Ecological Processes

RESEARCH

Open Access

The impacts of rice cultivation on an indigenous Fogera cattle population at the eastern shore of Lake Tana, Ethiopia

Mare Addis Desta[1*], Gete Zeleke[2], William A. Payne[3], Teshome Shenkoru[4] and Yihun Dile[5]

Abstract

Background: Even though increasing population pressure and associated increased demand for food and economic development have led to overexploitation and degradation of wetlands throughout the world, the drivers are most severe in developing countries. For generations, Fogera wetlands in Ethiopia which are parts of Lake Tana Biosphere Reserve have been widely used for grazing of indigenous cattle. Fogera cattle are one of several recognized indigenous breeds of Abyssinian zebu bovine cattle (*Bos primigenius indicus*) found in Fogera district, Ethiopia. This study was conducted to quantify impacts of rice expansion on cattle population in Fogera wetlands. Data were collected through questionnaire, focus group discussions, interviews, and land use/land cover analysis. Respondents were selected using systematic random sampling. Variance and LEVENES test were used to analyze the livestock unit and to check homogeneity.

Results: The study revealed that during the 20-year period preceding 2015, the number of cattle owned decreased from 3509 to 1510 heads. In the same period, rice cultivation increased from 182 to 9499 ha and production from 6701 to 714,013 qt. Grazing lands were reduced from 8550 to 3501 ha, wetlands from 3114 to 1060 ha, and forests from 1542 to 907 ha. Land use/land cover changes showed a negative balance of 40% dry matter requiring cattle feed to be increasingly supplemented through purchases, or reduction in herd number. The study also indicated that the land-use changes brought at the expense of traditional cattle production systems.

Conclusion: Hence, proper management is required to maintain these valuable resources and keep their role in socioeconomic development of the area.

Keywords: Indigenous cattle, Wetland, Agriculture, Rice, Grazing land, Ethiopia

Introduction

Wetland agriculture, which comprises crop cultivation, livestock, pisciculture, and fishing, has made a significant contribution to the well-being of humanity over the centuries (Bayliss-Smith and Golson 1992). Wetlands play a key role in pollution mitigation and flood control, provide habitat for many species of fish and wildlife, and help maintain groundwater supplies and water quality (Patrick 1976; Mitsch and Gosselink 1986; Dahl 1990). Wetlands commonly occur in human-dominated landscapes such as agricultural and urban regions (Neely and Baker 1989; Ehrenfeld 1991). Studies have shown that many human activities can have negative effects on wetland ecosystems (Morgan and Philip 1986; Aerts and Berendse 1988; Moore et al. 1989; Ehrenfeld and Schneider 1991; Ehrenfeld 1991; Morris 1991). Increasing population pressure and associated increased demand for food and economic development have led to overexploitation and degradation of wetlands throughout the world. These drivers are most severe in developing countries with rapidly growing economies and populations (Central Statistical Agency 2007). More than 50% of the world's wetlands have been altered, degraded, or lost in the last 150 years (O'Connell 2003). Wetlands should be managed in a sustainable manner to meet human needs for present and future generations (FAO 2008). To continue wetlands for the future generation, it is necessary to conserve these resources and reverse ecological changes (Lamsal et al. 2015).

* Correspondence: mare.addis@eiabc.edu.et; mareaddis2005@gmail.com
[1]Department of Geography and Environmental Studies, Wollo University, P.O. Box 1145, Dessie, Ethiopia
Full list of author information is available at the end of the article

Seasonal wetlands such as the Fogera plain can provide valuable feedstock for livestock because of their high biomass production (Millennium Ecosystem Assessment (MEA) 2005). For generations, the Fogera wetlands in Ethiopia have been widely used for livestock grazing (IPMS 2005). However, farmers increasingly prefer to grow rice instead of other crops due to its high yield and market price compared to other crops (Mesfin et al. 2016). The introduction of rice has changed income source and distribution (IPMS 2005).

Much research has been devoted to increase rice production and profitability in the Fogera wetlands. Studies include those on integrated fertilizer management ((Mulugeta and Heluf 2006; Tilahun et al. 2013), value chains (Astewel 2010; Birhanu 2017), weed management (Agegnehu et al. 2013), water availability and management as affected by livestock (Alemayehu 2013), climate change (Lemma 2013; Gashaw 2016), land-use patterns (Gashaw 2016; Gashaw and Mamaru 2017; Wubneh and Amare 2017), and nonpoint pollution in the Lake Tana basin (Moges et al. 2017).

In sustainable agricultural systems, natural ecosystems should be preserved to the extent possible, and land degradation should be minimized (MoWEM 1991). Furthermore, many international organizations have advocated for innovative land-use approaches that engage local communities and draw upon traditional knowledge and practices to facilitate the adoption of best practices and to sustain the environment (UNESCO 2000; UNCCD 2015). Studies suggested that rice cultivation has had detrimental impacts on traditional livestock systems, e.g., by restricting livestock movement (IPMS 2005). However, despite the threat that land-use change poses to Fogera ecosystems and traditional farming systems, there is limited research on the impacts of rice cultivation on indigenous cattle production systems, which have traditionally relied on the availability of grazing lands and adequate feed (Tadesse and Solomon 2014). This study is, therefore, to assess impacts of the expansion of rice production on land-use patterns in the Fogera wetlands and on traditional cattle production systems.

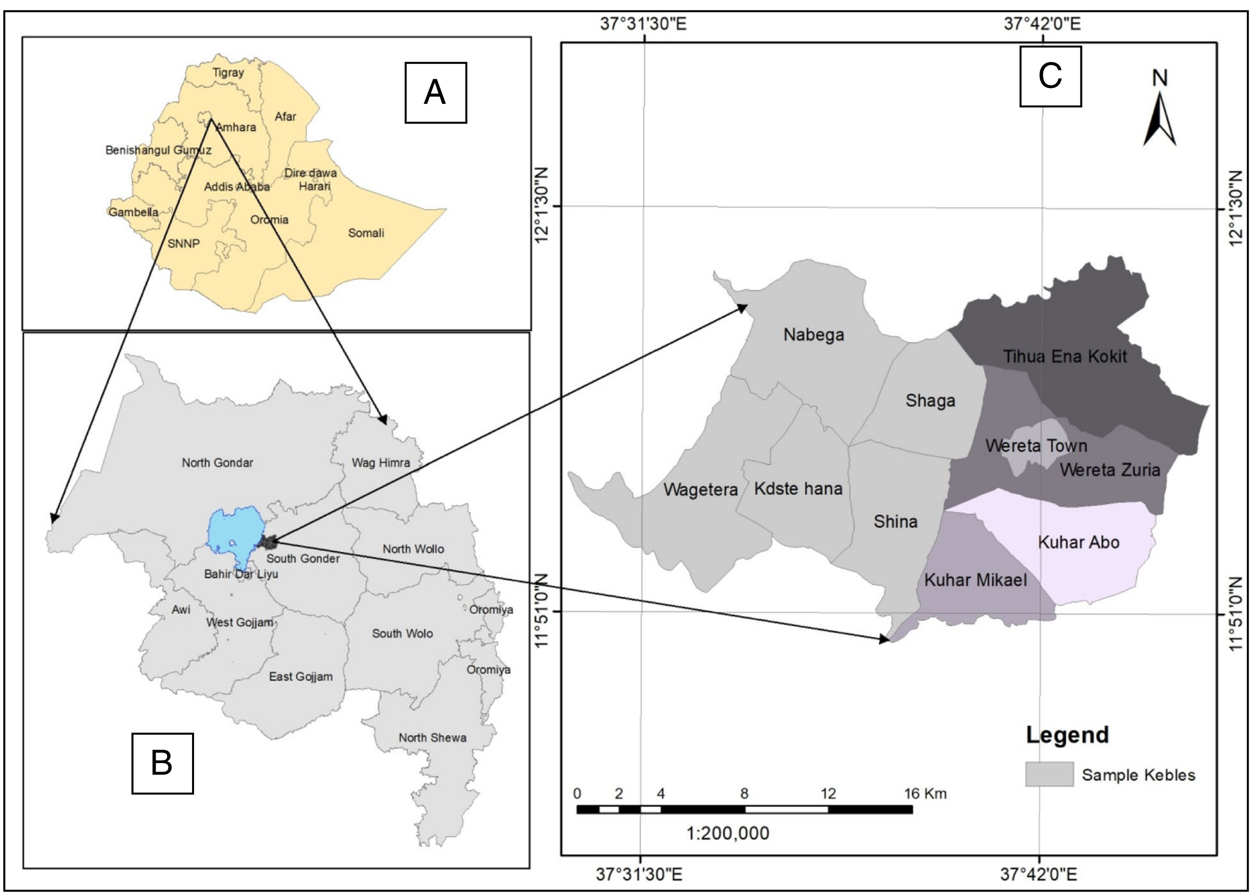

Fig. 1 Map of the study district including under biosphere reserve. The top figure (**A**) in the left shows the map of Ethiopia with regional boundaries and the bottom figure (**B**) in the left shows the Amhara region where the BR and Lake Tana are located. The figure (**C**) in right shows the districts of Fogera and study sample kebeles

Materials and methods

Study area

The biosphere reserve of Lake Tana (BR) (Appendix 3) is situated in the northern Ethiopian highlands between 11° 46′ and 11° 59′ North and 37° 33′ and 37° 52′ East. The woreda (districts) is bordered by Libokemkem woreda in the north, Dera woreda in the south, Lake Tana in the west, and Farta woreda in the east. Elevation ranges from 1774 to 2410 m, and the mean annual rainfall is 1216 mm with a bimodal distribution. The BR has two major rivers under my study site that flow into the Lake Tana, Rib, and Gumara, and consists of 10 districts divided into 137 kebeles.[1] Fogera is one of 10 districts in the BR and comprises 29 rural and 5 urban kebeles (Fig. 1). While much of the BR is known for rice production, the Fogera district is a surplus crop producing area that includes rice. The area is seasonally flooded by watershed drainage contributed by the two rivers, which also deposit soil eroded from uplands. Yields of flood deposition have made the floodplain deep and fertile. Rice is cultivated in lowlands of the floodplains where there is ample water for the growing period of it (Abaye 2007). In higher elevations or when flood water recedes, fields are irrigated using diverted water from Rib or Gumera rivers. Bunds are also used in a rain-fed rice production system to capture and hold water (IPMS 2005), as well as to increase infiltration and reduce soil erosion.

Data collection

Expert interviews were conducted during initial field visits to understand the situation of the wetlands of the study site and impacts of human activities on indigenous cattle population through rice cultivation to get appropriate sample sites and framing of data collection instruments. Based on the preliminary survey, the site has the largest wetlands under BR and expansion of intensive rice cultivation into what have been historically uncultivated wetlands, forested lands, and grazing lands. Our hypothesis was that conversion of the wetland into rice cultivation places pressure on these traditional land-use areas, and in particular grazing lands, which has negative implications for the sustainability of traditional livestock-based farming systems as well as indigenous Fogera cattle.

For this study, therefore, five kebeles were selected in the Fogera district and classified into buffer, core, and transition zones (Table 1). One focus group discussion was established for each sampled kebele with 7–9 participants. Participants for the discussion were selected based on their representativeness for their kebele. Interviewed farmers were also selected based on their living experience and job in the wetland areas and expertise working on this field. Households were interviewed in each kebele. The number of households interviewed in each kebele was a proportion of the total number of households (Table 1). Households were selected within each kebele using a systematic random sampling approach described by Kothari (2004).

Household contact information was provided by the kebele offices. Household information collected through interviews included the number of livestock, grazing system used, dry matter requirement of livestock, pattern of local livestock population, and production of rice crop in these study kebeles.

Primary data were collected using questionnaire, focus group discussions and interviews about number and types of livestock, land size and income from rice production, grazing land condition, other feed sources, and pattern of local livestock population. The data were collected using five enumerators together with the researcher himself especially focus group discussions, interviews were collected by the researcher himself, and the household survey were collected by the enumerators under the supervision of the researcher. Moreover, supporting data were also collected from different agricultural offices and literature. Landsat Thematic Mapper (TM) and multispectral scanner (MSS) imagery for the period 1973 and 2014 were downloaded from https://www.usgs.gov.

Table 1 Selected kebeles including the sample population from each selected kebele

No.	Name of kebele	Total household[a]	Sample[b]
1	Nabega	2283	87
2	Shina	2136	81
3	Kidis Hana	1790	69
4	Shaga	1515	57
5	Wagetera	2398	91
Total		10,122	385

Central Statistical Agency 2007
[a]The data was taken from Ethiopian Central Statistics Agency (CSA)
[b]The data was found from sample respondents using the formula of Kothari (2004)

Data analysis

Analysis of variance (ANOVA) was used to analyze the livestock unit. LEVENES test was used to check the homogeneity of variance (SAS 9.4 version). The data collected through focus group discussions and interviews were also analyzed through qualitative description or narration.

Estimation of available feed resource and land use

Dry matter yield of natural pasture The quantity of feed DM obtained annually from different land-use types was calculated by multiplying the hectare of land under

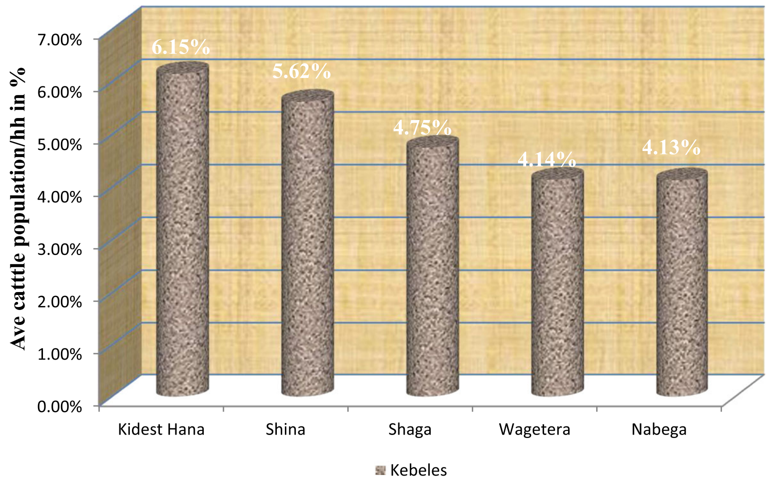

Fig. 2 Average cattle per household for sample kebeles

each land-use types by its conversion factors. Conversion factors of 2.0, 1.5, 1.3, 1.2, and 1.2 t DM/ha/year were used for natural pasture, teff (*Eragrastis tef*), rice (*Oryza sativa*), grass pea (*Lathyrus sativus*), and chickpea (*Cicer arietinum*), respectively (FAO 1984; FAO 1987). The quantity of available crop residues (dry matter basis) on the current crop production system was estimated from the total crop yields of the households using the above conversion factor. Amount of dry matter obtained from communal grazing land is factored into communal grazing areas for each total household and their associate tropical livestock units (TLU) eligible to graze on this land unit.

Estimation of balance between feed supply and demand The number of livestock population was converted into tropical livestock units (TLUs) using the approach in Varvikko et al. (1993) for comparison purpose. Total available dry matter per year from natural pasture and crop residues was compared to the annual dry matter requirements of the livestock population in the sampled households. The DM requirement of the livestock population was calculated based on the daily DM requirement of 250 kg dual purpose tropical cattle (an equivalent of one TLU) for maintenance requirement that needs 6.25 kg/day/animal or 2281 kg/year/animal (Jahnke 1982).

Land use/land cover analysis Image processing for the land use analysis was done using ArcGIS 10.2. Change matrixes were done to interpret change in grazing land in the years of 1973 and 2014. Data from Woreda agriculture offices were used to compare results from the land use analysis. The area covered by each land use/land cover (LULC) class was calculated, and subsequently, the changes were compared for the periods 1973 and 2014. Land use/land cover in the study area includes forest land,

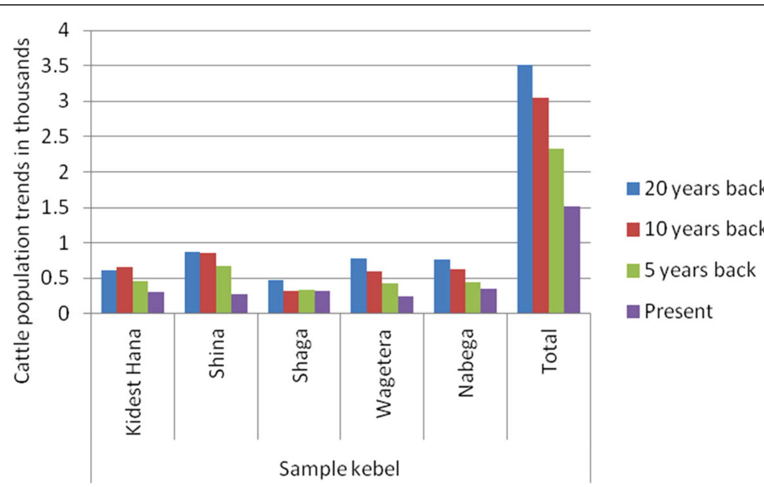

Fig. 3 Mean cattle number per household summed over five kebeles in the Fogera district

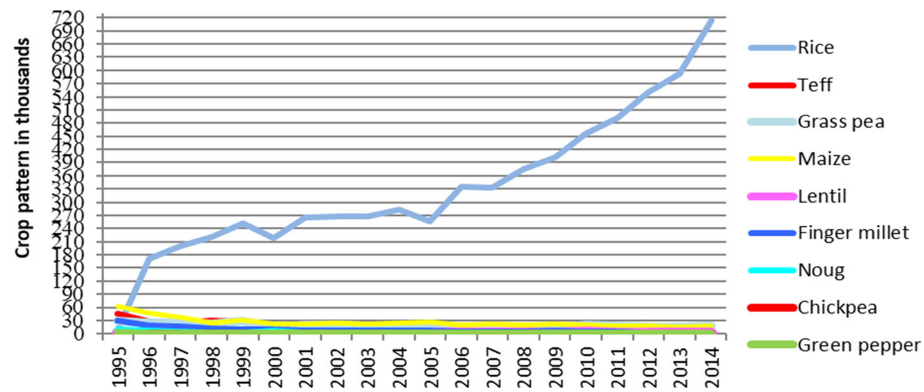

Fig. 4 Trends and growth rates of crop production in Quintal in the study kebeles from 1995 to 2014

agricultural land, water body, wetlands, and grasslands/grazing.

Land use/land cover (LULC) classification schemes used in this study include the following variables (Thompson 1996):

Forest areas: Areas dominated by trees having a height of 6 m and above which have a crown cover overlap of 15% and more.
Agricultural lands: These are land covers used to cultivate perennial or annual crops.
Water body: Areas covered with ponds and small lakes.
Grasslands: Areas with permanent grass cover located on a plain and water logging areas.
Wetlands: Areas of marsh, fen, peatland, or water, whether natural or artificial and permanent or temporary, with water that is static or flowing, fresh, brackish, or salty, including areas of marine water, the depth of which at low tide does not exceed 6 m.

Results

Livestock population

Figure 2 illustrates that the mean cattle holdings in the study area ranged from four to six animals per household among kebeles in 2015. Relatively, Kidest Hana kebele farmers hold the better number of livestock per household (6.15). Survey data suggest that the total number of cattle in all five kebeles steadily decreased over the last 20 years (Fig. 3).

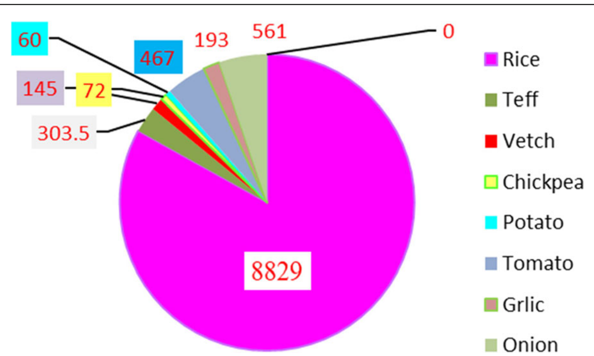

Fig. 5 Crop production in quintal in the year 2015 collected from sample household

The study also revealed that there was ~21% decline in cattle population from 2005 to 2014. In the contrary, the study also noted a concomitant increase in the number of sheep, donkey, mule, poultry, and beehives over the same period. In addition, analysis of livestock unit and checking of homogeneity of variance have been made (Table 6a and b in Appendix 1).

Kebele**	1	2	3	4	5	SEM
LSM of TLU	0.168^{ab*}	0.170^{ab}	0.216^{a}	0.161^{b}	0.127^{b}	0.019

*Means in the same row with different superscript are different at $P < 0.05$
**1 = Kidest hana, 2 = Shina, 3 = Shaga, 4 = Wagetera, 5 = Nabega

Kebele 3 was significantly different from kebele 4 and 5, and no significant difference was observed between kebeles 1, 2, and 3 (Table 6b). Kebeles 1, 2, 4, and 5 had no difference ($P > 0.05$) in TLU per household.

Table 2 Available feed and number of respondents on feed source usage

Kebele	Communal land	Purchased hay	Other crop residues	Rice residue
Kidest hana (*N* = 69)	68 (98.6%)	32 (46.4%)	22 (31.9%)	68 (98.6%)
Shna (*N* = 81)	81 (100%)	8 (9.9%)	22 (31.9%)	81 (100%)
Shaga (*N* = 57)	57 (100%)	13 (22.8%)	23 (40.4%)	57 (100%)
Wagetera (*N* = 91)	91 (100%)	27 (29.7%)	24 (26.4%)	91 (100%)
Nabega (*N* = 87)	87 (100%)	33 (37.9%)	26 (29.9%)	87 (100%)
Total	384 (99.7%)	113 (29.4%)	127 (34%)	384 (99.7%)

Source: surveyed data directly collected from sample household in 2015

Table 3 Animal feed supply and requirement in tons of dry matter (DM)

	Rice	Teff	Gp	Cp	GL	T DM	DM yield	Total	Required	Per hh	Difference
Kebele	Resi	Resi	Resi	Resi	kg/hh	Resi	Per hh	TLU	TLU	Required	
Kidest hana	301,990	21,150	17,520	0	320	340,980	13.539	185.1	1156.875	16.766	− 3.227
Shina	248,820	7875	10,320	360	400	267,775	9.057	207.9	1299.375	16.041	− 6.984
Shaga	140,270	5550	5520	0	240	151,580	7.285	131.9	824.375	14.462	− 7.177
Wagtera	243,620	4200	6600	0	100	254,520	7.662	195.9	1224.375	13.454	− 5.792
Nabega	213,070	6750	7200	8280	265	235,565	7.418	191.5	1196.875	13.757	− 6.339
Total	1,147,770	45,525	47,160	8640	1325	1,250,420	44.961	912.3	5701.875	74.480	− 29.519

Gp grass pea, *Cp* chickpea, *GL* grazing land per household, *TDM* total dry matter, *Resi* residue

Crop production

Before large-scale rice production was introduced, the Fogera wetlands flooded during the wet season. Tradition, multiple cropping systems were used and included teff (*Eragrastis tef*), maize (*Zea mays*), noug (*Guizotia abyssinica*), finger millet (*Eleusine coracana*), chickpea, lentil (*Lens culinaris*), and grass pea (*Lathyrus sativus*) (Fogera Woreda Agriculture Office 2015). During the dry season, horticultural crops were cultivated under small-scale irrigation, including mainly onion (*Allium cepa*), garlic (*Allium sativum*), green pepper (*Capsicum* spp.), and tomatoes (*Solanum lycopersicum*). Rice introduction began in the 1970s with two farmer associations and quickly expanded to 14 kebeles. Data from Woreda Agriculture Office (Fig. 4) showed that over a 10-year period, rice crop has become by far the most predominant crop, increasing dramatically, while during this same period, traditional crops decreased. This was also indicated by the primary data collected directly from the sample household (Fig. 5) that showed rice production had the highest position compared to the other crops in the areas. The predominance of rice and relative unimportance of the traditional crops are reflected in our 2015 household data as well (Fig. 5).

Animal feed

The feed resources of livestock in Fogera wetland areas consisted of uncontrolled communal grazing lands, purchased hay, rice crop residues, and other crop residues. In the study kebeles, out of 385 respondents, 99.7% of them used both free grazing communal lands and rice crop residue as the main feed source for their livestock. In addition, 29.4% of respondents buy hay from neighboring farmers, and 34% use other crop residues or rice residue as feed sources for their livestock (Table 2).

Feed dry matter supply

A total of ~ 45 t of feed dry matter (DM) were produced from crop residue and natural pasture across the sampled kebeles ($n = 385$) (Table 3). Total dry matter yield, which was estimated from grazing pasture and crop residues, is presented in Table 3. Data indicate much larger dependence on crop residue (99.89%) for feed than on grazing land (0.11%). Overall, available feed in terms of dry matter per annum was only ~ 60% of that needed to meet household TLU feed requirement. Yet, ~ 40% of dry matter per annum was required to meet the existing TLU requirement (Table 3). All dry matter was calculated for the present cropping system.

Traditional grazing system in the study wetland areas

When the main available feed resource was communal grazing land, animals were fed through a communal grazing system which caused overgrazing problems and unwanted breeding. The sample households were asked whether they used alternative grazing management systems for communal lands, such as cut and carry, or rotational grazing. Households with livestock responded anonymously that they used only free grazing system.

Table 4 Annual incomes of the sample household in the surveyed sample kebeles

Income in Ethiopian birr									
Kebeles	*N*	Rice	%	Animals	%	Other crop & sources	%	Total	Average/hh
Kidest hana	69	2,508,800	89.0	33,800	1.2	276,820	9.8	2,819,420	40,861.2
Shina	81	2,093,300	87.8	10,750	0.5	279,325	11.7	2,383,375	29,424.4
Shaga	57	1,192,600	83.6	5344	0.4	228,870	16.0	1,426,814	25,031.8
Wagetera	91	2,056,800	78.8	6066	0.2	546,804	21.0	2,609,670	28,677.7
Nabega	87	2,927,500	84.3	6340	0.2	537,340	15.5	3,471,180	39,898.6
Total	385	10,779,000	84.8	62,300	0.5	1,869,159	14.7	12,710,459	33,014.2

Table 5 The response of farmers on the effect of rice production on Fogera cattle population reduction

Kebeles	Number	Yes	No
Kindest hana	69	60 (87%)	8 (11.6%)
Shina	81	66 (81.5%)	15 (18.5%)
Shaga	57	47 (82.5%)	10 (17.5%)
Wagetera	91	75 (82.4%)	16 (17.6%)
Nabega	87	75 (86.2%)	12 (13.8%)
Total	385	323 (83.9%)	61 (15.8%)

Annual income gained

The household farming activities in the study kebeles were crop production, livestock rearing, horticulture, beekeeping, and fishing. Rice production contributed 84.8% of total income, clearly the lion's share. There were modest differences among the kebeles for percentages of income originating from other crops (Table 4). According to the respondents, the most important factors determining their annual average incomes were the landholding size, fertility of the farmland, availability of flood water, management practices of the individual farmer, and amount of livestock holding.

Livestock income

Income from livestock was a contributing a mere 0.5% on average among kebeles, significantly less than that from rice (84.8%) and other crops (14.7%). A focus group consisting of animal science experts concurred that farmers now pay less attention to livestock rearing, preferring instead to focus on rice production because of high grain prices (1100.00 Ethiopian birr per quintal). Livestock production was restricted because of limited forage and grazing lands. Together, these trends explain the gradual loss of indigenous livestock numbers.

The effect of rice production on Fogera indigenous livestock population

According to the five animal science experts (developing agents), the mean rice yield was estimated at about 35 qt/ha and ranges from 20 to 80 qt/ha depending on the land type and management practices. According to the Woreda or district agricultural office expert, still, there is a potential to expand rice production to 28,000 ha of land. Rice straw is used as animal feed and for roof thatching.

Even though Fogera district was dominantly characterized by mixed crop–livestock subsistence farming system, the extent of crop and livestock integration varied that farmers' attitude tends toward rice production and less attention for their cattle because of grazing land problem, so that according to 83.9% of sample respondents explanation, rice farming has caused a reduction of Fogera indigenous cattle population. Approximately 16% claimed that rice production had not caused a reduction in cattle numbers, but the panel of experts claimed this was because many of the 16% were using land illegally for rice production. All agreed that the number of pure breed Fogera cattle was declining over time (Table 5). Currently, pure Fogera cattle breed are found only in small numbers in the villages of Sindeye, Tigre mender, and Damote. In other kebeles, where the breed used to be common, there was an unwanted crossbreeding with other indigenous breeds such as the Estie, Dera, and Fareta during communal grazing in the Fogera plains.

Figure 6 indicated that increased rice crop production is negatively correlated with cattle population. Appendix 2 also showed that the correlation value of − 0.889** was significant at the $P < 0.01$. Rice crop production has gained more interest among farmers because of its potential to generate income. But increased income comes apparently

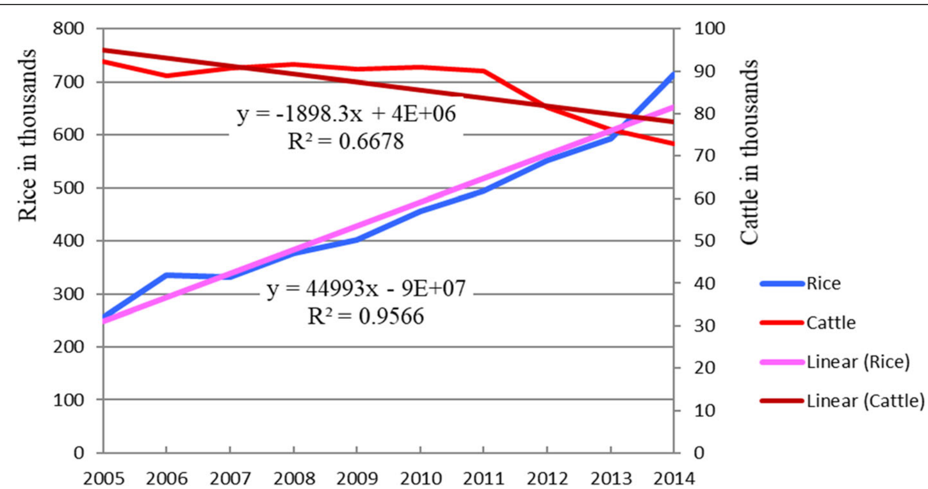

Fig. 6 Trends of cattle population and rice production in the sample kebeles from 2005 to 2014

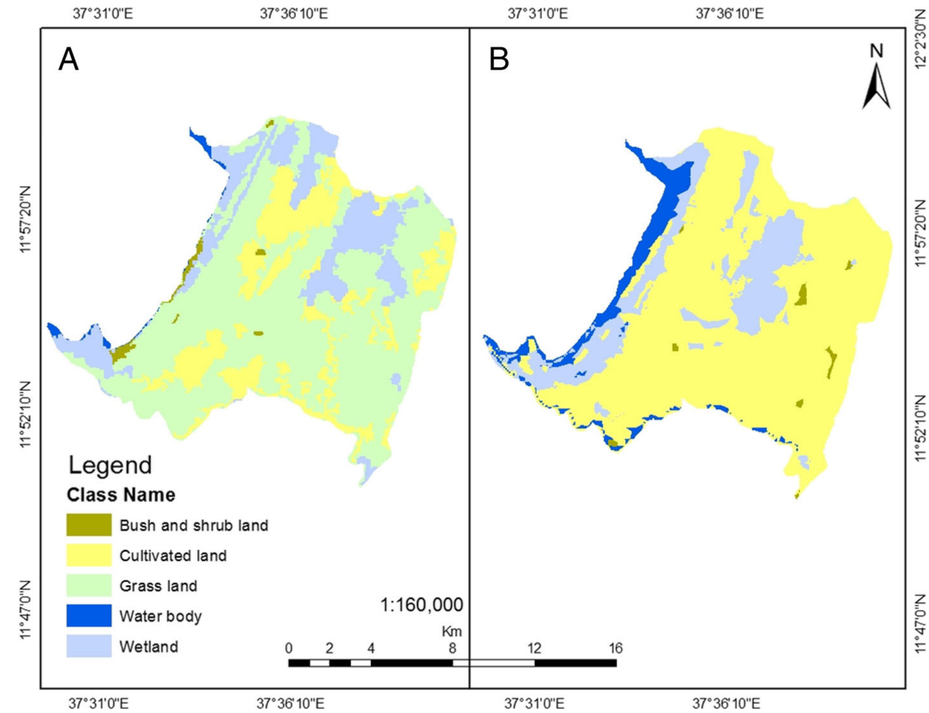

Fig. 7 Land use/land cover map of the study site. **a**, **b** The land use/land cover map of year 1973 and 2014, respectively. The classification results for 1973 and 2014 were summarized in (Table 7 in Appendix 1). Percentage of classes based on these results showed the land use/land cover practices observed in study area during 1973 and 2014

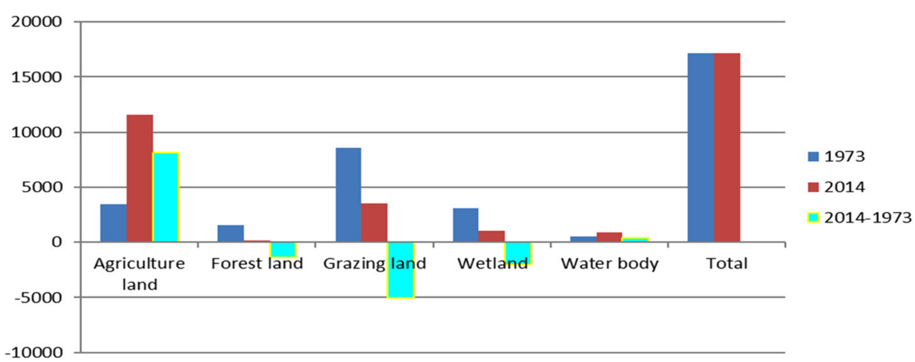

Fig. 8 Land use/land cover change of the study site map in the year 1973 and 2014

Fig. 9 Practice of small scale irrigation in the wetlands of Fogera and birds' interaction

Fig. 10 Rice production in the Fogera wetlands and farmers discussion regarding rice and cattle

at the cost of its indigenous cattle population and other wetland resources.

Grazing land reduction detection

The correlation trends indicated in Fig. 6 were further supported by land-use changes illustrated in Fig. 7. Grassland areas were greatly reduced in favor of cultivated rice between 1973 and 2014 (Fig. 8).

Other declines were observed in forested lands and wetlands. At the same time, the area under water slightly increased. Quantitative comparisons for changes in land use were shown in Fig. 9. Specifically, grazing lands were reduced from 8550 ha or 50% of land area to 3501 ha or 20% of land area, wetlands from 3114 ha or 18% of land area to 1060 ha or 6% of land area, and forestlands from 1542 ha or 9% of land area to 907 ha or 5% of land area. Concurrently, cultivated land area increased from 3441 ha or 20% of land area to 11,550 ha or 67% of land area, and water surface area from 502 ha or 3% of the study area to 907 ha or 5% of the area.

Previous to the massive introduction of rice production, the borderline of Lake Tana that was covered by papyrus and long grass has been cleared out now, exposed to sunlight, and visible for the remote sensing, respectively. In the previous time, the border of Lake Tana was covered by the vegetation such as reeds, *Butia capitata* (palm tree), long grasses, and papyrus, but nowadays, the vegetation has been removed around the border of the lake because of recession farming and for the dry season small-scale irrigation due to population dynamics (Appendix 3).

Discussion

Currently, the number of livestock population decreased because of intensive practice of rice agriculture. Since the 1970s, rice production practice was introduced in the wetland areas of Fogera. According to Fogera Woreda Agriculture Office, participant farmers in rice production have been increased, and in contrary, the number of livestock decreased over time. According to Alberro and Haile-Mariam (1982), Rege and Tawah (1999), IBC (2004), and Gebeyehu et al. (2004), the pure Fogera cattle population dropped down. Even other natural resources have also reduced like birds (see Fig. 9) was enjoyed in the wetlands because farmers compete to obtain land as the floodwaters retreat for the recession farming instead of left it for grazing (Tadesse and Solomon 2014). Therefore, due to the rice farming approach, the number of grazing land is reducing over time and it has an effect on Fogera cattle.

In terms of household income, the expansion of rice production was largely positive but the livestock number and their production as well as their movement were reduced (Tadesse and Solomon 2014). Fogera has a high potential for dairy production, but according to Woreda agricultural experts and Belete (2006), due to the feed shortage, farmers from highland kebeles move indiscriminate breeds to the plains during the dry season, which has resulted in the reduction of the better yielding Fogera breed in the plains (Fig. 10).

Insufficient land, problem of labor, lack of inputs such as the forage seeds, and lack of information were among the reasons given by respondents for not growing their own fodder. The area of the communal grazing land and rice crop residues are the main and the only feed sources available for the farmer's livestock feed as indicated in (Table 2 above). Generally, there are insufficient amount of grazing lands, and as a result, the productivity is also low due to feed.

The main reason, as mentioned above, is the introduction of rice production which has an influence on animal rearing. Belete (2006) approved that not only the reduction of their number but also productivity. In the area, the conversion of grazing lands into crop production especially rice, in this case, seems the main reason for the scarcity of feed resources. This was also approved by land use/land cover detection in GIS environment that the amount of grazing land was changed over time.

Agriculture land was pushed into formerly grazing and wetland areas. It has also been observed in the study site that the built-up areas were mostly surrounded by agricultural area. It means the area near the population has been cleared and shifted to crop production in order to fulfill the basic necessities of life (Bailly 2007). The introduction of rice farming caused the expansion of agricultural land at the expense of other land-use types in the area (Mesfin et al. 2016). In the woreda, rice is one of the food crop produced by the majority of the farmers in a study conducted by Gebremedhin and Hoekstra (2007).

The area covered by wetland and grazing class has also witnessed a decrease from 1973 to 2014. The land use/land cover changes observed in all other classes affected the wetlands and grazing class during four decades. According to Taddese and Solomon (2014), the overall land use/land cover change analysis of the Landsat image of the year 1986 and 2013 in Gummara and Rib watershed showed that grazing land has declined drastically and cultivated land has rapidly increased. Moreover, the grassland use type was changed into settlement and eucalyptus woodland. This increasing trend of LULC in the study area reinforces that economic forces are commonly a major stimulus on anthropogenic change of land (Wang et al. 2008).

Conclusions

The livestock feed sources are becoming declining due to the excessive conversion of grazing lands into cultivated land and settlement areas. Therefore, grazing land degradation should be given attention for the sustainable and healthy livestock productivity. The overall livestock productivity is a function of high human and animal population which in turn results in a shortage of pasture land. Moreover, most of the communal grazing/browsing lands are degraded providing only limited feed. In general, feed shortage and poor performance of local breed (because of unwanted breeding) affect the productivity of livestock. In the study site, the concerned body should take measures that could enhance improved feeding management techniques such as rotational grazing for extended pasture lands, forage development, fodder conservation, feeding fresh forage using the cut-and-carry method, and regulating the intake by different categories of stock to fill the gaps livestock feed. Moreover, the carrying capacity of the pasture land and stocking density need to be balanced.

Based on the results obtained by the employment of GIS and remote sensing applications to achieve the specific research objectives, it is concluded that the land use/land cover practices in the study area have altered significantly in 41 years. The LULC shift in the study kebeles was evident by the decline in the area of grazing land, bush, and shrubland and augmentation of the area covered by classes of agriculture and built-up areas. The haphazard expansion of built-up areas and agriculture area in the study site was mainly due to the lack of proper management and land-use planning since no Environmental Impact Assessment (EIA) report is generated prior to land development in the study area. The major impact of this expansion was subjected on grazing, bush and shrubland, and wetland class to forage resource reduction, deforestation, and water depletion, respectively. Hence, proper management of these study site resources is required because without proper management, these valuable resources like grazing, forest, and water resource will soon be lost or will no longer be able to play its required role in the socioeconomic development of the area. To sustain wetlands with the coexistence of rice production, concerned bodies have to join programs that help protect and restore wetlands, report illegal activities, enact proper disposal of all litter in appropriate trash containers, implement planting of local tree species, use living shoreline techniques to stabilize the soil, avoid artificial input use, stop the expansion of agricultural activities on wetlands and grazing lands, and give more attention to innovative traditional farming systems.

Endnotes

[1]Kebele is the smallest administrative unit in Ethiopia.

Appendix 1

Table 6 Least squares means for effect kebele (part a) and least squares mean comparisons among kebeles (part b)

(a)

Kebele	Least squares mean	Standard error	pr > *t*
1	0.1682	0.0173	< 0.0001
2	0.1702	0.0159	< 0.0001
3	0.2163	0.0190	< 0.0001
4	0.1613	0.0150	< 0.0001
5	0.1275	0.0154	< 0.0001

(b)

Kebele	1	2	3	4	5
1		0.9323	0.0622	0.7660	0.0807
2	0.9323		0.0643	0.6876	0.0558
3	0.0622	0.0643		0.0242	0.0003
4	0.7660	0.6876	0.0242		0.1183
5	0.0807	0.0558	0.0003	0.1183	

Table 7 Land use/land cover classes and areas in hectares

Class name	1973	Percent	2014	Percent	2014–1973
Agriculture land	3440.6	20	11,549	67.3	8108.4
Forest land	1542	9	131.3	0.8	− 1410.7
Grazing land	8549.5	49.9	3501	20.4	− 5048.5
Wetland	3113.9	18.2	1059.6	6.2	− 2054.3
Water body	501.9	2.9	907	5.3	405.1
Total	17,147.9	100	17,147.9	100	0.0

Source: generated from Landsat image classification

Appendix 2

Table 8 Correlations

		Rice	Cattle
Rice	Pearson's correlation	1	− 0.889**
	Sig. (two-tailed)		0.001
	Sum of squares and cross products	1.746E11	− 7.840E9
	Covariance	1.940E10	− 8.711E8
	N	10	10
Cattle	Pearson's correlation	− 0.889**	1
	Sig. (two-tailed)	0.001	
	Sum of squares and cross products	− 7.840E9	4.452E8
	Covariance	− 8.711E8	4.946E7
	N	10	10

**Correlation is significant at the 0.01 level (two-tailed)

Appendix 3

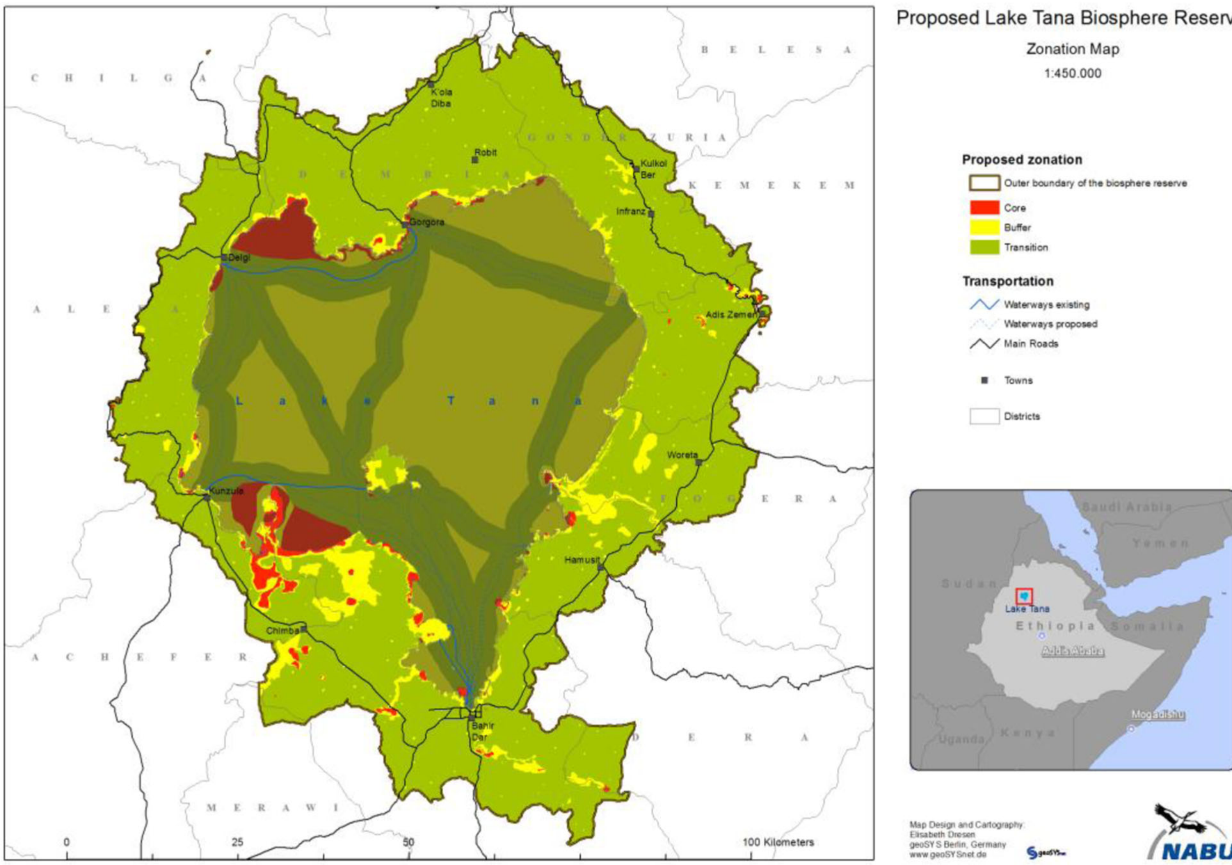

Fig. 11 The map of Lake Tana Biosphere Reserve (BR) area taken from NABU office

Abbreviations

ANOVA: Analysis of variance; BR: Biosphere reserve; CSA: Central Statistics Agency; DM: Dry matter; EIA: Environmental Impact Assessment; FAO: Food and Agricultural Organization of the United Nations; FWAO: Fogera Woreda Agriculture Office; GIS: Geographic information system; IBC: Institute of Biodiversity Conservation; IPMS: Improving Productivity and Market Success; LULC: Land use/land cover; MEA: Millennium Ecosystem Assessment; MoWEM: Ministry of Water, Energy, and Minerals; TLU: Tropical Livestock Unit; UNCCD: United Nations Convention to Combat Desertification; UNESCO: United Nations Educational, Scientific, Cultural Organization

Acknowledgements

The authors acknowledge Addis Ababa and Wollo University for sponsoring this project, University of Nevada Reno College of Agriculture, Biotechnology and Natural Resource management for accept me as visiting scholar, and also the College of Business and Economic of the University of Nevada for providing me offices and computers for facilitating for the writing up of this manuscript. I would like to thank Fogrea Woreda Agriculture office for providing me information and secondary data and development agents for assisting me in collecting data.

Funding

Not applicable.

Availability of data and materials

The data can be accessed from the corresponding author via the following address mare.addis@eiabc.edu.et or mareaddis2005@gmail.com. The data can be also accessed for research purposes.

Authors' contributions

MAD is the corresponding author who designed the research, developed the data collection tools, collected the data, analyzed the data, and participated in writing the paper. All co-authors contributed in guiding the researcher and editing the paper. All authors read and approved the final manuscript.

Authors' information

Mr. Mare Addis Desta is a PhD candidate at Addis Ababa University. His research interests focus on Sustaining Lake Tana Biosphere Reserve. His current PhD research focuses on the Environmental Trade-offs and Cross-Sectoral Institutional linkage Requirements of Rice Intensification in the Fogera Wetlands, Ethiopia. Dr. Gete Zeleke is a PhD holder working as a Director of the Water and Land Management Resource Center & Leader of NCCR-RP12 Landscape Transformation Research Project in Ethiopia and he is also a known lecturer at Addis Ababa University in the department of Ecosystem Planning and Management. William A. Payne is a professor working as Dean and Professor, College of Agriculture, Biotechnology and Natural Resources, University of Nevada, Reno, USA. Teshome Shenkoru is a PhD holder working on the department of Agriculture, Nutrition and Veterinary Sciences

at University of Nevada and Yihun Dile is a Postdoctoral Associate in the Department of Ecosystem Science and Management, Texas A&M University.

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Publisher's Note

Author details
[1]Department of Geography and Environmental Studies, Wollo University, P.O. Box 1145, Dessie, Ethiopia. [2]Water and Land Management Resource Center and NCCR-RP12 Landscape Transformation Research Project in Ethiopia, Addis Ababa, Ethiopia. [3]College of Agriculture, Biotechnology and Natural Resources, University of Nevada, Dean's Office/222, Reno, Nevada 89557-0222, USA. [4]Department of Agriculture, Nutrition and Veterinary Sciences, University of Nevada, Mail Stop 202, 1664 N, Virginia Street, Max Fleischmann Agriculture, Office 112 5, Reno, Nevada 89557, USA. [5]Department of Ecosystem Science and Management, Texas A&M University, College Station, USA.

Received: 14 December 2018 Accepted: 26 March 2019
Published online: 29 May 2019

References
Abaye A (2007) Vegetable market chain analysis in Amhara National Regional State: the case of Fogera woreda, South Gondar zone. An M. Sc Thesis Presented to the School of Graduate Studies of Haramaya University
Abebe W, Minale S (2017) Land use and watershed management practices in Lake Tana Basin. In: Stave K, Goshu G, Aynalem S (eds) Social and ecological system dynamics. AESS Interdisciplinary Environmental Studies and Sciences Series. Springer, Cham
Aerts R, Berendse F (1988) The effects of increased nutrient availability on vegetation dynamics in wet heathlands. Vegetatio 76:63–69
Agegnehu S, Fikremariam A, Agumas B, Eshetie A, Minwuyelet J, Getachew A (2013) Effect of time and frequency of hand weeding on yield of direct seeded rice in Fogera plain. Currt Res Microbiol Biotechnol 1(6):266–269
Alberro M, Haile-Mariam S (1982) The indigenous cattle of Ethiopia. Part-I. World Animal Rev 41:1–2
Alemayehu M (2013) Livestock-water interactions: the case of Gumara Watershed in the Upper Blue Nile Basin, Ethiopia. PhD thesis. Humboldt University of Berlin, Berlin
Astewel T (2010) Analysis of Rice Profitability and Marketing Chain: The case of Fogera Woreda, South Gondar Zone, Amhara National Regional State, Ethiopia. Thesis of Master of Science in Agriculture (Agricultural Economics), Haramaya University
Bayliss-Smith T, Golson J (1992) Wetland agriculture in New Guinea Highlands prehistory. In: Coles B (ed) The wetland revolution in prehistory: 15–27. Exeter: The Prehistoric Society and Wetland Archaeological Research Project
Belete A (2006) Studies on cattle milk and meat production in Fogera woreda: production systems, constraints and opportunities for development. MSc. Thesis. Debub Univeresity, Awassa
Birhanu T (2017) Water-induced shift of farming systems and value addition in Lake Tana sub-basin: the case of rice production and marketing in Fogera District, northwestern Ethiopia. In: Stave K, Goshu G, Aynalem S (eds) Social and ecological system dynamics. AESS Interdisciplinary Environmental Studies and Sciences Series. Springer, Cham
Central Statistical Agency CSA (2007) Ethiopia, Statistical abstract, Addis Ababa
Dahl TE (1990) Wetland losses in the United States 1780s to 1980s. U.S. Department of Interior, U.S. Fish and Wildlife Service, Washington D.C
Ehrenfeld JG (1991) The effects of changes in land use on swamps of the New Jersey pine barrens. Biol Conserv 25:353–375
Ehrenfeld JG, Schneider JP (1991) *Chamaecyparis thyoides* wetlands and suburbanization: effects on hydrology, water quality and plant community composition. J Appl Ecol 28:467–490
FAO (1984) Master land use plan, Ethiopia range/livestock consultancy report prepared for the government of the People's Democratic Republic of Ethiopia. Technical Report. AG/ETH/82/010 FAO, Rome
FAO (2008) Scoping agriculture–wetland interactions towards a sustainable multiple-response strategy, Viale delle Terme di Caracalla, 00153 Rome, Italy
FAO (Food and Agricultural Organization of the United Nations) (1987) Master land use plan, Ethiopian range livestock consultancy report prepared for the government of the People's Republic of Ethiopia technical report. AG/ETH/82/020/FAO, Rome, 94pp
Fogera Woreda Agriculture Office (FWAO) (2015) Fogrera woreda (district) agriculture office annual report
Gashaw G (2016) Evaluating the effect of climate change and land use/cover change on catchment hydrology of Gumara watershed. Volume 3 Issue 1, 2015 Open Water Symposium, Addis Ababa, Ethiopia
Gebeyehu G, Tegegne A, Mulugeta T, Agide A (2004) Preliminary report on the distribution of Fogera cattle around Lake Tana, Ethiopia, vol 203. Addis Ababa, ESAP. Proceedings of the 11th annual conference of the Ethiopian Society of Animal Production (ESAP), Addis Ababa, p 207
Gebremedhin B, Hoekstra D (2007) Cereal marketing and household market participation in Ethiopia: the case of teff, wheat and rice. AAAE Conference Proceedings, pp 243–252
Hagler B (2007) Environmental baseline study of Margala and Margala north blocks. MOL Pakistan Oil and Gas Company BV, Islamabad.
IBC (Institute of Biodiversity Conservation) (2004) The state of Ethiopia's farm animal genetic resources: a contribution to the first report on the state of the world's animal genetic resources. May 2004, Addis Ababa, Ethiopia
Improving Productivity and Market Success (IPMS) (2005) Fogera wereda pilot learning site diagnosis and program design. Kothari C. R. 2004
Jahnke, H. E. (1982) Livestock production systems and livestock development in tropical Africa. Kieler Wissenschaftsverlag Vauk. Kiel
Kothari, C. R. (2004) Research methods and techniques. New Age International (P) Limited, Publishers. 4835/24, Ansari Road, Daryaganj, New Delhi – 110002
Lamsal P, Pant KP, Kumar L, Atreya K (2015) Sustainable livelihoods through conservation of wetland resources: a case of economic benefits from Ghodaghodi Lake, western Nepal. Ecol Soc 20(1):10. https://doi.org/10.5751/ES-07172-200110
Lemma H (2013) Climate change impact assessment on water resources of Gumara watershed, upper Blue Nile River basin. Int J of Agric Policy Res 1(5): 142–149. http://www.journalissues.org/journals-home.php?id=1
Mesfin A, Mohammed A, Melanie DN (2016) Patterns, causes and consequences of land use/cover dynamics in the Gumara watershed of lake Tana basin, Northwestern Ethiopia. Environmental Systems Research 5:8
Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: synthesis. Island Press, Washington, DC, 102 pp. + app
Mitsch WJ, Gosselink JG (1986) Wetlands. Van Nostrand Reinhold, New York
Moges MA, Schmitter P, Tilahun S, Steenhuis TS (2017) Watershed modeling for reducing future non-point source sediment and phosphorus load in the lake Tana basin, Ethiopia. J Soils Sediments. https://doi.org/10.1007/s11368-017-1824-z
Moore DRJ, Keddy PA, Gaudet CL, Wisheu IC (1989) Conservation of wetlands: do infertile wetlands deserve a higher priority? Biol Conserv 47:203–217
Morgan MD, Philip KR (1986) The effect of agricultural and residential development on aquatic macrophytes in New Jersey pine barrens. Biol Conserv 35:143–158
Morris JT (1991) Effects of nitrogen loading on wetland ecosystems with particular reference to atmospheric deposition. Annu Rev Ecol Syst 22:257–279
MoWEM (1991) Report by principal secretary, Ministry of Water, Energy and Minerals (MWEM). Daily News 1:9–22
Mulugeta S, Heluf G (2006) Effects of N and P fertilizers on yield and N uptake of flooded rice grown on vertisols of Fogera plain of Ethiopia. Indian J Fertilizers 1(1):47–51
Neely RK, Baker JL (1989) Nitrogen and phosphorus dynamics and the fate of agricultural runoff. In: van der Valk AG (ed) Northern Prairie Wetlands. Iowa State University Press, Annes, pp 92–131
O'Connell MJ (2003) Detecting, measuring and reversing changes to wetlands. Wetl Ecol Manag 11(6):397–401. https://doi.org/10.1023/B:WETL.0000007191.77103.53
Patrick R (1976) The role of aquatic plants in aquatic ecosystems, biological control of water pollution. University of Pennsylvania Press, Philadelphia, pp 53–59

Rege JEO, Tawah LC (1999) The state of Africa cattle genetic resource II. Geographical distribution, characteristics and uses of present day breeds and strains
SAS 9.4. (2002–2012) SAS Institute Inc., Cary, No, USA
Tadesse A, Solomon A (2014) Assessment of grazing land and livestock feed balance in Gummara-Rib Watershed, Ethiopia. Curr Agric Res J 2(2):114–122
Thompson M (1996) Standard land cover classification scheme for remote sensing application in South Africa. S Afr J Sci 92:34–42
Tilahun T, Nigussie D, Wondimu B, Setegn G (2013) Effect of transplanting on terminal moisture stress, growth and yield of rain-fed lowland rice. Res J Agric Environ Manage 2(4):117–129 ISSN 2315-8719© 2013 Apex Journal International, Available online at http://www.apexjournal.org
UNCCD (2015) Preliminary conclusions. Combating desertification/land degradation and drought for poverty reduction and sustainable development: the contribution of science, technology, traditional knowledge and practices. 3rd UNCCD Scientific Conference, 9-12 March 2015, Cancun, Mexico
UNESCO (2000) Solving the puzzle: the ecosystem approach and biosphere reserves. UNESCO, Paris
Varvikko T, Kidane GM, Geda G (1993) Importance of early hay making in improving the standard of dairy cow feeding on small holder farms in the Ethiopian highlands, vol 28. Proceedings: VIIth world congress on animal production, Edmonton, pp 330–332
Wang X, Zheng D, Shen Y (2008) Land use change and its driving forces on the Tibetan Plateau during 1990–2000. Catena 72:56–66. Available online at www.sciencedirect.com