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 dhaaacci, 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 (dhaaacci) 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 dhaaacci 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.

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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. 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), Karaz (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’. 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...
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.5 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

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7 See Miller, Introduction (note 5).
9 Oral historians refer to this document ‘informants’ or the ‘narrators of the story’. See Giles-Vernick, Leaving a person behind (note 5).
11 See Fadiman, When We Began, There Were Witchmen (note 5).
12 See Miller, Introduction (note 5).
rains return. 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 wells, 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). The tula salan and their associated grazing lands cover 25,000 km². 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 technique that mystified nineteenth-century European visitors to the region. 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’. 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. Maud was of the opinion that the excavators were ‘civilized and energetic’. 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 dig 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.

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. The wells are invoked in political debates, ritual and cultural practices and religious blessings. They are the focus of social and political organization. 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 golf (see Fig. 3A).

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. 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. This regular power transfer makes the gada...
oral. Kjærland also notes:

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society. This suggests that the Borana are remarkably aware of
comprehensive understanding of the relation between time and human

According to Legesse, the Borana
imparted by the Borana’s
societies have such a structured knowledge of time as that
impacted 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. 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. Wilding, too, notes that gada is an important tool in reconstructing events using oral history.

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. 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). 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

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32 Miller, Introduction (note 5).
33 Legesse, Gada (note 18).
34 Legesse, Gada (note 18).
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.
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 dhaccii. The reliability of the Borana prediction is in terms of time events that allow the Calendrical the present and future,40 together with produce a ‘gada’ return of events might make no mathematical sense but they were awarded when the same gada 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 dhaccii. The reliability of the Borana prediction is in terms of time events that allow the Calendrical the present and future,40 together with produce a ‘gada’ return of events might make no mathematical sense but they were acknowledged by the society as oral historians. Among them were acknowledged by the society as oral historians. Among them were acknowledged by the society as oral historians. Among them were acknowledged by the society as oral historians. Among them were acknowledged by the society as oral historians. Among them were 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 dhaccii, 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 person- alities 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

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 dhaccii, returning during different gogessa following the scheme presented in Table 1.

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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.

It 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 patriarchal classes (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.44 Accordingly, the number and frequency of environmental disturbances reported by oral historians have shown dramatic increases 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 full-asa 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.
occurred in gada Biduu Dhoqqee (1568–1576) when there were eight years of heavy rainfall. 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. We have better knowledge of a more recent period (1800–1808) when excessive rainfall collapsed most of the tula wells during gada Ungale Lake Sade. The Borana oral sources explain the event using the phrase ganna 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. 

Proxy data from the Nile shows that there was a high frequency of floods during this period, which implies heavy rainfall in Ethiopia. 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 dhaacii 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 dhuqsaa (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 hogaya barba of gada Madha Galma (1952–1960); heavy rains—probably caused by El Niño—collapsed many wells. 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. Records show that most periods of exceptionally heavy rainfall were preceded by droughts. 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. 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. 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

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46 Borbor Bule, interviewed by WT.
48 Borbor Bule, interviewed by WT.
50 Bar0 is the accumulation of water not originating from the well, or a flood, in a well.
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 Table 1).

<table>
<thead>
<tr>
<th>Gada period</th>
<th>Year</th>
<th>Maqabas</th>
<th>Events</th>
<th>Primary source</th>
<th>Proxy data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arero Boru</td>
<td>1496–1504</td>
<td>6f</td>
<td>Moggasa</td>
<td>Borana decided to change the moiety marriage.</td>
<td>Oral</td>
</tr>
<tr>
<td>Titille Dula</td>
<td>1504–1512</td>
<td>7e</td>
<td>Makula</td>
<td>Drought and famine.</td>
<td>Oral</td>
</tr>
<tr>
<td>Luko Jarso</td>
<td>1512–1520</td>
<td>8d</td>
<td>Fullasa</td>
<td>Famine, epidemics and conflict.</td>
<td>NMSA</td>
</tr>
<tr>
<td>Dado Iddo</td>
<td>1520–1528</td>
<td>9c</td>
<td>Mardida</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Kura Dhalaa</td>
<td>1528–1536</td>
<td>10b</td>
<td>Darara</td>
<td>Period of peace.</td>
<td>Oral</td>
</tr>
<tr>
<td>Dagale Yayya</td>
<td>1536–1544</td>
<td>11a</td>
<td>Libasa</td>
<td>Severe drought and famine.</td>
<td>Oral</td>
</tr>
<tr>
<td>Aosa Titille</td>
<td>1544–1552</td>
<td>12g</td>
<td>Sabbaqa</td>
<td>Drought and famine.</td>
<td>Oral</td>
</tr>
<tr>
<td>Borawu Lukku</td>
<td>1552–1560</td>
<td>13f</td>
<td>Moggasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Abay Horoo</td>
<td>1560–1568</td>
<td>14e</td>
<td>Makula</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Biduu Dhoqee</td>
<td>1568–1576</td>
<td>15d</td>
<td>Fullasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Ooro Dula</td>
<td>1576–1584</td>
<td>16c</td>
<td>Mardida</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Yayya Horoo</td>
<td>1584–1592</td>
<td>17b</td>
<td>Darara</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Doyo Boru</td>
<td>1592–1600</td>
<td>18a</td>
<td>Libasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Baco Nadhda</td>
<td>1600–1608</td>
<td>19g</td>
<td>Sabbaqa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Urgumessaa Igg</td>
<td>1608–1616</td>
<td>20f</td>
<td>Moggasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Babho Horoo</td>
<td>1616–1624</td>
<td>21e</td>
<td>Makula</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Babo Sibu</td>
<td>1624–1632</td>
<td>22d</td>
<td>Fullasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Idhale Doyo</td>
<td>1632–1640</td>
<td>23c</td>
<td>Mardida</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Accu Abayu</td>
<td>1640–1648</td>
<td>24b</td>
<td>Darara</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Abu Lakku</td>
<td>1648–1656</td>
<td>25a</td>
<td>Libasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Abbayi Babbo</td>
<td>1656–1664</td>
<td>26g</td>
<td>Sabbaqa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Alle Kura Yayya</td>
<td>1664–1672</td>
<td>27f</td>
<td>Moggasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Wayu Huru Reelee</td>
<td>1672–1680</td>
<td>28e</td>
<td>Makula</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Morowa Abay</td>
<td>1680–1688</td>
<td>29d</td>
<td>Fullasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Gobba All</td>
<td>1688–1696</td>
<td>30c</td>
<td>Mardida</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Dawwe Gobo</td>
<td>1696–1700</td>
<td>31b</td>
<td>Darara</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Jarso Iddo</td>
<td>1704–1712</td>
<td>32a</td>
<td>Libasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Walee Waacu</td>
<td>1712–1720</td>
<td>33g</td>
<td>Sabbaqa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Sora Dhadacha</td>
<td>1720–1728</td>
<td>34f</td>
<td>Moggasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Dhadacha Bobale</td>
<td>1728–1736</td>
<td>35e</td>
<td>Makula</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Halake Doyo</td>
<td>1736–1744</td>
<td>36d</td>
<td>Fullasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Guyo Gedo</td>
<td>1744–1752</td>
<td>37c</td>
<td>Mardida</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Madha Boru Dadoyo</td>
<td>1752–1760</td>
<td>38b</td>
<td>Darara</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Dhadacha Oda</td>
<td>1760–1768</td>
<td>39a</td>
<td>Libasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Bule Dhadacha</td>
<td>1768–1776</td>
<td>40g</td>
<td>Sabbaqa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Liban Wata</td>
<td>1776–1784</td>
<td>41f</td>
<td>Moggasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Wayu Raale</td>
<td>1784–1792</td>
<td>42e</td>
<td>Makula</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Boru Madha Boru</td>
<td>1792–1800</td>
<td>43d</td>
<td>Fullasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Ungule Lake Sade</td>
<td>1800–1808</td>
<td>44c</td>
<td>Mardida</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Saqoore Dhadacha</td>
<td>1808–1816</td>
<td>45b</td>
<td>Darara</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Jilo Nencoo</td>
<td>1816–1824</td>
<td>46a</td>
<td>Libasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Sokore Anna</td>
<td>1824–1832</td>
<td>47g</td>
<td>Sabbaqa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Madha Boru Madha</td>
<td>1832–1840</td>
<td>48f</td>
<td>Moggasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Liban Jilo Hadhawa</td>
<td>1840–1848</td>
<td>49e</td>
<td>Makula</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Jalde Borno Dabasa</td>
<td>1848–1856</td>
<td>50d</td>
<td>Fullasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Doyo Jilo</td>
<td>1856–1864</td>
<td>51c</td>
<td>Mardida</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Haro Adi</td>
<td>1864–1872</td>
<td>52b</td>
<td>Darara</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Dida Bitata Mamo</td>
<td>1872–1880</td>
<td>53a</td>
<td>Libasa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
<tr>
<td>Guyo Boru Ungule</td>
<td>1880–1888</td>
<td>54g</td>
<td>Sabbaqa</td>
<td>Famine, war with Arsi.</td>
<td>Oral</td>
</tr>
</tbody>
</table>
Italian soldiers invading Ethiopia in 1887 introduced the rinderpest, a viral disease that wiped out ungulate species in the region. 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 Tiki and Obia, Ciinna (note 3); Spinage, Cattle Plague (note 55).
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\textsuperscript{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 losses of livestock during the epizootic. They sealed (tula\textsuperscript{58}) the entrances 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’.\textsuperscript{59} Vannutelli and Citeri 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’.\textsuperscript{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.\textsuperscript{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 (1664–1762), Walee Waccuu (1712–1720), Madha Boru Dadoy (1752–1760) and Dhadaacha 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 Dhadaacha (1768–1776) and Saqqoo Dhadaacha (1808–1816). These famines are remembered in an oft-repeated folklore song:

\begin{quote}
Oolaa Bule Dhadacha
Oolaa Saqqoo Dhadaacha
Ooolaa abao flimaa
Gagufi tiya duuti haadhaa ilme

my dear stumbler, death is that of mother and offspring
\end{quote}

While showing the severity of droughts that killed both mother and offspring, the folk-song highlights the cyclical occurrence (dhaccii) of droughts within the same gogessa. The abba gada Bule Dhadaacha and Saqqoo Dhadaacha 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.\textsuperscript{62} Other sources indicate that the whole period from 1760 to 1840 was characterized by drought and famine in East Africa.\textsuperscript{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’.\textsuperscript{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’.\textsuperscript{65} The maqabas called moggasa predicted severe droughts that returned repeatedly. These periods were followed by a collapse of the cattle economy, which

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figures.png}
\caption{(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).}
\end{figure}

\textsuperscript{57} Temporary closure or sealing of wells with wooden material to prevent cave-ins.
\textsuperscript{58} Borbor Bule, interviewed by WT.
\textsuperscript{59} L. Vannutelli and C. Citerni, Seconda spedizione botanica: Viaggio d’esplorazione nell’Africa Orientale, Milano, 1899.
\textsuperscript{60} C.W. Gwynn, A journey in southern Abyssinia, The Geographical Journal 38 (1911) 113–139.
\textsuperscript{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).
\textsuperscript{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, 1986.
\textsuperscript{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 Dабаса (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 Dабаса (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 ootaq qollajii. 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 (dhaacci) 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 other by means of event-repetition (dhaacci), 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.