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An indigenous time-related framework for reconstructing the impact of disasters on ancient water systems in southern Ethiopia, 1560–1950

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Abstract

This article uses an indigenous time-related framework to reconstruct the impact of disasters associated with floods, epidemics, droughts and famine on the ancient *tula* well systems in southern Ethiopia. We interviewed oral historians, who used the *gada* timeline to reconstruct the impact of disasters in the *tula* region from about 1560 to 1950. The Borana *gada* timeline is based on a system of social organization and transfer of power (each *gada* lasts for eight years) between five patri-classes called *gogessa* by the community. The Borana are able to recall events corresponding to a 40-year cycle (i.e. 5 × 8) when the same *gogessa* returns to power. With the return to power by each *gogessa*, grouped into seven naming clusters called *maqabas*, each *gogessa* experiences event-repetition or *dhaaccii*, which served as a repository of social memory. The time chronology in *gada* context and its social structure (*gogessa*), cyclical names (*maqabas*), and event-repetition (*dhaaccii*) are all connected in a complex historical narrative to reconstruct environmental events. To corroborate the oral history of the impact of disasters on *tula* wells, we used regional climatic information as proxy data. The findings showed that the *gada* timeline and its *maqabas* and event-repetition of *dhaaccii* correlated with the collapse of the wells, and with pastoral economy and human demographics. The *gada* timeline and its historical memory closely reflected climatic proxy data in terms of regional level disaster events.

Keywords: Climatic history; Disasters; *Gada* timeline; Ethiopia; *Tula* wells; Social memory

The impact of disasters on key ecosystems and on human populations can be reconstructed by relating these historical processes to the social and economic responses they elicit.[1] However, there is little research that aims to develop a framework to reconstruct the impact of disasters on ancient water systems, although people across the globe have relied on these systems since time immemorial. Historical geographers are familiar with ancient water systems such as the Mayan (in Amazonia) and the Nabataean (in the Middle East). Other water systems such as *Qanat* (Arabia), *Khettara* (North Africa), *Karez* (Central Asia), and *Engaruka* and *Sonjo* in East Africa, that facilitated the settlement and exploitation of arid lands during the first millennium BC, are of continuing interest to researchers because they have left behind cultural and environmental 'footprints'.[2] It is, however, rare for scholars to utilize oral sources to reconstruct past environmental disturbances affecting ancient water systems.

In this article, we develop an indigenous time-related framework for reconstructing the impact of disasters (floods, epidemics, droughts, and famines) on the ancient *tula* well clusters in southern Ethiopia. The *tula* well systems have provided water for people and cattle in the region for more than 500 years. The ancient wells are products of the indigenous water-engineering technology used to exploit water aquifers. They carry the cultural and physical imprint of past disasters, which are also etched in the memories of regional inhabitants. The interactions between humans and nature in the

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[1] J.D. Hughes, Three dimensions of environmental history, *Environment and History* 14 (2008) 319–330; S. Mosley, Common ground: integrating social and environmental history, *Journal of Social History* 39 (2006) 915–933.

[2] J.W. Eadie and J.P. Oleson, The water supply system of Nabataean and Roman Humayma, *Bulletin of the American Schools of Oriental Research* 262 (1986) 49–76; D. Lightfoot, The origin and diffusion of *qanats* in Arabia: new evidence from the northern and southern peninsula, *The Geographical Journal* 166 (2000) 215–226; P.W. English, The origin and spread of *qanats* in the Old World, *Proceedings of the American Philosophical Society* 112 (1968) 170–181; M. Kummu, Water management in Angkor: human impacts on hydrology and sediments transportation, *Journal of Environmental Management* 90 (2009) 1413–1421; T. Terkenli, Towards a theory of the landscape: the Aegean landscape as a cultural image, *Landscape and Urban Planning* 57 (2001) 197–208; T. Potkanski and W.M. Adams, Water scarcity, property regimes and irrigation management in Sonjo, Tanzania, *The Journal of Development Studies* 34 (1998) 86–116. L. Westerberg, K. Holmgren, L. Börjeson, N.T. Håkanson, V. Laulumaa, M. Ryner and H. Öberg, The development of ancient irrigation systems at Engaruka, northern Tanzania: physical and societal factors, *The Geographical Journal* 176 (2010).

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context of the *tula* well system therefore provide the basic framework for analyzing 'recurring themes', such as the risks of environmental disasters, human and livestock demographic collapses, and the use and disuse of wells (their use or disuse is related to the occurrence of floods, epidemics, droughts and famines).[3]

Our interest in developing a methodological framework for reconstructing the impact of disasters on environment and society grew from our desire to determine whether people living in the present-day *tula* wells area of southern Ethiopia still retained memories of past disasters and if so, how these were remembered. This requires an interdisciplinary methodological framework that utilizes historical narratives of responses to environmental risks in order to understand the nature of these responses over several centuries. The risks of disasters may be local but they must be analyzed within regional contexts; they can then be corroborated using regional environmental proxy data.[4] Our three main objectives were: a) to use the Borana indigenous time reckoning system to develop a methodological framework for reconstructing the calendar of historical events; b) to relate the historical event calendar to the impact of floods, epidemics, droughts and famine on *tula* well systems and the pastoral economy; and c) to understand how the reconstructed social memory relates to regional climatic proxy data.

Framework for reconstructing a historical timeline

The use of oral history for developing timelines of historical events is well established in African societies.[5] Oral histories serve as memory banks for the economic, social and political institutions that shape human–environmental interactions and the worldviews of particular communities.[6] Miller, a student of oral tradition and African history, suggests that oral narratives make up a 'chain of transmission' forged in social events such as night-time stories, ritual performances, initiation ceremonies, and social gatherings, as well as in daily interactions.[7] Certain historical events, such as famine and epidemics, become reference points in time.[8] Events that have a severe impact on human demography and the wider economy are remembered more clearly than events which were less severe. Major historical events that are socially, economically, politically and environmentally significant are recorded in the memory of oral historians, and summarized and compressed into forms that enable narrators to memorize them easily.[9]

According to Australian scholar Heather Goodall, oral history not only constitutes information and knowledge that allows researchers to understand the past, it also reveals the ways in which society in general, and narrators in particular, represent the past.[10] Writing of Kenya, Jeffery Fadiman emphasizes the importance of oral historians (or more properly the keepers of oral traditions, such as old people) as sources of knowledge, even likening them to 'public libraries'.[11] Despite the crucial role oral tradition plays in reconstructing the past, scholars need to examine how oral historians construct narratives and present evidence; they must be mindful of the procedures used to represent historical events, in order to minimize deliberate fabrications or biases.[12]

In non-literate societies in Africa, the chronologies of historical events are remembered with reference to socio-political structures such as lists of kings or chiefs.[13] In addition, oral information can be corroborated by proxy data such as changes in lake levels and river floods. For example, records from the oldest existing environmental proxy data system, the Nilometer (which records water levels in the Nile River), are widely used to reconstruct an overall environmental history in the Nile basin region.[14]

Background to the *tula* well systems and study context

In this article, we have utilized the time-recall system of the Borana Oromo people who live in southern Ethiopia and northern Kenya. We refer to this time-recall system, hereafter the '*gada* timeline' and we corroborate it using proxy data to reconstruct the impact of environmentally induced disasters. The Borana Oromo are part of Oromo linguistic group, the largest in Ethiopia. The Borana are considered to be the ancestors of the larger Oromo society and are accorded an important role in preserving Oromo culture. The Borana zone in southern Ethiopia comprises 13 *woredas* (districts). According to the Ethiopian central statistical agency (CSA), the zonal population in 2011 was 962,489.[15] The Borana have long occupied the cradleland of the Oromo people in the present-day southern Ethiopia where they developed the *gada* system; to the present-day they are characterized by their democratic and socially harmonious qualities.[16]

Boranaland in southern Ethiopia is arid and semi-arid with little surface water for the cattle-based pastoral economy. The region is characterized by erratic and unpredictable rainfall and recurring droughts. The rainfall cycle is bimodal, with a higher rainfall season between March and May (60–70%), and a lower one between October and November (30–40%).[17] The mean annual rainfall ranges from 400 mm to 700 mm. The Borana are well known for their skills in water-engineering technology.[18] The Borana depend on three types of water sources: *haro* (ponds), *adadi* (shallow wells), and *tula* (deep wells). The ponds are used for a short period immediately after the rainy season. *Adadi* wells are used during dry seasons but they generally run dry before the

[3] W. Tiki and G. Oba, *Ciinna* – the Borana Oromo narration of the 1890s Great Rinderpest epizootic in North Eastern Africa, *Journal of Eastern African Studies* 3 (2009) 479–508.
[4] S.E. Nicholson, A semi-quantitative, regional precipitation data set for studying African climate of the nineteenth century, part 1. Overview of the data set, *Climate Change* 50 (2001) 317–353.
[5] J. Vansina, *Oral Tradition as History*, Oxford, 1985; T. Spear, *Kenya's Past: An Introduction to Historical Methods in East Africa*, London, 1981; J.A. Fadiman, *When We Began, There Were Witchmen: An Oral History from Mount Kenya*, Los Angeles, 1993; J.C. Miller, Introduction: listening for the African past, in: J.C. Miller (Ed.), *The African Past Speaks: Essays on Oral Tradition and History*, Folkestone, 1980, 1–60; T. Giles-Vernick, Leaving a person behind: history, personhood, and struggles over forest resources in the Sangha Basin of Equatorial Africa, *The International Journal of African Historical Studies* 32 (1999) 311–338.
[6] J. Vansina, *Paths in the Rainforest: Towards a History of Political Traditions in Equatorial Africa*, London, 1990.
[7] See Miller, Introduction (note 5).
[8] A. Pankhurst, *Social Consequences of Drought and Famine: An Anthropological Approach to Selected African Case Studies*, MA thesis, Manchester University, 1985.
[9] Oral historians refer in this document to 'informants' or the 'narrators of the story'. See Giles-Vernick, Leaving a person behind (note 5).
[10] H. Goodall, Riding the tide: indigenous knowledge, history and water in a changing Australia, *Environment and History* 14 (2008) 355–384.
[11] See Fadiman, *When We Began, There Were Witchmen* (note 5).
[12] See Miller, Introduction (note 5).
[13] D.P. Henige, *The Chronology of Oral Tradition: Quest for Chimera*, Oxford, 1974.
[14] T. Tvedt, *The River Nile in the Age of the British: Political Ecology and the Quest for Economic Power*, London, 2004.
[15] CSA, *Ethiopia's Rural Facilities and Services Atlas*, Addis Ababa, 2011.
[16] A. Legesse, *Oromo Democracy: An Indigenous African Political System*, Trenton, NJ, 2006.
[17] G. Oba and D.G. Kotile, Assessments of landscape level degradation in southern Ethiopia: pastoralists versus ecologists, *Land Degradation & Development* 12 (2001) 461–475.
[18] A. Legesse, *Gada: Three Approaches to the Study of African Society*, New York, 1973.

rains return.[19] *Tula* wells provide more than 80% of the water supply during the dry season. They are the last resort during severe droughts and are therefore crucial to *Borana* pastoral production.

Tula well complexes, commonly known as *tula salan*, are found only in Borana, southern Ethiopia. Large numbers of similar wells are found in northern-eastern Kenya and Trans-Jubaland in southern Somalia. This research was conducted on six of the nine *tula salan* well clusters (i.e. Web, Erdar, Melbana, Dhas, Gayo, and Dubluq) in southern Ethiopia (see Fig. 1). Each well cluster consists of several operating wells (the number varies from 4 to 30) and this accounts for about 25% of the wells in the area (of which 70% are disused and 5% are under re-excavation).[20] The *tula salan* and their associated grazing lands cover 25,000 km^2.[21] The spatial distribution of *tula* wells within a cluster is not random, but is based on indigenous hydrological knowledge that takes into account potential underground sources, herd movements, sanitary conditions and disposal of livestock dung, as well as the diversion of flood waters (Fig. 2A).

Historically, the Borana have solved water problems by cutting wells into limestone – a unique technology that mystified nineteenth-century European visitors to the region.[22] Donaldson Smith, an American medical doctor and collector of botanical and zoological museum specimens who passed through the area in the 1890s, referred to the wells as 'extraordinary',[23] while Buxton, a British traveller, stated that 'these wells are among the most remarkable things … to have been dug in a distant past'. He continued:

> We found a great cutting, apparently artificial, leading down into the ground … At the foot of the cliff where this little ravine ended was the head of the well itself – a narrow opening in the rock. The rest of the shaft could not be seen, for these wells take many twists and turns in the ground before reaching water-level.[24]

Maud was of the opinion that the excavators were 'civilized and energetic'.[25] Gilles Stockton recently described the wells as follows:

> These are amazing wells dug over the centuries…After a certain depth, it is impractical to raise water by hand all the way to the surface, so the people dug trails into the earth to a staging area where the water troughs can be filled by a chain of…men perched on ledges of the wells. The staging area is 15 to 25 m below the surface of the earth; the water itself is another 10 to 15 m further down the well.[26]

Cattle walk below ground to reach the wellhead from where water is lifted into basins and troughs by a human chain (Fig. 2B). The *tula* wells are not only hydrological systems in a water-scarce landscape but also significant places of human habitation, and they acquire a symbolic importance in ritual performance.[27] The wells are invoked in political debates, ritual and cultural practices and religious blessings. They are the focus of social and political organization.[28] The wells are connected to human and livestock fertility, the continuity of lineages, and with the peace of Borana (*nagaa* Borana). This results in the creation of a strong environmental and pastoral ideology. Therefore, as far as the Borana perception of the environment is concerned, the functionality of the *tula* wells and the sustainability of the pastoral economy are inextricably linked. This knowledge, often recalled in the context of disasters that disrupted the functioning of *tula* wells, has enabled the Borana oral historians to remember and narrate the history of *tula* well systems.

During the periods under consideration (1560–1950s), *tula* wells fluctuated between collapse, disuse and re-excavation in response to climatic drivers such as exceptionally wet periods. Repairs were sometimes delayed because of a lack of labour or economic capacity. Sudden depletions in human population induced by epidemic, drought or famine disrupted the pastoral economy, and could leave the wells dysfunctional. Some of these wells, neglected, collapsed and unused for decades or even centuries, became known as *goof* (see Fig. 3A).[29]

An indigenous time-related framework

The gada *timeline*

The Borana *gada* timeline is based on the systems of social organization and transfer of power between the five patri-classes called *gogessa* (also called *luba*), into which the society is divided. Power is transferred from one *gogessa* to another in regular sequence after fixed terms of eight years (see Tables 1 and 2), so that each *gogessa* returns to power every 40 years.[30] In case of disruptions caused by natural disasters, or the death of the incumbent leader, the replacement leadership serves only for the time remaining for that specific *gada*. This meant that the incoming leader (*abba gada*, or father of *gada*) handed over the office to the next *luba* class without any deviation from the original timetable.[31] This regular power transfer makes the *gada*

[19] J. Helland, *Pastoralists and Development of Pastoralism*, Bergen, 1980.
[20] W. Tiki, G. Oba and T. Tvedt, Human stewardship, or ruining cultural landscapes of ancient *tula* wells, southern Ethiopia, *The Geographical Journal* 177 (2011) 62–78.
[21] N. McCarthy, A.B. Kamara and M. Kirk, Cooperation in risky environment: evidence from southern Ethiopia, *Journal of African Economies* 12, 2 (2003) 236–270.
[22] A.D. Smith, *Through Unknown African Countries*, New York, 1897.
[23] Smith, *Through Unknown African Countries* (note 22).
[24] D. Buxton, *Travels in Ethiopia*, London, 1949.
[25] P. Maud, Exploration in southern rangeland of Abyssinia, *The Geographical Journal* 23 (1904) 552–579.
[26] G. Stockton, Sugar for the tear: assistance and the state of pastoralism in the Horn of Africa, *Pastoralism, Research, Policy & Practice* 2, 6 (2012) http://dx.doi.org/10.1186/2041-7136-2-6, http://www.pastoralismjounal.com/content/2/1/6.
[27] G. Dahl and G. Megerssa, The sources of life: Boran concepts of wells and water, in: G. Pálsson (Ed.), *From Water to World-making*: *African Models and Arid Lands*, Uppsala, 1990, 21–37; Legesse, *Gada* (note 18). For symbolic meanings of water, see S. Burmil, T.C. Daniel and J.D. Hetherington, Human values and perceptions of water in arid landscapes, *Landscape and Urban Planning* 44 (1999) 99–109.
[28] Helland, *Pastoralists and Development of Pastoralism* (note 19); Dahl and Megerssa, The sources of life (note 27); N.J. Cossins and M. Upton, The Borana pastoral systems of southern Ethiopia, *Agricultural Systems* 25 (1987) 199–218; Maud, Exploration in southern rangeland of Abyssinia (note 25).
[29] Tiki, Oba and Tvedt, Human stewardship, or ruining cultural landscapes of ancient *tula* wells, southern Ethiopia (note 20); Tiki and Oba, *Ciinna* (note 3).
[30] *Gada* is a socio-political institution that guides rituals, politics, and pastoral production. The office is held for eight years, with no possibility of extension. See also Legesse, *Gada* (note 18).
[31] Historically, there were a few exceptions to this rule, such as when *gada* Dida Bitata Mamo (1872–1880) lasted for nine years as opposed to eight, as a result of internal conflict among the Borana. Other more recent incidents include the delay in transfer of power from Bule Dabasa (1928–1936) to Aga Adi (1936–1944) for four years during the Italian occupation of Ethiopia. When the Italians were defeated in 1941, the power transfer went ahead, but Aga Adi held office only for the remaining years of his term. The events that occurred during the first four years were considered to fall within the 'proper' time span, which was named after him and not after Bule Dabasa who preceded him.

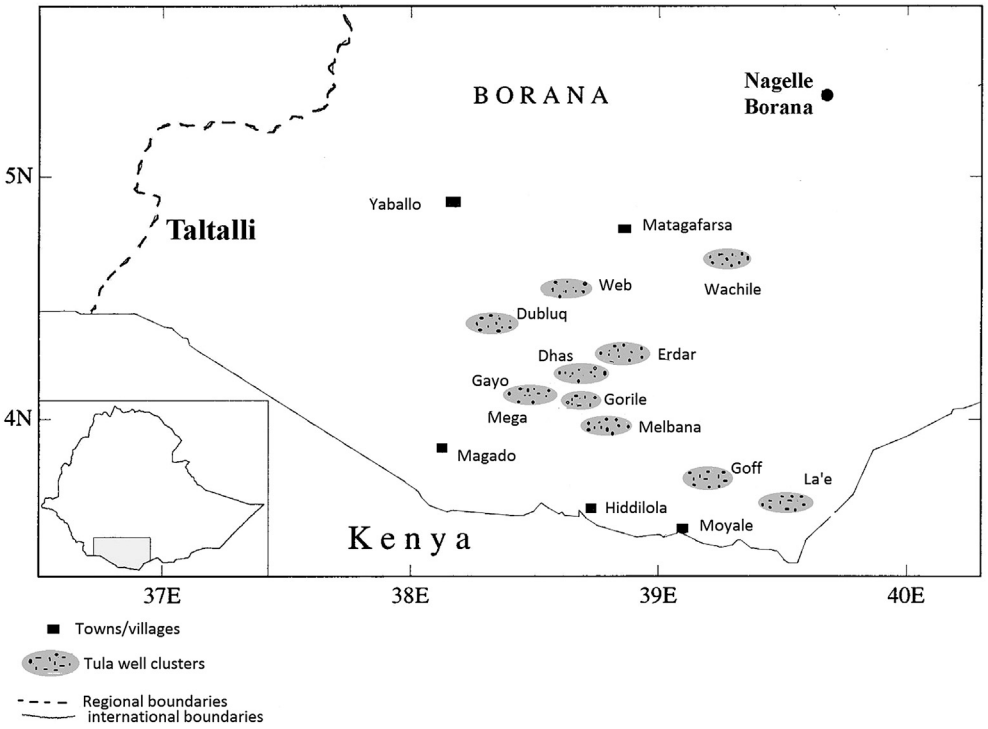

Fig. 1. Study area showing the locations of the nine *tula* well clusters. The regional boundaries refer to the boundaries between the regional states in the Federal Democratic Republic of Ethiopia, while the international boundaries refer to the boundaries between independent states. The disused well clusters are not indicated on the map. The elliptic shows a cluster and the dots denote the individual wells not drawn to scale.

timeline less susceptible to telescoping than the lists of kings used elsewhere in Africa.[32] According to Legesse,[33] *gada* is a socio-political concept that 'incorporates all history and the total cognitive framework in which historical processes unfold'. This suggests that the *gada* system serves as a societal memory of the past and that it 'predicts' the future. Legesse describes *gada* as a social engine that drives events in Borana. Few African societies have such a structured knowledge of time as that imparted by the Borana's system of ordering their history. According to Legesse, the Borana 'techniques of time reckoning promised to be one of the most sophisticated systems devised by man'. Legesse believes that the Borana system is one of the few indigenous institutions identified so far, that provides a comprehensive understanding of the relation between time and human society. This suggests that the Borana are remarkably aware of time and history, although their historical record remains largely oral.[34] Kjærland also notes: 'Since they have their past in 8-year cycles and attach the story to the names of the *abba gada*, reconstructing events back to at least 1552 can be done precisely by the name and years of each *gada*'. Using oral history, Kjærland has reconstructed *gada* cycles even further back, to 1416.[35] Wilding, too, notes that *gada* is an important tool in reconstructing events using oral history.[36]

Oral historians and members of the society reconstruct historical events and establish a chronology using three interconnected concepts for understanding time, which they refer to as *gogessa*, *maqabas*, and *dhaaccii*.[37] Thus the Borana might interpret events roughly as follows: the *gada* timelines are similar to a clock hand counting time by means of notches between the power transfer from one *gogessa* to another at forty-year intervals. The 'jump' – the moment of transition from one historical event (repeated during different *maqabas*) to another – may include major environmental, social, political and economic disturbances that leave imprints on the *gada* history. When the clock circles back to the starting point and the same *gogessa* returns to power (after 40 years), a return of similar events is expected (*dhaaccii*).[38] The relationship between *gogessa*, *maqabas*, and *dhaaccii* can best be explained by the schematic *gada* chronology (see also Legesse's *Gada* Table 7-2: 193) given in Table 1.

For the period of our study, there were 74 *gada* periods covering about 600 years. The transfer of power is between *gogessa* and returns in the cycles of five (A–E). When the same *gogessa* returns to power during the return of the *maqabas* cycle, *dhaaccii* is expected. In Table 1, the numbers at the top (71–74) represent the future or incoming *gada*, and the ones at the bottom (1–69) represent the old *gada*. The current *gada* is represented by the

[32] Miller, Introduction (note 5).
[33] Legesse, *Gada* (note 18).
[34] Legesse, *Gada* (note 18).
[35] G. Kjærland, *Culture Change Among the Nomadic Borana of Southern Ethiopia*, Ph.D. thesis, Psychology World Mission, 1977.
[36] R.F. Wilding, *The History of Pastoralism and the Emergence of the Borana Oromo: A Review of Issues*, Addis Ababa, 1985.
[37] In Borana there are seven *maqabas* and five *gogessa*. If the five *gogessa* are arranged from one to five, each *gogessa* in a *gada* leadership takes one *maqabas*, and the last two *maqabas* go to the sons of the first and second leaders. Two *maqabas* of major concern are that that return to the same *gogessa* every 35th *gada*. The other expectation of event-repetition is within a *gogessa* (like Saaqoo Dhadacha and Bule Dhadacha) from genealogical ancestors to their descendants.
[38] G. Oba, Assessment of Indigenous Range Management knowledge of the Boorana pastoralists of southern Ethiopia (Part I), Report to Boorana Lowlands Pastoral Development Program, BLDP/GTZ, Nagelle Borana, 1998.

Fig. 2. (A) Physical distribution of *tula* wells in a cluster. Each arrow shows the approximate location of wellheads in one of the clusters. (B) Cattle watering at a trough where water is lifted by chains of men. All the operations are about 25 m below ground level. Source: Waktole Tiki Uma.

number 70. The seven *maqabas* rotate among the five *gogessa* in a regular manner (i.e. in intervals of 40, 80, 120, 160, 200… years etc.). For example, from Table 1, the *maqabas* of the current *abba gada* (70e) is the return of the *maqabas* of the 35th *abba gada* (35e). This means that *maqabas* return to *gogessa* every 35th *gada*, and it is expected that what happened 280 years ago (i.e. 35 × 8) will be replicated when the same *gogessa* returns to power (Table 1) (see note [37] and Table 1 that describe how the cycles work in conjunction). The society expects environmental and political events that characterized the ancestral *maqabas* to return with the current *gada* through the system of *dhaaccii*. The reliability of the Borana prediction is in terms of time events that allow the Calendrical systems to work together. Legesse[39] was also puzzled by this fact. As a test, he used a mathematical model and found that for the Borana there are more than just events that coincide in time. The return of events might make no mathematical sense but they were accurately predicted by the Borana oral calendar. The oral experts might think that a particular conjecture of *gada* and *maqabas* would produce a 'repeat' disaster occurring, should the *gada* likely be 'awarded' to the *maqabas* in which disaster is expected.

The repetition of events or *dhaaccii* (i.e. a persistent influence on the present and future),[40] together with *gada* and their *gogessa* provide time experts with tools to memorize and narrate environmental and socio-political disturbances and human responses in relation to the dynamics of *tula* wells. In the cycles of *gogessa* and *maqabas*, natural disasters that affect at least one of the three interdependent and important aspects of the Borana pastoral system (i.e. the wells, the cattle economy, and the family or human demography) served as historical markers and references for time recollection.[41] This provides a suitable methodological tool for reconstructing the impact of disasters and the social, economic and institutional responses within a wider timeframe.

Methods of data collection

To reconstruct past environmental and social history, we interviewed oral historians. We interviewed at least ten key informants per well cluster ($n = 60$). All the key informants were individuals acknowledged by the society as oral historians. Among them were the *abba gada* (the *gada* leader), and a renowned oral historian, Borbor Bule, who in Vansina's terms, can be considered as the societal librarian.[42] The interviews mostly took place at encampments (*olla*) and the well clusters (*ella* – a generic name for all types of wells). All the informants were aged over 50 years. We also conducted two group discussions per cluster to corroborate the information from oral historians. The discussions covered major natural disasters (e.g. floods, epidemics, droughts and famines) that had affected the management of the *tula* well systems. The name of the *abba gada*, the events that occurred during particular *gada* periods, and the associated *gogessa* and *maqabas* were frequently repeated to guide the discussions and check the consistency. The occurrences of events (such as floods, epidemics, droughts and famines) were cross-referenced using *gogessa* and *maqabas*. We interrogated the evidence on the societal memory of *dhaaccii*, returning during different *gogessa* following the scheme presented in Table 1.

In the group discussions, general questions were followed by more specific questions, such as: When did the collapse of wells occur throughout the well clusters? How were these collapses related to the *gogessa* and *maqabas* cycles? How did the events affect the pastoral economy and human populations? The interviewer might interrupt, saying, 'Let us return to this earlier point made by X or Y' and so on, while an informant who wanted to make additional points would say, 'I am left with another word…' and he was given the opportunity to speak. In cases where some of the participants did not know about time-depth, others with more information would intervene. The events remembered were both local and regional. For local events, place names, the key personalities involved, and social and political events were specified in the metanarratives. Using these cues, the informants covered major environmental disturbances using the *gada* timeline. We applied their terminology to ask more questions until a comprehensive catalogue of information emerged; this enabled us to address the objectives of the study. We were, however, flexible during the discussions, and did not insist on following a strict order of questions. As has already been stated, we tended to be guided by the issues raised during the discussions, and allowed each issue to be followed up when the subject was related to the study questions. Throughout the interviews, we made every attempt to understand how the system worked. We tried to determine which of the seven cycles (*maqabas*) corresponded to which major environmental and socio-political disturbances identified by the informants. We

[39] Legesse, *Gada* (note 18).
[40] T. Leus and C. Salvadori, *Aadaa Boraanaa: A Dictionary of Borana Culture*, Addis Ababa, 2006.
[41] W. Tiki, *The Dynamics of Ancient Tula Wells Cultural Landscape: Environmental and Social History, ca. 1560 to the Present*, Ph.D. thesis, Norwegian University of Life Science, Noragric, 2010.
[42] Vansina, *Paths in the Rainforest* (note 6).

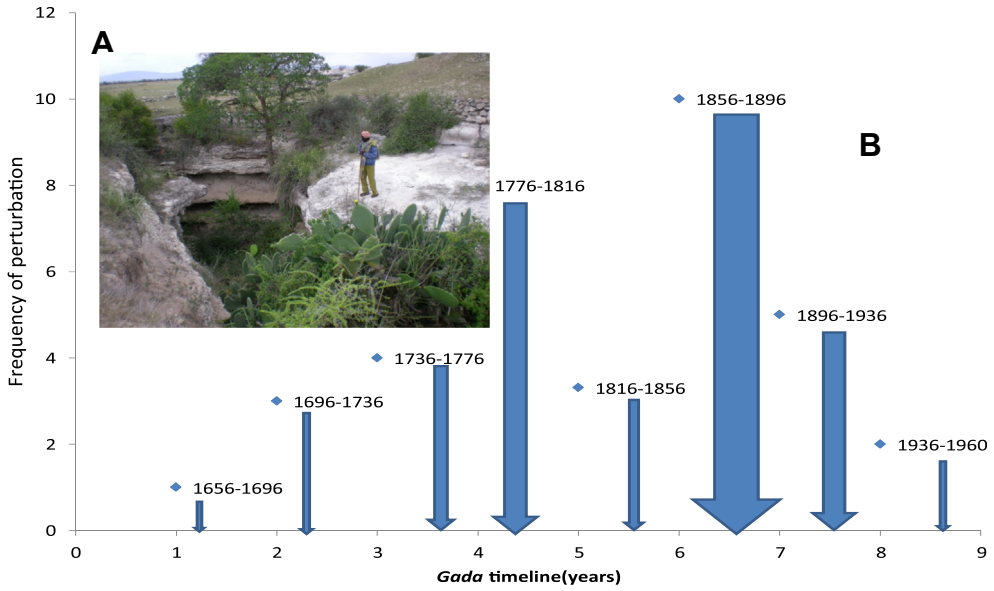

Fig. 3. (A) Inset: disused *tula* well. An informant is explaining the cause of well disuse. (B) Schematic representation of periods and severity of *tula* well collapses. The thickest and longest arrow shows the period when most severe disasters occurred, causing repeated collapse of wells, whereas the shortest and thinnest arrow shows the period when the frequency and severity of disasters were at lowest levels.

summarized the information from the interviews to construct an event historical calendar, linking the *gada* to the *maqabas* cycles and the returns of *dhaaccii* in terms of histories of disasters (Table 2). We made attempts to understand how the repetition of events was connected to the cyclical names (*maqabas*) and patriclasses (*gogessa*) to appreciate the roles played by *dhaaccii*. We tried to understand which of the seven cycles (*maqabas*) corresponded to which major environmental disturbances identified by the informants. All the discussions were recorded on tape with the knowledge of the informants.

We tested the hypothesis that events repeated themselves (*dhaaccii*), as believed by oral historians, in accordance with the *gogessa* and *maqabas* of the *gada* cycles (see Table 1). We further evaluated the oral information using the repeatability of environmental and social shocks that corresponded with a *gogessa*. We considered the frequencies of remembered disturbances: these returned in cycles of 40, 80, 120, 260, and 300 years that marked the return to power by the same *gogessa* (Fig. 4A). We used the frequency with which a particular historical event of major importance was reported (both social and natural disturbances reported during the intervals of 40 years), and took into account the number of informants. The results were organized chronologically to produce graphic representations of oral narratives to capture the trend of disturbances arranged in relation to the *gada* period. In order to place the oral-related timeframe into a framework of regional climatic change, we used environmental proxy data such as the levels of the Nile floods, as reported in historical literature. The purpose was to show the links between historical disasters reported by oral sources and the regional climatic records. It was however not our purpose to arrive at a one-to-one correlation. For the late nineteenth century, we used reports from European travellers whose experiences provided valuable glimpses of the changes described by the Borana.

Oral knowledge of environmental disasters

From the evidence provided in Table 2, it is possible to see that most of the natural events listed by oral historians under the respective *maqabas* and *gogessa* appeared to replicate themselves, albeit not as regularly as suggested. Our findings suggested that the informants were less knowledgeable about environmental disturbances that impacted on the *tula* well clusters before the seventeenth century. However, from then until the 1950s, the social memory of environmental and social disturbances was much more reliable. The more frequent environmental and social disturbances in recent years suggest that such a trend might be attributable in part to fresher societal memory, the most recent events being remembered better than the more distant ones.[43] Accordingly, the number and frequency of environmental disturbances reported by oral historians have shown a dramatic increase in the last 90 years (from the 1860s to the 1950s) (Fig. 4B). The written sources have revealed similar trends.[44] Another important factor may be the intensity of disturbances remembered by oral historians: the most severe disasters, those that caused fundamental changes in the operation of *tula* wells, cattle economy and social systems, were universally remembered.[45] This is mainly due to the fact that change (such as collapses of the pastoral economy) affects other aspects of this interactive system (such as the repairs of the *tula* wells). In terms of cyclical names (*maqabas*), the findings showed that *moggasa* seem to experience more disturbances, followed by *mardida*, while *fullasa* experienced least number of natural disturbances (Fig. 4B).

Periods of floods

Historically, major environmental disturbances were associated with the use and disuse of the wells. The wells collapsed most often during periods of excessive rainfall. The earliest well collapse

[43] Afato Dida, Borbor Bule, Sarr Jatani.
[44] Nicholson, A semi-quantitative, regional precipitation data set for studying African climate of the nineteenth century, part 1 (note 4).
[45] For similar discussion see J.C. Miller, The significance of drought, disease and famine in the agriculturally marginal zones of west-central Africa, *Journal of African History* 23 (1982) 17–61.

Table 1
Schematic representation of time chronology corresponding to *gada* classes in power during the period of the study. N.B. A–E represents *gogessa* cycles and a–g represents *maqabas*. The numbers they are associated with represent the time when the particular *gada* was in power. The scheme is modified from Legesse (1973: 193).

A	B	C	D	E
74a	73b	72c	71d	70e
69f	68g	67a	66b	65c
64d	63e	62f	61g	60a
59b	58c	57d	56e	55f
54g	53a	52b	51c	50d
49e	48f	47g	46a	45b
44c	43d	42e	41f	40g
39a	38b	37c	36d	35e
34f	33g	32a	31b	30c
29d	28e	27f	26g	25a
24b	23c	22d	21e	20f
19g	18a	17b	16c	15d
14e	13f	12g	11a	10b
9c	8d	7e	6f	5g
4a	3b	2c	1d	

The lower case letters (a–g) refer to the seven *maqabas* (cyclical names) and how they repeat themselves. According to Legesse (1973), there are no first or last *maqabas*, but the order of arrangement is important. The current *abba gada* is number 70 and his corresponding *maqabas* is represented by e (*makula*). Based on this starting point, we can represent each letter by respective *maqabas* as a = *libasa*, b = *darara*, c = *mardida*, d = *fullasa*, e = *makula*, f = *moggasa*, and g = *sabbaqa*.
The seven *maqabas* correspond with ritual cycles each representing a day of the week, not dissimilar in function to the Islamic seven days of the week.

occurred in *gada* Biduu Dhoqqee (1568–1576) when there were eight years of heavy rainfall.[46] Regional climate analysis shows that this period falls roughly into what is termed, in Europe, the Little Ice Age (LIA), when the environmental conditions in the Horn of Africa were much wetter than in the preceding period.[47] We have better knowledge of a more recent period (1800–1808) when excessive rainfall collapsed most of the *tula* wells during *gada* Ungule Lake Sade. The Borana oral sources explain the event using the phrase *gana sogaatu mo'a*, meaning, 'the era of Sogaa is the winner'; this refers to severe flood disaster. Oral sources recall that 'Prophet Sogaa', who predicted the excessive rain, was drowned in the floods. This is narrated by an oral historian as follows:

> There were three years of extended drought when the Borana prophet, Sogaa, advised people to move to the hills to escape the coming floods. Accordingly people migrated to the hills. At some point, the prophet himself returned to settlement in the valley to collect items he had left behind. Before he could return to the hills, the rain started and continued for seven days. The heavy flooding collapsed all *tula* wells and killed the prophet himself.[48]

Proxy data from the Nile shows that there was a high frequency of floods during this period, which implies heavy rainfall in Ethiopia.[49] Another period of well collapses occurred during *gada* Doyo Jilo (1856–64). We do not have precise information on the extent of the damage done to the *tula* wells, but it was recalled that lightning had killed many people. This latter incident is said to be *dhaaccii* from the perspective of the cyclical occurrence of events within the *maqabas* called *mardida* (see Table 2).

The next heavy rains that caused well collapses occurred during the period referred to as *dhuqisa* (the year of thunder) *gada* Dida Bitata Mamo (1872–1880). The oral historian Borbor Bule believes that the rainfall during this period was the heaviest ever, causing floods that collapsed most of the *tula* wells. The *maqabas* of *libasa* predicted droughts, famine or war, but heavy rainfall during the *gada* of Bule Dabasa (1928–1936) resulted in floods which caused wells to collapse across the *tula* clusters.

Depending on the extent of the damage, clan-wide organizations were activated to rehabilitate the wells. In most cases, only a small number of wells were rehabilitated, and many collapsed wells remained disused. Another flood disaster was that of *hagaya barba* of *gada* Madha Galma (1952–1960): heavy rains – probably caused by El Niño – collapsed many wells.[50] The regional climatic data shows high flood levels in the Nile River and a rise in the level of Lake Turkana during these periods, indicating a link to regional climatic forces, particularly in Ethiopia.[51] Records show that most periods of exceptionally heavy rainfall were preceded by droughts.[52]

The indication is that disasters influenced the operation of *tula* wells either by collapsing the wells directly (as a result of floods), or by denying important inputs, such as labour. The findings show a clear relationship between the collapse of wells, the status of the cattle economy, and human demographics. It is not only the community's vulnerability but also the capacity of the Borana to respond to disasters that is crucial for understanding the effects of natural disasters.[53] Sudden falls in human and livestock population would delay the re-excavation of wells that had fallen into disuse.

Disease epidemics

Well collapses due to flooding were followed by outbreaks of malaria or diarrhoea that greatly disturbed human populations. Malaria was responsible for huge fatalities that depopulated the region. Periodic outbreaks of diseases and epidemics, particularly during the late nineteenth century, decimated both the human and livestock populations, and disrupted the stewardship of the *tula* well system. The collapse of the pastoral economy resulted in the deterioration of *tula* wells because of the greatly diminished human and economic capacity to maintain them. Thus, a cholera epidemic during *gada* Haro Adi (1864–1872) undermined the pastoral economy, and led to collapse of the wells in all nine *tula* well clusters.[54] In the last quarter of the nineteenth century the operation of *tula* wells was more under threat than ever. Less than 20 years later, before the Borana were able to restore productivity after the very heavy rainfall of *gada* Dida Bitata Mamo (1872–1880), another serious natural disaster occurred: the Great Rinderpest outbreak of *gada* Liban Jaldesa (1888–1896). The

[46] Borbor Bule, interviewed by WT.
[47] B. Fagan, *The Little Ice Age: How Climate Made History 1300–1850*, New York, 2000; L.M. Kiage and K.B. Liu, Late Quaternary paleoenvironmental changes in East Africa. A review of multiproxy evidence from palynology, lake sediments, and associated records, *Progress in Physical Geography* 30 (2006) 633–658; H. Lamb, I. Darbyshire and D. Verschuren, Vegetation response to rainfall variation and human impact in central Kenya during the past 1100 years, *The Holocene* 13 (2003) 285–292; D. Verschuren, K.R. Laird and B.F. Cumming, Rainfall and drought in equatorial east Africa during the past 1,100 years, *Nature* 403 27 (2000) 410–413.
[48] Borbor Bule, interviewed by WT.
[49] K. Fraedrich, J. Jiang, F. Gerstengarbe and P. Werner, Multiscale detection of abrupt climate changes: application to River Nile flood levels, *International Journal of Climatology* 17 (1997) 1301–1315.
[50] *Barba* is the accumulation of water not originating from the well, or a flood, in a well.
[51] S.E. Nicholson, The methodology of historical climate reconstruction and its application to Africa, *Journal of African History* 20 (1979) 31–49.
[52] M. Indeje, F.H.M. Semazzi and L.J. Ogallo, ENSO signals in east African rainfall seasons, *International Journal of Climatology* 20 (2000) 19–46.
[53] C.G. Flint and A.E. Luloff, Natural resource-based communities, risk, and disaster: an intersection of theories, *Society and Natural Resources* 18 (2005) 399–412; M.L.K. Edwards, An interdisciplinary perspective on disasters and stress: the promise of an ecological framework, *Social Forum* 13 (1998) 115–132.
[54] Key informants and group discussions held at each well cluster provided similar information.

Table 2
Summary of major environmental disturbances and proxy data sources (column 3 is the short-hand representation of *gada* periods with their respective cyclical names from Table 1).

Gada period	Year	Rf. Table 1	*Maqabas*	Events	Primary source	Proxy data
Arero Boru	1496–1504	6f	*Moggasa*	Borana decided Sabbo-Gona moiety marriage.[a]	Oral	
Titille Dulacha	1504–1512	7e	*Makula*			
Luko Jarso	1512–1520	8d	*Fullasa*			
Dado Iddo	1520–1528	9c	*Mardida*			
Kura Dhala	1528–1536	10b	*Darara*			
Dagale Yayya	1536–1544	11a	*Libasa*	Great famine.[b]		NMSA
Asosa Titille	1544–1552	12g	*Sabbaqa*	Drought and famine.[c]	Oral	Degefu, Pankhurst
Borawu Lukku	1552–1560	13f	*Moggasa*	Drought.[d]	Oral	Pankhurst
Abay Horoo	1560–1568	14e	*Makula*	Borana started rearing camels, severe drought and famine.[e]	Oral	Schove
Biduu Dhoqqee	1568–1576	15d	*Fullasa*	Plenty of rainfall for the full 8-year period, but no good livestock productivity. All *hayu* died and *abba gada* alone survived.[f]	Oral	
Oroo Dulacha	1576–1584	16c	*Mardida*			
Yayya Horoo	1584–1592	17b	*Darara*	Drought in East Africa.		Schove
Doyo Boru	1592–1600	18a	*Libasa*		Oral	
Baco Nadha	1600–1608	19g	*Sabbaqa*			
Urgumessa Iggo	1608–1616	20f	*Moggasa*	Famine, epidemics.[g]		NMSA
Babbo Horoo	1616–1624	21e	*Makula*	Famine, epidemics.	Oral	NMSA
Babo Sibu	1624–1632	22d	*Fullasa*	Famine, swarms of locusts.	Oral	
Idhale Doyo	1632–1640	23c	*Mardida*	Famine, swarms of locusts.[h]		Pankhurst
Accu Abayu	1640–1648	24b	*Darara*			
Abu Lakku	1648–1656	25a	*Libasa*	Famine.		NMSA
Abbayi Babbo	1656–1664	26g	*Sabbaqa*	*Sodom Boro* (Borana) assimilated *Hero abba Biiya* groups[i]	Oral	
Alle Kura Yayya	1664–1672	27f	*Moggasa*	Serious conflict between Borana and Arsi. First attempt to introduce crop production, drought.[j]	Oral	NMSA
Wayu Huru Reelee	1672–1680	28e	*Makula*	Famine.		NMSA
Morowa Abay	1680–1688	29d	*Fullasa*	Period of peace.	Oral	
Gobba Alla	1688–1696	30c	*Mardida*	The nine *tula* wells divided among Borana clans, sub-clans and individual owners in the form of trusteeship appointed.	Oral	
Dawwe Gobbo	1696–1704	31b	*Darara*	Famine.[k]	Oral	NMSA
Jarso Iddo	1704–1712	32a	*Libasa*	Famine, war with Arsi.	Oral	
Walee Waccuu	1712–1720	33g	*Sabbaqa*	Severe drought and famine recorded in Ethiopia.[l]	Oral	Schove, Webster
Sora Dhadacha	1720–1728	34f	*Moggasa*	Famine and weak Nile flood.		Schove
Dhadacha Robale	1728–1736	35e	*Makula*	Period of normality.	Oral	
Halake Doyo	1736–1744	36d	*Fullasa*	Cursed *abba gada* for increasing the number of *hayu* from two to six.	Oral	
Guyo Gedo	1744–1752	37c	*Mardida*	Famine caused by locust plague.		Pankhurst
Madha Boru Dadoyi	1752–1760	38b	*Darara*	Serious conflict in which council of *gada*-elect perished. Famine and drought.[m]	Oral	Pankhurst
Dhadacha Oda	1760–1768	39a	*Libasa*	Constitutes the re-established *gogessa* and *gada* council; fall in the Nile flood level.[n]		Herring
Bule Dhadacha	1768–1776	40g	*Sabbaqa*	Severe drought and famine[o]; conflict with Orma.	Oral	Pankhurst
Liban Wata	1776–1784	41f	*Moggasa*	Era of prosperity, unity and consensus, and performance of all rituals. The leader was the 'wisest' man in Borana history. Famine.[p]	Oral	Schove, Herring
Wayu Raale	1784–1792	42e	*Makula*	Famine throughout Ethiopia; conflict.		Pankhurst
Boru Madha Boru	1792–1800	43d	*Fullasa*	Famine; enforced gada rules.	Oral	Wood
Ungule Lake Sade	1800–1808	44c	*Mardida*	Three years of drought but oral source says neither cattle nor people affected[q]; collapse of *tula*.	Oral	Degefu
Saaqoo Dhadacha	1808–1816	45b	*Darara*	The most severe drought in forty years, but similar to that of Bule.	Oral	
Jilo Nencoo	1816–1824	46a	*Libasa*	Drought and famine.[r]		Schove
Sokoree Anna	1824–1832	47g	*Sabbaqa*	Famine, cattle epidemics, conflict.[s]	Oral	Degefu, NMSA,
Madha Boru Madha	1832–1840	48f	*Moggasa*	Famine; era of misfortune and conflict.[t]	Oral	Wood
Liban Jilo Hadhawa	1840–1848	49e	*Makula*	The first irregularity in power transfer.	Oral	
Jaldesa Guyo Dabasa	1848–1856	50d	*Fullasa*	Conflict.[u]	Oral	
Doyo Jilo	1856–1864	51c	*Mardida*	Excessive rainfall, conflict.[v]	Oral	
Haro Adi	1864–1872	52b	*Darara*	Abandoning of cultural practices, epidemics, famine, and conflict.[w]	Oral	NMSA
Dida Bitata Mamo	1872–1880	53a	*Libasa*	Heavy rainfall and collapse of wells	Oral	
Guyo Boru Ungule	1880–1888	54g	*Sabbaqa*	Most extreme social disorganization in Borana history.[x]	Oral	

Table 2 (*continued*)

Gada period	Year	Rf. Table 1	*Maqabas*	Events	Primary source	Proxy data
Liban Jaldesa	1888–1896	55f	*Moggasa*	Epidemics, drought, famine, conquest.[y]	Oral	Wood
Adi Doyo	1896–1904	56e	*Makula*	Drought, recovery,[z] conquest	Oral	Wood
Boru Galma	1904–1912	57d	*Fullasa*	Livestock epidemic.	Oral	
Liban Kuse	1912–1920	58c	*Mardida*	Conflict, drought, epidemics.[aa]	Oral	Hodson
Arero Gedo	1920–1928	59b	*Darara*	Large-scale well re-excavation,[bb] conflict.	Oral	
Bule Dabasa	1928–1936	60a	*Libasa*	Heavy rainfall, drought, conflict, epidemics.[cc]	Oral	NMSA
Aga Adi	1936–1944	61g	*Sabbaqa*	Severe diarrhoea, Italian occupation.	Oral	
Guyo Boru	1944–1952	62f	*Moggasa*	Serious drought.[dd]		

[a] An exogamous marriage system introduced between the two moieties of Borana.

[b] NMSA (National Meteorological Services Agency of Ethiopia), Assessment of drought in Ethiopia, in: *Meteorological Research Report Series*, Addis Ababa, 1996. The agency reported severe famine that forced a change of food habits – people survived by eating the roots of trees.

[c] See W. Degefu, Some aspects of meteorological droughts in Ethiopia, in: M.H. Glantz (Ed.), *Drought and Hunger in Africa*, Cambridge, 1987, 23–36; R. Pankhurst, *The History of Famine and Epidemics in Ethiopia Prior to the Twentieth Century*, London, 1985.

[d] R. Pankhurst, *The History of Famine and Epidemics in Ethiopia Prior to the Twentieth Century*, London, 1985.

[e] Borbor Bule, interviewed by WT; D.J. Schove, African droughts and the spectrum of time, in: D. Dalby, R.J.H. Church and F. Bezzaz (Eds), *Drought in Africa 2*, London, 1977, 38–53.

[f] It was believed that there was some power in the eyes of *abba gada* himself – when he looked angrily at people, they died. Since then his lineage has never come to power again.

[g] The Amharic term *manin tita* meaning 'whom did it spare' was used to describe the epidemic, see NMSA (National Meteorological Services Agency of Ethiopia), Assessment of drought in Ethiopia, in: *Meteorological Research Report Series*, Addis Ababa, 1996.

[h] The locust invasion and consequent famine forced the Emperor to change his seat of government; see R. Pankhurst, *The History of Famine and Epidemics in Ethiopia Prior to the Twentieth Century*, London, 1985.

[i] The rule of adoption or the rule that enables a person to acquire Borana citizenship was announced. This might have been designed to assimilate the population the Borana conquered.

[j] Increment of grain price reported, see NMSA (National Meteorological Services Agency of Ethiopia), Assessment of drought in Ethiopia, in: *Meteorological Research Report Series*, Addis Ababa, 1996.

[k] Severe starvation was reported, particularly in northern Ethiopia; see NMSA (National Meteorological Services Agency of Ethiopia), Assessment of drought in Ethiopia, in: *Meteorological Research Report Series*, Addis Ababa, 1996.

[l] For drought records see D.J. Schove, African droughts and the spectrum of time, in: D. Dalby, R.J.H. Church and F. Bezzaz (Eds), *Drought in Africa 2*, London, 1977, 38–53; and for the fall in Nile flood levels.

[m] R. Pankhurst, *The History of Famine and Epidemics in Ethiopia Prior to the Twentieth Century*, London, 1985.

[n] R.S. Herring, Hydrology and chronology: the Rodah nilometer as an aid in dating interlacustrine history, in: F.B. Webster (Ed.), *Chronology, Migration and Drought in Interlacustrine Africa*, London, 1979, 39–86.

[o] Famine was recorded all over Ethiopia. The Amharic term *qacine*, meaning 'my thinness', was used to convey its serious impact; R. Pankhurst, *The History of Famine and Epidemics in Ethiopia Prior to the Twentieth Century*, London, 1985.

[p] It was reported as the worst famine of the century. A fall in Nile flood levels from Ethiopia was also recorded; see D.J. Schove, African droughts and the spectrum of time, in: D. Dalby, R.J.H. Church and F. Bezzaz (Eds), *Drought in Africa 2*, London, 1977, 38–53; R.S. Herring, Hydrology and chronology: the Rodah nilometer as an aid in dating interlacustrine history, in: F.B. Webster (Ed.), *Chronology, Migration and Drought in Interlacustrine Africa*, London, 1979, 39–86.

[q] Drought was followed by excessive rain that collapsed all the *tula* wells. This was termed *gana sogaa*. For more information on drought and famine, see W. Degefu, Some aspects of meteorological droughts in Ethiopia, in: M.H. Glantz (Ed.), *Drought and Hunger in Africa*, Cambridge, 1987, 23–36.

[r] Famine that affected many parts of the world, including Ethiopia was reported; see D.J. Schove, African droughts and the spectrum of time, in: D. Dalby, R.J.H. Church and F. Bezzaz (Eds), *Drought in Africa 2*, London, 1977, 38–53.

[s] The famine was known as *sabdii gada* Sokoree (1824–1832), when 'people ate but were not satisfied'. W. Degefu, Some aspects of meteorological droughts in Ethiopia, in: M.H. Glantz (Ed.), *Drought and Hunger in Africa*, Cambridge, 1987, 23–36 reported drought and famine all over Ethiopia, and NMSA (National Meteorological Services Agency of Ethiopia), Assessment of drought in Ethiopia, in: *Meteorological Research Report Series*, Addis Ababa, 1996 reported international drought and famine in most African countries, and the failure of crops and death of cattle in Ethiopia.

[t] The famine was known as *agarii gada* Madha (1832–1840). Drought and famine were reported in central Ethiopia as well as low Nile flood levels; see C.A. Wood, A preliminary chronology of Ethiopian droughts, in: D. Dalby, R.J.H. Church and F. Bezzaz (Eds), *Drought in Africa*, London, 1977, 68–73.

[u] The disagreement among the leadership led to their defeat in the war. The *gada* council was re-established three times (all killed during the war except *abba gada*). It was known as *duula cirrate*, meaning the battle of *cirrate*.

[v] It was known as the 'era of thunder'. Three branches of *gada* were established at three separate places (no agreement among *gada* councillors).

[w] There was a severe cholera outbreak in the east and ownerless cattle dispersed into the bush. Famine and lowering of Nile flood levels were reported in the northern part of Ethiopia – see NMSA (National Meteorological Services Agency of Ethiopia), Assessment of drought in Ethiopia, in: *Meteorological Research Report Series*, Addis Ababa, 1996.

[x] It was known as *kaayoo dhabuu* (misfortune). Many cattle were lost to competing tribes as there was no defence force.

[y] Considered to be the worst natural disaster both by oral history sources and written documents: rinderpest epizootic, famine, smallpox, cholera, and severe drought; see C.A. Wood, A preliminary chronology of Ethiopian droughts, in: D. Dalby, R.J.H. Church and F. Bezzaz (Eds), *Drought in Africa*, London, 1977, 68–73.

[z] Oral history tells of good rainfall and pleasant life. C.A. Wood, A preliminary chronology of Ethiopian droughts, in: D. Dalby, R.J.H. Church and F. Bezzaz (Eds), *Drought in Africa*, London, 1977, 68–73 acknowledges the absence of recorded drought but records falls in the level of Lake Rudolf (because of low discharge from rivers in Ethiopia), and lower Nile flood levels.

[aa] On the influenza outbreak, see A. Hodson, *Seven Years in Southern Abyssinia*, London, 1927.

[bb] This indicates the full recovery of the cattle economy.

[cc] Drought and a fall in the level of Lake Rudolf were documented – see NMSA (National Meteorological Services Agency of Ethiopia), Assessment of drought in Ethiopia, in: *Meteorological Research Report Series*, Addis Ababa, 1996. Severe malaria outbreak also reported by oral historians.

[dd] Severe drought occurred and the Borana started selling hides and skins for the first time. The remaining period characterized by heavy rainfall and a malaria outbreak.

Italian soldiers invading Ethiopia in 1887 introduced the rinderpest, a viral disease that wiped out ungulate species in the region.[55] This epizootic was a regional disaster that started at Maswa (present-day Eritrea) and spread all the way to South Africa within a decade. In Borana, it collapsed the cattle economy and exposed people to devastating famine and predator attacks. This weakened the social fabric, and dispersed the society, forcing the abandonment of the nine *tula* well clusters.[56]

[55] For detail, see Tiki and Oba, *Ciinna* (note 3); C. Spinage, *Cattle Plague: A History*, New York, 2003.

[56] Tiki and Oba, *Ciinna* (note 3); Spinage, *Cattle Plague* (note 55).

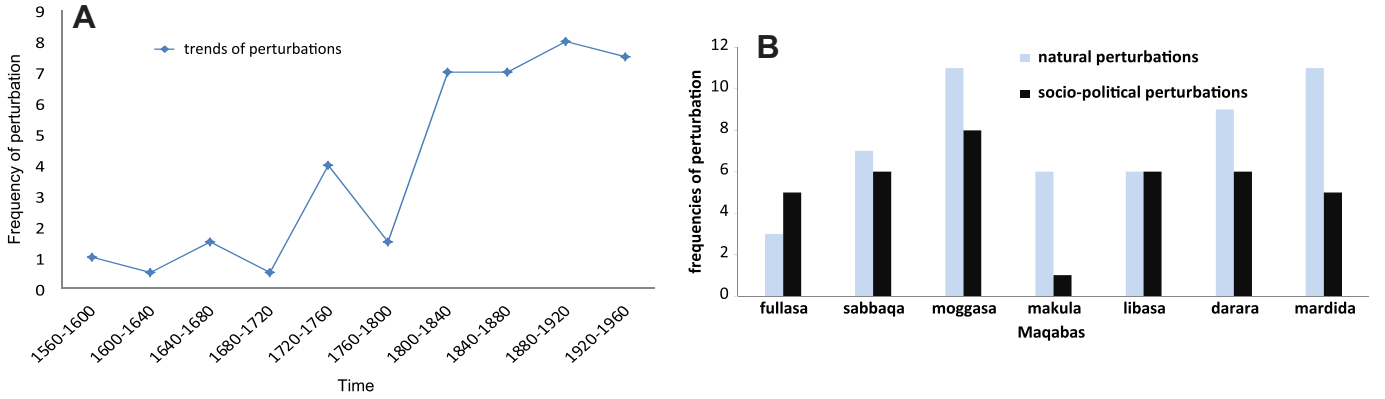

Fig. 4. (A) Trends of environmental and socio-political perturbations reported by *gada* chronology (40-year intervals). The *Y*-axis shows the number of disasters (i.e. frequency) reported during the period indicated on the *X*-time axis. (B) Socio-political and environmental perturbations by *maqabas* (cyclical names).

The Borana at the time of the Great Rinderpest epidemic had to plan for future recovery and protect the *tula* wells, despite huge losses of livestock during the epizootic. They sealed (*kala*[57]) many active wells, leaving only a few wells per cluster for human use. The strategy of temporarily sealing wells that were often vulnerable to silting from floods was a well-developed practice. In this particular case, economic, social and demographic conditions were different. Since it was impossible for the Borana to know how long economic recovery would take, the decision was to completely seal the wells. Tree logs were arranged across the wellhead, plastered with clay, and covered with earth. The well walls were propped up to reduce cave-ins and rockfalls, and rainwater was diverted to prevent it entering the wells. Before the *kala* of the wells had been finalized, a famine was experienced. The wells that were not sealed were lost as a result of silting.[58]

Italian travellers Vannutelli and Citerni, who visited some of the wells in 1895, a few years after the cattle epizootic, wrote: 'Wells were rarely utilized, others having been abandoned since most cattle had died of the contagious disease'.[59] Vannutelli and Citerni reported only four wells in use at one of the well clusters, Dhas, where there are more than 50 wells [including the disused wells]. Major Gywnn, at the end of 1908, noticed many disused wells. He reported: 'In the past it [the well] has been more utilized than at present and many old wells are choked'.[60] Heavy rainfall during the *gada* Guyo Boru (1944–1952), referred to as the year of high grass (*gana misaa*) or the year of white water (*gana bisaan adii*), did not affect the wells too badly, but this was followed by an outbreak of hepatitis (*birte*). More than 100 years after the rinderpest, despite extensive re-excavation, several of the wells studied remained in a disused state.[61]

Droughts and famine

A number of severe droughts (*oolaa*) and famine (*beela*-hunger) are remembered in the oral history. These include, among others, those that occurred during *gada* Abay Horoo (1560–1568), Alle Kura Yayya (1664–1672), Walee Waccuu (1712–1720), Madha Boru Dadoyi (1752–1760) and Dhadacha Oda Morowa (1760–1768). These droughts and famines resulted in the collapse of human and livestock populations. There were mega-droughts and famines reported by oral historians during the *gada* of Bule Dhadacha (1768–1776) and Saaqoo Dhadacha (1808–1816). These famines are remembered in an oft-repeated folklore song:

Oolaa Bulee Dhadacha	drought of *gada* Bule Dhadacha
Oolaa Saaqoo Dhadacha	drought of *gada* Saaqoo Dhadacha
Oolaan abaafi ilmaa	the droughts of father and sons
Gugufi tiya duuti haadhaafi ilme	my dear stumbler, death is that of mother and offspring

While showing the severity of droughts that killed both mother and offspring, the folk-song highlights the cyclical occurrence (*dhaaccii*) of droughts within the same *gogessa*. The *abba gada* Bule Dhadacha and Saaqoo Dhadacha were not biologically related but they were 'father and son' in the sense of being generations within the same *gogessa* (Table 1, column E, numbers 40g and 45b). Degefu, Pankhurst, and Schove refer to regional famines during these periods.[62] Other sources indicate that the whole period from 1760 to 1840 was characterized by drought and famine in East Africa.[63] Other *gada* periods that experienced serious famine were those of *gada* Sokoree Anna (1824–1832) and *gada* Madha Boru (1832–1840). The former is referred to as *sabdii* (unquenchable hunger) while the latter was known as *agaari* (voraciousness), and oral sources record that at that time 'people refused to share food' and were reportedly extraordinarily 'greedy'.[64] The famine coincided with an outbreak of lice. One oral source said, 'red lice covered the whole human body … [Individuals] scrubbed them off … People swelled in the face and died'.[65] The *maqabas* called *moggasa* predicted severe droughts that returned repeatedly. These periods were followed by a collapse of the cattle economy, which

[57] Temporary closure or sealing of wells with wooden material to prevent cave-ins.
[58] Borbor Bule, interviewed by WT.
[59] L. Vannutelli and C. Citerni, *Seconda spedizione bottego: Viaggio d'esplorazione nell' Africa Orientale*, Milano, 1899.
[60] C.W. Gwynn, A journey in southern Abyssinia, *The Geographical Journal* 38 (1911) 113–139.
[61] For the current status of *tula* wells, see Tiki, Oba and Tvedt, Human stewardship, or ruining cultural landscapes of ancient *tula* wells, southern Ethiopia (note 20).
[62] R. Pankhurst, *The History of Famine and Epidemics in Ethiopia Prior to the Twentieth Century*, London, 1985.
[63] K. Holmgren and H. Öberg, Climate change in Southern and Eastern Africa during the last millennium and its implications for societal development, *Environment, Development and Sustainability* 8 (2006) 185–195; F.B. Webster (Ed.), *Chronology, Migration and Drought in Interlacustrine Africa*, London, 1979.
[64] G. Oba, Shifting identities along resource borders: becoming and continuing to be Borana Oromo, in: T.W.P. Baxter, J. Hultin and A. Triulzi (Eds), *Being and Becoming Oromo: Historical and Anthropological Enquiries*, Stockholm, 1996.
[65] Archival interview collection of Oba Sarite Kura, interviewed by GO in Marsabit, 1992.

meant that the wells partially rehabilitated during *gada* Guyo Boru (1880–1888) were again lost.[66]

The famine that occurred at the end of the nineteenth century was widespread and severe, partly because the social disharmony that existed prior to the epizootic outbreak. The Borana were not ready to cope with the disaster or mitigate its effects, and they succumbed in large numbers to the famine that immediately followed the loss of cattle.[67] The famine caused a major decline in human population, institutional disruptions, and the deaths of whole families and well-owning lineages. This created ambiguity regarding well ownership and resulted in claims and counter-claims over well-property rights for generations. The transfer of wells across clans and moieties was reported; this was an anomalous and culturally undesirable practice.

In the twentieth century, *gada* Bule Dabasa (1928–1936) and Aga Adi (1936–1944) experienced severe droughts. A drought associated with a drop in the level of Lake Rudolf (now called Lake Turkana) was also reported in southern Ethiopia (1932–1933).[68] The *gogessa* of Bule Dabasa (Table 1, column E) is remembered for repeated cyclical occurrences of droughts and famines (this is the same *gogessa* of Bulle Dadacha and Saaqo Dadacha reported in the old woman's lore). This particular *gogessa* held office six times during the 200-year period (between 1768 and 1976), and at least four severe droughts were reported in that time. Four of the periods (40g, 50d, 55f, and 60a in Tables 1 and 2) each experienced at least one major drought.

A more recent severe drought that caused high cattle mortality was reported during *gada* Guyo Boru (1944–1952). This drought was referred to as *oolaa qollajjii*. It was a period when the hides and skins of cattle that had died in the drought were more marketable than living cattle. The Borana sold hides and skins in the Moyale market to buy grain from the grain-producing regions of southern Ethiopia. This famine was a cyclical return (*dhaaccii*) of the earlier event (*gada* Liban Jaldesa, 1888–1896) within the same *maqabas* called *moggasa*. This triggered population displacement and social unrest, and the increasing vulnerability led to a decline in the society's ability to manage *tula* wells.

The natural disasters and socio-economic disturbances had a number of effects on the operation of the *tula* wells:

(1) The link between the livestock economy and human demography (and therefore the labour available for operating, maintaining and re-excavating the wells) meant that economic recovery was necessary to restoring human stewardship of the wells after each disaster. The scale of responses depended on the extent of the damage caused to the pastoral economy and the strength of the social institutions for organizing re-excavation. Natural disasters denied the *tula* wells the human labour needed for their upkeep.
(2) The social disharmony disrupted labour organization and resource mobilization for the upkeep and rehabilitation of the wells.
(3) Institutional disruption (the death of clan leaders – *hayu*) mandated to organize rehabilitation, delayed the re-excavation of disused wells.
(4) The turmoil repeatedly displaced the population from the *tula* region, and this led to the wells being neglected.

Conclusions

Reconstruction of the impacts of environmental and social disasters on any ecosystem presents a challenge to historical geographers. The challenge has been to find an appropriate methodology that is amenable to empirical scrutiny. In this article, we have used oral history and the *gada* timeline to reconstruct and provide a timeline for past disasters and their impact on the dynamics of the *tula* wells, the environment and the pastoral economy. The chronology was established by putting the historical events in *gada* context and showing their relationship to each another by means of event-repetition (*dhaaccii*), cyclical names (*maqabas*), and social structure (*gogessa*). The imprints of the events on the social memory were successfully used to reconstruct the environmental history of these ancient well systems. The reliability of the oral-related timeframe can be gauged from its close relationship with findings from the proxy climatic data. The major indicators of disaster were considered: these were excessive rainfall (and its impact on the collapse of *tula* wells), epidemics, droughts, and famines. These disasters caused human and livestock demographic collapse. Human demographic collapse interrupted human stewardship of the wells and added considerably to the number of inactive *tula* wells. The society's response to these disturbances was influenced by other factors, such as the level of severity, human perceptions of these disasters and institutional resilience. We found that the proper functioning of the pastoral economy and a stable human demography were essential for effective human stewardship of *tula* wells. Understanding how Borana pastoralists perceived the impact of disasters was therefore crucial for understanding the historical geography of these fascinating ancient water systems in the Horn of Africa.

[66] Archival interview collection of Oba Sarite Kura, interviewed by GO in Marsabit, 1992.
[67] G. Oba. Assessment of Indigenous Range Management knowledge of the Boorana pastoralists of southern Ethiopia (Part I), 1998 (note 38).
[68] NMSA (National Meteorological Services Agency of Ethiopia), Assessment of drought in Ethiopia, in: *Meteorological Research Report Series*, Addis Ababa, 1996. The agency reported severe famine that forced a change of food habits – people survived by eating the roots of trees.