

## Vegetation Composition, Biomass Production, Carrying Capacity and Grassland Types in Ordolla Area of Shinile Zone, Eastern Ethiopia

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**Abstract:** A study was conducted to characterize vegetation composition and grassland types as well as to estimate biomass production and carrying capacity of the rangeland in Ordolla areas of Shinile zone, eastern Ethiopia in October 2004. The Ordolla grasslands covered 22,621ha on alluvial plain composed of sand and silt texture and clay in minor cases in small hydromorphic depressions. Seventeen vegetation types are identified in Ordolla areas based on soil types, vegetation structure and density, and drainage pattern described using LANDSAT image and geographical map of the area. The dominant grass species were *Cynodon dactylon*, *Cynodon nlemfuensis*, *Eragrostis cilianensis*, *Cenchrus ciliaris*, *Andropogon greenwayii*, *Brachiaria leersiodes*, *Setaria pumila* and *Sorghum arundinaceum*. *Acacia tortilis*, *Acacia nilotica*, *Acacia mellifera* and *Acacia seyal* were the most dominant shrubs with scattered *Caddaba rotundifolia*, *Caddaba furmisa*, *Seddera bagshawei*, *Tamarix nilotica*, *Dobera glabra* and abundant *Parthenium hysterophorus*, *Cissus rotundifolia* and *C. quadrangularis*. The grass biomass estimated in enclosed site near Ordolla village was 4.5 t DM/ha/yr and the total grass biomass produced in Ordolla rangeland was estimated around 27 534 t DM/year. The theoretical, dry and wet seasons carrying capacities were 0.16, 0.06 and 0.09 TLU/ha, respectively. There were good grazing lands in hydromorphic depression and well drained facets in Ordolla areas but the palatable grasses, trees and shrubs are decreasing due to overgrazing, runoff and drought and replaced by *Parthenium*, *Calotropis*, *Solanum* and *Xanthium* species, which are invader category of the plant community, indicating overgrazing and rangeland degradation.

**Keywords:** Biomass Production; Carrying Capacity; Grassland Types; Grazing Lands; Vegetation Composition

### 1. Introduction

The rangeland of Ethiopia covers about 60% of the total area (about 62 million ha) of which 88% receive less than 600 mm rainfall per year, and is the major source of livestock feed (BLPDP, 2004; PFE, 2004). The pastoral areas of Ethiopia are located around the peripheries almost surrounding the central mass below 1500 masl on degraded shallow soils and fallow lands, which cannot be successfully cropped because of physical constraints (Alemu and Lemma, 1991; Alemayehu, 1998). They are characterized by lowland plains and have relatively harsh climate with low, unreliable and erratic rainfall and high temperature (Coppock, 1994). The grasslands include sparse vegetation of grasses, bushes, shrubs, small trees and bare land with low level of surface water. The pastoral areas are sparsely human populated and are occupied by temporary and seasonal settlements with semi nomadic pastoral transhumant mode of life (Coppock, 1994).

The Somali Region in Ethiopia is one of the pastoral areas of the country covering about 285,000 km<sup>2</sup> and is divided into 9 administrative zones with 52 districts and the people depend on pastoral activity and in some extent agro pastoral agriculture (SORPARI, 2003). Evaluation and monitoring of rangelands is a useful

strategy to document the capacity of the rangeland that could accommodate a given number of livestock species and to develop proper interventions for future pasture utilisation. The vegetation compositions of rangelands vary depending on topography, climate and soil fertility (Coppock, 1994). The current study was designed to characterize vegetation composition and grassland types as well as to estimate biomass production and carrying capacity of the rangeland in Ordolla areas of Shinile zone, eastern Ethiopia in which information is lacking for designing and implementing range and natural resources management and development interventions.

### 2. Materials and Methods

#### 2.1. General Description of the Study Area

Ordolla is found in Shinile zone of the Somali Regional State of Ethiopia, 25 km north of Errer town and 12km west of Aydora and 15-20 km south of Azbuli at an elevation of 820 m, receiving 400-500 mm rainfall per annum with high temperature throughout the day. The study covered an area 227km<sup>2</sup>, about 22,651 ha of land. Ordolla area is classified as recent and pleistocene alluvium undifferentiated geologically and the soil is continental sediments including alluvium, aeolian deposits and eluvium differentiated

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into lacustrine deposits (Corra, 1993). There is wide alluvium expanding plain stripped by fast moving hydrographical net south of Errer in the direction of Awash Valley and Djibouti.

Ordolla Kebele (peasant Administration) and most of the settlements are located along the main Ordolla River that joins Asbuli river to the west, 20 km to the north of Ordolla. On east side, the biggest river is found crossing Aydora Kebele, coming from Tebi and Sedeti mountains and all the rivers in Ordolla areas are seasonal and do not have permanent flood. The hydro net, in addition of these main rivers, presented plenty of tributary rivers, hydromorphic veins and progressive gullies created by soil erosion (Map 1). The range land was mainly open grassland covered by short growth cycle annual vegetation which was originally predominant compared to woody stratus. Woody stratus was found in the southern part of the area on sandy soils near the hills surrounding Errer district but decreasing bit by bit when going to the north due to heavy grazing. The rangeland was mainly opened grassland covered by annual vegetation (Map 2).

## 2.2. Study Procedures

Vegetation and grassland characterization was done by interpretation and primary zoning of LANDSAT image based on the appearance of images and using GPS by clustering and delineation of similar grasslands and vegetation types together and taking samples of representative points to be surveyed. Twelve aerial photographs available for the area issued from the Ethiopian Mapping Agency (1: 50000) (edited 1999), Asbuli and Aydora topo maps (1:50000) (1999) and Dire Dawa geological map (1: 250000) (1985) were used during the field work (Map 1). During the field survey, visits were made to each representative grassland priority identified on LANDSAT image and moving to each site using GPS for validation in early October 2004. The latitude, longitude and altitude of the grasslands identified on the map were read on a hand held GPS during the fieldwork. The data include location, soil type, grazing land exploitation and grassland types, percentage of vegetation cover, grazing lands and barren soil, proportion of grasses, shrubs and trees and range and soil degradation.

## 2.3. Vegetation Composition, Biomass Production and Carrying Capacity

In the long rainy season of 2004, five half-hectare (50m x 100m) pasture sites were enclosed in all direction around Ordolla village on degraded rangeland dominated by weeds and barren soil to sensitize livestock herders and authorities about the impact of overgrazing and to estimate vegetation composition and potential biomass production. For biomass yield estimation of the vegetation inside the

enclosure, four samples of 1m x 1m quadrates in each site, a total of 20 samples were taken randomly, in which all the herbaceous species were cut at full maturity. All the plant species inside the quadrat were harvested and weighed and samples dried in an Oven at 65°C for 72 h to constant weight for dry matter yield determination (Tarawali *et al.*, 1995). In addition, in each grassland types and in the enclosures, all plant species were listed and identified on site primarily based on their morphological, structural and floristic characteristics while unknown species were collected for further identification at Haramaya University Herbarium in comparison with preserved specimens and using taxonomic keys (FAO, 1989; Hedberg and Edward, 1989; Sylvia, 1995).

In Ordolla areas, the rainfall pattern allows two vegetation growth cycles per year. The first rainy period called "Gu" which is the shortest one from mid-March to mid-May and "Karan" is the long rainy season from July to September. The enclosure biomass yield from the five random sites and 20 samples across Ordolla areas represented the Karan vegetation growth only, which is the main biomass production period. The Gu vegetation growth has not been assessed but elders in the community considers that the vegetation growth in Gu period is roughly half of the Karan season due to short and small rainfall even if the limitation in exactly estimating the biomass in Gu period is clear. Thus, the total vegetation productivity of the area was obtained by adding the GU season production onto the Karan season biomass production.

Estimation of livestock numbers grazing in Ordolla areas was done through community interview on average number of animals per household and number of household heads for each Kebele settlements and the TLU conversion factors for cattle, sheep and goats, donkey and camel which are 0.7, 0.1, 0.5 and 1, respectively (ILCA, 1990). The theoretical carrying capacity (CC) of a given grazing area is calculated as  $CC = (B \cdot K) / PD \times 6.25$  (Stoddart, 1976), in which B is the biomass edible in kg DM/ha, K is the animal use ratio which varies between 0.1 and 0.9 but usually 0.3 is considered as the grazing lands has limit for pasture regeneration properly and PD is the period duration in days and 6.25 is kg of DM consumed by one TLU/day. The pasture available for livestock is only for 3 to 4 months in Ordolla areas and the two rainy seasons are separated by a short dry spell resulting in creating two short vegetation growth cycles which limits the amount and duration of biomass production. During this dry spell the pastoralists move and displace their cattle by remaining sheep and goats and donkey. Therefore, the CC adapted to the transhumant condition for cattle in Ordolla areas was calculated for two short rainy seasons.

Five composite soil samples of each 1 kg were collected from hydromorphic veins, upper sandy areas and eroded gullies separately which constitute a total

of 15 samples. A composite sample was prepared at each sampling site for texture, pH (Bouyoucos, 1962), organic matter (Walkley and Black, 1934), total N (Jackson, 1970), available P, exchangeable K, Ca, Mg and Na (Olsen et al., 1954). Electrical conductivity was determined using sodium saturation ratio (SAR) as  $[Na^+]/\sqrt{1/2\{[Ca^{2+}] + [Mg^{2+}]\}}$  (Van Reeve Wijk, 1992) and the results of the soil test are presented in Table 1 and 2.

### 3. Results and Discussion

#### 3.1. Grassland Distributions

Seventeen grassland types are identified (Map 2) in Ordola areas based on soil type, vegetation structure and species composition according to vegetation classification of Pratt and Guwyanne (1977). The detail description of each grass land is indicated in Table 3 but some unique characteristics of each grassland type are discussed in brief as follows:

##### 3.1.1. Barren Land with Scarce *Caddaba rotundifolia* and Restricted Pockets of Mixed Perennial and Annual Herbaceous (ORD 1)

The grassland was covered by barren land (95%) with scattered shrubs (1%) and perennial grasses (4%). The dominant shrub was *Caddaba rotundifolia* and rare *Seddera bagshawei* and *Cissus quadrangularis* and the grass species were *Brachiaria leersioides* and *Dactyloctenium scindicum*.

##### 3.1.2. *Acacia nubica* Open Shrub Land (ORD 2)

It was open shrub vegetation composed of *Acacia nubica* syn. *Oerfota* and rare *Caddaba* with 40 and 10% canopy cover, respectively, and some weeds along the shallow gullies.

##### 3.1.3. Bushed Grassland Altered by Invading Species in Lower Hydromorphic Valley (ORD 3)

It was bushed grassland covered 40% by shrubs and 50 by various perennial grasses and 10% barren land. The grass species were *Cynodon*, *Setaria pumila* and *B. leersioides* and *C. rotundifolia* and some *S. bagshawei* and *A. nubica* were also found. The grassland was invaded by *Xanthium strumarium*, *Solanum somalense* and *Parthenium hysterophorus*.

##### 3.1.4. Tributary Riverbanks of Open Shrub-Land Dominated by *Acacia* Species and Annual Vegetation (ORD 4)

It was open shrub grassland in riverbanks and hydromorphic valleys with barren land (50%), shrubs (45%) and 5% herbaceous vegetation. *Acacia tortilis* covered 40%, *A. nubica* (2%) and *C. rotundifolia* (1%) and no grasses.

Table 1. Soil physical and chemical characteristics in Ordolla areas of Shinile zone, eastern Ethiopia

Description of the sampled area	Texture (%)			pH-H <sub>2</sub> O (1: 2.5)	OM (%)	Tot N (%)	EC (1: 2.5)
	Sand	Silt	Clay				
Experimental enclosure (hydromorphic vein.)	27.12	36	36.88	7.86	1.53	0.06	0.27
Experimental enclosure (upper sandy part)	63.12	20	16.88	7.94	0.54	0.02	0.21
Erosive gully (degraded banks)	87.12	2	10.88	7.89	0.25	0.01	0.13

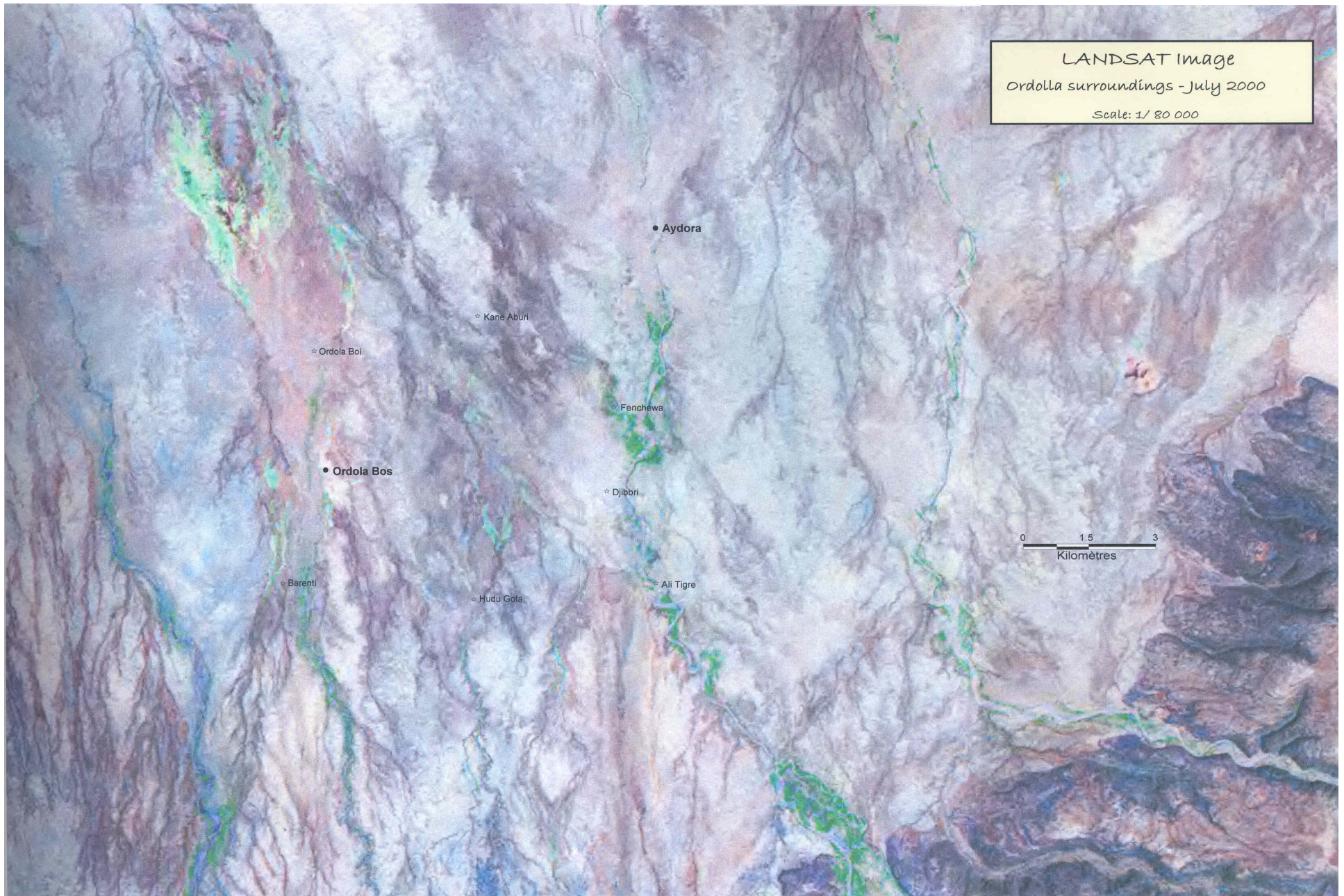
OM= Organic matter; EC=Electrical conductivity; Tot N = Total nitrogen

Table 2. Some soil macro nutrients in Ordolla areas of Shinile zone, eastern Ethiopia

Description of the sampled area	Available P (ppm)	Exch. Na	Exch. K	Exch. Ca	Exch. Mg
Experimental enclosure (hydromorphic vein.)	5.12	0.37	1.40	43.73	4.92
Experimental enclosure (upper sandy part)	4.45	0.38	0.67	33.37	2.92
Erosive gully (degraded banks)	3.20	0.23	0.29	25.36	1.70

Exch = Exchangeable; P = Phosphorus; Na = Sodium; K = Potassium; Mg = Magnesium





Map 1. LANDSAT Image of Ordolla surroundings, Somali Regional State, eastern Ethiopia



# Phyto-ecological facies of Ordola surroundings

Based on the interpretation of LANDSAT image (07/2000)  
Projection ; UTM - WGS 84 - Zone 37

Scale: 1: 80 000

## Administration and roads

- Kebeles
- ☆ Settlements
- Secondary roads (non asphalted)
- - - Pists

## Hydrographic net

- Main rivers (non permanent)
- Secondary rivers (non permanent)
- Tributary rivers and erosive galleys

## Vegetal characterization

- + Sampling points

### High pastoral value facies

- Bushland with dense coverage of mixed perennial grasses in hydromorphic valley (ORD 12)
- Bracharia leersioides dominated dense grassland with scattered Cadaba shrub (ORD 6, 10 bis)
- Bushed grassland altered by invading species (ORD 3,10)

### Medium pastoral value facies

- Widely opened bushed rangeland stripped with perennial grasses along small hydromorphic veins (ORD 7)
- Acacia nubica and Cadaba shrubs dominated open grassland (PS008)
- Dry riverbanks open bushland altered by invading species (ORD 9)

### Browsing facies

- Riverbanks open woodland with scarce annual vegetation (ORD 5)
- Acacia nubica open shrubland (ORD 2)
- Tributary riverbanks open shrubland dominated by Acacia sp and annual herbaceous (ORD 4)

### Barren soil dominating facies

- Hydromorphic fastland exclusively covered by Tribulus zeyheri (ORD14)
- Alluvial terrace barren land with scarce Cadaba shrub and annual herbaceous
- Upper barren rangeland with scattered Cadaba shrubs and annual herbaceous (ORD 8)
- Upper barren land with scattered Cadaba shrubs and annual herbaceous (ORD 13)
- Barren land with scarce Cadaba and restricted pockets of mixed perennial and annual herbaceous (ORD 1)

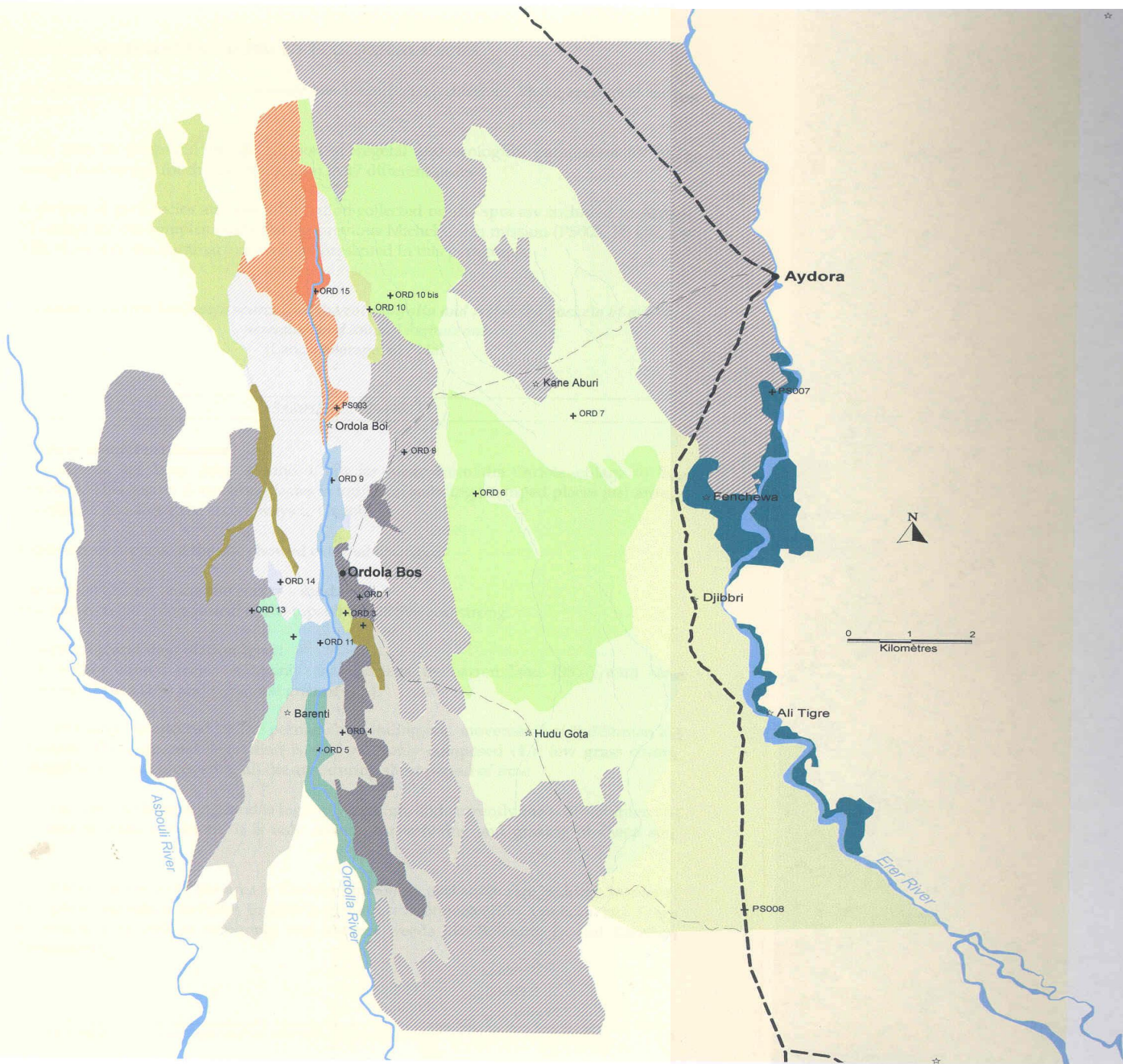
### Altered facies

- Xanthium strumarium monospecific population on degraded riverbanks (ORD 15)
- Calotropis procera dominated shrubland on river's overflow area (PS003)

### Others

- Tamarix nilotica and Cadaba shrubs open woodland (PS007)
- Non studied areas

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Map 2 Phyto-ecological grasslands of Ordolla areas in Shinile zone of Somali Regional State, eastern Ethiopia

### 3.1.5. Riverbanks Open Woodland with Scarce Annual Vegetation (ORD 5)

The grassland covered 40% barren soil and 40-45% woody vegetation especially *Acacia seyal* (10%) and grouped *C. rotundifolia* (20%) and few *Balanites aegyptiaca* along the riverbanks with 10 % *T. zeyheri* but no perennial grasses.

### 3.1.6. *B. leersioides* Dominated Dense Grassland with Scattered *C. rotundifolia* Shrub (ORD 6)

It was typical grassland 80% covered by perennial grasses with *C. rotundifolia* (15%) and 5% barren soil and the grass species was *B. leersioides* (70%) and *Cynodon* species (10%). Next to this grassland, about 4-5 km far from Ordolla village to the north east direction there was grassland represented by ORD 10 BIS dominated by *B. leersioides* (70%) and *Dichantium annulatum* (5%), *Cyperus* species (10%) and *Caddaba glandulosa* (15%).

### 3.1.7. Widely Opened Bushed Rangeland Striped with Perennial Grasses along Small Hydromorphic Veins (ORD 7)

This grassland was composed of two sub-grasslands: the long veins formed due to hydromorphic conditions and presented various perennial and annual grass mixed with weeds and the interfluves between hydromorphic veins were the upper land with dry and barren soil covered by scattered *C. rotundifolia* and *T. zeyheri*.

### 3.1.8. Upper Barren Rangeland with Scattered *C. rotundifolia* and Annual Vegetation (ORD 8)

It was covered 95% by barren land and 5% *C. rotundifolia* canopy cover. *T. Zeyheri* was only covering most of the barren land during the rainy season.

### 3.1.9. Dry Riverbanks Open Bush Land Altered by Invading Species (ORD 9)

The vegetation was covered by *C. rotundifolia* with 40% canopy cover, grouped in big and full pockets but it was increasing in size. The vegetation area was covered with 40% barren soil and the rest 20 and 20% covered with herbaceous layer and *X. strumarium*, respectively.

### 3.1.10. Bushed Grassland Altered by Invading Species in Lower Hydromorphic Valley (ORD 10)

It was covered 90% vegetation and 10% barren land and the vegetations were *C. rotundifolia* (20%) and *S. bagshawei*, stunted *Acacia seyal* and mixture of *B. leersioides* and *Cynodon nlemfuensis* (20%) and it was covered by *Xanthium strumarium* (20%), *Parthenium hysterophorus* (20%) and *Solanum* species (10%).

### 3.1.11. Bush Land with Dense Coverage of Mixed Perennial Grasses in Hydromorphic Valley (ORD 12)

It represented the highest productive vegetation covered by shrubs and perennial grasses (80%). It was divided into two parts: the central one where the vegetation coverage was around 100% of which *D. annulatum*, *B. leersioides* and *Ischaemum afrum* cover 50% and *A. seyal* and *C. rotundifolia* covered the remaining 50% canopy cover and the peripheral part of this vein was covered by *B. leersioides* and *C. rotundifolia* with 20 and 40 canopy cover, respectively.

### 3.1.12. Upper Barren Land with Scattered *C. rotundifolia* Shrub and Annual Herbaceous on Gravelled Soil (ORD 13)

The vegetation was covered 90% by barren soil and 5 to 10% scattered *C. rotundifolia*.

### 3.1.13. Hydromorphic Fast Land Covered by *Tribulus zeyheri* (ORD 14)

The vegetation was highly influenced by hydromorphic condition and covered only by barren soil without grasses but it was covered by *T. zeyheri* during the rainy season.

### 3.1.14. *Xanthium strumarium* Monospecific Formation on Degraded Riverbanks (ORD 15)

The vegetation area was characterized by 30% barren soil land and exclusively covered 65% by *X. strumarium* and 5% by *C. procera* but no herbaceous species at all.

### 3.1.15. *Calotropis procera* Dominated Shrub Land on River Overflow Area (ORD 15)

The vegetation was dominated by tall and densely populated *C. procera*, followed by *X. strumarium*, *Amaranthus hybridus*, *S. somalense* and *P. hysterophorus*, respectively.

### 3.1.16. Alluvial Terrace Barren Land with Scarce *Caddaba* Shrub and Annual Vegetation

This vegetation was dominated 15% by *Caddaba* species and 85% by barren land and some pockets of *T. zeyheri*.

### 3.1.17. *Acacia* and *Caddaba* Dominated Open Vegetation (PS 008)

This vegetation was characterized by distinct patches of *A.oerfota*, *C. rotundifolia* and *T. nilotica* and the presence of rare *Barleria eranthemoides*, *Lasiocorys abyssinica*, *C. quadrangularis* and stunted *Panicum coloratum*, *Chrysopogon plumulosus* and *Eragrostis cilianensis*.

### 3.1.18. *Tamarix nilotica* and *Caddaba* Dominated Open Vegetation (PS 007)

It was characterized by distinct patches of *C. rotundifolia* and *T. nilotica* and the presence of rare *Aerva jsvanica*, *L. abyssinica*, *Solanum indicum*, *S. somalense*, and *Abutilon figarianum*, *Cissus quadrangularis* and some stunt *P. coloratum*, *C. plumulosus*, *Setaria pumila*, *E. cilianensis* and *Dactyloctenium scindicum*.

### 3.2. Ranking of Vegetation Types

The grassland types were ranked into six pastoral values (Map 3) based on area coverage of palatable species mainly perennial grasses, species diversity and productivity of the pasture follows: -

#### 3.2.1. High Pastoral Value Grassland

It covered 3 275 ha (14.4%) representing the best pastures of the area including pure vegetation (ORD 6), the mixed vegetation (ORD 10) and the very productive grass and bush mixed land (ORD 12). These are the most productive rangelands because of more than 80% perennial vegetation coverage. Moreover, this vegetation was mainly composed of dense perennial grass carpet (ORD 6 and 10) except in the small over trampled part (central part of hydromorphic veins, depressions-ORD 10).

#### 3.2.2. Medium Pastoral Value Grassland

It covered 5 361 ha (23.6%) of Ordolla area and it included the hydromorphic vein vegetation (ORD 7), the close alluvial terrace (ORD 9) and the open shrub and vegetation (PS008). They were areas where some perennial and annual mixed grasses and weeds species were found in relatively dense coverage (ORD 7 and more weeds in ORD 9). It also included the PS008 grassland where only annual grasses and *T. zeyheri* were found but constituted an interesting potential area by its wide coverage and the presence of some *Acacia* shrubs. However, these rangelands have quite lower pastoral interest than the first group, as the vegetation coverage was limited to restricted areas (hydromorphic veins) or pockets (PS008).

#### 3.2.3. Preferred Shrubs Dominated Grassland

It covered 1 561 ha (almost 6.9 %) of Ordolla area and included all woody grasslands dominated by *A. nubica* syn oerfota, along the tributary riverbeds. The herbaceous coverage was absent or limited (ORD 2, 4, 5) and mainly composed of *T. zeyheri* and some rare annual grasses in secondary erosive gullies. These grasslands have limited potential due to the absence of grass and even herbaceous species but have pastoral interest as they constitute an important browse for camels.

### 3.2.4. Barren Soil Dominated Grassland

It occupied 11 418 ha (almost 50.4%) of Ordolla area representing ORD 1, 8, 13, 14 and the wide terrace. The contribution of these grasslands to grazing was very low to null as they were covered by more than 90% barren soil and 10% by *Caddaba* shrubs. Some of the barren soil was completely sterile, but remaining wide areas covered by *T. Zeyheri*, the only vegetation growing for few weeks. Due to its short-lived behaviour of *T. Zeyheri*, it is partially grazed by camels before blooming. Therefore, these grasslands are not considered as significant grazing lands.

### 3.2.5. Altered and Degraded Grassland

This grassland covered 606 ha (almost 2.7%) of Ordolla area representing grasslands invaded by *C. procerca* (PS003) and *X. strumarium* (ORD 15) where they were forming pure colony. These grasslands were located along the river, where trampling by animals during watering and do not have interest for animal grazing since there are no perennial grasses and preferred browse species.

### 3.2.6. *T. nilotica* Formation

It covered 400 ha (almost 1.8%) of Ordolla area. This vegetation (PS007) was isolated as it was pure population of *T. nilotica*. Moreover, it does have small value for grazing since there is no herbaceous species for animals.

### 3.3. Grazing Land Categorization

According to the ranking done, the grazing areas in Ordolla surroundings are categorized by considering the surveyed areas as a whole, based on the palatability of herbaceous vegetations (proportion of perennial grasses, shrubs and invaders available), total vegetal coverage and barren soil as follows:

1. Good and permanent grazing which represents only 15% of the surveyed area (grasslands of the first ranked group)
2. Complementary grazing lands, which represent additional 30% (medium pastoral value + browsing grassland), wide areas dominated by low productive barren soil as well as taking probably low part on livestock grazing
3. About 55% of the rangeland can be considered as non-grazing areas (barren soil dominated grassland + altered grassland + *Tamarix* colony) due to their limited values and it does have low value for livestock grazing or browsing.



### 3.4. Vegetation Composition, Biomass Production and Carrying Capacity

After enclosing the pasture, the difference between the inside and outside on vegetation composition was very clear and demonstrative. Although the place was looking degraded, barren, sandy and invaded by weeds, the grasses grown showed an unforeseen diversity and density. By protecting seasonal grazing, essential grass species has grown up, flowered and set seeds with in short period demonstrating high capacity of regeneration and presence of good soil seed bank. Moreover, it was impressive for herders to observe the grasses at full maturity as grasses were continuously grazed even up to the roots in the unprotected area. This showed that the area has good potential and capacity to support different livestock species if properly managed. The main grass species observed in the enclosure were *Cynodon dactylon*, *Cynodon nlemfuensis*, *Andropogon greenwayii*, *Brachiaria leersiodes*, *Setaria pumula* and *Cenchrus ciliaris* in order of abundance and rarely *Cyprus involucratus* Table 3. Enclosures are good sources of biodiversity of grass and shrub vegetations as indicated by different authors (Blench and Sommer, 1999; Emiru, 2002). The grasses are naturally palatable and important for livestock feeding and the height of these grasses reached around 25-50 cm. Similar research findings are reported by many authors in other parts of Ethiopia (Coppock, 1994; Baars, 1996; Ayana and Baars, 2000; Lema, 2001; Amsalu and Baars, 2002; Alemayehu, 2004; Yihalem, 2004; Yvan and Tessema, 2005).

Biomass produced measured inside the enclosure during the main rainy season was 4.5 t DM/ha. This biomass yield was obtained in the Karan rainy season (July to September) only herbaceous species due to the absence of trees and shrubs in the enclosure. The total grazing land annual biomass production in Ordolla areas may be estimated as  $4.5 + 2.25 = 6.75$  t DM/ha/year by taking the two short rainy seasons. This figure is comparable to most managed natural pasture (Tessema, 2005) and even higher than most of the communally grazed pasture in Ethiopia as reported by many authors (Coppock, 1994; Ayana and Baars, 2000; Lema, 2001; Amsalu and Baars, 2002). The productivity estimation for high pastoral value grazing lands, with no grass cover was  $3\ 275\ \text{ha} * 6.75\ \text{t DM/ha} = 22\ 106\ \text{t DM/year}$  and for medium pastoral value grazing lands, with 15% herbaceous cover was  $5\ 361\ \text{ha} * 0.15 * 6.75\ \text{t DM/ha} = 5\ 428\ \text{t DM/year}$ , and the total annual biomass produced by different grazing lands in Ordolla areas was estimated to be around 27 534 t DM/year.

For the 390 households in twelve settlements in the Ordolla areas, the number of different animal species was estimated as follows: shoats 39 340, cattle 11 396, camels 3 293 and donkey 315, total of 54 344 heads of

mixed livestock or 15 361.7 TLU (Table 4). According to the estimated biomass production of the pasture and available livestock species in TLU, the carrying capacity of the rangeland in Ordolla areas would be estimated as 0.16 TLU/ha/year ( $27\ 534\ 000 * 0.3/365 * 6.25$ ) or 6.25 ha grazing land for 1 TLU or 1 camel or 10 shoats without affecting vegetation composition and pasture productivity. The estimated carrying capacity of Ordolla areas with respect to transhumant pastoral condition was 0.06 and 0.09 TLU/ha in dry (5 months) and in wet seasons (7 months), respectively.

## 4. Conclusions

In general, large proportion of Ordolla rangelands was barren land without herbaceous vegetation except some scattered shrubs and trees. Seventeen grassland types were identified in Ordolla areas. Vegetation composition, grassland types and other phyto ecological characteristics of other districts of Shinile zone near Ordolla area has been reported by Corra (1993). The dominant grass species in Ordolla areas were *C. dactylon*, *C. nlemfuensis*, *E. cilianensis*, *C. ciliaris*, *A. greenwayii*, *B. leersiodes*, *S. pumila* and *Sorghum arundinaceum*. *A. tortilis*, *A. nilotica*, *A. mellifera* and *A. seyal* were the most dominant shrubs with scattered *C. rotundifolia*, *C. furmosa*, *S. bagshawei*, *T. nilotica*, *D. glabra* and abundant *P. hysterothorus*, *C. rotundifolia* and *C. quadrangularis*. The grass biomass estimated in enclosure near Ordolla village was 4.5 t DM/ha/yr and total annual biomass produced in Ordolla rangeland was around 27 534 t DM/year. The theoretical and transhumant context carrying capacities of Ordolla rangeland in dry and wet seasons were 0.16, 0.06 and 0.09 TLU/ha, respectively without affecting the pasture. There were good grazing lands in hydromorphic depression in Ordolla areas but the palatable grasses, trees and shrubs are decreasing due to overgrazing, runoff and drought and replaced by *Parthenium*, *Calotropis*, *Solanum* and *Xanthium* species, which are invader plant species and replaced palatable plants (decreasers and increasers mainly perennial grasses) indicating overgrazing and rangeland degradation as observed in most parts of Ethiopia.

## 5. Acknowledgment

The authors would like to thank Handicap International for financing the study and Haramaya University for the expertise and the pastoralists for their assistance during the fieldwork.



Table 3. Description of different grassland types in Ordolla areas of Shinile zone, eastern Ethiopia

Vegetation types code	Area covered (ha)	Altitud (masl)	Vegetation type descriptions						
			Proportion of		Drainage pattern	Estimated field texture	Hypochloride Test	Vegetation	
			Vegetation	Barren soil				Use level	Pastoral interest
ORD1	417	827	5	95	External	Silty sand	Strong efferscence	High to very high	Quasi in existent
ORD2	147	823	50	50	External	Silty	Strong efferscence	Very high	Low
ORD3	486	808	90	10	External	Silty	Strong efferscence	Medium	Very high
ORD10	-	800	90	10	External	Silty	Strong efferscence	Low	Very high
ORD4	1208	824	50	50	External	Silty clay	Strong efferscence	High	High to very high
ORD5	207	-	60	40	External	Silty clay	Strong efferscence	Very high	Low
ORD6	2604	800	95	5	external	Sand silty	Strong efferscence	Low	Very high
ORD10B15	-	790	95	5	External	Sand silty	Strong efferscence	Low	Very high
ORD7	2891	804	10	90	External	Clay	Strong efferscence	High	Low
ORD8	7160	802	5	95	External	Silty clay	Strong efferscence	Very high	Low
ORD9	279	800	60	40	External	Silty sand	Strong efferscence	Very high	low
ORD12	133	814	80	20	External	Clay silt	Strong efferscence	Medium	Very high
ORD13	2505	822	10	90	external	Sandy clay	Strong efferscence	In existent	Very low
ORD14	20	-	5	95	External	Silty-clay	Strong efferscence	Very high	Very low
ORD15	103	817	70	30	External	Silty loam	Strong efferscence	Very high	in existent
ORD5 & 9	1317	-	20	80	External	Silty	Strong efferscence	Very high	Low to null
PS008	2243	863	40	60	External	-	Strong efferscence	High	Low
PS007	400	802	35	65	External	Clay	Strong efferscence	High	Low

Table 4. Vegetation composition of Ordolla areas of Shinile zone, eastern Ethiopia

Caesalpinioideae	Gramineae	Convolvulaceae
<i>Cassia italica</i> (Mill.)	<i>Andropogon greenwayii</i> Napper	<i>Seddera bagshawei</i> Rendel
<i>Senna Alexandria</i> (L.) Link	<i>Brachiaria leersioides</i> (Hochst.) Stapf	<i>Seddera hallieri</i> Engl. and Pilgr
<i>Tamarindus indica</i> L.	<i>Cenchrus ciliaris</i> L.	<i>Seddera latifolia</i> Steud.
Papilionoideae	<i>Chrysopogon plumulosus</i> Hochst.	Cactaceae
<i>Crotalaria spinosa</i> Benth	<i>Cynodon dactylon</i> (L.) pers	<i>Opuntia ficus indica</i>
<i>Indigofera amorphoides</i>	<i>Cynodon nlemfuensis</i> Vanderyst	Cyperaceae
Salvadoraceae	<i>Dactyloctenium scindicum</i> Boiss	<i>Cyprus involucratus</i> Rottb.
<i>Dobera glabra</i> (Forsk.) Juss.	<i>Eragrostis cilianensis</i> (All.) Link	Euphorbiaceae
Mimosoideae	<i>Setaria pumila</i> (Poir.) Roem.	<i>Euphorbia tirucali</i> L.
<i>Acacia horrida</i> (L.) Willd Subsp.	<i>Sorghum arundinaceum</i> (Willd). Stapf	Solanaceae
<i>Acacia mellifera</i> (Vahl) Benth	<i>Sporobolus ioclades</i> (Tri.) Nees	<i>Datura stramonium</i> L.
<i>Acacia nilotica</i> (L. Del. Subsp.	Tamaricaceae	<i>Solanum indicum</i> L.
<i>Acacia senegal</i> (L.) Willd.	<i>Tamarix nilotica</i> (Ehrenb.) Bunge	<i>Solanum somalense</i> Franchet
<i>Acacia seyal</i> Del. Var. seyal	Tiliaceae	Vitaceae
<i>Acacia tortilis</i> (Forssk.) Hayne	<i>Grewia bicolor</i> Juss	<i>Cissus quadrangularis</i> L.
Balanitaceae	<i>Grewia erythraea</i> Schweinf.	<i>Cisus rotundifolia</i> (Forssk.) Vahl
<i>Balanites aegyptica</i> (L.) Del	<i>Grewia tenax</i> (Forssk.) Fiori	Amaranthaceae
<i>Balanites glabra</i> Mildbr.	<i>Grewia villosa</i> Willd	<i>Amaranthus hybridus</i> L.
Capparaceae	Salvadoraceae	Compositae
<i>Caddaba farinose</i> Forssk.	<i>Dobera glabra</i> (Forsk.) Juss.	<i>Parthenium hysterophorus</i>
<i>Caddaba glandulosa</i> Forssk.	Convolvulaceae	<i>Vernonia cinerascens</i> Sch. Bip.
<i>Caddaba heterotracha</i> Stocks.	<i>Seddera bagshawei</i> Rendel	<i>Xanthium strumarium</i> auc. Non L.
<i>Caddaba rotundifolia</i> Forssk	<i>Seddera hallieri</i> Engl. And Pilgr	Verbenaceae
	<i>Seddera latifolia</i> Steud.	<i>Lantana camara</i> L.

# Map of grazing areas in Ordolla surroundings

Pulled out from PE map  
Based on the interpretation of LANDSAT image (07/2000)  
Projection ; UTM - WGS 84 - Zone 37



Scale: 1: 80 000

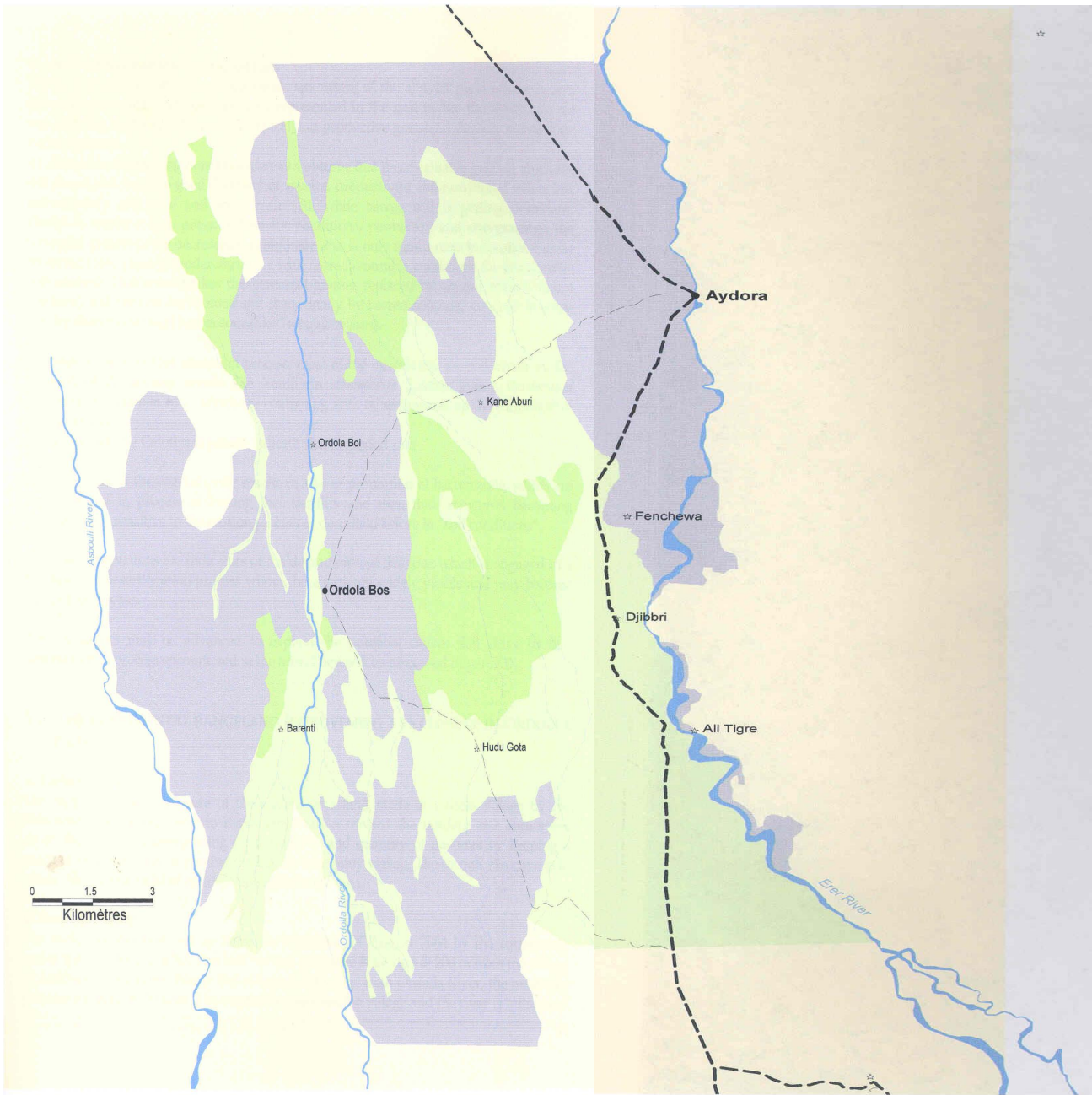
### General

- Kebeles
- ☆ Settlements
- Secondary roads
- - - Pists

- Main rivers (non permanent)
- Secondary rivers (non permanents)
- Tributary rivers and erosive galleys

### Thematic

- Grasslands - 3 275 Ha - (14/100)  
( >80/100 of perennial grass coverage)
- Complementary grazing lands - 6 922 Ha - (38/100)  
(restricted areas of various herbaceous or tree with 30-85/100 of barren soil)
- Non-grazing areas - 12 425 Ha - (55/100)  
( > 90/100 barren soil exclusively covered by cadaba < 10/100 and partially by short lived Tribulus zeyheri)
- Non studied areas



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Map 3 Types of grazing lands in Ordolla areas of Shinile zone, Somali region, eastern Ethiopia

Table 5. Average and total of number of livestock species in Ordolla areas of Shinile zone, eastern Ethiopia

	Number of livestock species per household (HH)				Total heads	TLU		
	Poor group (70%)	Medium group (15%)	Better off group (15%)					
Cattle	0-7	273 HH	20-40	58 HH	100-200	58 HH	11396	7977
Shoats	30-50		60-120		300-500		39340	3934
Camel	0-5		15-30		80-120		3293	3293
			Total				54344	15361.7

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