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Research article

When is a terrace not a terrace? The importance of understanding landscape evolution in studies of terraced agriculture

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ABSTRACT

Before the invention of modern, large-scale engineering projects, terrace systems were rarely built in single phases of construction, but instead developed gradually, and could even be said to have evolved. Understanding this process of landscape change is therefore important in order to fully appreciate how terrace systems were built and functioned, and is also pivotal to understanding how the communities that farmed these systems responded to changes; whether these are changes to the landscape brought about by the farming practices themselves, or changes to social, economic or climatic conditions. Combining archaeological stratigraphy, soil micromorphology and geochemistry, this paper presents a case-study from the historic and extensive terraced landscape at Konso, southwest Ethiopia, and demonstrates – in one important river valley at least – that the original topsoil and much of the subsoil was lost prior to the construction of hillside terraces. Moreover, the study shows that alluvial sediment traps that were built adjacent to rivers relied on widespread hillside soil erosion for their construction, and strongly suggests that these irrigated riverside fields were formerly a higher economic priority than the hillside terraces themselves; a possibility that was not recognised by numerous observational studies of farming in this landscape. Research that takes into account how terrace systems change through time can thus provide important details of whether the function of the system has changed, and can help assess how the legacies of former practices impact current or future cultivation.

1. Introduction

In common parlance the term 'agricultural terrace' is well understood, and it is well understood too that terraces can produce a range of benefits including limiting surface water run-off and reveting soils, thereby reducing soil erosion; increasing topsoil depth and water infiltration and retention, thereby increasing yields; improving drainage or redirecting excess water flows, thereby mitigating erosion, conserving water and protecting dry-adapted plants; as well as increasing soil temperatures, thereby promoting seed germinating. However, it should be clear even from this very short summary that no single terrace can perform all of these functions: a terrace could not be designed to both improve water retention and improve drainage, for example. This is not simply a question of engineering semantics (i.e. that the catch-all term 'agricultural terrace' encompasses a range of structures that are built in different ways to solve different problems) because a particular type of terrace such as the common cut and fill levelled bench terrace could be managed to perform different functions even within the same hillside: exposed to increased soil temperature in one location, while shaded and irrigated in another. Cost-benefit analyses reporting positive results for the construction of terraces in a given time and location (e.g. Bizoza and De Graaff, 2012; Tesfaye et al., 2016) must therefore be taken in context, and produce conclusions that cannot, of course, be readily transposed to a different time and place.

This point, though in some ways a statement of the obvious, is illustrated in the current paper by reference to archaeological and pedological research at the impressive terraced landscape in Konso, southwest Ethiopia; a landscape that was listed as a UNESCO World Heritage Site in 2011, includes some 40 historic walled towns surrounded by an estimated 200 km^2 of dry-stone agricultural

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terracing (Kimura, 2006), and which is thought on the basis of genealogical evidence to have included terracing and perhaps supplementary irrigation approximately 500 years ago (Amborn, 1989). Whether or not this date is a true reflection of when terracing was first employed at Konso has yet to be confirmed archaeologically, but it is clear from early 20th-century accounts (e.g. Harrison, 1901) that the area was extensively terraced at this time, and it is thus reasonable to assume that the practice of building terraces began more than a century earlier. Attempts to date the terraces directly are underway, but regardless of the exact date of inception it would be a mistake to assume that the whole of the 200 km^2 of terraces were built simultaneously, and mere conjecture to conclude that the function of the terraces has remained constant: terraces constructed to produce high value tradable crops might have later been converted to grow staples for domestic consumption, for example. A long-term perspective can provide these answers (Hayashida, 2005), employing archaeobotanical methods to examine what crops were grown and consumed (the results of which for the current case-study are forthcoming), and employing archaeological stratigraphy combined with studies of soil formation to define the function of particular terraces and the consequences of their construction. This is because archaeological excavation is designed to discern the order in which sediments are deposited and the sequence in which structures are built, meaning that excavation is able to effectively 'reverse engineer' features such as agricultural terraces. This is important because doing so helps discern which of the priorities listed above a particular terrace was designed to fulfil, and can help assess how effective a particular terrace system was at achieving these.

Unsurprisingly, the use of archaeological excavation to map how terrace systems have changed through time has typically been applied to abandoned agricultural landscapes (e.g. Soper, 1996, 2002; Stump, 2006; Widgren et al., 2016), but examining an extant system offers important opportunities for interdisciplinary studies. Indeed, this is particularly true for the current case-study, since Konso has long been a focus of anthropological research (e.g. Amborn, 1989; Amborn and Straube, 2009; Hallpike, 2008 [1st edition 1972]; Jensen, 1936, 1960; Minker, 1986; Nowack, 1954; Straube, 1967), with the agricultural system itself subsequently studied by geographers (Watson, 2009) and by agronomists and others interested in the developmental lessons that might be learnt from studies of so-called 'indigenous knowledge' (e.g. Abate, 1992; Beshah, 2003; Demeulenaere, 2002; Förch, 2003; Tadesse, 2010). This offers clear advantages, because the social, cultural and managerial aspects of the operation of the agricultural system that would be hard or impossible to see archaeologically are well understood, at least for the late 20th and early 21st centuries. By examining historic terraces directly it is possible to extend this understanding back into the deeper past, but direct examination of structures and the soils within terraces that continue to be farmed can also be used to test the conclusions drawn by these observational studies. As the results outlined below illustrate, this ability can generate insights that both complement and extend those derived from other research techniques.

Importantly, this ability to examine the function, efficacy, construction sequence and environmental consequences of terrace systems strongly suggests that previous observational studies did not fully appreciate some elements of the Konso landscape by assuming that terraces were designed to conserve the original topsoil from erosion, and by underestimating the value of a particular type of agricultural 'terrace' (more properly described as a sediment trap or check dam) that are mentioned only briefly in previous published accounts (Amborn, 1989; citing Kuls, 1958; and Straube, 1967) or which were described as only existing in the far northwest of the landscape (Beshah, 2003). The argument here, therefore, is that assessments of the efficacy, sustainability or resilience of a system of environmental management are substantially strengthened by an understanding of its history; a point of direct relevance to Konso given that a report by the United Nations Food and Agriculture Organisation described the terrace system as offering important "lessons from the past" (FAO, 1990), and given that agricultural practices in Konso have been the subject of research by the British-based NGO FARM-Africa (see Hallpike, 2008 citing FARM-Africa, 1993a and 1993b) which produced recommendations for large-scale irrigation projects in the area (Camacho, 2000; unpublished report), aspects of which were subsequently implemented. The research reported here helps place such interventions in their historical context, and serves to emphasize that there are many reasons why a community might choose to build or abandon agricultural terraces.

2. Study area. topography and overview of previous research

The densest concentration of agricultural terracing in the Konso highlands centre on approximately 5°18′30″ North/37°23′30 East, with the entirety of the terraced landscape located within the Konso Special Woreda (district), one of the eight special *woredas* in the Southern Nations, Nationalities, and Peoples Region (SNNPR) of south-western Ethiopia (Fig. 1). Ranging in height from 1400 m above sea level (m asl) to 2100 m asl, the Konso highlands extend for approximately 200 km^2, and are bounded by the river Sagan to the east and south, by the plains of Gumaide and Lake Chamo to the north, and the Gidole mountains and Woito river to the west. The climate is dry montane type, with rainfall ranging from between 300 mm and 900 mm per year (Förch, 2003). Rainfall follows a bimodal pattern: a long rainy season (the *belg*) occurring between March and May when c.70–80% of grain production is harvested, followed by shorter rains (the *kiremt*) from September to November (Watson, 2009). Rainfall can be erratic, however, with frequent intense storm events and common severe droughts (Förch, 2003; see also Messeret, 1990).

Highlands of this type are highly economically significant in Ethiopia, since nearly half of the country's total area and approximately 95% of the country's cultivated land lies above 1500 m asl (Krüger et al., 1996). This area is also the most populous, with estimates from the 1990s indicating that nearly 90% of the population lived above 1500 m asl (Krüger et al., 1996) while approximately 60% of the country's population live at altitudinal ranges similar to those in Konso: the cool, sub-humid agro-ecological zone between 1500 and 2300 m asl classified in Ethiopia as *Woina Dega* (Tadesse, 2010). With temperatures varying from 15 to 33 °C these areas are potentially highly productive agriculturally, but are also highly susceptible to soil erosion; a problem considered to be a major threat to agricultural development and food security in highland Ethiopia (FAO and ITPS, 2015; Lemenih et al., 2005; Tadesse, 2001). Vertic and argic soils are frequent in stable topographical positions, but the steep topography and the high erodibility of edaphic materials have a major effect on the distribution of fertile soils, with shallow and stoney soils frequently found on hill slopes, thereby creating challenges in maintaining soil fertility.

The construction of terraces is of course a potentially highly effective way of mitigating these risks, and this has prompted - in Ethiopia as elsewhere - an interest in local systems of agricultural terracing that might act as models for erosion mitigation and/or agricultural intensification to maintain soil fertility and achieve higher crop yields (e.g. Bruins et al., 1986; Hogg, 1988; Reij et al., 1996). Given an estimate by the Ethiopian Environmental Protection Authority (EPA) that 80% of the cultivable land in Konso is terraced (EPA, 2004) it is unsurprising that the area has been a focus