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Rural land use problems and management options in Debre Tsyon *Kebele*, Ethiopia

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Abstract Examining the current land use problems is essential for designing management options for sustainable use and to obtain optimal benefit out of land. This study was intended to examine the current land use problems and propose management options and strategies for sustainable land use in Debre Tsyon *kebele* of Enebsie Sar Midir district, Ethiopia. The Landsat-8 OLI-TIRS of 2017, ASTER Global Digital Elevation Model, interview and field observation was employed to generate data on the current land use, land use problems and management options for the future use. The hybrid pixel-based image classification (supervised and unsupervised) method was used to map the land use classes. The results show that the cropland occupy the vast portion (75%) of the study area. However, the improper land use was very high in agricultural and grazing lands use classes. The growing demand for land resources pushed the community to expand farmlands to fragile steep areas with slope $> 30\%$. Of the total agricultural land, 12.6% found in fragile areas with slope $> 30\%$. Likewise, the grazing land has already deteriorated and could not bring pasture for livestock year-round. The vegetation cover has been declining due to improper use. Hence, this calls for the local government to implement appropriate land use plan and efficient land management options to curb the unsustainability spiral.

Keywords Rural land use · Land use problems · Management options · Land use planning · Ethiopia

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Introduction

The growing pressure of population coupled with increasing variety of demands made on land resources has brought extra pressure on the available land resources all over the world (Eniolorunda et al. 2016). Similarly, the International Organization of Supreme Audit Institutions Working Group on Environmental Auditing (INTOSAI 2013) noted that the world is increasingly experiencing severe environmental, social and economic problems that are challenging the current production systems and the sustainability of all human activities. It further explained that the resources on which these activities depend are significantly imbalanced, land resources, in particular. Therefore, the challenges presented by land degradation from poor land management highlight the need for focus on the issue. In light of this idea, analysing the current land use problems is crucial for proposing management options and strategies for sustainable use. Such undertaking is fundamental in sub-Saharan

Africa, where land has been considered as an important socio-economic asset and the status and prestige of most people is determined (UN ECA 2010, 2011; Legesse et al. 2018). The region is particularly vulnerable to threats of natural resource degradation and poverty due to various factors including a high population growth rate, heavy reliance on agriculture that is vulnerable to environmental change, fragile natural resources and ecosystems and high rate of erosion and land degradation (Liniger et al. 2011).

In Ethiopia, alike other sub-Saharan Africa countries, the land has been used in unplanned manner and without due attention to its's potential for a very long period. As a result, severe natural resources degradation has already been occurring. As Bewket (2007); Hurni et al. (2010); Nyssen et al. (2015) clearly noted, the natural resources base is still under great pressure from rapid population growth, inappropriate land use and poor management practices. The problem is very severe in rural areas, where different land uses are often in competition with one another. Studies have shown that soil erosion, overgrazing, deforestation and cultivation on fragile steep slope areas are common environmental problems in the rural areas of the country (Haregeweyn et al. 2012; Bewket and Abebe 2013; Miheretu and Yimer 2017; Sewnet and Abebe 2017). To alleviate these problems and to reverse the unsustainability spiral, Godschalk (2004), Lu et al. (2004), Ran and Bo (2013) recommended that examining the current land use practices and devising management options is required.

In order to use the land optimally and achieve its sustainability, it is necessary to have the information on existing land use (Eniolorunda et al. 2016). He argued that land use is a major issue that has to be addressed before sustainable land management could be achieved. As long as it is one of the key aspects which has highly supported the socio-economic development of human beings (Liu 2018), land use can be used to evaluate the extent to which human activities are jeopardising or promoting sustainable land management (Mashi and Shuaibu 2018). It is thereof essential to examine issues related to land use and land use problems, so that management options can be discerned, and sustainable land use planning can be framed. Therefore, the main objective of this study was to investigate the current land use problems and management options for sustainable use in Debre Tsyon *kebele*, North central Ethiopia. The specific objectives were to: (1) examine the land use problems that lead to rural unsustainability, and (2) suggest management options to improve the land use while achieving optimal benefit out of land and ensuring its sustainability.

The roots of rural land use problems

During the 21st century, land as a global resource is likely to become the focus of intensified competition from a variety of uses (Harvey and Pilgrim 2011). The problem is more prevalent in rural areas of developing countries with rapid population growth (Kerselaers et al. 2013). Evidences from literature have shown that the degradation of land resources and using unproductive land is escalating in these countries (Mitiku et al. 2006; Bewket 2007; Liniger et al. 2011; Nukala and Mutuz 2015). Consequently, the creation of a more sustainable countryside has become a very important challenge in these regions (Domon 2011; Ran and Bo 2013; Liu 2018). In countries like Ethiopia, the current inappropriate use of farmland (Nyssen et al. 2009, 2015; Haregeweyn et al. 2017), which is resulted from the ever-increasing demand for boosting crop production (Godschalk 2004; Albaji et al. 2009; Liu 2018; Liu et al. 2018) has necessitated the best land management practices than ever. As a result, the designing of effective and efficient management systems has attracted international, national and local attentions (UNEP and FAO 1999; Aribigbola 2007; Owei et al. 2010; Ziadat et al. 2017).

Evidences from literature indicate that in Ethiopia, the land has been used in unplanned manner and without due attention to its's potential for a very long period (Emiru and Taye 2012; Negash 2012; Hailemariam et al. 2016; Teklemariam et al. 2016; Gashaw et al. 2017; Gebeyehu et al. 2017; Miheretu and Yimer 2017; Sewnet and Abebe 2017). As a result, land degradation has been one of the severe environmental problem of the country which requires great effort and resources to ameliorate (Taddese 2001; Hurni et al. 2005; Adgo et al. 2013; Nyssen et al. 2015). The problem is more severe in the highlands (above 1500 m above sea level and covering 45% of total area) where roughly 90% of the population lives and 95% of the regularly cultivated lands are found (Bewket and Sterk 2002; Bewket 2007; Hurni et al. 2005, 2010; Nyssen et al. 2009, 2015; Adgo et al.

2013). According to Schmidt and Zemadim (2015), deforestation due to farmland expansion, fragile soils, undulating terrain, and heavy seasonal rains makes the highlands of Ethiopia vulnerable to soil erosion. Soil erosion has been severe throughout the highlands, but mainly on agricultural land; the current severity and extent of soil degradation seriously threaten food security (Hurni et al. 2010).

To curb this unsustainability spiral, the better understanding of issues related to land use and rural sustainability and putting forward countermeasures favouring sustainability are becoming crucially important (Lu et al. 2004). Therefore, it is imperative to examine issues related to land use and land use problems, thereby management options can be designed, and land use planning can be formulated. Land use planning has been recognized as a key instrument for identifying and ensuring sustainable land uses (Wrachien 2003; Kerselaers et al. 2013; Obayelu 2013; Ran and Bo 2013) and improving the livelihood of rural communities and thereby achieve sustainable development (UNEP and FAO 1999; Bourgoin 2012; Bourgoin et al. 2012; Eniolorunda et al. 2016). Likewise, as clearly pounced by Nukala and Mutuz (2015), Picuno et al. (2015) land use planning puts appropriate land units for efficient land uses in the most rational way to satisfy the diverse needs of the society and to conserve natural resources sustainably for the future.

Heretofore, studies on land use have been conducted at various scales, ranging from local to global. In case of many developing countries, very few studies are conducted so that effective and efficient land use planning and management is not well established (Wrachien 2003; Owei et al. 2010). Although land use studies which have been conducted at global scale enabled to examine the land use problems and its management options by using different methods and approaches, they tend to overlook the local scale setting (Mengistu et al. 2012). Conversely, local level studies are essentially about abandoned, pocket and secluded areas that barely get the glutted attention, justifying the essence of conducting more of such studies. In the milieu of rapidly growing population, deep rooted poverty, high dependence of the local economy on land resources, in appropriate land uses and severe land degradation, local level land use studies are utmost important. Thus and so, in this study, we integrated participatory methods with the geo-spatial data and techniques to investigate the current land use problems and devise management options for the sustainable land use which could serve as evidence for rural areas of developing countries.

Study area and methods

Study area

The Debre Tsyon *kebele* located in Enebsie Sar Midir District, East Gojjam Zone of the Amhara National Regional State, North central Ethiopia, with area coverage of 186.5 km^2 (Fig. 1). The *kebele* (smaller administrative unit) has very diverse topographic features such as river valleys, plains, deep gorges and steep sloppy areas. An undulated plateau dominates in the southern and very rugged terrain in the northern part. The altitude of the *kebele* ranges between 1743 and 2450 m and slopes range from nearly flat (< 2%) to steep (> 40%). The *kebele* has mean annual temperature of 20–25 °C and 1000–1200 mm mean annual rainfall. Rainfall in the area is characterized by mono-modal rainy season (summer season) which covers from June to September. In some occasions, small amount of the rainfall occurs in May and October. Luvisols (on gentle slopes) and leptosols (on steep slopes) are the predominant soil types in the area (Agriculture and rural development office (ARDO) of the district 2015).

Mixed farming is the dominant economic activity of people in the study area. Most people engaged in both traditional crop production and livestock rearing practices. The main crops grown in the area are *teff* (*Eragrostistef*), wheat (*Triticum vulgare*), barley (*Hordeum vulgare*), maize (*Zea mays*), and Chickpea (*Cicer arietinum*), sorghum (*Sorghum bicolour*), field pea (*Pisum sativum*), and fababean (*Viciafaba*). Likewise, cattle, equines, sheep, goats and poultry are major livestock resources reared in the area. The major land use patterns in the kebele are farmland, grazing land, marginal land, settlement, forest and bush land. The proportion of cultivable land dominates others by far which is about 75% of the total. In the kebele, land distribution was conducted during the socialist regime and under the current government (Abebe 2018).

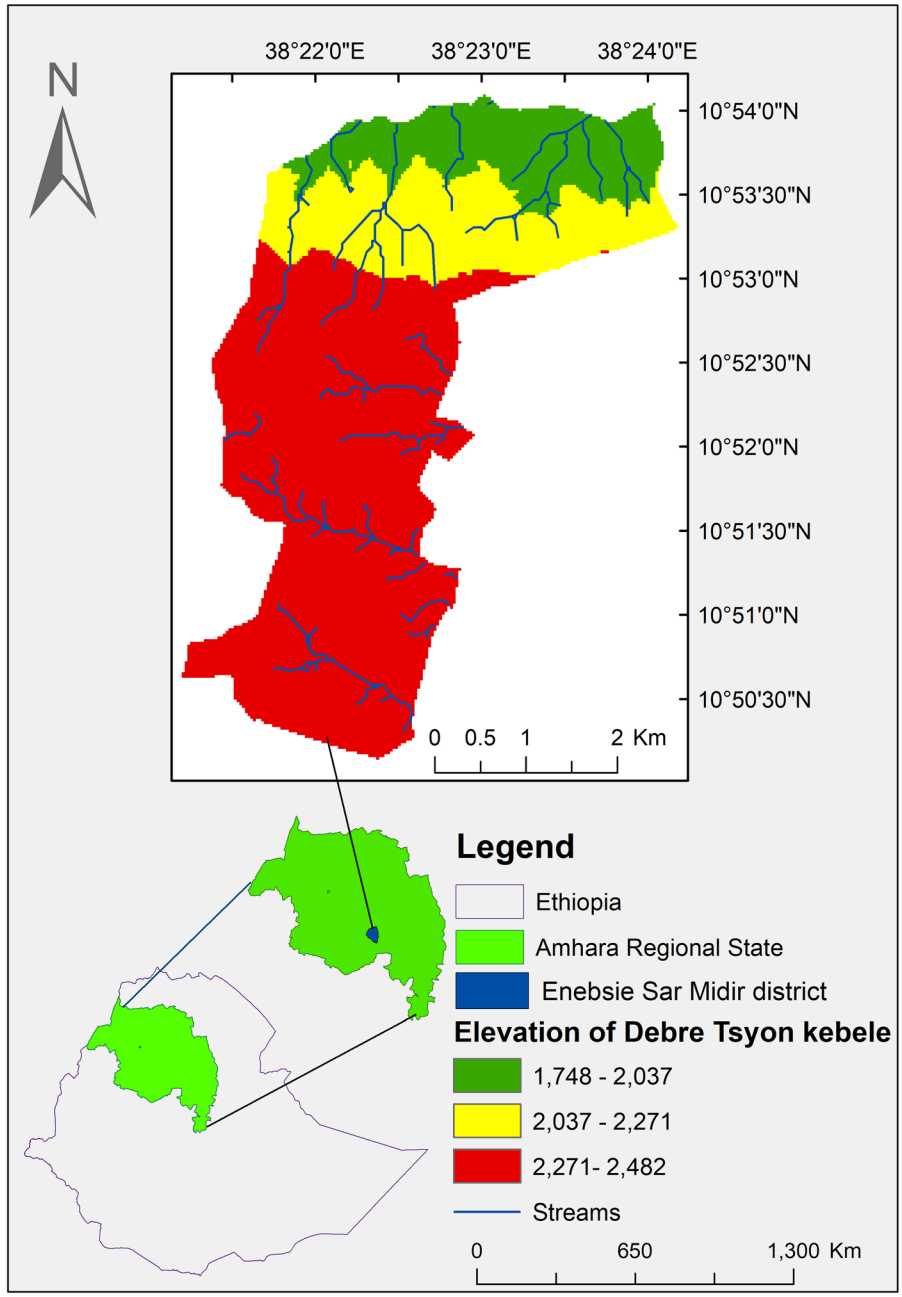

Fig. 1 Location of Debre Tsyon kebele

Methods

The study used both quantitative and qualitative datasets. Quantitative data extracted from Landsat image and digital elevation model, while the qualitative data was derived from interview and field observation. The Landsat-8 OLI-TIRS was acquired on February 2017 (path-169 and raw-53) from United State of Geological Survey (http://glovis.usgs.gov/), whereas ASTER GDEM with 30 m cell size obtained from Aster Global Digital Elevation Map (http://gdex.cr.usgs.gov/gdex).

The Landsat image was cloud free images taken during dry season to observe the actual land use of the study area. Prior to image classification, clipping, image geo-referencing, image enhancement and

colour composites were applied (Rogan and Chen 2004; Jovanović et al. 2015; Sewnet and Abebe 2017) on remotely sensed image to change and alter the original raw spectral data to increase the information availability (Abdelrahman et al. 2016). Then unsupervised classification in iterative self-organizing data analysis algorithm was employed first to determine the number of land uses classes (LUC) in the study area (Lillesand et al. 2014; Gashaw et al. 2017; Miheretu and Yimer 2017). The supervised classification with maximum likelihood classification algorithm (Rogan and Chen 2004; Bewket and Abebe 2013; Miheretu and Yimer 2017; Gashaw et al. 2018) was carried out by using ground control points (training areas) taken from each land use class. The land uses were farmland, vegetation, settlements, grazing lands and bare lands (Table 2). The classification had an overall accuracy of 85.19% with a kappa coefficient of 0.82. The image was processed through ERDAS Imagine 14.0 and LUC map was produced by using Arc GIS 10.3.

Apart from the GIS and remote sensing, rapid rural appraisal method, which promotes active participation of local population (FAO 1996; Bourgoin et al. 2012) is widely used method in land use planning studies (Chambers 1994; Bourgoin 2012). Tools developed under this paradigm encompasses a range of village based interviews and focus groups (Bourgoin 2012). It serves to diagnose a current situation which can be a short-term springboard for devising solutions (Mitiku et al. 2006). Thus, to obtain insight on the current land use problems, in-depth interview was carried out with land users and development agents (Garedew et al. 2009). Informants were selected based on snowball sampling method (Bernard 2011). In this method, the first interviewee, who served as an entry point was selected based on village or *kebele* officials' recommendation. Overall 28 respondents were interviewed.

Terrain analysis

As terrain controls the land use condition, terrain analysis is an important factor in land use planning studies (FAO 2006, 2007; Ran and Bo 2013). Hence, ASTER DEM was used to generate elevation and slope data in arc GIS by using digital terrain analysis technique (Deng et al. 2001; Hengl et al. 2003). As relief maps show, the topography of the Debre Tsyon *kebele* is characterized by undulating high plateau that is relatively flat and suitable for agriculture in the eastern, western and southern part. The deep dissected gorges, valleys, depressions, ridges and rugged upland relief features are common in the northern part of the village. Flat to very gently sloping (0–2%), gently sloping (2–5%), sloping (5–10%), highly sloping (10–15%), moderately steep slope (15–30%) and steep slope (> 30%) are slope classes in the *kebele*.

Slopes with higher percentage such as highly sloping, moderately steep sloping and steep sloping slopes classes are concentrated in the northern parts of the *kebele*. They share 33% of the *kebele* and each cover 11, 18 and 4% respectively. Both flat to very gently sloping and gently sloping shared 39% of the total area and each comprises 18% and 21% respectively (Table 1). The relative flatness of these areas made them ideal for farming. The sloping slope classes were major slope classes covering 28% of the total area and concentrated in northern, central, and eastern parts of the kebele where agricultural lands are common (Fig. 2).

Results and discussion

The current land use practices in Debre Tsyon *kebele*

As can be seen from Table 2, the major land uses identified in the study area were barren land, settlement, grazing land, cropland and vegetation. The crop land shared the highest proportion of (75%) the land, while barren land and settlement covered 10% and 9.2% of the area respectively. The remaining very small part of land is shared by vegetation (3%) and grazing land (2.4%). It has been well recognized in literature (Tekle and Hedlund 2000; Hurni et al. 2005; Bewket and Abebe 2013; Amare et al. 2014; Tesfaye et al. 2014; Hailemariam et al. 2016; Gashaw et al. 2017; Miheretu and Yimer 2017; Sewnet and Abebe 2017; Gashaw et al. 2018) that the cropland has been a dominant land use type in the highlands of Ethiopia.

Cropland: is a type of land use allotted to cultivation of annual crops such as field crops, cereals, pulses, vegetables, fodder crops, etc. It is the major land use type class covering 75% of the total area in the study area (Table 2). In Debre Tsyon *kebele*, the average size of landholding is 0.5–1 hectare while the average family size accounted for 5–7 persons per household head (ARDO 2015). This implies that there was very

Table 1 Description of slope classes

Class	Description	Value (%)	Coverage (%)
1	Flat to very gently sloping	0–2	18
2	Gently sloping	2–5	21
3	Sloping	5–10	28
4	Highly sloping	10–15	11
5	Moderately steep sloping	15–30	18
6	Steeply sloping	> 30	4

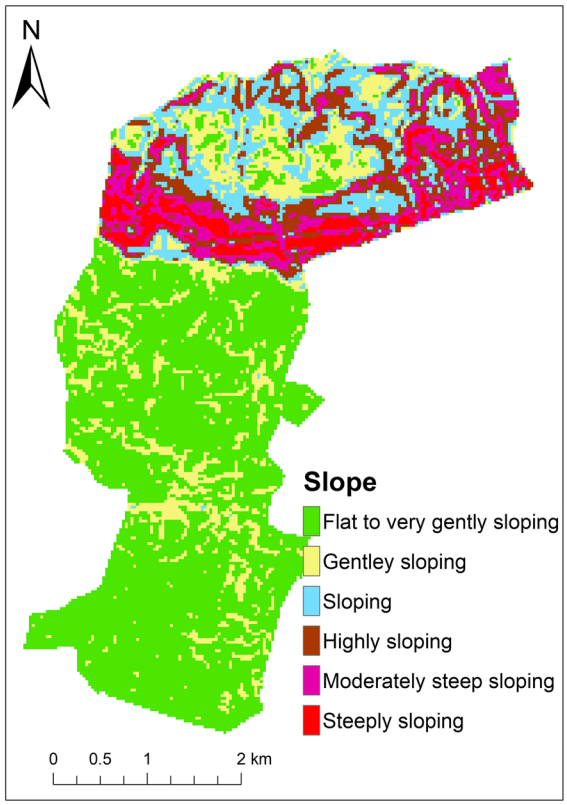

Fig. 2 Slope of Debre Tsyon kebele

small landholding which was not enough even to feed the existing population. As population aspired to grow, demand for land and other resources increased. For this reason, farmers expanded their farmlands to grazing lands and marginal lands that have higher slope value (> 30%) especially in northern parts of the kebele. This problem coupled with improper land use resulted in land degradation.

Of the total agricultural land, 12.6% found in areas which are steeply slope (> 30%) that is not suitable for agriculture unless bench terraces are constructed. However, traditional soil and stone bunds were the only conservation measures constructed in such areas. The attempts carried out to address soil erosion problem were unable to bring significant impact in protecting the land and reversing the soil erosion problem. As a result, soil erosion is common environmental problem in steeply slope parts of the village (Table 3). Moreover, 52.6% of the farming practiced in slope gradient range between 5 and 30%. Although the slope gradient is relatively low, the top soil from cultivated lands is removed through sheet and gully erosion. Thus, the formation of gullies is common in these areas. To curb this problem, soil and water conservation measures such as stone bunds, soil bunds, traditional ditches, and cut-off drains were constructed (Fig. 3).

However, as the development agents reported, the unsustainability of the conservation structures was serious problem in the study area. Farmers' willingness to maintain and reconstruct the prepared structures was very low. They would rather complain that the conservation structures were not suitable for oxen to turn while ploughing, consume and fragment their land and structures created favourable conditions for the reproduction of rodents. This finding is in agreement with earlier research findings which confirms that the unsustainability of conservation measures is a major challenge to achieve benefit out of conservation works in highland of Ethiopia (Bewket and Sterk 2002; Bewket 2007; Tefera and Sterk 2010; Moges and Taye 2017).

The results of interview indicated that, besides to physical conservation works, farmers accomplished some agronomic land management techniques such as crop rotation, mixed cropping, contour ploughing and terracing. However, these measures are usually associated with annual crops; are repeated routinely each season or in a rotational sequence; are of short duration and not permanent; do not lead to changes in slope profile and are normally independent of slope (Mitiku

Table 2 Description of land use classes (LUC)

LUC	Description	Coverage (%)
Barenland	It is deteriorated land with limited ability to support life which is covered with rocks, sands, buries, etc	10.0
Settlement	Settlement comprised areas of intensive use with much of the land covered by structures such as villages, small foot paths and rural roads	9.2
Grazing land	Land used for animal feed and production of animal forage or graze	2.4
Cropland	Land used for cultivation of crops (annual and perennial) e.g. field crops, cereals, vegetables, fodder crops, etc	75.0
Vegetation	Land used mainly for wood production, other forest products, recreation, protection e.g. natural forests, cash crop plantations, afforestation, etc	3.4

Table 3 Land use problems and their indicators. *Source*: Field survey (2017)

Land use problems	Indicators
Cultivation on marginal and steep lands	Low vegetation cover
Overgrazing	Rills and gullies
In appropriate farming/ploughing	Shortage of animal fodder
Deforestation	Shortage of fuelwood
	Soil erosion

et al. 2006). As a result, soil degradation, which resulted from overexploitation and mismanagement, is severe problem in the study area. The finding is in agreement with previous results which confirms that the landscape combined with factors such as a long history of settlement, improper farming practices, and increasing population pressure which forces people to cultivate even steeper slopes all exacerbate land degradation (Adenew and Abdi 2005; Hurni et al. 2010; Haregeweyn et al. 2012; Mekuria et al. 2012; Nyssen et al. 2015).

Grazing land: this land use class cover very small (2.4%) portion of steep slope and marginal lands in the kebele (Table 2). Unfortunately, this tiny portion of land deteriorated and changed to bare land and gullies due to over grazing. The grazing land could not provide pasture for animals as the capacity of the land is declined (Fig. 4). During the interview, farmers noted that forage availability and quality is not favourable year-round. The gains made in the wet season are totally or partially lost in the dry season. Due to this, free grazing is practiced and this in turn has adverse impact on land. In connection to this, Mengistu (2006) described that crop residues provide 10–15% of total feed intake for animals in the mixed-farming highlands. Hence, it is could be inferred that the improper land use coupled with outnumbered livestock had resulted in degradation of the grazing lands. Similar studies conducted so far also found that uncontrolled and free grazing system in many of parts of rural Ethiopia has caused severe degradation of these resources (Badege 2001; Gebremedhin et al. 2004; Mekuria and Aynekulu 2013).

Settlement: is one of land use class covering 9.2% of the area. The settlement pattern of the area is clustered where the society chosen suitable site for permanent residence. However, during field observation, it was found that land degradation induced by rain water erosion during summer season has threatened the society. Thus, there is a strong need for conservation and rehabilitation works.

Barren land: share 10% of the total area in the *kebele* (see Table 2). It is one of the land use classes expressed as deteriorated land with limited ability to support life which is covered with rocks, sands, buries, etc. This land use class is common in most of northern and some of eastern parts of the kebele which is resulted from previous outright cultivation of steep lands and excessive grazing. Asked why the land is declined and changed to barren land, farmers

Fig. 3 **a** Stone bund constructed on slopping area of Debre Tsyon kebele. **b** Terraces constructed on slopping area of Debre Tsyon kebele

Fig. 4 Degraded grazing land in Debre Tsyon kebele

responded that the barren land was previously covered with vegetation and grass. Gradually, the land has been deteriorated due to overgrazing and deforestation followed by severe soil erosion. Thus, it is suggested that this parcel of land need to be free from human and animal influence so that it could be rehabilitated.

Vegetation: referred as land used mainly for production of wood products, others forest products and cash crop plantations. This type of land use class covered 3.4% of the village. The banana, coffee, orange and chat are cash crops plantations practiced in small scale irrigation. *Eucleashchimperi*, *Carissa Spinarum*, *Acacia*, *Cordia Africana*, *Olivera Africana*, etc. are the major natural vegetations. As observation results show, these vegetation resources degraded due to the unwise aggravated by an increasing demand for wood products. Thus, the society use eucalyptus as an alternative to natural vegetation, although eucalyptus plantations covered very small areas around settlements. Asked what the reasons for the degradation of vegetation resources are, farmers responded that the vegetation resources have been being diminished time to time due to the expansion of croplands and growing demand for fuel wood. This result is inconsistent with research findings of Badege (2001), Bekele (2001), Teketay (2001), Dejene (2003), Gashaw et al.(2017), Miheretu and Yimer (2017), Sewnet and Abebe (2017) that confirmed as the expansion of agriculture and the growing demand for fuel wood are the main reason for deterioration of the forest resources in the highlands of Ethiopia (Fig. 5).

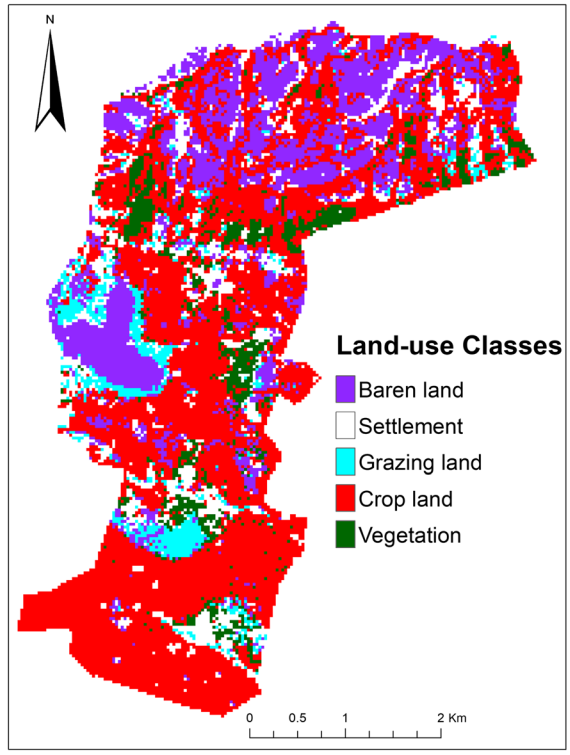

Fig. 5 Land use of Debre Tsyon kebele

Management options

The results show that land use problems were more severe in agricultural lands and grazing lands than others. Changes in land use, however, can only be justified if there are no other options for soil conservation (Caracalla 1995; FAO 1996; UNEP and FAO UNEP and FAO 2009; Liniger et al. 2011). For example, cultivation on steep lands with a very short future use must be changed to land use systems with a much denser vegetative cover (Mitiku et al. 2006; Hurni et al. 2010; Adgo et al. 2013; Gelagay and Minale 2016; Gashaw et al. 2018). In the study area, 12.6% of the cropland found in steeply slope areas (> 30%) that is not suitable for agriculture. In this area, farming could be practiced with strong conservation measures mainly through constructing bench terraces. However, implementing these conservation measures in sloppy areas could be difficult it demands intensive labour and expensive mechanical engineering works. Therefore, this calls for strong collaboration of stakeholders among them and requires a strong commitment from both the government and the local community.

Moreover, 52.6% of the farming practiced in slope gradient range between 5 and 30% where sustainable conservation works ought to be practiced. In Ethiopia context, as clearly stipulated in FDRE (2005); Mitiku et al. (2006); Negash (2012); Hurni et al. (2016); recommendations, the management of rural lands with slope < 30% shall follow the strategy of soil conservation and water harvesting. On the other hand, slopes between 31 and 60% could be allowed only through making bench terraces. And lands with slope > 60% shall be used for development of trees, perennial plants and forage production. Besides, in a place where soil and water conservation works are undertaken, free grazing shall be prohibited and a system of cut and carry feeding shall be introduced bit by bit

(Mitiku et al. 2006; Bewket 2007; Adgo et al. 2013; Amare et al. 2014; Hurni et al. 2016).

In Debre Tsyon *kebele*, the grazing land is deteriorated and the grazing capacity has declined. Thus, it could not bring pasture in the long winter season. As a result, new management option is imperative. In connection with the management options of severely degraded grazing land, Gebremedhin et al. (2004), Mitiku et al. (2006), Mengistu (2006), Liniger et al. (2011), Mekuria and Aynekulu (2013), recomeneded the use of fencing or exclosure of the area for a period of several years for rest. Furthermore, both on steep slopes and degraded grazing land, livestock grazing cannot be allowed, rather cut and carry grazing system is suggested. Therefore, the grazing land in the *kebele* need to be free from animal contact and after good regeneration, controlled or cut and carry grazing could be implemented. The barren land also need to be left free of animal and human influence for rehabilitation (Mitiku et al. 2006; Mengistu 2006; UNEP and FAO 2009). The introduction of plants with complex root systems such as bamboo trees, Makarikari grass (*Panicum coloratum mararikariense*) and vetiver grasses (*Vetiver zizanioides*) could be viable solutions for reclamation of the degraded land in the *kebele*. Besides rehabilitating the degraded area, plants grown in the area can bring forage for livestock and increase the livestock production.

Conclusion

Land use determines whether a resource could be conserved or not and the level of conservation attainable for natural resources. In the absence of planning, the exploitation of land resources has been virtually unguided and uncontrolled. This is evident in Debre Tsyon *kebele* where there is an increasing rate of hostile man-land relationship. The growing demand for land resources combined within inappropriate land use have brought the expansion of farmlands to fragile steep lands (> 30%), destruction of vegetation resources and deterioration of grazing lands. As a result, people could not meet the maximum benefit they could secure from the land. The adoption of a comprehensive approach that views land use and management in an integrated manner is thus a viable solution. This calls for the introduction of local level land use planning that promotes the allocation of land to the uses that give the highest sustainable benefit.

Therefore, the local government with non-governmental organizations and development partners ought to work hard to develop the land use plan based on the management options forwarded above, and then put it into effect. Moreover, in the process of adoption and implementation of land management measures, the role played by professionals in provision of accurate information about the pros and cons of measures is vital. Thusly, there has to strong functional link between the development agents and farmers. Constructing conservation measures such as bund terrace on steep slope areas need high labour and material costs. Therefore, incentive and motivation mechanism ought to be coined by the local government so that farmers will be actively engaged on conservation work. Furthermore, as the area is prone to erosion, the introduction of conservation agriculture is utmost important. This system saves the land from over ploughing and thus, the organic matter holds the soil particles together, making it harder for water to carry them away.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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