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8 Aksum: Water and Urbanization in Northern Ethiopia

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> "Complain when you see the king; sow when you see the water"
> (Tegreña proverb; Conti Rossini, 1942: 57).

INTRODUCTION[1]

The region between modern northern Ethiopia and central Eritrea offers an example of the intricate links between water and urbanization. This history has received little scholarly attention, even though the region has long been recognized as a center of plant domestication (Harlan, 1971) and host of some of the earliest state societies in sub-Saharan Africa (Fattovich, 2008, 2010; Phillipson, 2012). The highlands of Tigray between northern Ethiopia and Eritrea (Figure 8.1) saw the emergence of complex societies from the second millennium BC (Phillipson, 2009, 2012; Fattovich, 2010), leading to the emergence of the kingdom of Aksum[2] (50 BC–AD 700/800). The development of urbanism at Aksum was strongly influenced by its strategic geographical and topographic position, and the availability of water and land resources. The new kingdom thrived for a thousand years, engaging in long-distance trade and commerce, developing a written literature and coinage, and acting as a gateway for the introduction and spread of Christianity into Africa (Phillipson, 2012).

Aksum's position, together with its water and land resources, sustained local communities and, subsequently, their engagement in, and intermittent control over, regional and interregional trade. A somewhat independent subsistence system was already in place by the first millennium BC and survived the collapse of temporal power towards the late first millennium AD. These developments were followed by the southward expansion of the state in the late first–early second millennium AD. A new polity emerged further south in central Ethiopia (Zägwe Dynasty, *c*.AD 1137–1270), and was soon overtaken by the Solomonic Dynasty (AD 1270–1974) and the establishment of the Ethiopian Empire.

By eliciting environmental, archaeological, and historical sources, this chapter discusses how the early societies of northern Ethiopia and Eritrea

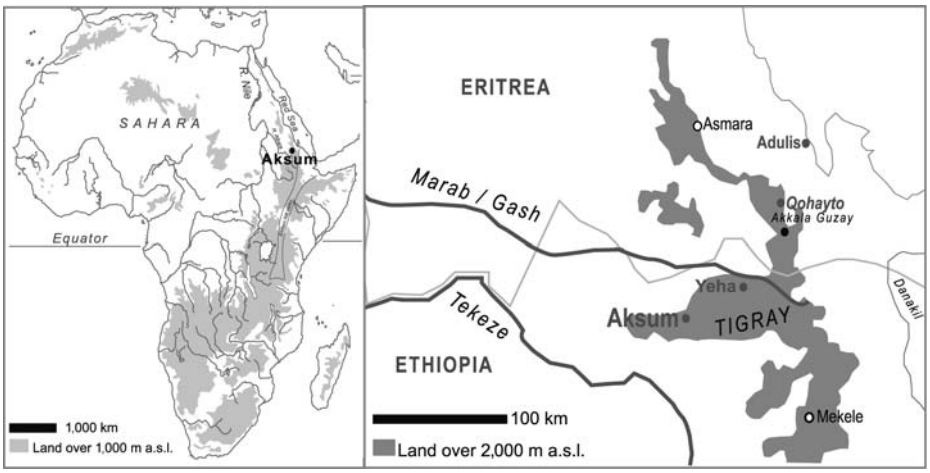

Figure 8.1. Map of northern Ethiopia and Eritrea.

interacted with a highly diversified environment, and the types of strategies they have developed to manage water and land resources.

THE EMERGENCE OF THE AKSUMITE KINGDOM

By the early first millennium BC, several large-scale settlements had arisen across the region spanning the Tigrean highlands to the coastal plains of the Red Sea. A main polity, known as D'MT (*c*.900/800–400 BC), was centered at Yeḥa (Figure 8.1) and associated with the Pre-Aksumite culture. The Pre-Aksumite culture was characterized by a strong influence from southern Arabia and was only part of a mosaic of different cultures present in Tigray and Eritrea during the first millennium BC (Schmidt *et al*., 2008; Phillipson, 2009, 2012; Fattovich, 2010). By the mid-first millennium BC, permanent settlement is amply documented in the Aksum area with a new polity centered on Betä Giyorgis (Proto-Aksumite, 400–50 BC; Figure 8.2). The main residential area ('Ona Nägäst) and an elite cemetery ('Ona Enda Abboy Zägwe) were located on the hilltop, and small settlements and rural homesteads were scattered across the greater Aksum area (Fattovich, 2008; Sernicola, 2008). Subsequently, the residential area increased and, from the mid-first millennium AD, the focus of political control shifted from Betä Giyorgis hilltop to its southern pediment and the plain, marking the rise of the kingdom of Aksum (50 BC–AD 700/800). Aksum soon consolidated its influence on a regional and interregional scale, and extended its political and economic control towards the Red Sea, the Eastern Desert, and possibly the upper Nile Valley. A centralized state emerged by the

second century AD and the Aksumite court officially adopted Christianity by the early third century AD. The spread of the new religion among the sub-strata of the society is likely to have taken place within the following two centuries (Conti Rossini, 1928: 141–95; Phillipson, 2012: 91–106). By the late third century AD, the kingdom began minting coins in gold, silver, and copper, which rapidly spread towards commercial partner regions as far as India (Munro-Hay, 1991; Phillipson, 2012: 181–93). At this time, Aksumite influence can be detected as far afield as the Red Sea coast, the western Sudanese lowlands, the regions to the west of the Tekeze River (Ethiopia), and part of southwestern Arabia (Phillipson, 2012: 200–3).

The results of intensive archaeological surveying and excavations show changing patterns of settlement throughout the development of Aksum (Sernicola, 2008). Even though the number of people present in a given time is not known, it is commonly accepted that the ancient capital hosted a population of several thousands at the peak of its expansion (Michels, 2005; Fattovich, 2008). Aksumite settlements included towns, villages, isolated hamlets and, following the introduction of Christianity, churches and monasteries (see Sernicola, 2008). By the mid-first millennium AD, the

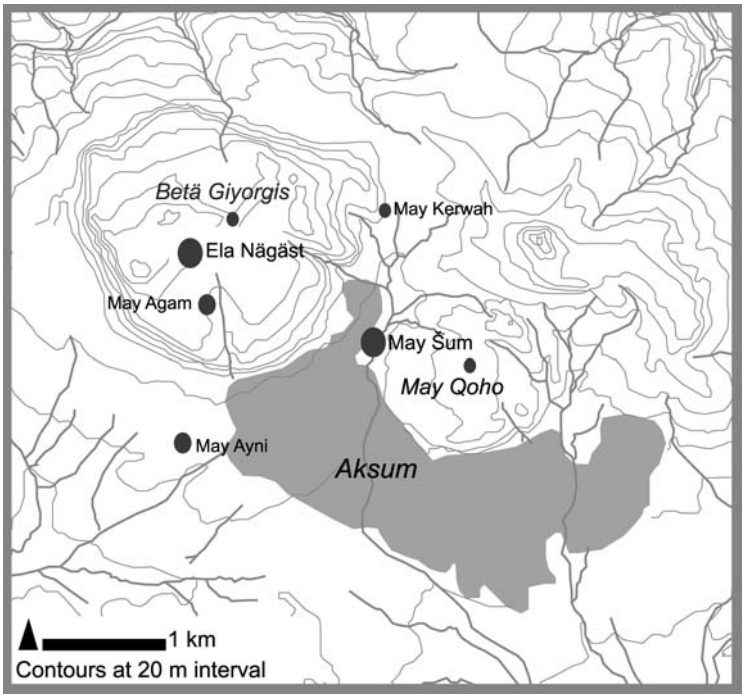

Figure 8.2. Map of Aksum showing the location of water cisterns and springs (circles) mentioned in the text.

kingdom had reached its maximum expansion in terms of both territorial control and urban development (Fattovich, 2008). In the capital itself, the urban quarters were located in the flood plain: a large residential area, including monumental buildings (commonly referred to as palaces) and (royal) funerary complexes, stretched along Betä Giyorgis pediment to the north and northwest of the modern town. Lower-class residential structures were also present in the plain and on the hilltop of Betä Giyorgis, and at small rural sites in the surrounding countryside.

In the sixth and seventh centuries AD, the settlement at Aksum occupied a much smaller area, concentrated around the Cathedral of Maryam Ṣeyon. The archaeological evidence indicates that a social and economic crisis occurred around this time. The triggers of change are still uncertain, but great emphasis has been placed upon the combined impact of demographic pressure, overwhelming exploitation of the land, and climate deterioration, which eventually would have led to the decline of Aksum (Butzer, 1981, 2012). From the late sixth century, Aksum's commerce in the Red Sea and Indian Ocean was gradually eroded by external powers: the Persians' expansion in southern Arabia and, shortly afterward, the Arab conquests and control of the Red Sea trade route. At home, tribal movements into the Eritrean highlands threatened Aksumite activities away from the capital and toward the coast (see Fattovich, 2010). By the late seventh/early eighth century AD, Aksum was no longer the capital city. While the decline of the elite occupation is well expressed in the archaeological record, rural compounds persisted in relatively significant numbers in the countryside (Sernicola, 2008; Sernicola and Sulas, 2012). Very little is known about the following few centuries, but archaeological survey data indicate that between the tenth and fifteenth centuries, settlement was concentrated mainly along the southern pediment and on the hilltop of Betä Giyorgis. Moreover, buried soil records from the hills and river valley s north of the town reflect the persistence of settlement and arable land use in relatively stable landscape conditions until about AD 1600 (French *et al*., 2009; Sulas, 2010).

WATER IN THE MODERN ETHIOPIAN HIGHLANDS

Discussions on the development of ancient societies, whether farming communities or complex states, in northern Ethiopia and Eritrea often concentrate on rainfall, and largely exclude other forms of water and the impact of these on society. In a region where water waste is a critical factor due to prolonged dry periods and droughts, the management of soil moisture has always been vital for productive farming and domestic activities. Yet catchment hydrology finds no consideration in literature, even though its dynamics are fundamental in understanding past human decisions (see Pikirayi, in press). Moreover, an important caveat against addressing water history in the region concerns the types of records and

processes associated with water. While built infrastructures such as dams can survive for millennia and provide information about the types and uses of water resources, research on supply provided by rainfall and groundwater is complicated, as these forms of water operate at multiple scales through time, and are influenced by several factors. In northern Ethiopia and Eritrea, built evidence of water management is limited, but archaeology, environmental sciences, and historical sources provide relevant data. The landscape and its farming communities offer further insights into aspects of land and water management that have characterized this region for millennia.

Ethiopia is a land of rivers and, as the highlands slope northwestwards, nearly all the large rivers flow in that direction to the Nile. Aksum lies on a water-divide between two main drainage systems (Figure 8.1): the Tekeze/Atbara River (a major Nile tributary) and the Märäb/Gaš River (which flows into the Sudanese lowlands). Linked to these two main rivers is a network of smaller tributaries and streams, most of which afford high and often erratic flows during the rainy season, but rapidly become dry during the following months.

The undulating topography of the Aksum area is characterized by flatlands and hills with gently sloping to steep sides, covered by scattered bushes and shrubs, and sparse patches of trees. The town lies on a large plain at an average elevation of about 2,200 m above sea level and is surrounded by a number of hills. The local geology is dominated by trachytic and phonolitic domes, stratified flood basalts with reddish sandstone, laminated siltstones, and conglomerates. Quaternary deposits of alluvium, colluvium, and tufa are found along river valleys, foot-slopes, and in depressions (Assefa and Russo, 1997). At the contact between hard and soft rocks, flat-topped hills, known as *ambat* (sing. *amba*), provide good land for settlement and cultivation over the tops, and gently sloping to steep sides (Coltorti *et al*., 2007). Foot-slopes and piedmonts are made of hillwash, and open onto fertile flood plains.

The regional climate is complex and varies significantly within short distances, shifting from the extreme low temperatures of the mountain tops to the tropical desert of the lowlands. Most of Tigray falls within the main climatic belt known locally as *wäyna däga* ("land of vineyards"), a temperate zone between 1,500 m and 2,500 m above sea level with annual temperature means of 15–20°C, and moderate rainfall of 200–700 mm per year. However, rainfall and temperature vary significantly across the region, and there have been few attempts to regionalize rain patterns (Nyssen *et al*., 2005). The highly seasonal rainfall pattern is determined by the monsoon, which is largely controlled by the movement of the Inter-Tropical Convergence Zone. Most of the rain falls between June and August, and less reliable rains may occur between March and May. In the decade 1995–2005, Aksum received less than 650 mm rainfall per year, most of which was concentrated in July and August. Its temperature

reached the annual mean of 19.7°C, and evapotranspiration shifted between 613 mm and 569 mm per year (Tadesse *et al*., 2010).[3]

If rainfall has always been a vital, yet uncontrollable resource, the underground reserves significant amounts of water: the volcanic geology (trachyte, flood basalt, sandstone, and alluvial deposits) provides optimal rock bodies for aquifers, and parent material for medium- to light-textured soils. Shallow aquifers are confined to sediments of low productivity, but the deep ones found in fractured basaltic rocks afford good permeability (Alemayehu *et al*., 2011).[4] Groundwaters are recharged by direct infiltration of rainfall and through lateral flow. Springs are thus relatively common in Aksum's landscape (Figure 8.2), and the ones associated with flood basalts, sedimentary rocks, and lava flows afford high yields. The flood plains, where most farming takes place, are recharged every year by mountain streams—many of which have shallow water tables filled with coarse-grained alluvium with good hydraulic conductivity. As such, flood plains maintain shallow water tables during the dry season.

Rainfall, surface water, and groundwater underpin the rural farming population, to which land is not only the basic means of livelihood and a resource for income, but also a source of shared history and culture. Traditional farming combines the use of *maräša* (ard-plough), cattle, and annual crops (Simoons, 1960). In the highlands, altitude and temperature offer favourable conditions for growing a variety of cereals (ṭef, barley, wheat, sorghum, finger millet), legumes (chickpeas, lentils, beans, broad beans), and oilseed plants (flax, noug). Soil management, particularly the preservation of moisture, has always been a fundamental task for the highlanders, who employ crop rotation and short-period fallows to allow land recovery.[5] The crop repertoire, together with the use of plough, has been historically stable (McCann, 1995), and is still preferred in the countryside against state-sponsored mechanized and monoculture agriculture.

LANDSCAPE HISTORY AND URBAN DEVELOPMENT

Environmental proxies indicate that present climatic conditions began sometime in the second millennium BC (Bard *et al*., 2000), and the record from Tigray is broadly consistent with the sequencing of the northeastern African palaeoclimate during the late Holocene, which is characterized by increasing aridity interspersed by wet pulses (Dramis *et al*., 2003; Marshall *et al*., 2009). In the Tigrean highlands, wet conditions seem to have prevailed during three main periods: *c*.2050–1550 BC, *c*.550 BC–AD 450, and around AD 1000 (Machado *et al*., 1998; Gebru *et al*., 2009; Terwilliger *et al*., 2011). A rapid increase in aridity occurred after the mid-first millennium AD (*c*.AD 500–50; see Machado *et al*., 1998; Terwilliger *et al*., 2011). However, alternating intervals of minor high and minor low Nile flood discharge between the seventh and the early tenth centuries (Hassan, 2007) suggest

that rainfall on the Ethiopian highlands provided a relatively consistent input to the Nile. The following centuries until the mid-second millennium AD saw the recurrence of abnormal floods, either excessively high or low, which triggered famines both in Egypt (Hassan, 2007) and in northern Ethiopia (Pankhurst, 1985).

The rise and decline of Aksum have been linked to environmental issues for a long time. In the late 1930s, Monneret de Villard (1938) first identified two main phases of sediment depositions next to the Cathedral of Maryam Ṣeyon (Figure 8.3): the earliest phase would have preceded the rise of Aksum and a second phase would have taken place after the decline of the kingdom. These first environmental data found later support in the geoarchaeological investigations by Butzer (1981), who recorded four aggradation phases and linked them to climatic changes and cultural developments. In particular, the first aggradation phase was associated with a period of increased precipitation and the growth of Aksum as a political center; a second aggradation phase was linked to the erosion of degraded agricultural lands upslope and heavy rains, following a period of settlement and demographic increase. The last two phases of aggradation occurred several centuries after the decline of the Aksumite

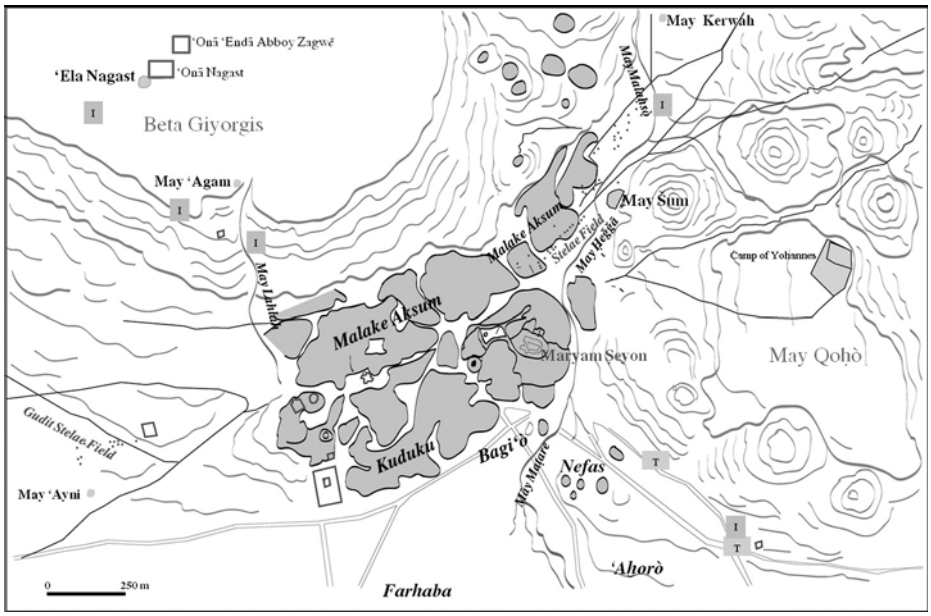

Figure 8.3. Figurative map of Aksum, based on Littmann *et al.* (1913) and Monneret de Villard (1938). Squares: Aksumite structures (buildings, churches and funerary complexes), inscriptions (I), and throne-bases (T); dots: stelae; circles: cisterns and springs; dark-grey outlines: compounds and homesteads as in the 1930s.

kingdom. Combined, these data provided the basis for a model of urban growth linked to climate change and environmental degradation. During the last two decades, intense research in and around Aksum has provided new local data that suggest a more complex scenario (see Sernicola and Sulas, 2012). On the one hand, studies of plant remains from archaeological and landscape contexts (seeds, charred wood, pollen, and phytoliths; see Boardman, 1999; Bard *et al*., 2000; D'Andrea, 2008; French *et al*., 2009; Sulas, 2010) indicate that a woody savannah vegetation cover was in place at Aksum before, during, and after the kingdom, whereas there is no evidence for the presence of woodland. On the other hand, new sedimentary records from the hilltop of Betä Giyorgis, hillsides, and river valleys north of the town reflect prolonged landscape stability associated with settlement and land uses from the mid-fourth millennium BC until about AD 1600 (French *et al*., 2009; Sulas *et al*., 2009; Sulas, 2010). On hilltops and uplands, buried thick soil horizons were associated with settlement and farming, while buried soil records from hillside deposits may have been linked to pastures. The botanical remains (phytoliths and charred wood) from the buried soils reflect a substantially stable woody savannah vegetation cover with tree patches along watercourses and settlements, of which palm trees were a significant component. In addition, there is some indication of changes in soil moisture conditions that seem to have been concomitant to both phases of landscape stability and localized soil erosion, suggesting that changing rainfall was not the main trigger of soil moisture change (Sulas, 2010).[6]

WATER, FARMERS, AND KINGS

The subsistence of the ancient societies in the Tigrean highlands was based on farming and husbandry. During the early first millennium BC, non-elite farming communities cultivated grains such as barley and emmer (Boardman, 1999; D'Andrea, 2008; D'Andrea *et al*., 2008, 2011). Near Eastern crops[7] were most frequently grown by these early communities, who largely depended upon a vegetarian diet (D'Andrea *et al*., 2011). As indicated by Boardman (1999: 144), the archaeobotanical evidence implies "the existence of dry-land agriculture based on ox-plough and mixed annual crops by the mid-first millennium BC and possibly earlier". A more varied suite of crops were grown at Aksum from the mid-first millennium AD. To support such a farming-based subsistence and urban development, former research has emphasized the use of stream-fed ditch irrigation as it was observed at Yeḥa in the mid-1970s (Michels, 2005). However, this is only sparsely practiced in northern Ethiopia (Simoons, 1960; McCann, 1995), and, today, rainwater drainage is mainly controlled by ploughing along field boundaries and digging shallow channels (depths of 15–20 cm), a practice occasionally observed in historical periods (Salt,

1814: 19; McCann, 1995: 59). Since the onset of the present climate (second millennium BC), rainfall, cool temperatures, and low evaporation have supplied enough water and moisture for ensuring yields in the highlands.[8] However, some form of irrigation may have been practiced, though it is unlikely that this was on a wide scale. In Akkälä Guzay (Figure 8.1), for example, horizontal fields and remnants of old dams and canals may be linked to ancient irrigation (Brunner, 2005). Similarly, the remains of massive walls together with a terrace on Betä Giyorgis hilltop have been associated with water management (Fattovich, 2008). The buried soil records associated with the Pre-Aksumite and Aksumite occupations from Betä Giyorgis and other upland and river valley sites north of Aksum yield no indication of irrigation, but there is evidence of moisture changes, most likely in relation to changing water-table levels (Sulas, 2010).

More substantial evidence for ancient irrigation comes from the lowlands and coastal plains of Eritrea. Here, much drier conditions and higher evaporation rates would have impinged upon crop growing that was solely dependent on rainfall for its water supply. The vast plain of Adulis, for example, borders a large river and may well have provided a "man-made oasis where flood irrigation accumulated fertile silt" (Brunner, 2005: 36). Further inland, the area of Kärän preserves silty terraces and relict canals that Brunner (2005: 33) links to early irrigation, possibly dating to the second millennium BC. Indeed, there may have been no need for irrigation before the onset of present climatic conditions.

Most of the highland farming may have thrived without the support of irrigation, but significant water supply was needed to sustain a multifaceted population of farmers, craftsmen, traders, priests, and rulers. Water-storing structures have been recorded in the Aksum area and on the Qoḥayto plateau (Eritrea), but none has been fully investigated. Many of these structures are located in between or in close proximity to Aksumite settlement sites. On the hilltop of Betä Giyorgis, for example, the two modern cisterns of May ʿAgam (Figure 8.2) cut into alluvial (probably crystalline) rock that afford a high water yield, and a series of Aksumite sites are located in the immediate vicinity.[9] By far the largest and most important cistern on the hilltop is ʿEla Nägäst,[10] located next to the early residential area of ʿOna Nägäst (Ricci, 1974, 1990: 139; Fattovich, 2008). The cistern cuts across stratified sedimentary rocks and is elliptical in shape (*c*.25 m by 20 m long, originally 7 m deep). It is recharged by groundwater, direct precipitation, and overland flow during periods of rain (Fattovich *et al*., 2000: 42). The mixed potsherds recovered from the fill date to all phases of the Aksumite periods.

At Aksum itself, several springs and water cisterns are present, but none firmly predate the fifteenth century. The most celebrated water source is May Šum (Figure 8.2); the structure was originally about 65 m in diameter and 5 m deep, and has been enlarged at various stages (Littmann *et al*., 1913, Vol. 2: 70–3; Monneret de Villard, 1938: 8–11; Phillipson, 1997:

156–60).[11] In addition to rainfall, the cistern receives substantial runoff from the surrounding hillsides and, presumably, from natural springs along the slope and hilltop of May Qoḥo. Local traditions place the building of the structure in the fifteenth century (Phillipson, 1997: 156–60), though a much earlier date is very likely (see also Michels, 2005: 142).

In Eritrea, a series of ancient cisterns have been recorded within major Aksumite settlement areas on the Qoḥayto plateau (*c*.2,600 m above sea level, Figure 8.1), and provisionally ascribed to the Aksumite Period (Wenig, 1997; Wenig and Curtis, 2008). Among them, the so-called "Safira Dam" is located at the beginning of a shallow valley that falls down into a gorge. The basin is square (*c*.67 m long and approx. 3 m high at its center) and has natural borders on three sides, whereas the downstream side is made up of a built wall constructed from regular courses of fitted blocks with rough stone steps. Early descriptions emphasize the resemblance with the famous dam of Mārib in highland Yemen (e.g. Bent, 1893: 219–20), but others recognize it as a cistern for rain-capturing, similar to the reservoir of May Šum at Aksum (e.g. Littmann *et al*., 1913, Vol. 2: 148–52; Conti Rossini, 1928, Vol. 2: 243). The structure awaits in-depth study, but a recent assessment by Brunner (2005: 34) interprets it as a rain-harvesting cistern,[12] arguing that "the knowledge for the arrangement of the cistern came from Yemen, but the architecture of the wall is definitely Aksumite". The location on top of a plateau, where rainwater is abundant, and the lack of waterproof revetment, favored water draining into the valley floor downstream.

While archaeological and environmental records illuminate some of the ways water was used, local traditions and micro-toponyms emphasize a connection between Aksum and water. The very origin of the name "Aksum" may illustrate this bond: the syllable "*ak-*" may derive from the Cushitic root for "water", and "šum" is the Semitic term for "chief" (Munro-Hay, 1991: 96; Finneran, 2007a: 152). Other hypotheses favor a western Agaw etymology ("*akuəsəm*"), meaning "water reservoir".[13]

According to the *Liber Axumae*,[14] the "capital" was moved three times, and a swamp covered most of the present site (Monneret de Villard, 1938; Munro-Hay, 1991). The latter was chosen by the kings Abreha and Aṣbeḥa, who miraculously drained the area of a great lake.[15] Monneret de Villard (1938: 19) argues that the plain was very low and covered by pools in ancient times; this hypothesis is supported by his investigations of alluvial deposits next to the Cathedral of Maryam Ṣeyon. Indeed, part of the marshland persisted at least until recently, as indicated by the "marshy ground" marked in the first topographic map of Aksum, drawn by Salt in 1805 (Mountnorris, 1809, Vol. 3: 100). It is noteworthy that most of the major Aksumite monuments and buildings are located on a strip of land running from the pediment of May Qoḥo with no extension westwards (Figure 8.3). Aerial photo interpretation (Fattovich *et al*., 2000: 42–3) suggests the presence of a cross-pattern dividing the town into four sectors (main axes N–S and E–W), which are consistent with the spatial

distribution of the archaeology: the elite residential palaces are located mainly in the southwestern sector, and the ceremonial area (churches and stelae fields) occupies the northwest sector.

Another local tradition from the *Liber Axumae* mentions the presence of 72 water sources at Aksum (Conti Rossini, 1909: 5; cf. Beckingham and Huntingford, 1961: 522–3). Further on, the text refers again to Aksum:

> the Mother of God spoke to Abba Heryakos… and to Yared the priest of Aksum, and brought them together in one place which is called May Kerwah… and they… came to a district of Aksum, the name of which is May Kerwah…
> (Beckingham and Huntingford, 1961: 523–4; see also Conti Rossini, 1909: 5)

May Kerwah is also mentioned in the hagiography of Yared, deacon and musician from near Aksum, who lived sometime in the sixth century and became saint of the Ethiopian Orthodox Church. This tradition places May Kerwah near the "house of Gäbrä Mäsqäl" (Conti Rossini, 1904: 27; see also Finneran, 2007b). The name is used today with reference to a well dedicated to Saint Yared and located to the north of the town (Figure 8.2), on the way to the tombs of the Aksumite kings Kaleb and his son Gäbrä Mäsqäl (*c*.sixth century AD). The very mention of May Kerwah by two distinctive sources is significant if we consider that the main reservoir of May Šum is not attested as such until the late nineteenth century AD (e.g. Vigoni, 1881: 138), though its presence has been recorded since the early sixteenth century. For example, a Portuguese account from the 1520s (Beckingham and Huntingford, 1961: 38) describes it as a "very handsome tank of (or lake of) spring water", next to where the market was held; perhaps an indication that the center of urban life was toward the north of the town (cf. Monneret de Villard, 1938: 14).[16] Travelers' accounts and, later, colonial reports indicate that May Šum was Aksum's main supply of water from the early seventeenth century until at least the early twentieth century (e.g. Barradas, 1634: 12, 119; Bruce, 1790, Vol. 3: 132; Mountnorris, 1809, Vol. 3: 100; Parkyns, 1853: 208; Bent, 1893: 125; Monneret de Villard, 1938).

The written sources also provide ample references to the rural landscape with cropping fields and rich orchards. Summer rains, streams, springs, and the dew provided abundant "good" water for plough-farming a variety of grains and pulses (e.g. Barradas, 1634: 12–15, 119–20; Ludolf, 1684: 26–7; Bruce, 1813, Vol. 5: 233–4; Parkyns, 1853: 206–10); the majority of which was already cultivated in Aksumite times. Irrigation ditches were only observed near Yeḥa in the early sixteenth century (Beckingham and Huntingford, 1961: 141) as there was no particular need for it:

> moisture continually distilling from the mountains: for the solid stones not admitting the rain, the water falls off them, and spreading under the fertile turf, wonderfully recreates and enlivens the growing plants.
> (Ludolf, 1684, Vol. 9: 48)

WATER AND SOCIETY IN THE RISE AND DECLINE OF THE AKSUMITE KINGDOM

African countries are among the most afflicted by water scarcity[17] and, yet, the continent has a substantial amount of groundwater, which is estimated to provide fresh water more than a hundred times the annual renewable freshwater resources (MacDonald *et al*., 2012). Scaling the picture down, 75 percent of about 4 million people of Tigray are food-insecure and plagued by recurring droughts. Is this a result of climate change? We know that present climatic conditions were established sometime in the second millennium BC. In this region of northeastern Africa, the water-landscape–people relationship shaped the development of urbanism, a process that lasted for a thousand years. Following the decline of the Aksumite kingdom in the late first millennium AD, urbanism disappeared from the Ethiopian highlands, and several centuries passed before new urban centers emerged.

Rather than discussing the main agents of such changes, the following section outlines the interactions of water and societies, and the processes that led to urban development and, subsequently, ruralization at Aksum. The available information drawn from environmental, archaeological, and historical records indicates the persistence of substantially stable climate and soil conditions, a local knowledge of water resources and specific management choices, and a tailored and flexible subsistence system.

What, then, was required for a successful water management at Aksum? Under monsoonal climate and at high altitude, wet and dry seasons have a significant impact on land productivity and water quality. A main challenge was, and still is, associated with predicting the end of the dry season and the beginning of the rainy one. This is a critical factor and, today, farmers sow their main staples immediately before the rains begin. At a household level, there was the need to have access to clean water, particularly during long dry periods when water from rivers and streams may have been scarce. Sizable cisterns are likely to have been the main device for harvesting and storing rainwater. To ensure adequate and safe supply, water harvesting and storing technologies had to meet the following minimum requirements: to impound enough water to satisfy the demand; to store the maximum quantity of water possible; to limit any leakage; and to be located where stored water could be put to the best use.

From a topographic point of view, broad valleys where streams run slowly into steep-sided cross-sections offer suitable conditions for reservoirs. Where rainfall patterns and runoff are the main concern, catchments with steep, rocky slopes are favored, as the rain falling runs downhill into a well-defined stream-bed, in which absorption and evaporation are at a minimum. Geological settings and building technology influence the possibility and amount of leakage and the infiltration potential of reservoirs. The cistern of ʿEla Nägäst on Betä Giyorgis (Figure 8.2), for example, was

cut into sedimentary rocks and recharged by groundwater, direct precipitation, and overland flow during periods of rain. ʿEla Nägäst is located on higher ground on the southwestern sector of the hilltop, facing gently sloping lands to the southeast, and bordering a crest to the southwest. The sloping lands opposite to the cistern form a shallow depression where rainwater collects and channels into a small seasonal stream (May Lahlah), which drains along the southwestern slope until it reaches the old quarter of Malake Aksum (Figure 8.3). In the southwestern sector of Betä Giyorgis hilltop, a seasonal stream (May Lahlah?) and possibly springs (May ʿAgam?) would have supplied water during the rainy season, while the cistern of ʿEla Nägäst ensured supply for the following dry months. Similarly, May Šum is located at the foot of a steep hill and to the side of a seasonal stream, called the May Ḥeğğa[18] (Figures 8.2 and 8.3)—a position that guaranteed direct capture of rainfall from the hillsides and mutual groundwater recharging via the seasonal stream.

Stored water needed to be kept clean from toxins and waterborne diseases. In this respect, classic Maya farmers succeeded in keeping clean the water stored in large reservoirs by "transforming artificial reservoirs into wetland biospheres" (Scarborough, 2009; Lucero *et al*., 2011). The understanding of wetland biosphere principles would have allowed classic Maya farmers to control the spread of water-loving plants and other organisms. While there is no physical evidence to support such claims, the cisterns associated with Aksumite settlements, such as ʿEla Nägäst on Betä Giyorgis and Safra in Qoḥayto, would have required control of water quality throughout the year. Indeed, these two examples still provide the main water supply for the local farming communities.

Compared to anywhere else in Africa, the early and medieval history of Ethiopia is exceptionally well documented. However, we can say very little for the earlier periods, including the Aksumite ones, as regards provincial organization, inheritance laws, or settlement of an army. Archaeological evidence for the early period of urban development at Aksum provides some indications of a social and economic structure. Fattovich (2008), for example, argues for the presence of three main groups within the Aksumite society: upper elite (kings and nobles), lower elite (lower-status nobles and/or wealthy farmers), and farmers. There is also evidence for an increasing social hierarchy that, from a division between elite and commoners in the last few centuries BC, culminated in further differentiation and the emergence of an intermediate group (lower elite or rich farmers) in the mid-first millennium AD. Fattovich (2008) also draws evidence for land tenure from landmarks and inscriptions. Isolated, rough monoliths on Betä Giyorgis hilltop, dated to the last few centuries BC, may have been erected to mark control of the territory. A series of short inscriptions with family names or lineages (*c*.third century AD) from Betä Giyorgis and the early to mid-fourth-century royal inscriptions along roads at the entry of Aksum may also be considered landmarks. Whether these features

marked territorial boundaries or not, they can only hint at some form of land holding, but they bear no indication of how or by whom land and water resources were managed. It is relevant to consider the situation in place in the following centuries, for which a rich manuscript literature elucidates the social structure and land tenure of historical Ethiopia from the thirteenth century AD (Crummey, 1980, 2000).

Strongly hierarchical, the society of historical Ethiopia was not rigidly stratified, and the nobility and the peasantry both believed themselves linked by common ancestry. Social differences were related to two main property rights: *gwelt*, the right to surpluses through tribute; and *rest*, the right to direct access to land. The ruling class had only a modest degree of direct access to land, as most of it was under peasant control, and so were the associated means of production, mainly oxen. As Crummey (1980: 131) outlined it: "ploughs were simple, irrigation elementary, the exploitation of water-power non-existent and of animal-power low…". Farmland was, thus, held on an individual basis by peasants, while pastures were common land. Most peasants had direct access to the land through hereditary, normally inalienable rights (*rest*), for which they paid a royal tithe; in addition to this, they might pay a tribute (a portion of their production). All forms of land tenure were conditioned by rights that frequently overlapped and, in practice, they might be held by farmers, holders of overrights (*gwelt*), and the court (Crummey, 2007). The farmers of medieval Ethiopia, thus, enjoyed a certain degree of independence from the state and their lords. The control of agricultural production, including the decisions about what to plant, where and when, was in the hands of farming households. Ethiopian nobles, churches, and endowed monasteries, even though they acquired titles to extensive lands, never converted these nominal rights into estates united by a centrally directed economy (Crummey, 2000).

If ancient Aksumite farmers enjoyed a certain degree of independence, similar to the farmers of medieval Ethiopia since the thirteenth century, it would be expected that changes of ruling groups (kings, chiefs, nobles) would not have affected land and water management practices significantly.[19] The available documentation points to an efficient management of water resulting from an *ad hoc* balance of soil/landscape factors and land-use strategies. As argued by D'Andrea *et al.* (2008), dry-farming fields may have been strategically placed in areas where runoff is naturally concentrated, and limited small-scale water diversion and terracing may have been used to cultivate lands in less favorable topographic positions.

Aksum's countryside appears to have been farmed continuously since at least the late first millennium BC. Although direct information is lacking, it has been suggested that Aksum hosted a population of several thousands in its heyday.[20] Firm data on population density are not available until the early twentieth century, when historical sources record a figure of 10,000 for the inhabitants of Aksum (e.g. Consociazione Turistica Italiana, 1938:

259). At this time, the quarters of the town had different names and, among those listed in the *Liber Axumae*, six were still in use (see Monneret de Villard, 1938: 13; Consociazione Turistica Italiana, 1938: 261): Malake Aksum, Kuduku, Bagiʿo, Nefas, Farheba, and ʿAḫorò (Figure 8.3). Most of these quarters unfolded along the banks of the May Ḥeğğa, the pediment of Betä Giyorgis, and the little watercourse of May Lahlah. During the rainy season, the plain was drained by the May Ḥeğğa to the east and the May ʿAbagät (May ʿAyni) to the west, and several wells and the large cistern of May Šum supplied water for domestic use.

Throughout the twentieth century, the understanding of the relationship between the development of subsistence systems and environmental change at Aksum was based on a combination of multi-scale and multidisciplinary data. In particular, the narrative about the rise and decline of state societies in the region has emphasized the role of rainfall changes: increased rainfall would have boosted agricultural productivity to sustain state formation first; and, subsequently, it had a detrimental impact on an overexploited landscape, which eventually led to the demise of the kingdom in the later first millennium AD. This model heavily draws from regional and continental environmental proxies and context-specific archaeological records. On the one hand, Aksumite urban development has long been linked to the idea of an agricultural substratum dependent on irrigation. On the other hand, regional and continental records of rainfall changes have been directly applied to explain cultural and economic developments in the Aksum area. This type of argument restrains societal responses to environmental change and, significantly, fails to account for other factors, including hydrological processes. It is now clear that neither woodland nor irrigation were a common feature of the local landscape before and during the Aksumite period. A greater amount of environmental and archaeological records are needed to contextualize non-environmental factors affecting societal decision-making over time. Indeed, the paucity of local landscape records implies that any attempt at modeling synchronous histories of forest expansion/clearance or the impact of changing rainfall, to mention just two important topics, has to rely on assumptions of environmental and cultural uniformity across vast regions.

In the Zambezi region of southern Africa, for example, negative environmental consequences such as droughts, excess rainfall, and flooding pushed ancient societies to converge into social formation beyond the village and, in some cases, to develop state organizations (Pikirayi, in press). Some of these early states depended on groundwater resources, rather than bounding themselves to the major rivers present in the region. The Zambezi region, thus, provides an example of how people responded to unfavorable environmental conditions beyond the commonly cited scenario of environmental degradation, followed by a "collapse". Indeed, the literature on past societies often emphasizes direct connections

between population increase and intensification of resource use, resulting in environmental degradation and collapse. Abandonment of the main urban centers is irredeemably taken as an expression of collapse, but history shows how such direct connections can be misleading (see, for example, Tainter, 2006). Furthermore, the abandonment of urban quarters does not necessarily imply the disappearance of a culture (Fletcher, 2011).

At Aksum, the decline in occupation recorded for the late first millennium AD has been described in terms of "abandonment". However, recent research has shed new light on the trajectories of post-Aksumite and medieval Ethiopia (see Phillipson, 2012), and there is now evidence that the disappearance of elite settlement did not mark the "disappearance of a tradition of social life" (cf. Fletcher, 2011: 311). At Aksum, the "traditional" ox-plough farming persisted despite significant changes in power and authority over the last 3,000 years. Beginning with the shift of political focus from Betä Giyorgis hilltop onto the Aksum plain in the late first millennium BC, a change in power is likely to have played a significant role in the decline of the permanently based Aksumite civilization in the late first millennium AD. The subsequent state society was mobile and emerged in the central highlands of Ethiopia with the establishment of the Solomonic Dynasty (AD 1270). More recently, a shift occurred in resource management and power associated with the modernization policy of Hayla Sellase (r. 1930–74), which since the 1950s has sought to reform agriculture by implementing land fragmentation, damming watercourses, and large-scale irrigation (Kloos, 1991; Kiros, 1993; Abegaz, 2005). For the first time in Ethiopia's history, decisions on water and land use were taken in the capital (Addis Ababa), rather than by local farmers, and the control of water became a symbol of political and socioeconomic power.

CONCLUSION

Water management was, and still is, an important aspect of the subsistence of northern Ethiopian and Eritrean farmers. In the highlands, abundant rains, suitable temperature, good soil moisture retention, and groundwater supplied water for ancient farming and households. The arid lowlands and coastal plains of modern Eritrea, instead, needed substantial watering to grow cereals and pulses; this may have been achieved by flood irrigation. The apparent lack of centralized control of water resources may be an indication that the Aksumite kings exerted power through means other than controlling access and management of water and land. But water, as is often the case, has been an "agent in the constitution and continuity of societies" (Tvedt and Oestigaard, 2010: 15) of northern Ethiopia and Eritrea. In spite of sociopolitical shifts that punctuated the history of this region, "traditional" plough farming has continued for almost two millennia.

Small-scale land and water management was sustainable in times of both population expansion and contractions. Moreover, a farming cycle governed by a bi-modal climate with long dry seasons and short rainy periods allowed several months for farmers to engage in other activities, which might have been controlled by the central state (McCann, 2001; Sulas *et al*., 2009). The findings of recent research open up new avenues for reframing the settlement trajectories in the Ethiopian and Eritrean highlands from the late Aksumite onwards. While the Aksumite legacy was feeding into the emergence of the Ethiopian Empire, settlement continued at Aksum.

The example from Aksumite and, later, historical Ethiopia is of immense importance for framing discourses on water history and land tenure in sub-Saharan Africa. Besides dynastic Egypt, archaeological and documentary records for early forms of land and water management are only available for the Ethiopian and Eritrean highlands.

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NOTES

1 The transliteration of Ethiopian names follows, wherever possible, the system used in the *Encyclopaedia Aethiopica* (2003–10), Wiesbaden: Harrassowitz.
2 The term "Aksumite" embraces several meanings, being used to refer to the cultural traits of northern Ethiopian and Eritrean archaeology, and their chronology. Here, I follow the cultural sequence developed by Fattovich (2008, 2010) and Phillipson (2000, 2009, 2012). "Pre-Aksumite" is used for the cultural developments of the first millennium BC (*c*.1000/900–400/300 BC) in western and central Tigray; "Aksumite" refers to the kingdom of Aksum, dating between *c*.50 BC and AD 700/800. The term "Proto-Aksumite" refers to the intermediate period (*c*.400–50 BC) between the decline of the Pre-Aksumite culture and the rise of the Aksumite kingdom.
3 The rainfall mean is, thus, nearly level with the evapotranspiration mean, suggesting that in the context of rainfed farming, yields are secured by balancing water gaining (rainfall) and losing (evapotranspiration).

4 Groundwater recharge preferentially occurs at the unconfined area of elevated topography, which consists of the hills made of fractured phonolite and trachyte; see Alemayehu *et al.* (2011).
5 Cereals tend to be the most important crop within the rotation, providing a highly nutritious food source. Legumes are also an essential part of the rotation, as they fix nitrogen, allowing a build-up of soil fertility; see McCann (1995: 50–2).
6 Changing soil moisture levels have been poorly understood in the past as well as in the present day, although they are clearly a key factor in active landscape modification and resource management.
7 The Near Eastern crops identified in Pre-Aksumite and Aksumite contexts are free-threshing wheat, emmer, barley, lentil, linseed/flax, and grape. The African crops attested in Aksumite contexts are ṭef and finger millet; see D'Andrea (2008).
8 At present, there is no archaeological record of cultivation of species requiring more water than those attested in Aksumite times, and that are still cultivated today.
9 These include the remains of a substantial building at Da'aro, two churches, and a lithic workshop; see Sernicola (2008).
10 'Ela Nägäst means "well of the kings" and, according to local traditions, this name was used to refer to 'Ona Nägäst; see Fattovich *et al.* (2000: 26).
11 In particular, the structure was enlarged and reinforced in 1927 under the supervision of A. Pollera; see Consociazione Turistica Italiana (1938: 264).
12 The cistern was rebuilt about 30 years ago, with no respect for its authentic appearance. Today, it supplies water for about 100 households, though the Safra administrative region has a population of just about 2,500 people; see Raadvad (2007: 96).
13 For a review, see Schneider (1996), who also mentions a further link with water inferred from the regalia on two coins of the Aksumite king Afilas (*c*.300 AD). The latter depict the king's bust framed by semicircles that are interpreted as water gushes, indicating that Aksum was located near a river or remarkable water source.
14 The *Liber Axumae* (the original name is Mäṣḥafä Aksum, or "Book of Aksum") is a composite work incorporating information on the historical topography of Aksum, a detailed description of its Cathedral of Maryam Ṣeyon, and the church cartulary record of endowments dating from the fifteenth to the nineteenth centuries; see critical edition by Conti Rossini (1909) and discussion by Lusini (2003).
15 Conti Rossini's (1909: 3) translation of the Ge'ez reads: *'Pour la troisième fois, la ville fut édifiée par Abrehā et Asbeha… mais sa construction s'accomplit à l'aide d'un miracle et d'un prodige. En effet, jadis il y avait là une grande étendue d'eau…*'; see also Beckingham and Huntingford (1961: 521–5). The tradition is preserved in Ms d'Abb. 97, the source of Conti Rossini, which possibly dates to the fiteenth century; see Monneret de Villard (1938: 50–2) and Munro-Hay (2003: 183).
16 The marked place was moved further south sometime before the 1860s, when it was first recorded in its current location. In the late 1890s, Wylde (1901: 146) noted how the May Ḥeğğa, after running across the "sacred grove" (next to Cathedral's precinct), cuts through the "market green", before dying into the valley. Monneret de Villard (1938) suggests that the moving of the market

may have been influenced by a progressive desiccation of the plain to the south of the town.

17 Water scarcity affects some 1.6 billion people worldwide and, by 2025, two-thirds of the world's population are expected to be living under water-stressed conditions; see Gilbert (2012) and United Nations' press release on March 22, 2012: www.fao.org/news.

18 The May Ḥeğğa watercourse has different names: May Melaḥso for the upstream section, May Ḥeğğa for the central part, and May Maṭare for the downstream section.

19 Crummey (2000: 11) argues that the "class relations which characterised the Salomonic state and its predecessors on the Ethiopian highland plateau accompanied the making of those states and were embedded in their very fabric".

20 For example, Michels (2005: 158) derives a stunning figure of just over 39,000 people living in the greater Aksum area at the peak of urban expansion. This estimate is based upon settlement models and should be taken with great caution, but at least it reflects the extent of residence sites and structures recorded at Aksum.

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