1
The Nile Basin: An Introduction

Ex Africa semper aliquid novi

("There is always something new coming out of Africa")
After Pliny the Elder (AD 23–79), who adapted it from Aristotle (384–322 BC)

1.1 Introduction

The following comments relate to the hydrologic status of the Nile before construction of the dams that today regulate the flow of water and sediment in its vast drainage basin (see Chapter 3). The reason for this is simple. Only by understanding the hydrologic behaviour of the unregulated Nile River and its tributaries can we begin to make the journey back in time and reconstruct the pattern and tempo of past hydro-climatic changes.

The Nile is the longest river in the world (6,853 km) and has the third largest drainage basin (3.3 million km^2), after the Amazon (7.2 million km^2) and the Orinoco (3.8 million km^2) (Williams et al., 1998, Table 8.1; Woodward et al., 2015a). Three main tributaries (and their associated tributaries) provide water and sediment to the main Nile: (a) the White Nile, (b) the Blue Nile and (c) the Atbara (Fig. 1.1). The White Nile rises in the equatorial uplands of Uganda, Rwanda and Burundi, and flows from Lake Victoria into Lake Kyoga and then into Lake Albert, after which it flows across a vast low-angle alluvial fan into the Sudd swamps of South Sudan and thence on to meet the Blue Nile at Khartoum. Fed by numerous small tributaries in its mountainous upper reaches, the headwaters of the Blue Nile flow down from the highly dissected Ethiopian Highlands into Lake Tana, which contributes about 9% of the total Blue Nile discharge (Hurst, 1952; Shahin, 1985; Sutcliffe and Parks, 1999; Sutcliffe, 2009). Below Lake Tana, the Blue Nile is entrenched in a gorge nearly 2 km deep, into which flow major tributaries such as the Jema, Guder, Didessa, Dabus and Beles Rivers. These tributaries provide much of its total discharge and sediment load. The Blue Nile then emerges from the Ethiopian uplands and flows across the Gezira alluvial fan to its confluence with the White Nile. The main Nile or 'Desert Nile' flows north from Khartoum for 320 km, at which point it receives water and sediment seasonally from another Ethiopian tributary, the Tekezze-Atbara River, and then flows north for a further

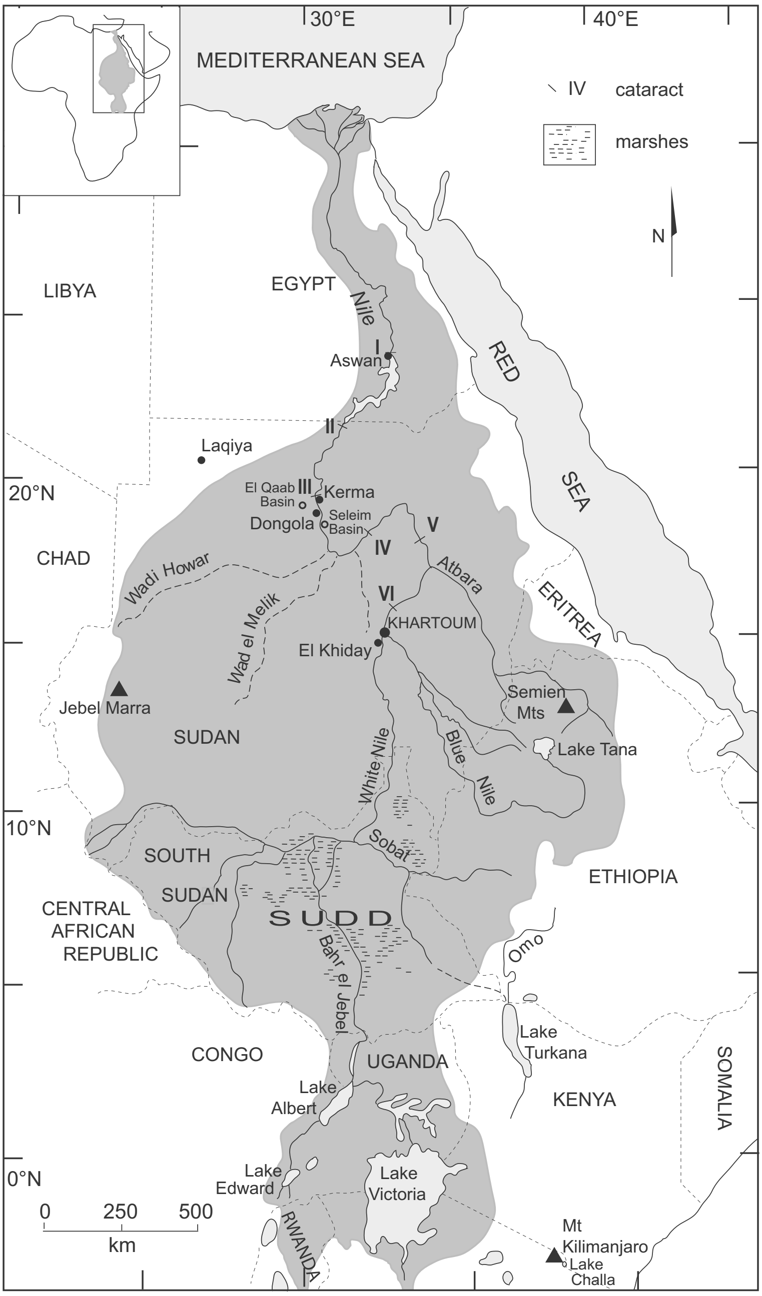

Figure 1.1 The Nile Basin.

2,689 km across the now waterless desert country of northern Sudan and Egypt, finally to reach the Mediterranean.

The Nile Basin contains an unparalleled record of how prehistoric human societies adapted to regional climatic events and to changes in the Nile flood regime, from the time of Early Stone Age/Lower Palaeolithic hunter-gatherers to the Neolithic food-producing economies based on plant and animal domestication. The lower Nile Valley was one of the cradles of urban civilisation, totally dependent on floods from the upper Nile, just as Egypt is today, albeit moderated through the Aswan High Dam reservoir. The inhabitants of the arid lands of northern Sudan and Egypt owe their very existence to the Nile. By the year 2020 more than 300 million people will depend on its waters for their livelihood, so that a clear understanding of present land use and the impact of climate change on Nile flooding is essential for any rational and long-term future planning (Swain, 1997; Ayoub, 1999; Mohamed et al., 2005; Williams, 2009b). One way to appreciate the possible impact of future climate change on the Nile is to investigate how the Nile has responded to past changes in global and regional climate. Within the Nile Basin there is widespread evidence of past environmental fluctuations in the form of landforms and sediments from now defunct rivers and lakes as well as fossil remains of plants and animals. Much of this evidence is very well preserved, thanks in large part to the aridity prevalent today across the northern half of the basin. As we shall see, the Nile Basin contains a generous slice of the climatic history of northeast Africa within the confines of its vast catchment of 3.3 million km^2.

Much of this volume deals with events that took place during the Quaternary Period. The Quaternary is the most recent of all the named geological periods and epochs of the past 4.6 billion years (4.6×10^9 years) of Earth history, and was a time of geologically rapid and frequent changes in climate. It was also the time when prehistoric humans emerged, initially in Africa, later spreading to every continent except Antarctica. The Quaternary Period covers the last 2.6 million years (2.6 Ma) and includes the Pleistocene Epoch (2.6 Ma to 12 ka) and the Holocene Epoch (12 ka to the present). Ma denotes a million years and ka denotes a thousand years. The Pleistocene is divided into three time units: Lower Pleistocene (2.6 Ma to 780 ka), Middle Pleistocene (780 to 125 ka) and Upper Pleistocene (125 to 12 ka) (Gibbard et al., 2010). Where a precise and accurate chronology is lacking and use is made of fossils or prehistoric stone tool assemblages to specify a general age, lowercase lower, middle and upper are used to alert the reader to the lack of precise chronology. Walker et al. (2012) have proposed on a provisional basis that the Holocene be divided into three: Early Holocene (12 to 8.2 ka), Middle Holocene (8.2 to 4.2 ka) and Late Holocene (4.2 ka to present). We follow their suggestion where there is adequate age control, but otherwise use lowercase for early, middle and late Holocene.

1.2 Early Speculation about the Nile

Herodotus (ca. 485–425 BC) deserves pride of place among the scholars and explorers who have long sought to understand the Nile. He was an indefatigable traveller, a shrewd listener and a highly observant man. It was Herodotus who concluded that 'Egypt is a gift of the river'. Some authors have translated this as 'the gift of the Nile' but the word Nile is a later corruption of the original Egyptian term for 'the river'. (For a scholarly review of this topic, see Griffiths, 1966.) Herodotus was very intrigued by the Nile (Herodotus, trans. 1954) and by the people and monuments of Egypt, commenting that the Egyptian climate was 'peculiar to that country and the Nile different in its behaviour from other rivers elsewhere' (Herodotus, trans. 1954, p. 115).

On a day's journey by boat offshore from the coast of the Nile Delta, in the eastern Mediterranean, he found that casting a weighted line into the sea revealed a muddy bottom at a depth of eleven fathoms (20 m), 'which shows how far out the silt from the river extends' (op. cit., p. 104). His voyage over 1,100 km upstream led him to agree with the priests, whom he had questioned at length and often sceptically, that 'the greater part of the country I have described has been built up by silt from the Nile' (op. cit., p. 105). He also concluded that an arm of the Nile near the coast could become silted up within 20 to 10 thousand years, preferring the shorter estimate. He displayed a truly geological sense of time. However, what really puzzled him was the flood regime of the Nile: 'What I particularly wished to know was why the water begins to rise at the summer solstice, continues to do so for a hundred days, and then falls again at the end of that period, so that it remains low throughout the winter until the summer solstice comes round again in the following year' (op. cit., p. 109). He then mentioned three possible explanations, all seemingly logical, but none in fact correct. He was dismissive of the first two as 'not worth dwelling upon, beyond a bare mention of what they are'. The first was that the summer winds caused the river to rise by checking the flow of the current towards the sea. Since the summer winds had little effect on other, smaller rivers, he rejected this notion. He rejected the second explanation of the Nile flowing from the ocean and then around the world as entirely fanciful. He considered the third explanation more plausible but utterly far-fetched, with the Nile said to derive its water from melting snow, a suggestion he castigated as 'obviously, this view is worthless' (op. cit., pp. 109–110). Of the three, the third hypothesis was closer to the mark than he realised.

Of special interest was his discovery (op. cit., p. 108) that during the reign of Moeris (some 900 years before his visit) 'the whole area below Memphis used to be flooded when the river rose only twelve feet' (4 m) but that during the time that he was there the river never flooded until it had risen 24 feet (8 m), indicating that the land adjoining the Nile was rising or aggrading. (The ancient city of Memphis is located 24 km [15 miles] south of present-day Cairo.) Napoleon's engineers and later observers were to confirm this progressive build-up of the Nile's flood plain (Bell, 1970). Herodotus also commented that he had seen shells on the hills near the coast and 'noticed how salt exudes from the soil to such an extent that it affects even the pyramids' (op. cit., p. 106), which is perhaps the first written record of salt weathering. Whether the shells he saw were carried there by humans and were historic or prehistoric shell middens is not made clear but does seem possible.

In addition to Herodotus, many other scholars have engaged in speculation about the Nile (see reviews by Harrington, 1967 and Biswas, 1970). For example, Aristotle (384–322 BC) and Eratosthenes of Alexandria (276–194/192 BC) correctly attributed the Nile summer floods in Egypt to seasonal rainfall in the Nile headwaters (wherever those headwaters might be). Eratosthenes was to use the length of the sun's midday shadow at two widely separated locations (Alexandria and modern Aswan) on the Nile of known distance apart to calculate the circumference of the earth, which he did with astonishing accuracy. Leonardo da Vinci (1452–1519 AD) considered that the Nile headwaters flowed from the Mountains of the Moon into three great lakes located at an elevation of about 2,000 m. This conjecture seems remarkably accurate as far as the Ugandan headwaters of the White Nile are concerned. In 1613 the Portuguese Jesuit Pedro Paez described the source of the Blue Nile upstream from Lake Tana in Ethiopia, a discovery scoffed at by the great Scottish explorer James Bruce of Kinnaird (Bruce, 1790) but confirmed a hundred years later by the Portuguese Jesuit Hieronimo Lobo, who stated unequivocally that the floods in Egypt were a result of rainfall in Ethiopia (Moorehead, 1972; Rzóska, 1976).

1.3 Unique Attributes of the Nile

The Nile spans 35° of latitude (3°S to 32°N). As a result, the Nile Basin (Fig. 1.1) embraces a very wide range of climates (equatorial, monsoonal, seasonally wet tropical, semi-arid, arid, hyper-arid, Mediterranean), equivalent to a Southern Hemisphere climatic transect from equatorial Indonesia and Papua New Guinea to the winter rainfall regions of southern Australia. Roughly a third of the Nile Basin (1,070,000 km^2) is presently devoid of perennial rivers (Woodward et al., 2015a). The White Nile provides much of the low season flow to the Nile but very little sediment. The Blue Nile and Atbara together provide most of the flood flow and much of the sediment. There could hardly be a greater contrast than that between the Blue Nile and the White Nile. This distinction was pithily (and feelingly) encapsulated by Sir Samuel Baker (1866), who described the Blue Nile as 'a mountain stream, rising and falling rapidly' while the sluggish White Nile flowed through 'a land of malaria, marshes, mosquitoes, misery'.

1.4 Aims and Structure of This Volume

As the title of this volume indicates, the primary aim of this work is to review what is currently known about the Quaternary geology, geomorphology and prehistoric environments of the Nile Basin. The geographical focus will be the Nile Basin, but wherever relevant we will also discuss the evidence from adjoining regions such as the Sahara and Middle East, and most especially the eastern Mediterranean. Chapter 2 sets the scene with a concise overview of the evolution of the Nile Basin. This is followed in the next three chapters with succinct accounts of the climate and hydrology of the Nile Basin, including historic floods and droughts (Chapter 3), its geology and soils (Chapter 4) and its vegetation and current land use (Chapter 5), including the thorny problem of flood control, dams, reservoirs and disease. Figure 1.2 shows the geographical location of each regional chapter.

Cambridge University Press
978-1-107-17919-6 — The Nile Basin
Martin Williams
Excerpt
More Information

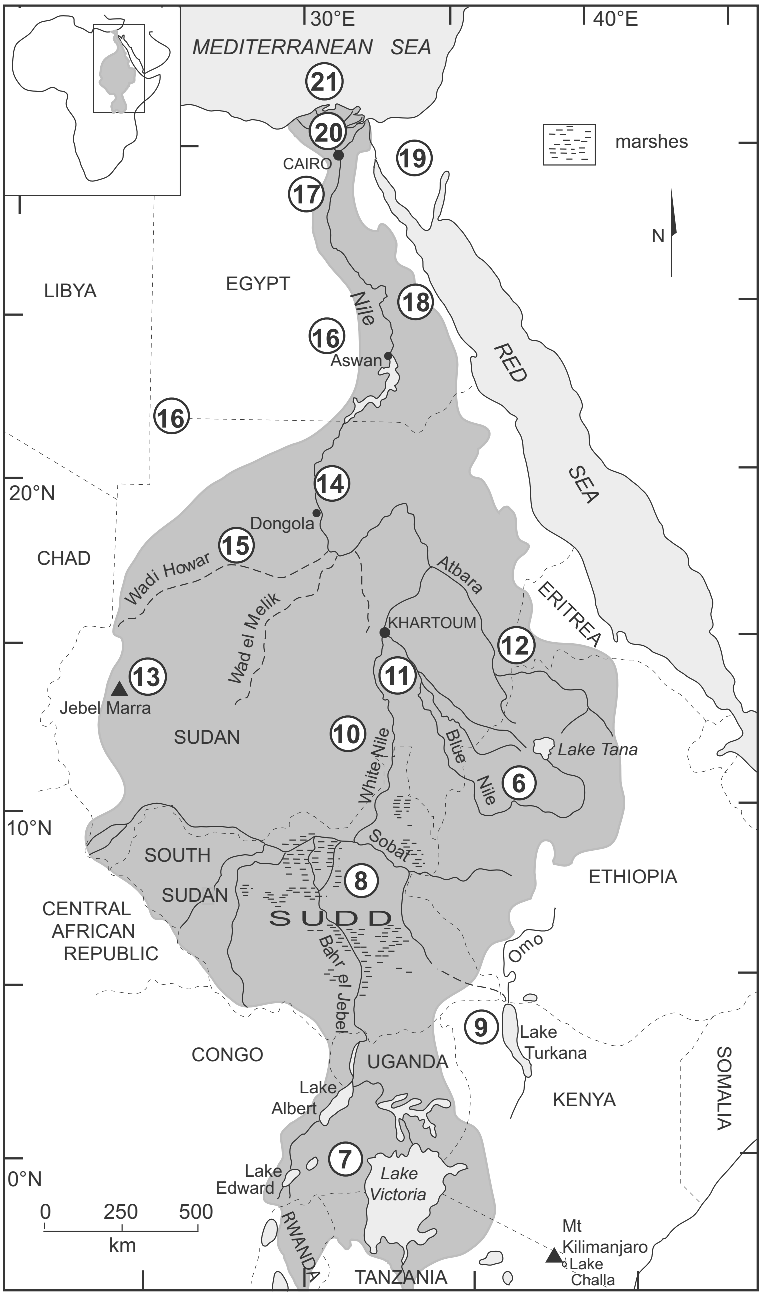

Figure 1.2 Location of the regional chapters.

The physical regions within the Nile Basin are considered in some detail in Chapters 6 to 20, proceeding from the headwaters of the Blue and White Nile (Chapters 6 and 7), along the White Nile (Chapter 8) and its tributaries (Chapters 9 and 10) to the lower Blue Nile (Chapter 11) and the Atbara River (Chapter 12). We then discuss the western borders of the Nile Basin, visiting Jebel Marra volcano and its environs (Chapter 13) as well as the now defunct river systems of Wadi Howar, Wad el Melik and Wadi Muqadam. Given their very great importance in prehistory, four presently arid regions are reviewed in some detail: Nubia, the Butana Desert and the Desert Nile in Egypt (Chapter 14) and the Western Desert of Egypt (Chapters 15 and 16) and the Fayum (Chapter 17). Equally significant in prehistory are the Red Sea Hills (Chapter 18) and the Sinai Desert (Chapter 19). A recurrent theme in all of the chapters mentioned so far is the persistent and complex set of interactions between river and desert in prehistory.

Chapters 20 and 21 discuss the Nile Delta and the Nile Cone, respectively. The evidence from sediment cores from both the Delta and the submarine Nile Cone provides a wealth of information about past changes in Nile sediment flux, river discharge and changes in Nile sediment sources. Chapter 22 discusses the complex question of plant and animal domestication in the Nile Basin and reviews some of the models that have been proposed to account for the origin and spread of plant and animal domestication across the Nile Basin. The final chapter (Chapters 23) concludes with an attempt to unravel the nature and timing of prehistoric migrations to and from the Nile Basin and the various ‘Out of Africa’ scenarios that have been proposed.

2

Evolution of the Nile Basin

> The Soudan is joined to Egypt by the Nile, as a diver is connected with the surface by his air pipe. Without it there is only suffocation. Aut Nilus, aut nihil!
>
> *Winston S. Churchill (1874–1965),* The River War *(1899)*

2.1 Introduction: How Old Is the Nile?

Churchill's play on words *aut Nilus, aut nihil* is a whimsical corruption of the old Latin tag *aut Caesar, aut nihil*, and may be rendered very roughly as 'without the Nile there would be nothing'. It is a succinct epigram designed to underscore the importance of the Nile River to the lands through which it flows. We return to this theme in Chapters 3 to 5.

The aim of this chapter is to provide a concise overview of the evolution of the Nile Basin in order to set the scene for Chapters 6 to 21. Talbot and Williams (2009) have pointed out that 'the Cenozoic evolution of the Nile Basin reflects a complex interaction between tectonic, volcanic and climatic events' (p. 37). As we shall see, it is not possible to have a clear appreciation of Nile history without first understanding the tectonic and volcanic events that have shaped the Nile Basin and that have in their turn influenced the climatic and hydrologic history of the Nile and its tributaries. The White Nile joined the main Nile only comparatively recently in geological terms, most likely no earlier than about 0.5 Ma ago (Talbot and Williams, 2009). In contrast, the inception of the Blue Nile and Tekezze/Atbara Rivers goes back to almost 30 Ma ago (Pik et al., 2008; Fielding et al., 2016, 2018), following the final eruption of the Trap Series basalts in Ethiopia and the associated uplift of what became the Ethiopian Highlands (see Chapter 6). Erosion into and through the basalts has removed roughly 100,000 ± 50,000 km^3 of rock from the headwaters of the Blue Nile and Tekezze/Atbara Rivers (McDougall et al., 1975), creating huge gorges in which we see exposed the Precambrian bedrock. The volume of the Nile Cone is the same order of magnitude as the volume of rock eroded from Ethiopia, providing initial circumstantial evidence that the main Nile may well have been connected, at least intermittently, with its Ethiopian headwaters since Oligocene times some 30 Ma ago (McDougall et al., 1975; Williams and Williams, 1980). More recent work has confirmed that the Nile Cone has been in receipt of sediment from the Ethiopian Highlands for at least 30 million years (Fielding et al., 2016, 2018), and that former rivers that eroded into the Red Sea Hills have also contributed significantly to the amount of sediment deposited in the Nile Cone (Macgregor, 2012).

During the Messinian Salinity Crisis (Hsü et al., 1977; Hsü, 1983), now precisely dated to between 5.96 Ma and 5.33 Ma (Cosentino et al., 2013), the Mediterranean dried out and refilled perhaps a dozen times and up to 1 km of halite and other evaporites accumulated on the floor of what became the Mediterranean salt desert (Hsü et al., 1977). During times of peak desiccation, the base level of the late Miocene Nile was lowered to the floor of this salt desert and the ancestral Nile eroded vertically to depths of –2.5 km north of Cairo, –0.8 km at Assiut and –170 m at Aswan, located some 1,200 km upstream of the present Delta (Chumakov, 1967; Said, 1993, p. 38). Said (1993) called this late Miocene Nile canyon the 'Eonile' canyon. This canyon became an estuary during the Pliocene and eventually filled with sediment, some of which came from the Nile and some from previously active rivers flowing westwards from the Red Sea Hills and eastwards from the presently arid Western Desert of Egypt. These rivers seldom flow today. Said (1993, p. 39) referred to the Nile River that flowed into the estuary and eventually succeeded it as the 'Paleonile'.

2.2 Ethiopian Uplift and Volcanism

Over the past fifty years and more, many geologists have worked to establish a detailed chronology of the Ethiopian Trap Series basalts (Merla, 1963; Mohr, 1968; McDougall et al., 1975; Hofmann et al., 1997; Chorowicz, 2005; Pik et al., 2003, 2008; Gani et al., 2007; Prave et al., 2016). The Trap Series were erupted over a prolonged interval between 45 and 15 Ma but the bulk of the eruption took place between 31 and 29 Ma. Hofmann et al. (1997) considered that eruption of the Trap Series basalts had occurred about 30 Ma ago and was largely accomplished within about a million years. The apatite helium ages obtained by Pik et al. (2003, 2008) to test models of landscape evolution in Ethiopia revealed that there had been a partial resetting of pre-existing basement rock ages because of burial of the basement rocks beneath a thick cover of Trap Series flood basalts roughly 30 Ma ago. From this they concluded that erosion of the Blue Nile gorge was underway as early as 29–25 Ma ago, vindicating the earlier conclusions of McDougall et al. (1975).

Chorowicz (2005) proposed that a mantle plume began to form 30 Ma ago in the region around present-day Lake Tana (Fig. 2.1), resulting in domed uplift and faulting in three main directions that converged on the present lake. More recent work by Prave et al. (2016) has confirmed that the uppermost basalts in the uplands around Lake Tana date back to about 30 Ma, but these authors also consider that there had been a super-eruption and that a very large volcanic caldera formed in the region now partially occupied by Lake Tana.

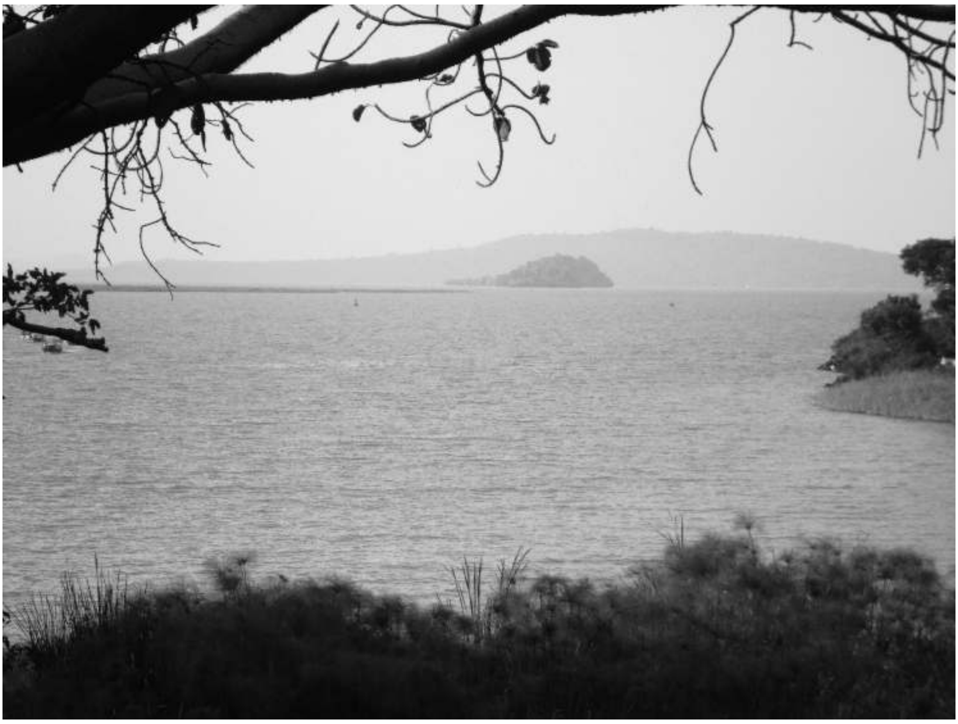

Figure 2.1 Lake Tana, Ethiopia. (Photo: Frances Williams.)

Figure 2.2 The Blue Nile Tisisat Falls downstream of Lake Tana, Ethiopia.