica *L.*
Amaranthaceae	Alternanthera sessilis (*L.*) *DC.*	Alternanthera sessilis (*L.*) *DC.*		Alternanthera sessilis (*L.*) *DC.*, Digeria muricata (*L.*) *Mart.*
Amaryllidaceae	Crinum abyssinicum *Hochst. Ex A. Rich*			
Apiaceae	Oenanthe palustris (*Chiov.*) *Norman.*	Oenanthe palustris (*Chiov.*) *Norman.*	Oenanthe palustris (*Chiov.*) *Norman.*	
Aponogetonaceae				Aponogeton abyssinicus *Hochst.ex A. Rich.*
Asphodelaceae				Bulbine abyssinica *A. Rich.*
Asteraceae	Artemisia abyssinica *Sch. Bip. ex A. Rich*, Gerbera viridifolia (*DC*) *Sch. Bip.*, Gnaphalium rubriflorum *Hilliard*, Guizotia schimperi *Sch. Bip. ex Walp.*	Artemisia abyssinica *Sch. Bip. ex A. Rich* Gerbera viridifolia (*DC*) *Sch. Bip.*, Gnaphalium rubriflorum *Hilliard*, Guizotia schimperi *Sch. Bip. ex Walp.*	Artemisia abyssinica *Sch. Bip. ex A. Rich* Cirsium schimperi (*atke*) *C.Jeffrey ex Cufod.*, Gerbera viridifolia (*DC*) *Sch. Bip.* Gnaphaliumru briflorum *Hilliard*, Guizotia schimperi *Sch. Bip. ex Walp.* Lounaea cornuta (*Hochst. ex Oliv. & Hiem*) *C. Jef* Senecio fresenii *Sch. Bip. Ex Oliv. & Hiern*	Artemisia abyssinica *Sch. Bip. ex A. Rich*, Artemisia afra, Gerbera viridifolia (*DC*) *Sch. Bip.*, Gnaphalium rubriflorum *Hilliard*, Guizotia schimperi *Sch. Bip. ex Walp.* Senecio fresenii *Sch. Bip. Ex Oliv. & Hiern*
Boraginaceae	Heliotropium ceylanicum (*Burm f.*) *Lam.*	Heliotropium ceylanicum (*Burm f.*) *Lam.*	Heliotropium ceylanicum (*Burm f.*) *Lam.*	Cynoglossum densefoliatum *Chiov.*, Heliotropium

Family Name	Chancho site	Sululta site	Holeta site	Sendafa site
				ceylanicum (*Burm f.*) *Lam*.
Brassicaceae		Rorippa plaustris *L. Bess*.	Rorippa plaustris *L. Bess*.	Cardamine trichocarpa *A.Rich*., Rorippa plaustris *L. Bess*.
Caryophyllaceae				Polycarpaea eriantha *Hochst*.
Commelinaceae	Commelina kotschyi *Hassk.*	Commelina kotschyi *Hassk.*		Commelina kotschyi *Hassk.*
Cyperaceae	Cyperus rigidifolius *Steud.*, Eleocharis marginulata *Hochst. ex A. Steud.* Schoenus nigricans *L*.	Cyperus rigidifolius *Steud.*, Eleocharis marginulata *Hochst. ex A. Steud.* Schoenus nigricans *L*.	Cyperus rigidifolius *Steud.*, Eleocharis marginulata *Hochst. ex A. Steud.* Schoenus nigricans *L*.	Cyperus difformis *L*. Cyperus rigidifolius *Steud.*, Eleocharis marginulata *Hochst. ex A. Steud.* Schoenus nigricans *L*., Schoenoplectus lateriflorus (*Gmel*.) *Lye*.
Eriospermaceae	Eriospermum abyssinicum *Baker.*	Eriospermum abyssinicum *Baker.*	Eriospermum abyssinicum *Baker.*	Eriospermum abyssinicum *Baker.*
Fabaceae	Trifolium semipilosum *Fresen*., Trifolium simense *Fresen*.	Trifolium simense *Fresen*.	Trifolium semipilosum *Fresen*., Trifolium simense *Fresen*.	Trifolium semipilosum *Fresen*., Trifolium simense *Fresen*.
Lamiaceae	Mentha aquatica *L*., Ocimum basilicum *L*.	Mentha aquatica *L*., Ocimum basilicum *L*.	Gerbera jamesonii *Bolus ex. Adlam*, Mentha aquatica *L*., Ocimum basilicum *L*.	Mentha aquatica *L*., Ocimum basilicum *L*.
Marsileaceae	Marsilea vera *Launert*.	Marsilea vera *Launert*.	Marsilea vera *Launert*.	Marsilea vera *Launert*.
Oleaceae		Jasminum grandiflorum *L*.	Jasminum grandiflorum *L*.	Jasminum grandiflorum *L*.
Piperaceae	Peperomia abyssinica *Miq.*		Peperomia abyssinica *Miq.*	Peperomia abyssinica *Miq.*
Poaceae	Andropogon abyssinicus Fresen., Cynodon aethiopicus	Agrostis stolonifera L., Andropogon abyssinicus Fresen.,	Andropogon abyssinicus Fresen., Cynodon aethiopicus	Agrostis stolonifera L., Andropogon abyssinicus Fresen., Bromus

Family Name	Chancho site	Sululta site	Holeta site	Sendafa site
	Clayton & Harlan., Cynodon dactylon (L.) Pers, Festuca simensis Hochst. ex A. Rich., Harpachne schimperi (Hochst.ex Rich.), Hemarthria altissima (Poir.) Stapf & C.E. Hubb., Odontelytrum abyssinicum Hack., Polypogon monspeliesis (L.) Desf., Sacctolepsi africana C.E. Hubb. & Snowden., Setaria pumila (Poir.) Roem. & Schult., Sporobolus consimilis Fresen.	Cynodon dactylon (L.) Pers., Festuca simensis Hochst. ex A. Rich., Harpachne schimperi (Hochst.ex Rich.), Hemarthria altissima (Poir.) Stapf & C.E. Hubb., Odontelytrum abyssinicum Hack., Sacctolepsi africana C.E. Hubb. & Snowden., Setaria pumila (Poir.) Roem. & Schult., Sporobolus consimilis Fresen.	Clayton & Harlan, Digitaria abyssinica (Hochst. ex A. Rich.) Stapf., Festuca simensis Hochst. ex A. Rich., Harpachne schimperi (Hochst.ex Rich.), Hemarthria altissima (Poir.) Stapf & C.E. Hubb., Polypogon monspeliesis (L.) Desf., Sacctolepsi africana C.E. Hubb. & Snowden, Setaria pumila (Poir.) Roem. & Schult., Sporobolus consimilis Fresen.	pectinatus Thunb., Cynodon nlemfuensis Vanderyst, Digitaria abyssinica (Hochst. ex A. Rich.) Stapf, Festuca simensis Hochst. ex A. Rich., Hemarthria altissima (Poir.) Stapf & C.E. Hubb., Lapeirousia schimperi (Asch. & Klatt) Milne-Redh, Lolium temuletum L., Odontelytrum abyssinicum Hack., Polypogon viridis (Gouan) Breistr. Sacctolepsi africana C.E. Hubb. & Snowden, Sporobolus consimilis Fresen.
Polygonaceae	Rumex nepalensis *Spreng*.			
Ranunculaceae	Delphinium wellbyi *Hemsl*. Ranunculus oligocarpus *Hocst. ex A. Rich*.	Delphinium wellbyi *Hemsl*.	Delphinium wellbyi *Hemsl*. Ranunculus oligocarpus *Hocst. ex A. Rich*.	Ranunculus oligocarpus *Hocst. ex A. Rich*.
Solanaceae	Discopodium penninervum *Hochst*.	Discopodium penninervum *Hochst*.		
Urticaceae			Urtica simensis *Steudel*	

Plant Species Composition of the study wetlands

Species richness of Chancho, Sululta, Holeta and Sendafa sites are 35, 31, 36, and 46 respectively. Dominant families are Poaceae (11) and Asteraceae (4) Poaceae (10) and Asteraceae (Poaceae (10)

and Asteraceae (7) Poaceae (13) and Asteraceae (6). Co dominant families are Cyperaceae (3), Lamiaceae (2) Cyperaceae (3), Lamiaceae (2) Cyperaceae (3), Lamiaceae (3) Cyperaceae (5), and Lamiaceae (2). The present study results reveal that, about 60 plant species belonging to 24 families were identified from all of the four studied wetlands. Among the total of 60 species, the most dominant and diverse families of the study wetland plants were Poaceae family (29.73%) contributing about 11,10, 10 and 13 species followed by Asteraceae family (14.19%) contributing about 4, 4, 7, and 6 species in Chancho, Sululta, Holeta and Sendafa sites respectively (Table 1). This result is similar with (Teferi et al., 2019) who stated as the families with the highest number of species were Poaceae with 12 (18%) species followed by Asteraceae with 7 (11%) and Cyperaceae with 6 (9%) species and the rest with 1 to 3 (1.5% – 4.5%) species in Gedeb wereda wetland. The next families considered as co-dominants were Cyperaceae family (9.46%) (3, 3, 3 and 5), Lamiaceae family (6.08%) (2, 2, 3 and 2) and Fabaceae family (5.41%) (2, 1, 3 and 2) species in Chancho, Sululta, Holeta, and Sendafa sites, respectively (Table 1).

Similarly, two families (Boraginaceae and Ranunculaceae) consist of about two species each in Chancho, Sululta, Holeta, and Sendafa sites, Amaranthaceae consists of two species each in Chancho, Sululta, and Sendafa sites, Aponogetonaceae consists of about two species in Sendafa site, and Brassicaceae consists of about two species in Sululta, Holeta, and Sendafa sites (Table 1). The other three families found in all sites comprising only one species were Marsileaceae, Acanthaceae, and Eriospermaceae. There are five families with only one species composition: Apiaceae (Chancho, Sululta, and Holeta), Commelinaceae (Chancho, Sululta, and Sendafa), Oleaceae (Sululta, Holeta, and Sendafa), Piperaceae (Chancho, Holeta, and Sendafa), and Solanaceae (Chancho and Sululta). Further, three families (Alismataceae, Asphodelaceae, Caryophyllaceae) comprising only one species were found only in Sendafa, two families (Amaryllidaceae and Polygonaceae) comprising only one species were found only in Chancho, but one family (Urticaceae) comprising only one species was found only in the Holeta site (Table 1).

Species richness, classification and description of plant community types

The species richness of all the studied wetlands was 60. The species richness distribution of the five well defined vegetation communities in 120 total quadrats of the study areas ranged from 43 (24.29%) species in each 40 quadrats, 40 (22.60%) species in each 27 quadrats, 27 (15.25%) species in each 21 quadrats, 37 (20.90%) species in each 19 quadrats, and 30 (16.95%) species in each 12 quadrats as in Fig. 4 and Table 2.

Table 2
Community type, quadrat included species richness, diversity and evenness in each community .

Community type	Quadrats included in each community	Species number (*n*)	pilnpi (n/Nlnn/N)	pi^2 $(n/N)^2$	Eveness
Community 1	1, 2, 8, 11, 12, 13, 15, 17, 23, 25, 30, 38, 42, 43, 46, 47, 48, 49, 53, 58, 62, 65, 66, 73, 77, 85, 94, 96, 99, 101, 103, 105, 107, 109, 110, 111, 117, 118, 119, 120	43	0.344	0.059	0.451
Community 2	31, 32, 35, 39, 40, 54, 56, 61, 63, 67, 71, 72, 75, 78, 79, 81, 82, 83, 84, 86, 89, 91, 97, 100, 102, 112, 114	40	0.336	0.051	0.459
Community 3	3, 5, 7, 10, 16, 24, 26, 28, 29, 34, 36, 37, 41, 45, 55, 59, 70, 88, 93, 98, 115	27	0.387	0.023	0.514
Community 4	19, 21, 22, 27, 33, 44, 50, 51, 57, 60, 64, 68, 69, 74, 80, 92, 104, 106, 116	37	0.327	0.044	0.469
Community 5	4, 6, 9, 14, 18, 20, 52, 76, 90, 95, 108, 113	30	0.301	0.029	0.498

$\sum n(N) =$ 177. **$\sum pi^2 =$** 0.206. **$H'(\sum pilnpi)$** = -(-0.344+-0.336+-0.387+-0.327+-0.301)= -1.695. **$D(1/\sum pi^2)$** = 1/(0.059 + 0.051 + 0.023 + 0.044 + 0.029) = 4.85. Sorenson's Coefficient (CC) for community 1 and 2 = 2*14/43 + 40 = 28/83 = 0.34, community 1 and 3 = 2*14/43 + 27 = 28/70 = 0.40, community 1 and 4 = 2*14/43 + 37 = 28/80 = 0.35, community 1 and 5 = 2*14/43 + 30 = 28/73 = 0.38. Similarly, Sorenson's Coefficient (CC) for community 2 and 3 = 2*14/40 + 27 = 28/67 = 0.42, community 2 and 4 = 2*14/40 + 37 = 28/77 = 0.37, community 2 and 5 = 2*14/40 + 30 = 28/70 = 0.40, community 3 and 4 = 2*14/27 + 37 = 28/64 = 0.44, community 3 and 5 = 2*14/27 + 30 = 28/57 = 0.49 for community 4 and 5 = 2*14/37 + 30 = 28/67 = 0.42 (Table 3). According to Sorenson's coefficient, community 3 and 5 (0.49) have quite a bit of overlap or similarity than others. he cluster analysis identified groups of sampled vegetation that are similar in terms of their species composition using a hierarchical cluster Dendrogram and map that depicted the five community types of wetland plant species (Figs. 4 and 5).

Cluster analysis of the vegetation data identified about five vegetation communities present in the studied areas. The five plant community types were obtained between 60 and 80 heights (8.54–69.75% dissimilarity levels) of the hierarchical cluster analysis map (Fig. 5) from classification output as described based on the communities with their dominant and co-dominant species they contained as follows.

Based on the Dendrogram and the map of the five defined wetland vegetation communities, out of the five groups, one is wholly dominated by Cyperus rigidifolius Steud. and the other group is fully dominated by Schoenus nigricans L. The third group is dominated by Eleocharis marginulata Hochst. ex A. Steud. that was followed by Festuca simensis Hochst. ex A. Rich. and Sacctolepsi africana C. E. Hubb. & Snowden. The fourth and fifth dominating species (Table 1, 2, and Fig. 4, 5).

1. Cyperus rigidifolius Steud - Eleocharis marginulata Hochst. Ex A. Steud- Schoenus nigricans L. community type: This community is comprised of 40 quadrats and consists of about 43 species. This community type was dominated by Cyperus rigidifolius Steud, Eleocharis marginulata Hochst. Ex A. Steud., and Schoenus nigricans L. Festuca simensis Hochst. ex A. Rich., Marsilea vera Launert., Sacctolepsi africana C. E. Hubb. & Snowden, Artemisia abyssinica Sch. Bip. ex A. Rich., Eriospermum abyssinicum Baker and Heliotropium ceylanicum (Burm f.) Lam was also an important species with high occurrence values in this community type, as in Fig. 4, Table 1, 2, and cluster 5, as in Fig. 5.

2. Schoenus nigricans L. community type: This community is comprised of 27 quadrats and consists of about 40 species. This community type was dominated by Schoenus nigricans L. Species like Eleocharis marginulata Hochst. ex A. Steud, Cyperus rigidifolius Steud. Festuca simensis Hochst. ex A. Rich. Artemisia abyssinica Sch. Bip. ex A. Rich. Andropogon abyssinicus Fresen. Eriospermum abyssinicum Baker. Aponogeton vallisnerioides Baker.and Marsilea vera Launert. Also contributed a high percentage of occurrences in this community type. Moreover, the next widely occurring herbaceous species (between 10–15% of the species) are Ocimum basilicum L., Jasminum grandiflorum L. C, Sacctolepsi africana C. E. Hubb. & Snowden as in Fig. 4, Table 1, 2, and cluster 4 of Fig. 5.
3. Eleocharis marginulata Hochst. Ex A. Steud community type: This community is comprised of 21 quadrats and consists of about 27 species. This transitional vegetation community type was rich in species, and the dominant species of this community type was Eleocharis marginulata Hochst. ex A. Steud. Species such as Schoenus nigricans **L.**, Trifolium simense Fresen. Festuca simensis Hochst. Ex A. Rich. Odontelytrum abyssinicum Hack. Sporobolus consimilis Fresen. Marsilea vera Launert and Sacctolepsi africana C. E. Hubb. & Snowden also contributed a high percentage of occurrences to this community type, as in Fig. 4, Table 1, 2, and cluster 3 of Fig. 5.
4. Festuca simensis Hochst. Ex A. Rich. community type: This community is comprised of 19 quadrats and consists of about 37 species. This vegetation community type was dominated by Festuca simensis Hochst. ex A. Rich. The other species recorded from this community type were Cyperus rigidifolius Steud. Eleocharis marginulata Hochst. ex A. Steud, Schoenus nigricans L. Sacctolepsi africana C. E. Hubb. & Snowden and Heliotropium ceylanicum (Burm f.) Lam as in Fig. 4, Table 1, 2, and cluster 2 of Fig. 5.
5. Sacctolepsi africana C. E. Hubb. & Snowden community type: This community is comprised of 12 quadrats and consists of about 30 species. This community type (Fig. 4) was dominated by Sacctolepsi africana C. E. Hubb. & Snowden. Cyperus rigidifolius Steud. Eleocharis marginulata Hochst. ex A. Steud, Festuca simensis Hochst. Ex A. Rich and Schoenus nigricans L. were other important species contributing most to the composition of this community type, as in Fig. 4, Table 1,2, and in cluster 1 of Fig. 5.

Plant Species Richness, Diversity, Evenness, and similarity

There is a large difference in the abundance, occurrence, and distribution of all the explored plant species in the four studied sites in which the highest species number was recorded in Sendafa (46 species, 31.08%), followed by Holeta (36 species, 24.33%) and Chancho (35 species, 23.65%), Sululta (31

species, 20.95%) as in Table 1. There were about twenty plant species that showed occurrences in almost all studied areas. The most common herbaceous plant species that occurred in all quadrats were Cyperus rigidifolius Steud., Schoenus nigricans L., and Eleocharis marginulata Hochst. Ex A. Steud., Festuca simensis Hochst. Ex A. Rich., and Sacctolepsi africana C. E. Hubb. & Snowden. as in Fig. 5. Therefore, the characteristic species, or the species found only in Chancho site, were two (Crinum abyssinicum Hochst. ex A. Rich, and Rumex nepalensis Spreng), in Holeta was one (Urtica simensis Steudel), and in Sendafa were four (Alternanthera sessilis (L.) DC., Aponogeton abyssinicus Hochst. ex A. Rich., Bulbine abyssinica A. Rich., Polycarpaea aeriantha Hochst.). Thus, a total of seven plants were the characteristic species of the four sites (Table 1).

The average species richness of the 60 quadrats of the Chancho and Sululta wetlands was 7.83 and 7.63, while the average species richness of the 60 quadrats of Holeta and Sendafa wetlands was 8.33, respectively. The Shannon diversity (H') of Chancho and Sululta sites was 2.3 and 2.2, respectively, while Holeta and Sendafa sites were 2.0 and 1.87, respectively. In addition, the distribution of the plant species or evenness (J) values of Holeta, Sendafa, Chancho, and Sululta sites was 0.83, 0.86, 0.94, and 0.97, respectively. According to Sorenson's similarity coefficient (SSC), both the Sululta and Holeta site (0.60) and the Chancho and Sululta site (0.61) have more overlap or similarity than others. This means the highest similarity was observed between Chancho and Sululta site (0.61) or 61%, followed by Sululta and Holeta site (0.60) or 60%. Relatively, the lowest similarity was observed between the Chancho and Sendafa sites (49%) and the Holeta and Sendafa sites (49%).

Discussions

In order to assess the distribution and diversity of vegetation in the studied wetlands, four sites were selected. The result of this study reveals that about 60 plant species belonging to 24 families were identified and documented. Among the total of 60 species, the most dominant and diverse families of the studied wetland plants were Poaceae contributing about 11, 10, 10, and 13 species, followed by Asteraceae, contributing about 4, 4, 7, and 6 species in Chancho, Sululta, Holeta, and Sendafa sites, respectively. These two most dominant families contributed about 30% and 13.35% of the total plant species of the study areas, respectively. Further, the next chief families considered as co-dominants were Cyperaceae (3, 3, 3, and 5), Lamiaceae (2, 2, 3, and 2), and Fabaceae (2, 1, 3, and 2) species in Chancho, Sululta, Holeta, and Sendafa sites, respectively. While comparing the four studied sites in terms of their dominant families, Holeta and Sendafa wetlands supported a larger number of families than Chancho and Sululta wetlands (Table 1). This finding is in line with the report of (Moges et al., 2017) from Ethiopia. Similarly, two families (Boraginaceae and Ranunculaceae) consist of about two species each in Chancho, Sululta, Holeta, and Sendafa sites, Amaranthaceae consists of two species each in Chancho, Sululta, and Sendafa sites, Aponogetonaceae consists of about two species in Sendafa site, and Brassicaceae consists of about two species in Sululta, Holeta, and Sendafa sites (Table 1).

Cluster analysis of the vegetation data identified five vegetation communities present in the studied wetlands. The analysis identified groups of sampled vegetation that are similar in terms of their species

composition using a hierarchical cluster Dendrogram and a map that depicted the five community types of wetland plant species (Figs. 4 and 5). Based on the Dendrogram and map of the five defined wetland vegetation communities, one of the five communities is wholly dominated by Cyperus rigidifolius Steud. And the other communities are fully dominated by Schoenus nigricans L. The third group is dominated by Eleocharis marginulata Hochst. Ex A. Steud., which was followed by Festuca simensis Hochst. Ex A. Rich. and Sacctolepsi africana C. E. Hubb. & Snowden. The fourth and fifth dominating species (Table 1, 2, and Fig. 4, 5).

The richness per quadrat (4m2) in the study areas ranges from seven (7) to nine (9), with an average species richness of 8.33. This means that more than eight plant species were found per 4m2 (eight species per 4m2), showing a large number of species per 4m2. The species richness of the plant species distribution in 120 total quadrats of the study area ranged from 43 species in each of 40 quadrats, 40 species in each of 27 quadrats, 27 species in each of 21 quadrats, 37 species in each of 19 quadrats, and 30 species in each of 12 quadrats. The richness of the plant species in communities 1 and 2 was 43 and 40 (in a total of 40 and 27 quadrats), and in communities 3, 4, and 5 was 27, 37, and 30 (in a total of 21, 19, and 12 quadrats), respectively. According to Sorenson's similarity coefficient, communities 3 and 5 (0.49) have quite a bit more overlap or similarity than the others.

There was a difference in the number of plant species recorded in the sites. There were about twenty plant species that showed occurrences in almost all studied areas. Still, there were variations in species richness among all studied wetlands.

The highest percentage of plant diversity was recorded for Sendafa and Holeta, which shows the presence of 46 (31.08%) and 36 (24.33%) plant species followed by Chancho and Sululta sites that shows the presence of 35 (23.65%) and 31 (20.95%) plant species respectively (Table 1). This might be due to the variations in their ecological status. As to (Mulatu et al., 2015) and (Moges et al., 2017) from the southwestern highlands of Ethiopia, the disturbed wetlands support more plant species than the non-disturbed ones. Regarding the plant habits, there were only two habits (herbs and shrubs) identified in the study areas. Of those, the majority of the species (98%) were herbaceous, followed by shrubby (2%). This might be due to the wetlands having surface or subsurface water, which mostly supports more herbs than other plant habitats or shrubs.

The characteristic species, or the species that characterize the specific site as being unique and found only in the Chancho site, were two species (Crinum abyssinicum Hochst. ex A. Rich., and Rumex nepalensis Spreng). In Holeta, there was one (Urtica simensis Steudel), and in Sendafa, there were four (Alternanthera essilis (L.) DC., Aponogeton abyssinicus Hochst. ex A. Rich., Bulbine abyssinica A. Rich., Polycarpaea aeriantha Hochst.). Thus, in total, seven plants were the characteristic species of the four sites. The average species richness of the 60 quadrats of Chancho and Sululta wetlands was 7.83 and 7.63, while the average species richness of the 60 quadrats of Holeta and Sendafa wetlands was 8.33, respectively. While considering Shannon's diversity and evenness of all sites, the Shannon diversity (H') of Chancho and Sululta sites were 2.3 and 2.2, respectively, while Holeta and Sendafa sites were 2.0 and

1.87, respectively. In addition, the distribution of the plant species or evenness (J) values of Holeta, Sendafa, Chancho, and Sululta sites was 0.83, 0.86, 0.94, and 0.97, respectively. This is because wetlands, by nature, are dynamic ecosystems; there are always ecological changes or disturbances in wetlands due to anthropogenic activity (Menbere & Menbere, 2018). (Moges et al., 2017) also reported as environmental heterogeneity, disturbance, and competitive exclusive processes are the determinant factors for either increasing or decreasing the diversity of an ecosystem. According to Sorenson's similarity coefficient (SSC), both the Sululta and Holeta site (0.60) and the Chancho and Sululta site (0.61) have more overlap or similarity than others. This means the highest similarity was observed between Chancho and Sululta site (0.61) or 61%, followed by Sululta and Holeta site (0.60) or 60% in their plant species composition. Relatively, the lowest similarity was observed between the Chancho and Sendafa sites (49%) and the Holeta and Sendafa sites (49%). (Murillo-pacheco et al., 2016) from Colombia, and (Moges et al., 2017) from Ethiopia reported the opposite result, that the similarity in composition of aquatic plants among the study sites was low. These also imply that although the SSC showed similarity between the present study sites due to their similar agro-ecological and climatic factors, the four study sites could have significant differences owing to the variations of the extent of ecological disturbances, resulting in increasing heterogeneous microhabitats, which in turn, lead to supporting different species.

Conclusions

The present research work is the result of a complete and detailed survey of the wetland vegetation of four study sites. There is a vast difference in the number of plant species in the four studied wetland areas.

A total of 60 wetland plant species were recorded, identified, and documented from 120 different quadrats that belong to 24 families from the four studied wetlands, located in the North Shewa zone of the Oromia region, Ethiopia. The most dissimilar family of wetland plants in the studied areas is the Poaceae family, which contributed the largest number to the total species (twenty species), followed by the Asteraceae family (eight species) and the Cyperaceae family (five species). There is a large difference in the abundance and distribution of all the explored plant species in all of the studied wetlands. In all studied wetlands, the dominant plant species were widely distributed, resulting in an overlap among plant community types. The species richness distribution in 120 total quadrats of the study area ranged from 43 species in each of 40 quadrats, 40 species in each of 27 quadrats, 27 species in each of 21 quadrats, 37 species in each of 19 quadrats, and 30 species in each of 12 quadrats. Out of the five defined wetland vegetation communities, about two communities, one that is wholly dominated by Cyperus rigidifolius Steud, and another community that is dominated by Schoenus nigricans L. The third group is dominated by Eleocharis marginulata Hochst. Ex A. Steud. Followed by Festuca simensis Hochst. ex A. Rich and Heliotropium ceylanicum (Burm f.) Lam as a fourth and fifth dominating species, respectively. According to Sorenson's similarity coefficient, communities 3 and 5 (0.49) have quite a bit more overlap or similarity than the others. Furthermore, the highest number of plant species was recorded in the Sendafa site (46 species, 76.67%), followed by the Holeta site (36 species, 60%),

Chancho (35 species, 58.33%), and Sululta (31 species, 51.67%). The species diversity, richness, and evenness of the Sendafa and Holeta sites were higher than those of the Chancho and Sululta sites. Therefore, the characteristic species, or the species found only in the Chancho site, were two species; in the Holeta site, there was one, and in the Sendafa site, there were four species. Thus, in total, seven plant species were the characteristic species of the four studied sites. According to Sorenson's coefficient, Sululta and Holeta sites, as well as Chancho and Sululta sites, have quite a bit of overlap or similarity. This means that the highest similarity was observed between Chancho and Sululta sites (61%), followed by Sululta and Holeta sites (60%). Relatively, the lowest similarity was observed between Chancho and Sendafa (49%), and Holeta and Sendafa sites (49%). Differences in plant distribution, abundance, and floristic composition of wetland plant communities in the studied wetlands could be associated primarily with the differences in geographic location, hydrologic condition, patterns, and degree of human disturbance in the surrounding areas of wetlands. The studied wetland area and its plant resources are severely affected by various anthropogenic factors (due to an increase in the human population) such as agricultural activities, deforestation, overgrazing, and building construction. Therefore, the wetlands should be given suitable and effective protection and conservation measures from human disturbances such as grass harvesting, agricultural farming, and building construction or infrastructure (the construction of buildings and roads). Thus, if appropriate protection and conservation measures are not taken soon, all studied wetlands, especially Chancho and Sululta sites, will reach un-restored conditions. Therefore, to ensure a long-term conservation and sustainable use of these wetlands, it is essential to develop and implement the proper restoration and management strategies that may take both reservoirs and natural wetlands with their catchments into consideration.

Declarations

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Authorship Contribution Statement

Minda Shiferaw Gurmu contributed to conceptualization, methodology, data collection, software validation, investigation, writing original-draft, writing- review, editing, visualization, and project administration and funding acquisition. Minda Shiferaw Gurmu also involved in reviewing the manuscript. Dr, Bikila Warkineh Dullo provided project administration, editing, enhancement, and supervision. Also offered support in shaping the overall structure of the manuscript, provided guidance, and conducted quality checks.

Prof. **Sileshi Nemomissa Duguma** contributed to conceptualization, data validation, supervision and project administration, All the authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: All supporting information will be provided up on the request.

We declare that the submitted manuscript is original, has not been previously published in any form, and is not currently under review for publication elsewhere. We also declare that we have obtained all necessary permissions for using any copyrighted material in the manuscript. We confirm that both authors have contributed significantly to the research reported in the manuscript and that all authors have read and approved the final manuscript.

Ethics approval and consent to participate

All participants received comprehensive information regarding the study's objectives, procedures, and potential risks prior to their involvement. Informed consent was obtained in writing from each participant, ensuring that their research process. For studies utilizing publicly available data, no additional ethical approval was necessary.

Competing interests: The authors declare no competing interests.

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Figures

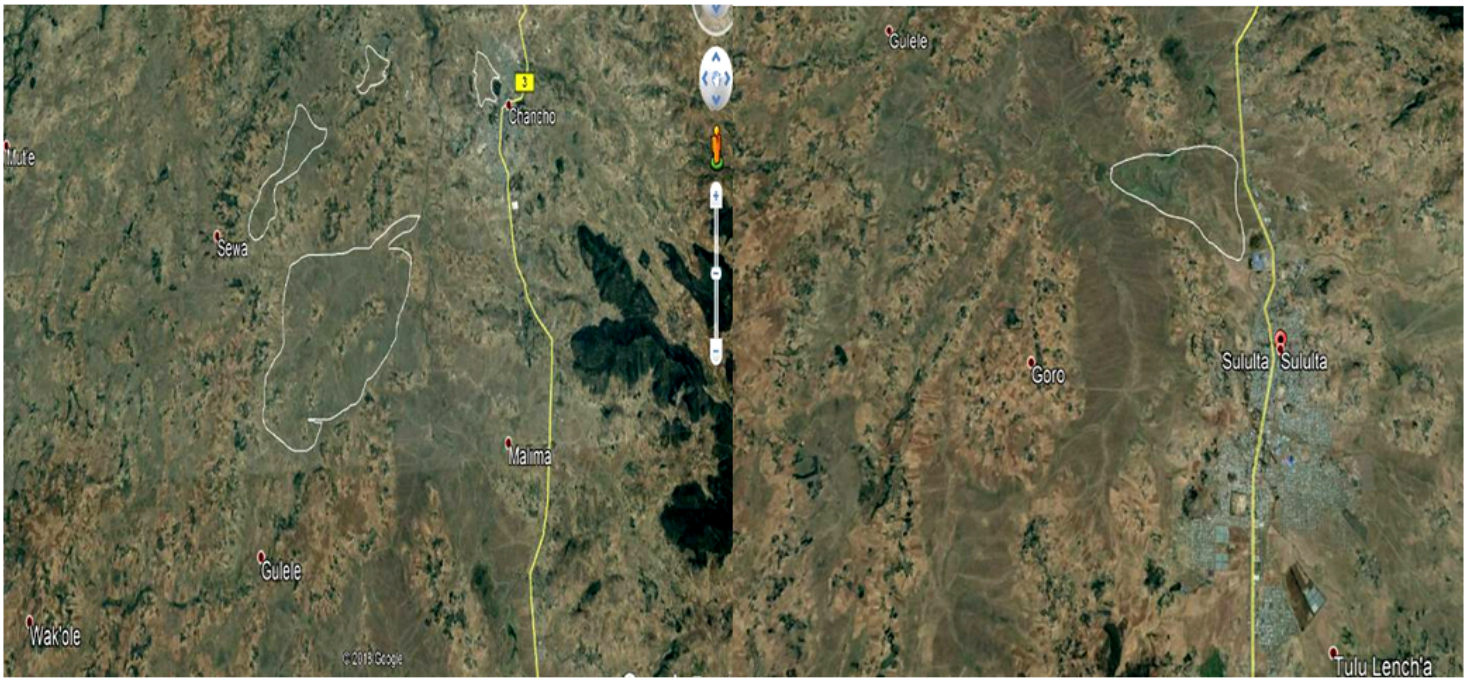


Figure 1

Chancho area and Sululta plain Sites



Figure 2

Holeta – Muger and Sendafa area Sites

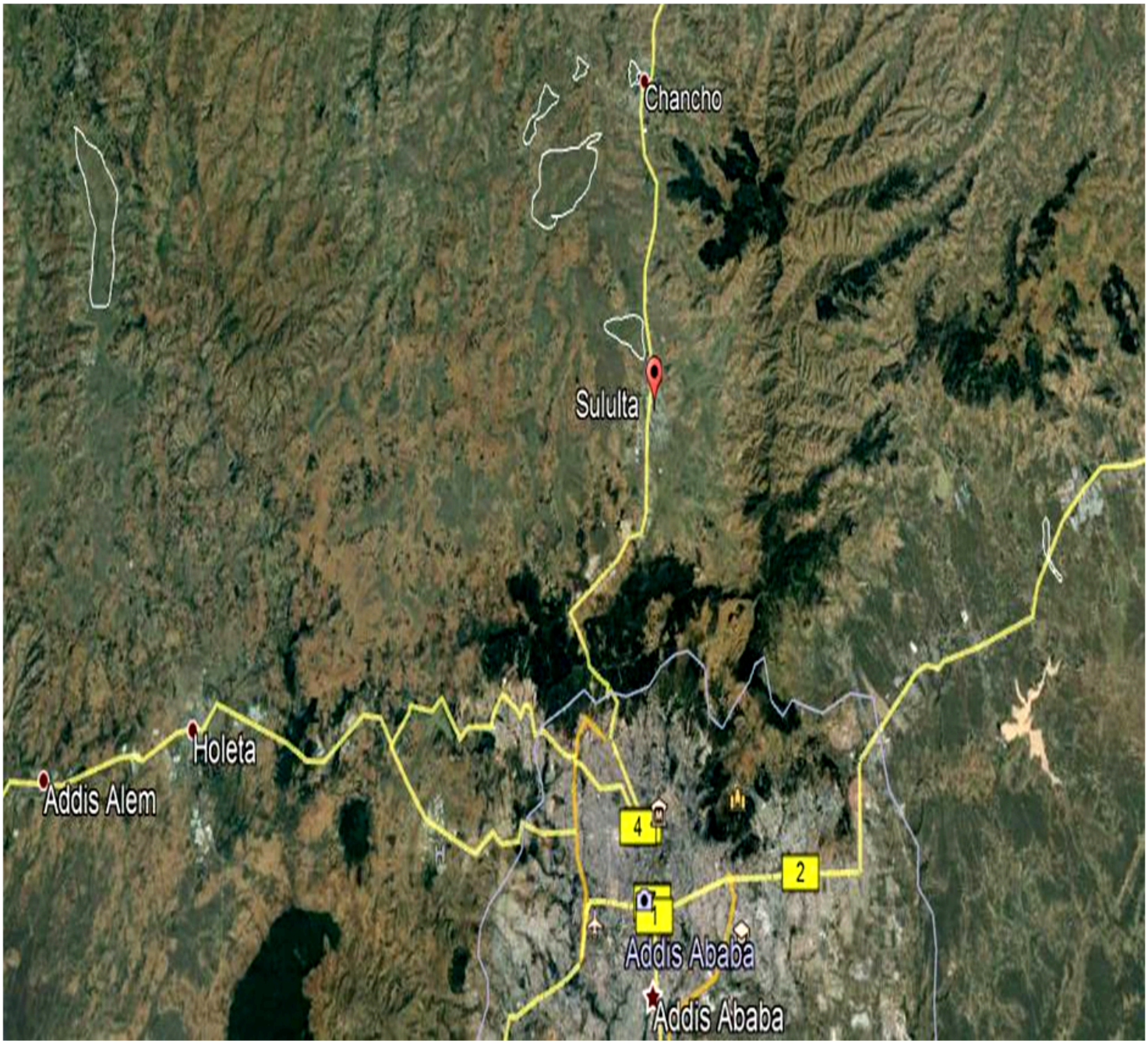


Figure 3

General spatial distribution of the study areas

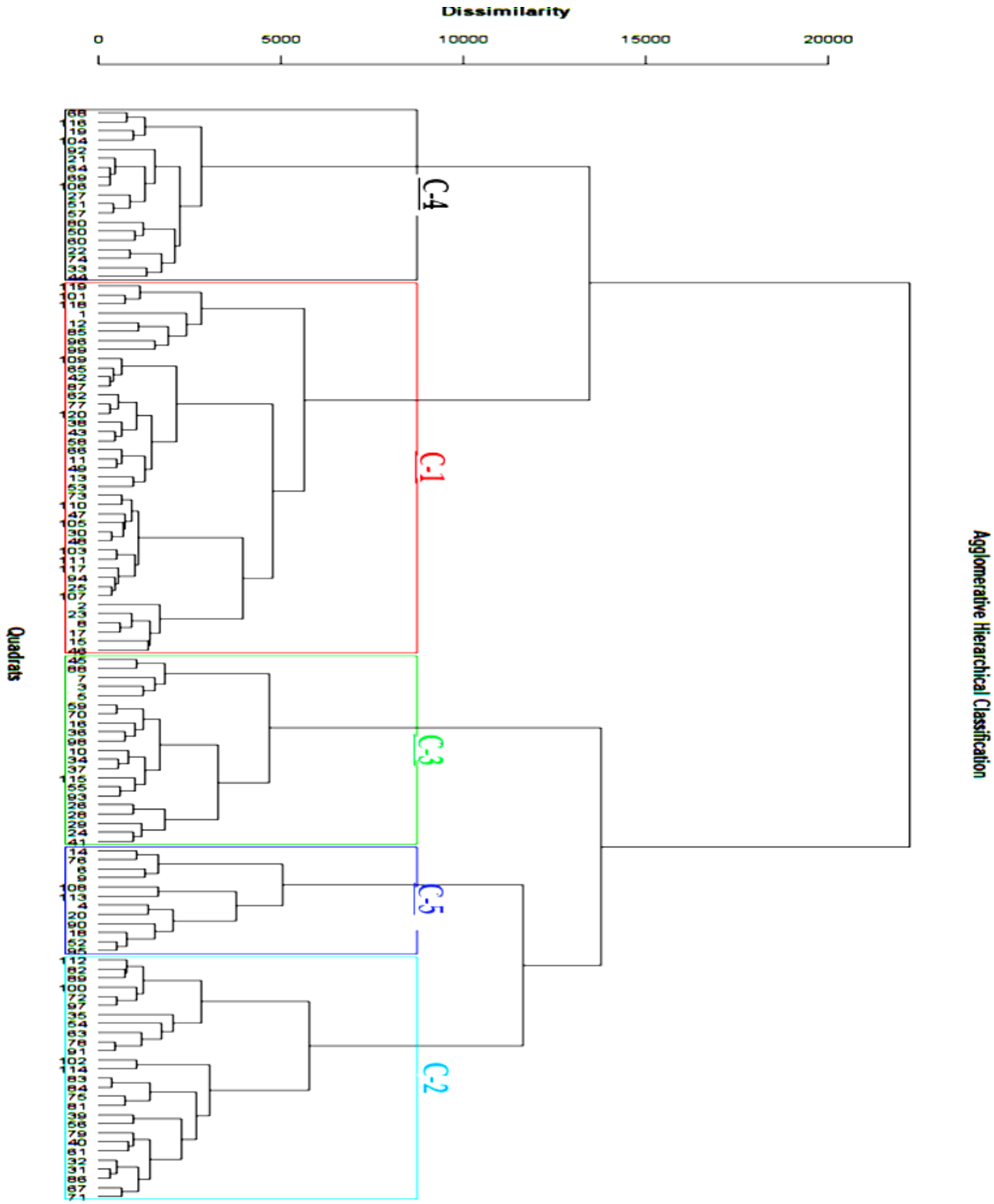


Figure 4

Dendrogram output of vegetation data obtained from hierarchical cluster analysis depict 5 communities

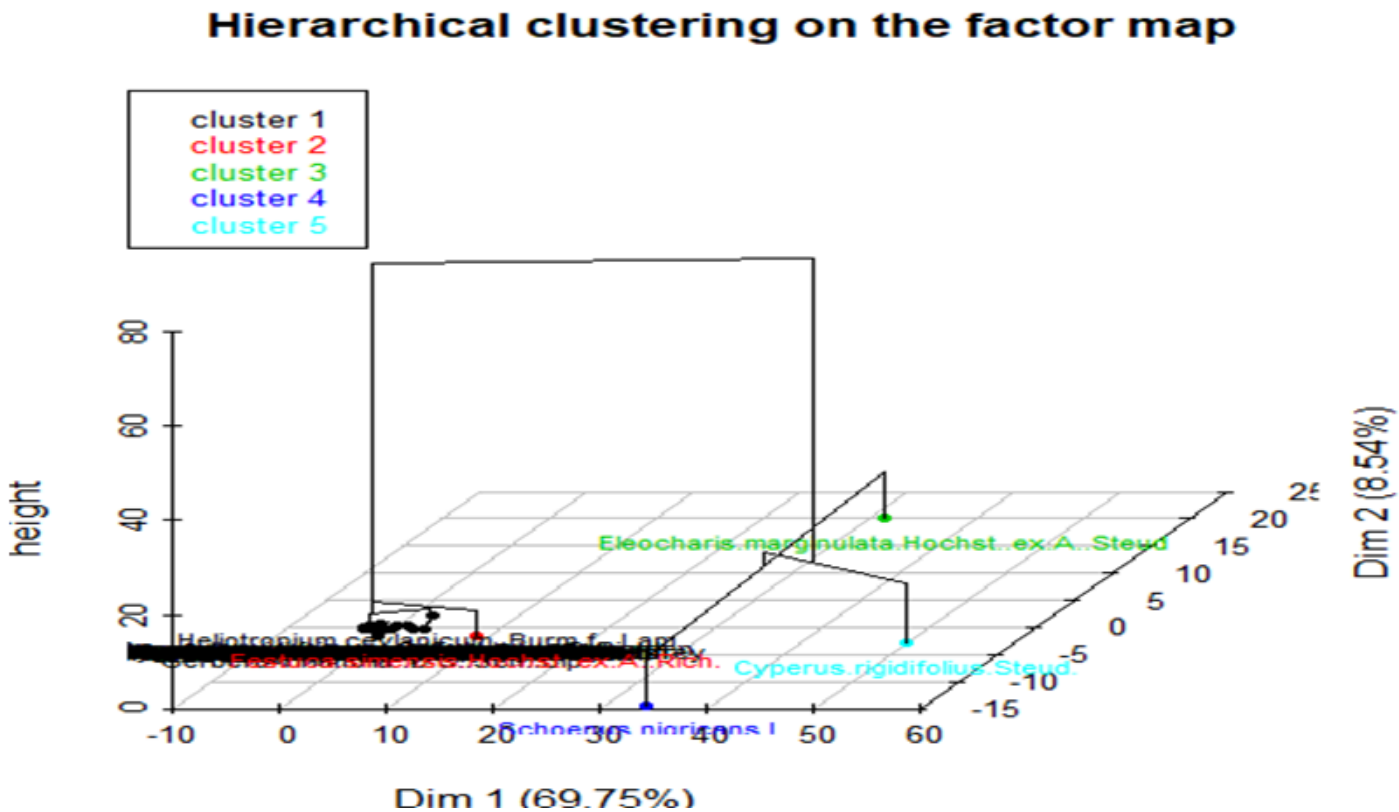


Figure 5

Map of the hierarchical cluster analysis depicting the five communities.