REPORT

Long-Term Indigenous Soil Conservation Technology in the Chenchä Area, Southern Ethiopia: Origin, Characteristics, and Sustainability

Assefa Engdawork, Hans-Rudolf Bork

Received: 20 October 2013 / Revised: 31 March 2014 / Accepted: 11 April 2014 / Published online: 8 May 2014

Abstract The purpose of this study is to examine the origin, development, and characteristics of terraces (*kella*), plus their potentials and determinants for sustainable use in the Chenchä–Dorze Belle area of southern Ethiopia. Field surveys were conducted to determine the various parameters of the indigenous terraces and in order to collect samples for radiocarbon dating. To identify farmers' views of the terrace systems, semi-structured interviews and group discussions were also carried out. Terraces were built and used—as radiocarbon dating proves—at least over the last 800 years. The long-term continued usage of the indigenous terraces is the result of social commitments, the structural features of the terraces, and the farmers' responses to the dynamics of social and cultural circumstances. We dubbed that the terraces are a success story of fruitful environmental management over generations. Thus, a strong need is to preserve and develop this important cultural heritage and example of sustainable land use.

Keywords Indigenous terrace ·

Soil and water conservation · Sustainable land use ·

Traditional knowledge · Chenchä · Ethiopia

INTRODUCTION

Agricultural practices in Ethiopia have long been accompanied by soil erosion. The estimated annual soil loss in Ethiopia is approximately 1.5 billion tons and soil nutrient losses may be as high as 30 kg ha⁻¹ of nitrogen and 15–20 kg ha⁻¹ or more of phosphorous (FAO 1986; Hurni 1993). Sustainable use and management of soil are thus pivotal in order to enhance the immense role of agriculture in the present economic development of Ethiopia. The government of Ethiopia initiated soil and water conservation

measures following the devastating droughts of the 1970s. Terraces were built in highly degraded areas, on marginal land and along steep slopes with a total length of approximately 1 000 000 km (FAO 1990; NCS 1990). From 1980 until 1990, roughly 200 million US dollars and over 30 million annual farmer's working days were invested (Krüger et al. 1996). However, over time it was recognized that the interventions proved to be unsustainable and unpopular. Most terraces were not maintained and were removed, particularly during government upheaval in the 1990s. Failures of newly introduced soil and water conservation measures were also reported in other countries such as Zimbabwe, Nigeria, Cameroun, and South Africa (Reji et al. 1996; Showers 2006). Various researchers documented that the main attributing factor for the limited success of the soil and water conservation programs was their top-down approach (Krüger et al. 1996; Reji et al. 1996; Herweg and Ludi 1999; Admassie 2000; Alemneh 2003; Bewket 2007; Dessie and Carl 2008). Hence, these conditions also heighten the need for significant soil and water conservation practices. Lessons should also be drawn from the success stories of indigenous soil water conservation measures, ISWC. Focusing on examples of indigenous intensive agriculture in Eastern Africa, Stump (2010) reviewed the potential use of past and precedent data for sustainable resource conservation.

However, Ethiopian farmers have long been aware of soil erosion problems and devised techniques to halt soil erosion and to conserve land resources, as part and parcel of agricultural systems. This indicates that most Ethiopian farmers have been practicing land uses that involve inherited soil and water conservation measures. Hence, there is a wide range of soil management practices such as structural, agronomic, and biological measures (Westphal 1975; Asrat et al. 1996; Krüger et al. 1996; Million 1996; Reji et al. 1996; Herweg and Ludi 1999; Nyssen et al.

2000; Osman and Sauerborn 2001; Besha 2003; Mitiku et al. 2006).

Among others, indigenous soil conservation terraces are a well-developed practice in different parts of Ethiopia, namely in Konso (southern Ethiopia), south Shewa (central Ethiopia), and the Harangue plateau (eastern Ethiopia) (Westphal 1975; Asrat et al. 1996; Krüger et al. 1996; Besha 2003; Watson 2009). The design and construction of these terraces range from rudimentary stone lines to sophisticated terracing infrastructures. Konso, in particular, is famous for its stonewalled terraces. In recognition of the role played by Konso's traditional stonewalled terraces as a part of the cultural landscape, they were designated as a world heritage by UNSECO in June 2011 (UNESCO 2011). Indigenous terraces constructed with stonewalls are also common over a wide range of environmental settings in other parts of Africa, for example, in Cameroon, Nigeria, Tanzania, and Zimbabwe (Hiol et al. 1996; Igbokwe 1996; Reij et al. 1996). Agricultural terraces are also an ancient practice outside Africa, used to protect soil from erosion, for water conservation, and in the creation of agricultural fields (Sandor 2006; Showers 2006).

Archeological and historical records indicate that terracing has been a part of agriculture for millennia. Terraces have been established under different environmental settings for various purposes across five continents and Oceania (Sandor 2006). But there is no single position or time for the origin and development of the traditional agricultural terraces; instead they have multiple independent origin sites (Showers 2006). Purposes, construction techniques and materials, as well as the uses of indigenous terraces vary enormously from region to region (Reij et al. 1996; Sandor 2006; Showers 2006). Terraces have been used in Yemen for the past 5000–6000 years; in China for at least 4500 years; on the island of Cyprus for at least 3000 years; in Peru, Mexico, and Guatemala for approximately 2000 years and in Tanzania for about 300–500 years (Bork 2006; Sandor 2006; Showers 2006).

However, there is limited scientific research on terraces and other indigenous soil and water conservation technologies in Ethiopia and the studies conducted to date are not uniform and scattered. It is also to be noted that Ethiopia is marked by varied ecological and socioeconomic conditions; different regions have unique forms of resource management practices. Furthermore, scientific archeological determination of the age of terraces is also lacking in Ethiopia. In Ethiopia, different studies roughly estimated and refereed the age of the terraces from 100 to 400/500 years (Amborn 1989; Grove and Sutton 1989; Sandor 2006; Showers 2006). The sources for the estimation of the ages of terraces in Ethiopia were travel accounts, oral history traditions, and genealogies. In particular, the work of Amborn (1989), who used genealogy and oral history to determine the age of the terraces of the Konso area, has often been cited. Such work should ideally have been supplemented

with chronometrical and stratigraphical investigations. However, the stonewalled terraces of Konso have been reworked and thus it is difficult to find untouched areas for radiocarbon dating (Watson 2009). Thus, the estimated ages of terraces in Ethiopia, besides lacking in accuracy, do not represent their real age at different places.

The purpose of this study is to examine the origin, development, and characteristics of the indigenous soil conservation technology in the Chenchä–Dorze Belle area. Moreover, it assesses the potentials and determinants of the sustainable use of the measures. The study attempted its objectives with the broader context of the study of the dynamics of landscapes in a chronological and spatial order in mind in order to identify trends, driving forces, and impacts of land use systems, land cover, and landscape structures during the last century in the Chenchä and Arbaminch areas, southern Ethiopia. The methods used in the broader study entailed detailed field and lab investigations, including C¹⁴ dating, satellite image interpretation, transect surveys across agricultural land, interviews and group discussions, and comparisons with earlier surveys conducted in the late 1960s (Assefa 2012).

It has been found that the agricultural land use systems and forestland of Chenchä and Arbaminch have undergone significant changes during the last century. Cultivated land has increased by 39 % over the last four decades. Household holdings of cultivated land have decreased over time despite an increase of the extent of total acreage of arable land in the highlands, on average from 1.6 ha in the 1960s to 0.5 ha per household at present. About 37 % of grasslands in the highlands were converted to cultivated land from 1973 to 2006. Large grassland areas were already converted to cultivated land in the 1960s as revealed by Jackson et al. (1969). In particular, private grazing land was totally abandoned as witnessed by the surveyed households. Similarly, there is a significant downward trend in regional forest cover, which shows a 23 % decline from 1972 until 2006, with the most significant change from 1986 to 2006. The most cited factors that cause deforestation in the study area are agricultural land expansion, fuel wood demand, and settlement. According to the informants in the highland, the main reasons for agricultural land expansion are low agricultural production and population increase. Population growth is among the main causes for the scarcity of cultivated land in the area. The problem of land scarcity has been very acute over time, since the existing land was shared and distributed mainly to the male children. Fuel wood demand is another chief cause of deforestation. Farmland scarcity has already caused farmers to cultivate marginal land areas and fragile ecosystems. This, coupled with deforestation and cattle grazing on the remaining forestland, resulted in a decline in soil fertility and an increase in soil erosion by water.

The farmers, however, were resourceful and have well-established land use systems and a wealth of local experience in maintaining and managing landscapes. Despite the recent disruptions, they have used intensive cultivation systems, integrating crop–livestock practices and diversified cultivation. Moreover, the people of the area have long had rules and regulations to maintain the sacred forests, woodlots, and stands of trees around the homesteads and on the farm fields. Farmers also practice manuring, crop rotation, fallowing, and tree plantation on farm fields, along with terracing as a survival strategy in steep mountainous topography prone to resource scarcity. Terracing is another salient method to manage the soil of the areas (Assefa 2012).

The study area of Chenchā–Dorze Belle, in particular, is covered by a series of traditional terraces and embankments made of stones; thus the slopes were converted to a series of steps. Chenchā–Dorze Belle is situated at the lower border of the highlands, above the steep escarpment of the rift valley. Except for some very flat sites, the area is terraced. Terraces were built over generations based on the farmers' perception of the problems, as well as their knowledge, skills, energy, and survival strategies. The area is also referred to as a megalithic territory due to its ancient stonewalled terraces (Jackson et al. 1969; Jackson 1972). In this study, radiocarbon dating was undertaken to determine the age and origin of the indigenous terraces.

The study of the long-term terracing has multifold objectives such as adding to scientific knowledge on terraces in view of their evolution, functions, forms, and implications. Indigenous soil water conservation (ISWC) with terracing represents the socioeconomic and cultural landscape of the area, justifying its investigation and documentation. Moreover, the current investigation is important since at present many cultural landscape practices are on the verge of disappearance due to cultural assimilation and integration, coupled with the high dynamism of political and economic conditions. Furthermore, the long-term perspectives of the terraces represent guiding efforts toward sustainable agricultural systems. The skills, knowledge, survival strategies, and coping mechanisms of farmers have led to sustainable use of the resources for a long period of time. Thus, these have multitude benefits, which planners may integrate into agricultural development plans for the wide adoption of sustainable land management practices such as terraces. Although this research investigation is not exhaustive, it is still the only survey that aimed to answer the question on the age of the agricultural terraces in Ethiopia with empirical archeological information. It is also worth noting that other investigations on ancient agricultural land management practices would enrich the results of this investigation.

MATERIALS AND METHODS

Description of the Study Area

Chenchā (6°15'N, 37°34'E) is situated in the southwestern highlands of Ethiopia, about 600 km south of Addis Ababa (Fig. 1). It is bounded by Lake Abaya in the Great Rift Valley and Arbaminch in the east and south, respectively. The elevation in the area ranges from 1100 to 3200 m above sea level. Chenchā is characterized by diversified topography, consisting of the rift valley escarpment, high plateaus topped by hills and mountains, plains, and river valleys.

The monthly average maximum temperature in Chenchā is 15 °C (occurring in February) and the monthly average minimum temperature is 13 °C (occurring in October), based on meteorological measurements taken from 1970 to 2009 by the meteorological station in the town of Chenchā at an elevation of 2800 m a.s.l. The mean annual precipitation for Chenchā measured 1255 mm.

The population of the Woreda (district) of Chenchā in 2005 was 127 193 (CSA 2006). The density is estimated at

Fig. 1 Location of the study area

roughly 336 persons per square kilometer. The main economic activity of the area is subsistence agriculture. People mainly cultivate enset, barley, and wheat. To a lesser extent they also grow maize, teff, peas, beans, potatoes, and tree cabbage. Raising livestock is also an integral part of the economy.

Methods

Various methods of data collection and analysis techniques were employed to generate empirical and socio-economic data for the study.

Field Survey: Measuring and Describing Terraces

A transect walk, as a reconnaissance survey, was undertaken to understand the study area before conducting the detailed data collection. Such a survey is a useful technique to observe and become familiarized with the different features of land use systems in general and terraces in particular. The observations were also based on checklists. Later, repeated visits to farm fields by transect walk were also useful for refining or verifying data collected from interviews and group discussions.

Measurements of different aspects of terraces, namely rise, horizontal distances between terraces, depth of foundations, and stone sizes, were undertaken. Moreover parameters, which are pertinent to terraces, such as establishment, construction, and maintenance processes, among others, were described. The forms for measurements and observations of ISWC were adopted from the ISWC inventories format, which was designed to measure ISWC practices in Ethiopia (Krüger et al. 1996). In conjunction with the measurements and descriptions, discussions were conducted with the owners of farmland about the history of the terraces.

Household Surveys

Forty households were randomly selected from the study area of Dorze Belle. The interview questionnaires were composed of both closed and open-ended questions. The main items that were covered by questionnaires include settlement history, evolution, characteristics, benefits, reasons for long-term indigenous terraces, limitations of the terraces, and techniques for the construction and maintenance of terraces. The interviews were carried out with the help of assistants. The assistants were college graduates, proficient in the local languages. Training was provided for assistants on interview methods, including establishing contact and conducting interviews, procedures, and cultural issues (Figs. 2, 3, 4).

Fig. 2 Terraces of Chench, Dorze-Belle

Fig. 3 Trees are common in a terraced cultivated land

Fig. 4 Terraces on steep slope of Chench, Dorze-Belle

Collection of Datable Material and ^{14}C Analysis

Dorze-Belle is situated at the lower border of the highlands, above the steep escarpment of the rift valley. Except for some very flat sites, the area is terraced. Moderately inclined slope segments with large agricultural terraces and steep slope segments with small terraces are interleaved.

Here, the length of the terraces is mostly less than 3 m and the height of the terrace wall measures often 0.7–1.5 m, only sometimes reaching 3 m in height (for details of construction of traditional terraces refer to “[Forms and Characteristics of Indigenous Soil and Water Conservation Measures](#)” section).

On one of the steep slope segments, a profile was opened at the wall of an agricultural terrace. The terrace has a maximal height of 2.5 m at the terrace wall, a length of 2–3 m in the direction of the slope, and a width of approximately 20 m along the contour. The upper 1.5 m of the profile, directly behind the terrace wall, consists of dark-colored, fine soil material with a high content of organic matter. Below this terrace fill, a debris layer was found at a depth of 1.5–2.5 m. Intensively weathered bedrock (saprolite) was exposed below the debris layer at the base of the profile. In the profile at the terrace wall, the fine soil fill and the debris layer were investigated in detail and sampled for radiocarbon dating at two depths: samples were taken in the profile beneath the recent cultivation layer (fine soil material; sampling depth: 30 cm below soil surface; fraction: charcoal, alkali residue, 2.4 mg C) and above the base of the terrace fill (debris layer; sampling depth: 240 cm below soil surface; fraction: charcoal, alkali residue, 5.7 mg C).

The influence of wood coming from outlying areas was insignificant as charcoal originates from the fuel wood trees from the surrounding forests that cover the escarpment. The dominant tree type is *Juniperus* spp., which normally has an age limit of 50–100 years. The forest is still an important source of wood for fuel for the local population. Thus, the effect of wood or charcoal coming from other areas is less probable.

The charcoal samples were dated at the Leibniz Laboratory for Radiometric Dating and Stable Isotope Research, Christian-Albrechts-University of Kiel, Germany. The laboratory used the following procedures (Nadeau et al. 1998): Samples were checked under the microscope for impurities. Then the charcoal particles were purified with 1 % HCl, 1 % NaOH at 60 °C, and again 1 % HCl (alkali residue). The combustion to CO₂ was performed in a closed quartz tube together with CuO and silver wool at 900 °C. The sample CO₂ was reduced with H₂ over about 2 mg of Fe powder as a catalyst to produce graphite. The resulting carbon/iron mixture was pressed into a pellet in the target holder for the AMS measurement. The ¹⁴C concentration of the samples was measured by comparing the simultaneously collected ¹⁴C, ¹³C, and ¹²C beams of each sample with those of Oxalic Acid standard CO₂ and coal background material. Conventional ¹⁴C ages were calculated according to Stuiver and Polach (1977) with a δ¹³C correction for isotopic fractionation based on the ¹³C/¹²C ratio measured by the laboratory's AMS system

simultaneously with the ¹⁴C/¹²C ratio. “Calibrated” or calendar ages were calculated using “CALIB rev 5.01.”

RESULTS AND DISCUSSION

Origin and Development of Indigenous Terraces

The AMS dating of one piece of charcoal, which was found at a depth of 30 cm below the soil surface, resulted in a radiocarbon age of 795 ± 30 BP (Laboratory No. KIA41856). The calibrated age is AD 1186–1202 and AD 1206–1277 (2 sigma range). Another charcoal fragment, which was found at a depth of 240 cm, has a radiocarbon age of 815 ± 30 BP (KIA 41857). The calibrated age is AD 1172–1267 (2 sigma range). These dates prove that the terrace was built in one event or at least over a very short period of time. It was most likely established in the late twelfth century or in the first half of the thirteenth century.

The material characteristics of the terrace fill and the terrace wall, which was constructed using local stones, prove that the terrace was built in one event; there are no indications at all that the terrace developed over many centuries. This conclusion from field observations was verified by the radiocarbon dating of two pieces of charcoal (Table 1).

This radiocarbon dating attests that the terrace investigated in Chenchä–Dorze Belle is probably one of the oldest relics of agricultural activities in the region. Archeological investigations prove that the area has been settled since at least approximately 6400 years cal BP (Arthur et al. 2010). The remains of a church, which was found inside a sacred forest by ethnoarcheological investigations, also provide some evidence regarding the age of settlements (informal discussion with John Arthur, Associate Professor of Anthropology, University of South Florida, Saint Petersburg). This church was among those, which were deserted by people coming from the northern part of Ethiopia during the war that took place in the sixteenth century. The war is known as the *Ahmed Gagn* war, in which a large number of orthodox churches were burned and some of them moved southward—mainly the covenant arks. This suggests that settlement in the area has a longer duration.

In the discussions with the elder people in Chenchä–Dorze Belle about the history of terraces and land use systems, they disclosed that the terraces were as old as the agricultural activities in the area. They also pointed out that their ancestors were the ones who designed and constructed the terraces. Senior members of the communities are well aware of the cultural landscape since information passes from one generation to another. Oral history is thus an important source of information for reconstructing the environmental history. For instance, based on the oral history of the elder people in the area, Arthur et al. (2010)

Table 1 Results of the radiocarbon dating of samples from an agricultural terrace in Dorze-Belle

Sample depth (cm)	Laboratory no.	Radiocarbon age (BP)	Calibrated age (2 sigma)
30	KIA41856	795 ± 30	AD 1186–1202 and 1206–1277
240	KIA 41857	815 ± 30	AD 1172–1267

have identified the site of an old settlement that has an age of about 6400 years. Moreover, during our field survey we also observed that the rock blocks, which were used for the construction of the terraces, changed color due to intensive chemical and biological weathering processes and lichens that have also grown on the rocks, implying the existence of the terraces for a long period of time.

Farmers also reported that the existing indigenous soil and water conservation technology was originally developed by their ancestors over a long period of time mainly to prevent erosion. In our discussion with the farmers from other parts of Chench, where terraces have been part of their agriculture for a long period, they also acknowledged that the terrace technology was adopted from the Chench–Dorze Belle area. They all considered the Chench–Dorze Belle area as the initial center of the technology, from where the terrace concept has been transferred to other places.

Forms and Characteristics of Indigenous Soil and Water Conservation Measures

The indigenous soil and water conservation technology of Chench–Dorze Belle is based on stonewalled terraces. The main construction materials for terrace walls are stones and bedrock, which are abundant in the area. The type of the stone found in the area is primarily basaltic rock, which was formed during the Tertiary period by volcanic activities. These stones are compact and solid and thus attributed to the stability and permanency of the terraces in the area. The stones have various sizes and shapes. The size of the stones used for the construction of terraces varies from about 10 cm to more than 1 m in diameter. People formerly collected stones from their agricultural fields and accumulated them at specific sites in order to build terraces.

When farmers construct terraces they first excavate trenches up to half a meter in depth. The soil is deposited downslope, just below the terrace wall. In contrast, in the newly introduced *fanya juu* terraces, soil from the trench is thrown upslope. Some portion of soil is used to cement the terrace, while the remainder is spread to the lower sides, behind the walls. Then they place the big stones in the excavated trench as a foundation for the terraces. In some cases if bigger stones were found in the trenches, they were

used as a base and terraces were built on these stones instead of removing them from the ground.

The method of piling stones to build the embankment of the terraces involves placing them with decreasing stone size from the base to the top. If there are gaps in the walls, they are packed with small stones, although in some cases they use soil as a filling to stabilize the walls. The position of the terrace wall is vertical or slightly inclined. It is slanted at the steep slope while it is vertical at the lower slope. The height of the terraces is often 0.7–1.5 m, only sometimes reaching up to 3 m depending on the gradient of the slope, with the height declining in accordance with the slope. Where there is a steep slope gradient, the height of the terraces is increased to retain a high amount of runoff. Along a contour, a single long wall was not built; rather a series of shorter terrace walls were constructed. The length of the terraces measures mostly less than 3 m. This is attributed to the individual farmers' views of the terraces and farm plot sizes. The tops of the walls were used to grow grass and trees. The water outlets on the side of the walls were also built to dissipate and divert water flows. In some cases, there are spaces between the stones of the terrace walls to allow water to exfiltrate safely.

The distances between the terraces along the slope vary from 3 to 15 m. Larger distances between terraces are observed at lower slope segments, whereas short distances are common on steep slope segments. The soil, which is accumulated due to slight hillslope erosion just above the terrace walls, is brought back to the upper part of the terrace where it was eroded earlier. Due to terracing, the original steepness of the slope was reduced drastically on the terrace surfaces under cultivation. The steep slope segments are thus marked by terraces with higher walls and shorter distances of terrace spacing to protect them from runoff and removal of soils. The soils of the terrace fields are well managed and used to grow various crops and to plant trees.

The construction of terraces demands a large amount of labor; it is time consuming. The role of social organization and the culture of the people is an integral component in constructing and maintaining terraces. People usually construct terraces in groups, known as *debo*. The formation of a *debo* ranges from 5 to 15 people. The members are commonly neighbors and relatives of the person who owns the terraces. The owner is expected to collect stones and put them at different places of the farm field ahead of the construction. In addition, the owner should also prepare food and drinks to serve those people who participate in terrace construction. Before the group starts to construct a terrace, some ritual activities are conducted to ensure the longevity of the terrace. The group members can comment upon and discuss the design of a terrace. If there is some disparity among the group members, the owner is the one who makes all final decisions.

Functions of Indigenous Soil Conservation

Farmers have been using diversified measures for soil and water conservation in several combinations. Terraces stand out as the most important measure, coupled with manuring, crop rotation, fallowing, and tree plantation in farm fields. The area, with its characteristic mountainous steep slopes and showery tropical storm precipitation, is prone to erosion by water, resulting in intensive hillslope, rill, and gully erosion. Among the surveyed respondents about 63 % acknowledged the problem of soil erosion on the cultivated land. The most frequently cited indicators of soil erosion by surveyed farmers include coarse soil texture (87 %), plowing problems (67 %), rills (55 %), soil color changes (52 %), shallow soil depth (51 %), exposure of the subsoil (47 %), and removal of the top soil (43 %). The land, which is not seriously affected by erosion, was described as having a thick soil depth, a fine texture, and a brown-reddish color; and as being easy to plow. A large number of interviewed farmers (78 %) stated that the problem of soil erosion was very low. This is mainly attributed to the indigenous terraces. All interviewed farmers unanimously pointed out that the main role of terraces is to prevent soil erosion and in effect they stated that they were able to grow various crops on their farmlands.

Farmers of the Chenchā–Dorze Belle area do not only construct terraces and plant trees on their fields; they also widely practice soil fertility improvement techniques. Among others, the most common practices to increase soil fertility include manuring (used by 75 % of the surveyed respondents), crop rotation (used by 64 % of the surveyed respondents), and cultivation of grass and trees along strips (used by 55 % of the surveyed respondents). These practices play vital roles in boosting macronutrients such as nitrogen, phosphorous, and potassium into the soils of the area.

Potentials of Indigenous Terraces and Conditions for Long-Term Sustainable Use

The government of Ethiopia through the agricultural bureau of the *Woreda* has been undertaking various types of soil water conservation measures, SWC, in the area since the early 1970s. SWC measures include terraces (conventional terraces), *fanya juu* (digging a ditch and moving the excavated soil upslope, as opposed to terraces), and stone or soil bunds (walls of soil or stones aligned across the slope). Bunds with maintenance eventually will develop into terraces. As a part of the countrywide program of the Ethiopian government to undertake SWC activities, newly introduced terraces were constructed in a large part of the study area, particularly at the beginning of the 1980s.

The design of introduced terraces and other SWC measures are based on a manual prepared by Hurni (1986).

The governmental local bureau of agriculture, which is responsible for executing the program for soil and water management practices, has compelled the farmers to build the newly introduced terraces. Teams of 50–100 farmers undertook the constructions (including the collective efforts of women, men, and children who were capable to work). Farmers had to participate in the construction of terraces at least once a week and were expected to construct about 1000 m of terraced walls within 30 days. Construction was usually carried out before the plowing period, during the agricultural slack season. In return for their efforts, they received food aid or money.

Farmers have expressed their view that indigenous terraces have multifold advantages, which contributed to the sustainable long-term use of these structures. Two of the advantages of the indigenous terraces are the farmers' familiarity with their design, and the simplicity of their implementation and maintenance. The design of indigenous terraces is based on the individual farmer's perception of runoff, soil erosion, farm plot size, slope gradient, and availability of materials. As a result, the forms of terraces (rise, alignments, consecutive distances between terraces, material for construction, etc.) vary from one household to another. These enable the farmers to decide on the various features of the terraces and also their means of execution. They modify or alter the terraces to cope with various environmental and socio-economic dynamics. This grass-roots level of problem identification, planning, and execution has a massive psychological significance that enhances self-reliance and feelings of empowerment as the farmers do not only possess the terraces, but are also capable of designing and constructing them. This is one of the factors leading to the long-term popularity of this technology.

The design of introduced terraces, which is based on Hurni (1986), is customized and prepared as an official manual with specifications to be applied across the entire country. The development agents, workers of the *woreda* agricultural bureaus, are in charge of implementing the construction plans for introduced terraces. Farmers are to participate in the construction of terraces at least once a week and in return they receive food aid or money. Besides construction, terraces can also be developed from bunds (walls of soil or stones aligned across the slope) with maintenance.

Farmers are not familiar with the design of the introduced terraces and they reported this to be one of the disadvantages. In order to construct the introduced terraces, the guidance of the extension workers is vital. In some cases, the design was wrongly implemented, causing gullies to form, as was the case in *Zollo*, Chenchā. Moreover, the structure of the introduced terraces does not consider the size or existing problems of each individual farmer's land. Instead, they have a rigid design that should be

applied according to the universal features of the terrace. It does not also take into account farmers' traditional knowledge of land management practices. As a result, the introduced terraces inconvenience farmers. In comparison, the success story of the US terrace construction in the 1930s resulted from planning approaches, which were based on farmers' field conditions and individual know-how (Showers 2006). Lack of flexibility is one of the constraints of conventional soil and water conservation measures, as documented by various studies in Ethiopia (Asrat et al. 1996; Krüger et al. 1996).

Farmers also perceived that indigenous terraces are strong and last for a long time compared to the introduced terraces. This is mainly attributed to the materials and construction techniques; bedrock and larger stones were used as a base or foundation for the indigenous terraces. Smaller stones were used to strengthen embankments. In comparison, the foundation for introduced terraces is commonly placed directly on the soil and they often use soils to construct and to cement the walls of terraces. The period of maintenance also varies between the two types of terraces; the indigenous terraces last for eight to 10 years and the introduced terraces for 4 years, according to the farmers. The low interest of the farmers in maintaining the terraces aggravates the problem of the stability of the introduced terraces. In some cases, farmers frequently demolish introduced terraces. A development agent told us that terraces were demolished seven times in a place known as *Mafena Zolo* since the first introduced terraces were constructed in the 1970s. The lack of maintenance and also demolition are symptoms of non-acceptance of the measures and show the farmers' resistance to this government policy, as reported by various studies (Reji et al. 1996; Showers 2006).

Farmers also witnessed the role of the indigenous terraces in significantly reducing soil erosion and runoff compared to the introduced terraces. Along with indigenous terraces, manuring, crop rotation, and tree planting on farmland are common practices, which also have positive effects in reducing erosion by enhancing the surface cover and soil structure. However, the introduced terraces lack other associated measures such as crop cover and tree plantation, even though they struggle to halt erosion by themselves, as stated by various studies (Sandor 2006; Showers 2006). Similarly, Krüger et al. (1996), based on plot experiments at different agro-climate regions of Ethiopia, have also reported that the impact of introduced terraces in reducing erosion was not satisfactory.

According to farmers' views, the water channels that were built at the sides of the indigenous terraces have been effective in collecting and removing runoff from cultivated land. In comparison, the unprotected water channels of the introduced terraces are in some cases constructed from upslope to lower slope segments following the direction of

the slope; in these cases concentrated runoff is not led to infiltration areas nearby, or into other channels after short distances. This results in an enormous increase of runoff downslope and in intensive gully erosion, as is the case in the *Zollo* area.

Farmers also pointed out that yields on the indigenous terraced land are better compared to the introduced terraced cultivated land. One of the suggested causes for this is that indigenous terraces have existed for a long time, and are thus stable and effective in halting soil erosion. Measures, which enhance soil fertility, such as manuring, crop rotation, and farm-level tree plantation, are mainly applied to indigenous terraces. This results in boosting the soil quality of indigenous terraces, promoting agricultural production. Moreover, indigenous terraces are significant in the effective use of the existing land, as no space is excluded from agricultural production. In addition, unlike the introduced terraces, rodents or other pests are not harbored in indigenous terrace walls. The economic benefits of the indigenous terraces, along with other traditional techniques of soil fertility management, are also the main rationale for the continued use of the technology. On the other hand, the main focus of the introduced terraces is to restore degraded land in which soil fertility is very low. However, the problem is exacerbated by the lack of integration of soil fertility management practices at introduced terraces. Thus, in order to rehabilitate this land and to obtain sufficient agricultural production, a much longer period of time is needed. Despite these problems, introduced terrace construction has continued to date instead of evaluating their performance and identifying the reasons for the failures. There is hardly any attempt by planners to evaluate the performance of introduced terraces. Mistakes in the adoption of terraces were also reported for different places in Ethiopia (e.g., Admassie 2000; Bewket 2007).

To sum up the discussion on the farmers' view on the potentials of terraces, it should be maintained that farmers have a positive attitude toward the indigenous terraces compared to the introduced ones. This is due to the multifold advantages of the indigenous terraces, such as their positive impacts on soil erosion, runoff reduction, and soil fertility, and the consequent effects for an optimization of sustainable agricultural land utilization. Hence, farmers adopted the terracing technology from their parents, which has been continuously used for generations. In contrast, the negative views of farmers toward the introduced terraces, which have been constructed during the last four decades, are not the result of farmers' assumed ignorance but rather of the disadvantages of this type of terrace. As a result, the introduced terraces are in most cases either demolished or poorly maintained.

The unique social organization of the area has played a significant role in the success of the indigenous terraces. The

link between the people and the land is enormous; they put much effort into taking best care of their land. There is a social norm, which dictates that a person who does not maintain or construct terraces on his farmland is considered a lazy farmer. In addition, the community may also fine or cast out the person from social interaction. This circumstance also implies the community's appreciation of agricultural work and the value placed on the land. Social organization has also played a significant role, for example, in the long-term sustainable use of the terraces in Konso (Besha 2003; Watson 2009). Generally, farmers' positive views on the potentials of the indigenous terraces are reflected not only by social acceptability, but also by their environmental efficiency and economic feasibility, which are basic prerequisites for the sustainability of the practices.

Limitations of Indigenous Terraces

Despite their environmental compatibility and socio-economic benefits, the indigenous terraces of Chenchā–Dorze Belle are not without limitations. Stone is the main material used to construct and maintain the terraces of Chenchā–Dorze Belle. However, the availability of stones is one of the factors that limit the expansion of terraces to other places.

In Dorze Belle, labor shortages for the construction and maintenance of terraces are also a recent challenge. This is attributed to the migration of young people to towns for economic reasons. The recent modern transformation and assimilation of cultures and religions as well as urbanization processes have also exacerbated the problem of land management. For example, some people who went to urban areas, where they worked in off-farm jobs, returned to their rural environment with little interest in the construction and maintenance of terraces. The older people rightly stated that their parents were better at constructing and maintaining the terraces than themselves, with the current younger generation being yet weaker in this regard.

The narrow spaces between consecutive terraces are another limitation. As a result, a farmer's main means of land cultivation is limited to the two-pronged hoe. Hoe cultivation is time and energy consuming compared to other means of cultivation.

Last but not the least, the recent pronounced dynamics of land management and land use systems in the area appear to be the main limitations affecting terraces. Among others, the reduction and abandonment of fallowing and manure application, and the decline of crop rotation practices are the main limitations. Nevertheless, the lack of off-farm employment keeps the people heavily dependent on the cultivation of their land and this is a major reason for the enormous pressure on cultivated land. The demographic pressure and changes in land management

practices affect the agricultural practices, causing a decline in agricultural productivity. These, in turn, have adverse impacts on the indigenous terraces. Therefore, the present situation calls for an urgent assessment of the underlying causes of agricultural landscape dynamics and accordingly the development of knowledge-based policies, which take indigenous techniques and behavior into consideration.

CONCLUSION

Radiocarbon dating of a terrace from Chenchā–Dorze Belle has provided evidence that the stonewalled terraces have been part and parcel of long-lived agricultural activities in the region. Although this research investigation is not exhaustive, it is still the only survey in determining the ages of agriculture terraces in Ethiopia, which in most cases were reported based only on oral history and travel accounts, lacking the support of empirical investigations.

Indigenous terraces have significant impacts on the creation of a stable topography, marked by a well-managed soil, which allows the infiltration of nearly all precipitation and is rarely affected by few mass movements. Through the use of such terraces, cultural landscapes were created many centuries ago for the cultivation of crops in the area, leading to an enormous increase of land availability for cultivation. In addition, the existing landscape was maintained for sustainable production. Had this not been the case in the area, agricultural activities would have been abandoned (collapse of agriculture) due to the erosion sensitivity of the steep slopes.

The significance and importance of indigenous terraces thus lies beyond their contribution to land productivity and economic significance. We dubbed the terrace a success story, in which people invested their skills, labor, energy, and knowledge in constructing the terraces in order to manage the environment over generations. It also shows the traditions of the people, which have placed high value on the land and have respected land management practices. The specific indigenous terrace systems are a major part of the cultural landscape, which is unique not only for the region and Ethiopia but also on a global scale. Thus, there is a strong need to preserve and develop this important cultural heritage as an example of sustainable land use and living.

Acknowledgments We are very grateful to all farmers and the enumerators who took part in the research. We are also gratefully indebted to the staff of the Leibniz Laboratory, especially Dr. Marie-Josée Nadeau for the radiocarbon dating. We would also like to thank the German Research Foundation (DFG) and the Graduate School "Human Development in Landscapes" for their financial support of the study. Thanks are also due to Eileen Kuecuekarakara and Nicole Taylor for language editing of the manuscript. The insightful

comments made by two anonymous reviewers are also gratefully acknowledged.

REFERENCES

- Admassie, Y. 2000. *Twenty years to nowhere. Property rights, land management, and conservation in Ethiopia*. Asmara: Red Sea Press.
- Alemneh, D. 2003. Integrated natural resource management to enhance food security. The case for community-based approach in Ethiopia. Working Paper No. 16. FAO, Rome.
- Amorn, H. 1989. Agricultural intensification in the Burji-Konso cluster of South-Western Ethiopia. *Azania* 34: 71–83.
- Arthur, W.K., W.J. Arthur, C.M. Curtis, B. Lakew, J. Lesur-Gebremariam, and Y. Ethiopia. 2010. Fire on the mountain: Dignity and prestige in the history and archaeology of the Borada Highlands in Southern Ethiopia. *The Society for American Archaeology* 10: 17–21.
- Asrat, K., K. Idris, and M. Semegn. 1996. The ‘flexibility’ of indigenous soil and water conservation techniques: A case study of the Hararghe Highlands, Ethiopia. In *Sustaining the Soil: Indigenous Soil and Water Conservation in Africa*, ed. C. Reij, I. Scoones, and C. Toulmin, 156–162. London: Earthscan.
- Assefa, E. 2012. Landscape Dynamics and Sustainable Land Management in Southern Ethiopia. PhD Dissertation. Kiel, Germany: Kiel University, Graduate School, Human Development in Landscape and Institute of Ecosystem Research and Geoarchaeology.
- Besha, T. 2003. Understanding farmers: Explaining soil and water conservation in Konso, Wolaita and Wello, Ethiopia. Tropical Resource management papers, No. 41. Wageningen, Netherlands: Wageningen University.
- Bewket, W. 2007. Soil and water conservation intervention with conventional technologies in northwestern highlands of Ethiopia: Acceptance and adoption by farmers. *Land Use Policy* 24: 404–416.
- Bork, H.-R. 2006. *Landschaften der Erde unter den Einfluss des Menschen*. Gotha: Klett-Perthes.
- CSA (Central Statistical Agency of Ethiopia). 2006. *Ethiopia Statistical Abstract*. Addis Ababa: Central Statistical Agency of Ethiopia.
- Dessie, G., and C. Carl. 2008. Forest Decline and Its Causes in the South-Central Rift Valley of Ethiopia: Human Impact Over a One Hundred Year Perspective. *AMBIO* 37: 263–271.
- FAO (Food and Agriculture Organization of the United Nations). 1986. Ethiopian highlands reclamation study, Ethiopia. Final Report, Rome.
- FAO (Food and Agriculture Organization of the United Nations). 1990. *The Conservation and Rehabilitation of African Lands*. Rome: An International Scheme.
- Grove, A.T., and J.E.G. Sutton. 1989. Agricultural terracing south of the Sahara. *Azania* 24: 113–122.
- Herweg, K., and E. Ludi. 1999. The performance of soil and water conservation measures case studies from Ethiopia and Eritrea. *Catena* 36: 99–114.
- Hiol, H.F., N.N. Mbeyo, and T.F. Abina. 1996. Traditional soil SWC techniques in the Mandara mountains, northern Cameroun. In *Sustaining the Soil: Indigenous Soil and Water Conservation in Africa*, ed. C. Reij, I. Scoones, and C. Toulmin, 191–201. London: Earthscan.
- Hurni, H. 1986. Soil and Water Conservation in Ethiopia: Guidelines for Development Agents. Addis Abeba, Ethiopia and Bern, Switzerland: Menschen für Menschen and Centre for Development and Environment (CDE).
- Hurni, H. 1993. Land degradation, famine, and land resource scenarios in Ethiopia. In *World Soil Erosion and Conservation*, ed. D. Pimentel, 27–61. Cambridge: Cambridge University Press.
- Igbokwe, I. 1996. A SWC system under threat: A visit to Maku, Nigeria. In *Sustaining the Soil: Indigenous Soil and Water Conservation in Africa*. Toulmin, ed. I. Scoones, and C. Reij, 121–143. London: Earthscan.
- Jackson, R.T. 1972. Land Use and Settlement in Gamu Gofa, Ethiopia. Department of Geography Makerere, University Kampala. Occasional Paper No. 17, Kampala, Uganda.
- Jackson, R.T., T.R. Rulvaney, and J. Forster. 1969. *Report of the Oxford University expedition to the Gamu Highlands of Southern Ethiopia*. Oxford: Oxford University Press.
- Krüger, H.J., B. Fantaw, Y. Gebre-Michael, and K. Kajala. 1996. Creating inventory of indigenous SWC measures in Ethiopia. In *Sustaining the Soil: Indigenous Soil and Water Conservation in Africa*, ed. C. Toulmin, I. Reij, and I. Scoones, 170–180. London: Earthscan.
- Million, A. 1996. Traditional ditches in Northern Shewa, the Ethiopian Highlands. In *Sustaining the Soil: Indigenous Soil and Water Conservation in Africa*, ed. C. Reij, I. Scoones, and C. Toulmin, 163–169. London: Earthscan.
- Mitiku, H., K. Herweg, and B. Stillhardt. 2006. Sustainable land management—A new approach to soil and water conservation in Ethiopia. Land resources management and environmental protection Department, Mekelle University, Ethiopia; CDE, University of Bern, NCCR North-south, Switzerland.
- Nadeau, M.J., P.M. Grootes, M. Schleicher, and P. Hasselberg. 1998. Sample throughput and data quality at the Leibniz-labor AMS facility. *Radiocarbon* 40: 239–245.
- NCS (National Conservation Strategy). 1990. Prepared for the Government of the People of the Republic of Ethiopia. With the assistance of IUCN. Phase 1 Report. Addis Ababa, Ethiopia.
- Nyssen, J., H. Mitiku, J. Moeyersons, J. Poesen, and J. Deckers. 2000. The daget: A traditional soil and water conservation technique in Tigray (northern Ethiopia) and its integration with introduced techniques. *Land Degradation and Development* 11: 199–208.
- Osman, M., and P. Sauerborn. 2001. Soil and water conservation in Ethiopia. Experiences and lessons. *Journal of Soil and Sediments* 2: 117–123.
- Reij, C., I. Scoones, and C. Toulmin. 1996. Sustaining the soil. Indigenous soil and water conservation in Africa. In *Sustaining the Soil: Indigenous Soil and Water Conservation in Africa*, ed. C. Toulmin, C. Reij, and I. Scoones, 1–27. London: Earthscan.
- Sandor, J.A. 2006. Ancient agricultural terraces and soils. In *Footprints in the Soil. People and Ideas in Soil History*, ed. P.B. Warkentin, 505–553. Amsterdam: Elsevier.
- Showers, K.B. 2006. Soil erosion and conservation: An international history and a Cautionary Tale. In *Footprints in the Soil. People and Ideas in Soil History*, ed. P.B. Warkentin, 369–406. Amsterdam: Elsevier.
- Stuiver, M., and H.A. Polach. 1977. Reporting of ^{14}C data. *Radiocarbon* 19: 355–363.
- Stump, D. 2010. Ancient and backward or long-lived and sustainable: The role of the past in debates concerning rural livelihoods and resource conservation in E. Africa. *World Development* 38: 1251–1262.
- UNESCO (United Nation Educational, Scientific and Cultural Organization). 2011. Convention Concerning the Protection of the World Cultural and Natural Heritage. World Heritage Committee 35th Session. Paris. Retrieved 25 March, 2012, from <http://whc.unesco.org/en/decisions/3991>.
- Watson, E. 2009. *Living Terraces in Ethiopia. Konso landscape, culture and development*. Oxford, UK: James Curry.
- Westphal, E. 1975. Agricultural systems in Ethiopia. Agricultural Research Report No. 826. Wageningen: Centre for Agriculture Publications.

AUTHOR BIOGRAPHIES

Assefa Engdawork (✉) is a Assistant Professor at Center for Environment and Development, College of Development Studies, Addis Ababa University. His research interests include Indigenous soil and water conservation, Political ecology, Soil survey, characterizations and soil erosion, and Climate changes, adaptations and mitigations, Environmental impact assessment, Watershed managements, Landscape dynamics, Sustainable environmental management. *Address:* Center for Environment and Development, College of Development Studies, Addis Ababa University, P.O. Box 80191, Addis Ababa, Ethiopia.
Address: Institute for Ecosystem Research, Kiel University, Olshausenstrasse 75, 24118 Kiel, Germany.

Address: Graduate School 'Human Development in Landscapes', Kiel University, Kiel, Germany.
e-mail: eassefat5@gmail.com; engduasef@yahoo.com

Hans-Rudolf Bork is with the Institute for Ecosystem Research. His research interests include integrated ecosystem and landscape research, geoarchaeology, soil science, hydrology and geomorphology, and analysis of the consequences of the use of technology in the landscape. *Address:* Institute for Ecosystem Research, Kiel University, Olshausenstrasse 75, 24118 Kiel, Germany.
Address: Graduate School 'Human Development in Landscapes', Kiel University, Kiel, Germany.
e-mail: hrbork@ecology.uni-kiel.de