The Angolan Catchments of Northern Botswana's Major Rivers: The Cubango, Cuito, Cuando and Zambezi Rivers

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2 The Angolan Catchments of Northern Botswana's Major Rivers: The Cubango, Cuito, Cuando and Zambezi Rivers

John Mendelsohn

Abstract

Other than modest amounts of local rainfall, all other surface water in northern Botswana comes from river catchments in Angola, and to a lesser degree from north-western Zambia. The four major river systems that supply water to Botswana are the Cubango and Cuito (which jointly supply the Okavango Delta), the Cuando (which provides the water of the Linyanti Swamps and Savuti Channel) and the Zambezi (which fills the Chobe river). The catchments lie either on shallow soils (much of the Cubango catchment and the eastern upper catchment of the Zambezi), or on deep sands (all of the Cuito and Cuando, part of the Cubango, and much of the Western Zambezi catchment). River discharges following rain from the former are relatively rapid, reaching northern Botswana towards the end of the rains. Those from catchments of deep sand are extremely slow, arriving in Botswana later during the dry months.

Keywords

Okavango • Cubango • Cuito • Cuando • Zambezi

2.1 Introduction

Much of the surface water, wildlife and economic production in northern Botswana is a direct or indirect product of river water from catchments that are spread across central and eastern Angola. The water is delivered by rivers from four sub-catchments (Fig. 2.1): the Cubango (also called the Okavango or Kavango) and Cuito rivers into the Okavango Delta; the Cuando river (also known as Kwando or Mashi) into the Linyanti Swamps; and the Zambezi river into the Chobe river. The catchments of the Cubango, Cuito and Cuando lie entirely in Angola, while the catchment of the Zambezi is split between Angola and Zambia. Strong flows into the Okavango Delta may continue further down the Boteti river and into the Lake Xau. Likewise, high flows reaching the Linyanti Swamps may flow into the Savuti Channel and Mababe Depression.

Much of the highland catchment consists of thick layers of aeolian Kalahari sands which hold and then gradually release water, rather like a gigantic sponge. This controls the quality, volume and seasonality of water that flows to Botswana. Parts of the upper catchments also lie on the Bié or Central Angolan Plateau.

Topographically, south-eastern Angola drops gradually from the highest elevations in the north (above 1,500 masl) to the lowest areas along the Namibian border, which are about 1,000 masl. The terrain is hilliest in the northern areas, particularly in the headwaters of the Cuito, Cuando and Lungue-Bungo of the Western Zambezi, while the southern parts of the catchments are extremely flat. The origin of the high topography (1,500–1,850 masl) of the Bié or Central Angolan Plateau is not clear (R. Swart pers. comm.).

The four rivers run south off the Great Equatorial Divide, a watershed running across Angola from east to west (Fig. 2.2). Major rivers flowing northwards off the Divide include the Casai (or Kasai), the Cuanza and the Queve.

The upper and lower catchments of the Cubango, Cuito and Cuando separate northern areas that are steeper and more elevated (see Fig. 2.1) with surface flows that are more permanent, from the lower areas that are much flatter, with more ephemeral tributaries. The Western Zambezi catchment is likewise a hilly upland, while the Bulozi floodplain is flat.

Annual average rainfall in the upper catchments ranges between about 800 mm in the south and 1,200 mm in the north of the Zambezi catchment and 1,300 mm in the north of the Cubango catchment (Mendelsohn and Martins 2018). Almost all rain falls between early October and late April. Rainfall along the Namibian border in the south of the lower

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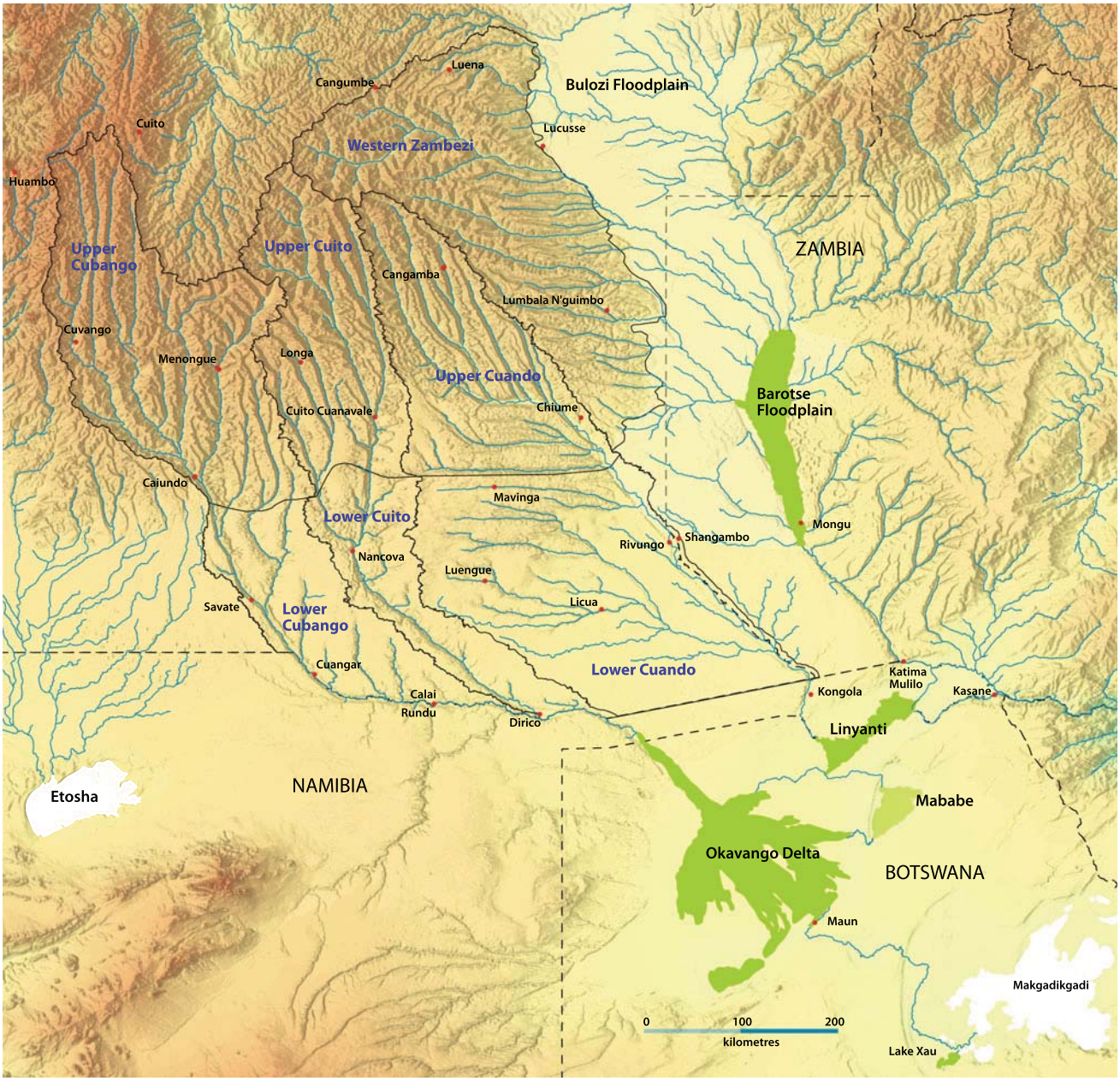

Fig. 2.1 Elevations and major catchment areas in Angola, and the major wetlands fed by rivers flowing off the central and eastern highlands. Elevation data from NASA SRTM (90 m)

catchments varies between 500 and 650 mm/year. Most flows of water into Botswana therefore come from the upper catchments, while limited supplementary flows from the lower catchments occur only during extremely wet periods.

The complementary functioning of these rivers and catchments is considerable. For example, the Western Zambezi in Angola produces a steady flow of water, while river discharges from the Bulozi and Zambian zone to the east are more episodic and variable. How these complementary flows support downstream wetlands—such as the Barotse floodplains—remains to be understood. The complementary nature of the Cubango and Cuito rivers in supplying water to the Okavango Delta is described below.

2.2 Gradients

The profiles of the Cuito and Cuando rivers are similar (Fig. 2.3). They and their respective upstream sister rivers—the Cuanavale and Kembo—flow in parallel from comparable elevations and over similar gradients until they merge. Within approximately 300 kms of their sources, the Cuito

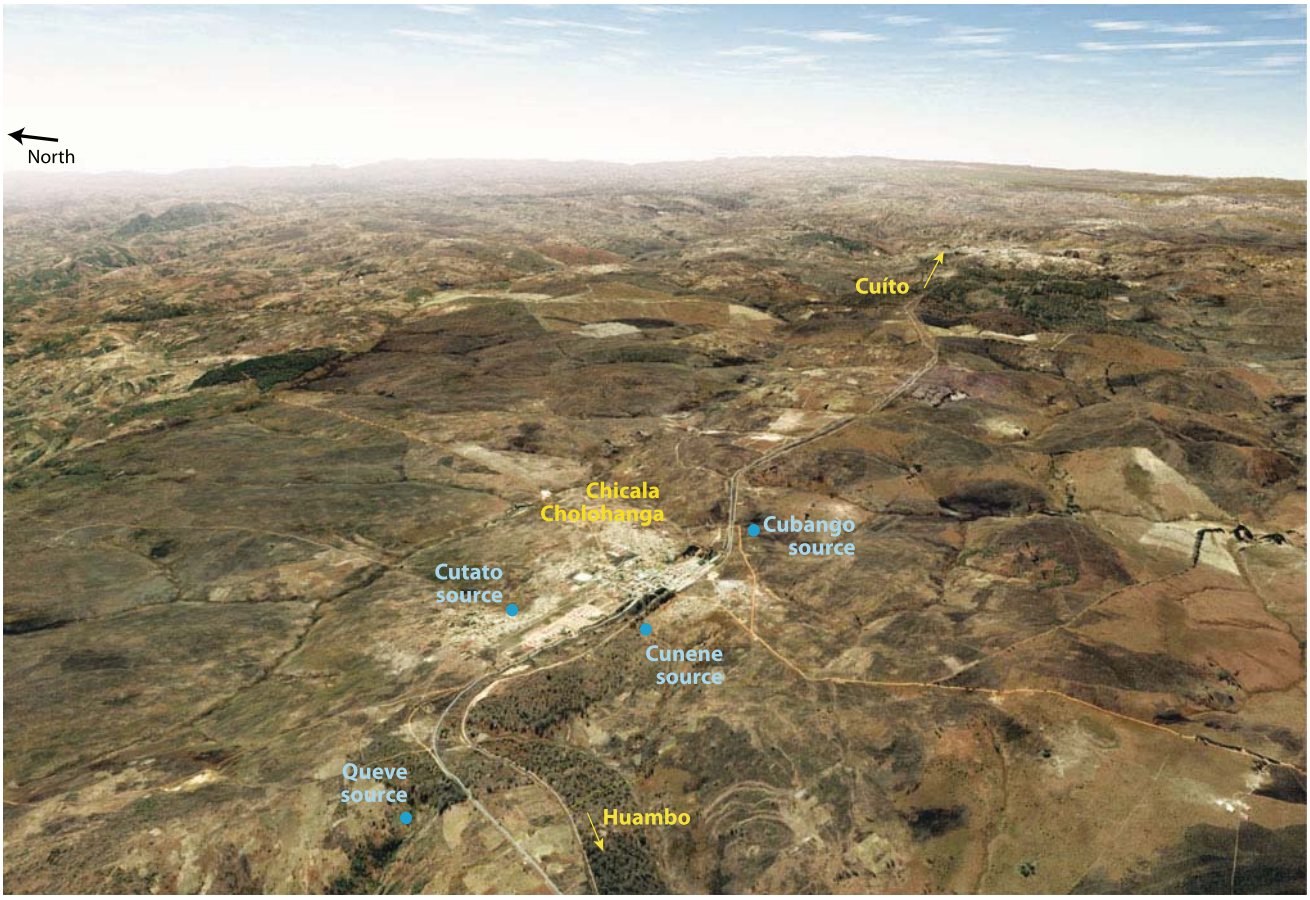

Fig. 2.2 A major road and the railway line (the Caminho de Ferro de Benguela) run across Angola from Benguela on the Atlantic to Luau in the far east. Both the road and the railway line follow the Great Equatorial Divide. This watershed separates rivers flowing north and south in Angola, including those that are the focus of this review. The small town of Chicala Cholohanga is on a gentle hill on this watershed. Within a few hundred metres of the town centre are the sources of two rivers flowing south—the Cunene and Cubango—and two that flow north—the Queve and Cutato (Microsoft Bing Maps Image rendered by RAISON)

and Cuando drop about 210 and 250 m, respectively. In contrast, the Cubango and its associated parallel rivers (the Cuchi and Cutato Nganguela) drop about 400 m over their *first* 300 kms.

The Cubango, Cuito and Cuando then flatten out, and their flows slow over the lower gradients. Thus, in their *last* 300 kms before reaching the southern border of Angola, the Cubango falls about 100 m, the Cuito 90 m and the Cuando only 70 m. As the most sluggish of the three, the Cuando, therefore, drops just 23 cm per kilometre, or 0.23 mm per metre.

2.3 Soils

The highlands are one fundamental feature of the catchments. Another is the expanse of unconsolidated Arenosol sands and Ferralsols which make up 73% and 24% of the area, respectively (Fig. 2.4). These soils have several impacts on the geography of the catchments. First, the broad ridge—or water tower—of sandy, permeable and deep soils functions as a sponge, slowly releasing water to provide steady flows into the major rivers. Perhaps it also stores vast volumes of water in deep aquifers, such as in the newly discovered aquifer in the Cuvelai (www.bgr.bund.de/EN/Themen/Wasser/Projekte/laufend/TZ/Namibia/ceb_fb_en.html).

Second, the soils have extremely few plant nutrients and little water-holding capacity (Asanzi et al. 2006; Ucuassapi & Dias 2006; Wallenfang et al. 2015). Thus, most catchment areas have poor agricultural potential, yields of staple cereals and manioc being among the lowest in Africa (https://datamarket.com). As a result, relatively few people live in this part of Angola. Of those living here, the majority reside in towns that provide other economic opportunities.

Third, soils in areas with the highest rainfall are generally less fertile than the same soils in drier areas, a probable result of most nutrients being leached by rain or absorbed and bound up in luxuriant vegetation growing in high rainfall areas.

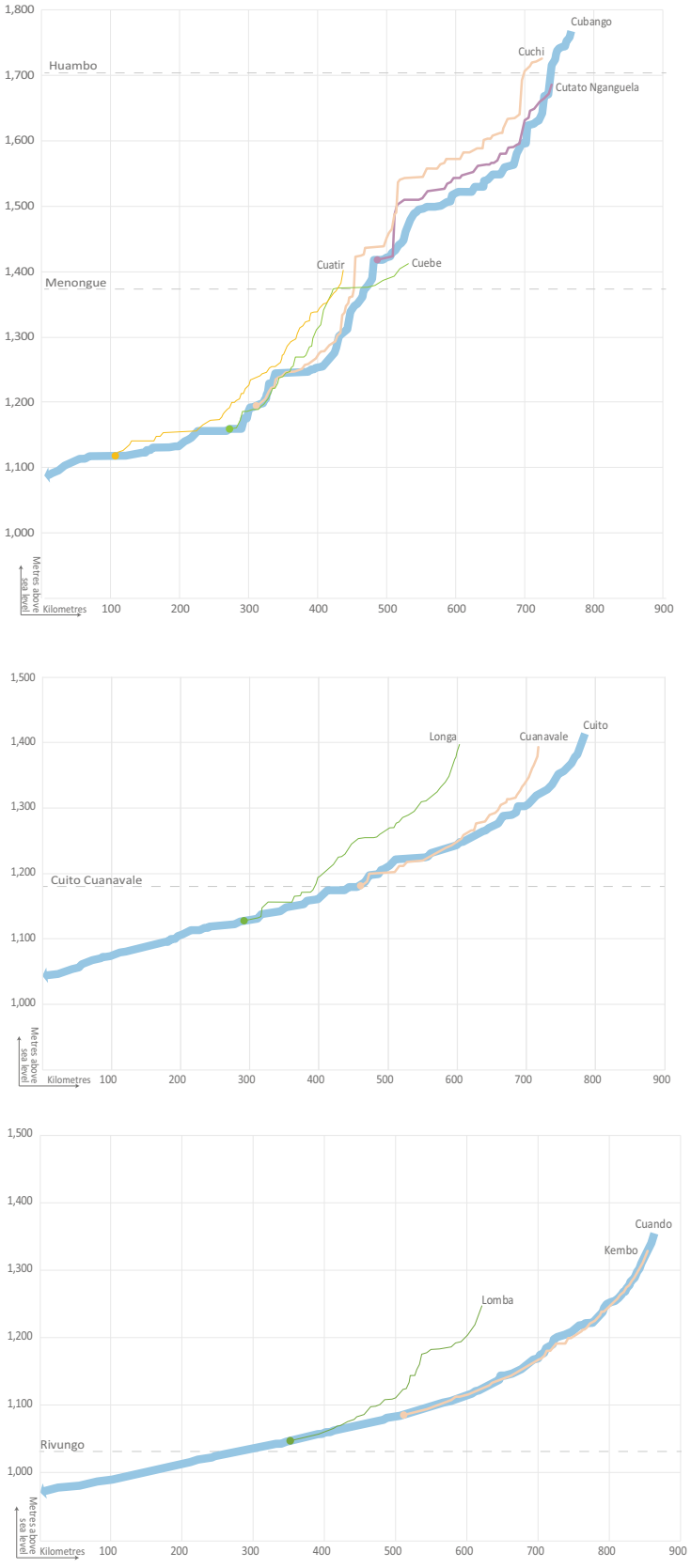

Fig. 2.3 Elevational profiles of rivers of the Cubango, Cuito and Cuando systems running from their sources on the right to the southern border of Angola. The x-axis is the distance from the Angola border to the sources, while the y-axis is the elevation in metres above sea level

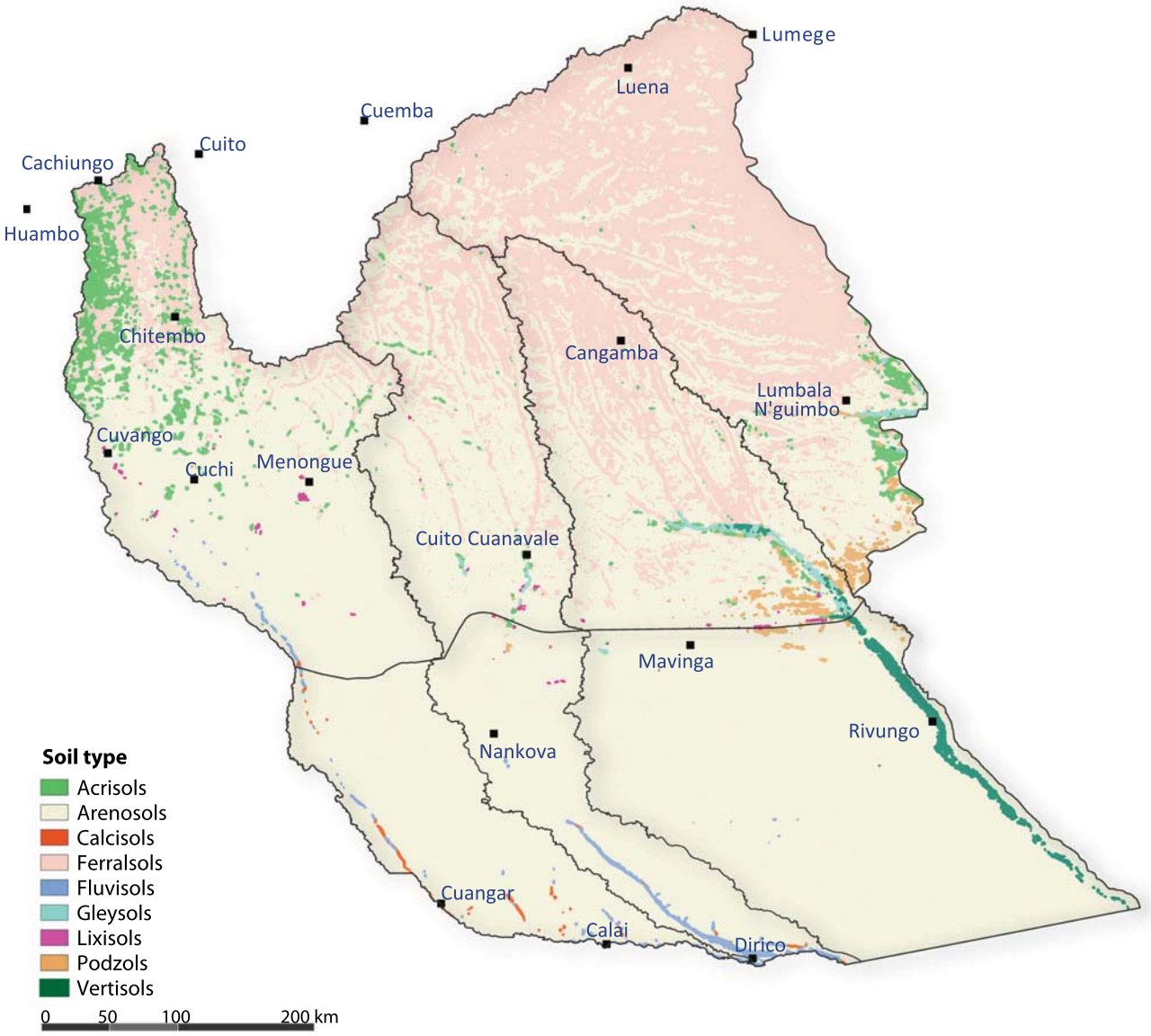

Fig. 2.4 The distribution of soils in the catchments of south-eastern Angola. Although soils in the upper catchments of the Cuito, Cuando and Western Zambezi are classified in the ISRIC data set as Ferralsols, they are more likely to be Ferralic Arenosols. (*Source* International Soil Reference and Information Centre (ISRIC) https://soilgrids.org)

Fourth, there is little erosion, particularly over the vast, flatter areas of sandy arenosols.

Fifth, as a result of the limited erosion and seepage of groundwater filtered by the sandy soils, most river water is extremely clear and free of dissolved minerals and suspended solids (NGOWP 2020a, b; von Brandis and Boyes 2017; Mendelsohn and Martins 2018). This is especially true of the relatively acidic water seeping out of arenosol sands.

Sixth, due to winds prevailing from the east, soils on the western sides of rivers are generally more fertile than those to the east. The easterly winds carry fine alluvial silts from the rivers and their floodplains, when these are dry, to deposit the fine sediments in the west. Here they mix with sand, forming soil that is more fertile and loamy. Most people therefore live and farm to the west. This is also where most roads run, and where the natural vegetation is normally more luxuriant than east of the rivers.

Substantial beds of peat fill the low-lying centres of many river valleys, especially those that meander across broad, sandy landscapes, and particularly those in the broad Cuando river valley. The depth and value of the peat remain unknown (the Vertisols shown in Fig. 2.4 are most likely peat).

A characteristic feature of the sandy upper catchments of the Cuito, Cuando and Western Zambezi is the presence of numerous headless valleys shaped as amphitheatres. These range in size from a few hundreds of metres to over 10 kms wide

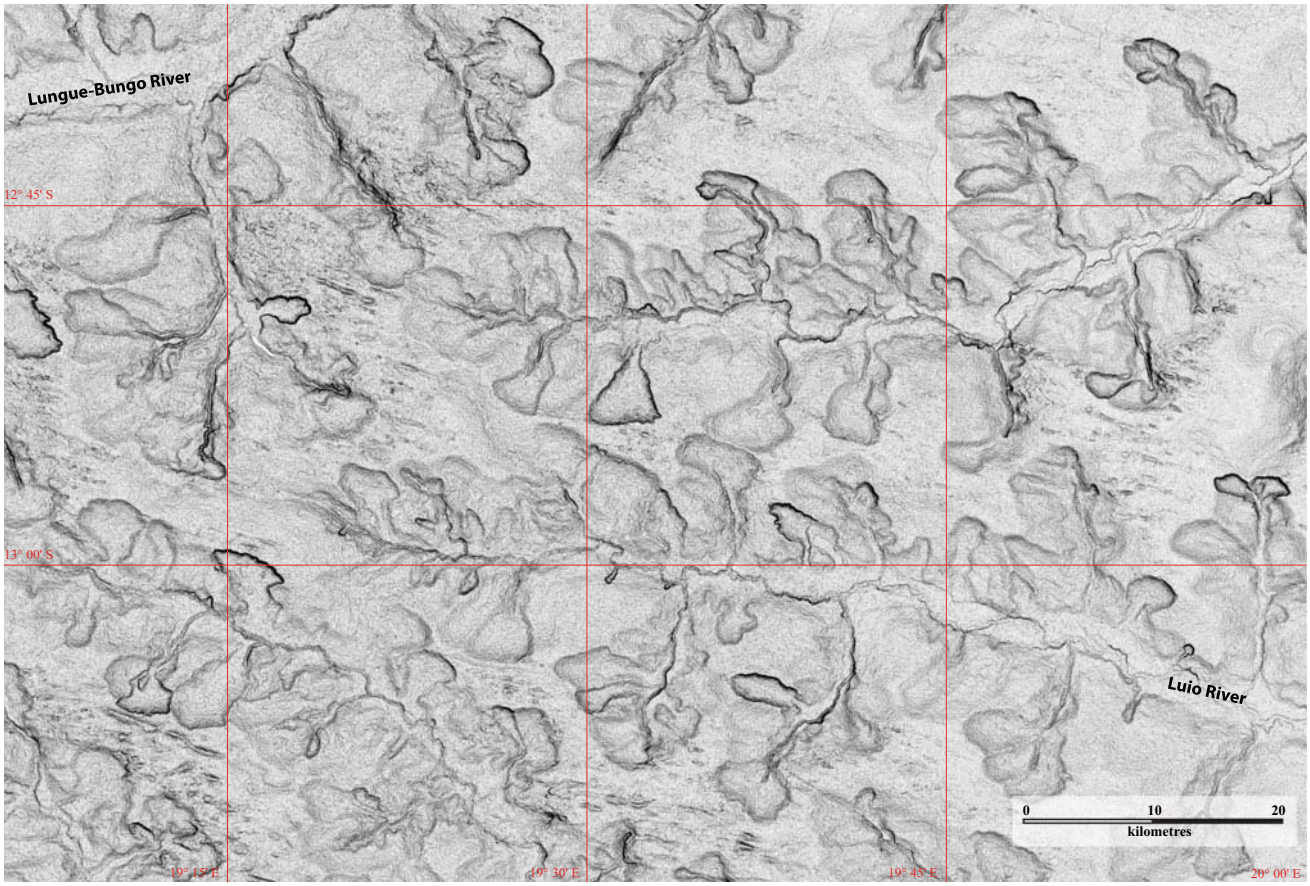

Fig. 2.5 Shaded SRTM elevations showing amphitheatre valleys along the Lungue-Bungo and Luio rivers

and up to 100 m deep (Fig. 2.5). In any one area, many of these features may be of a similar size and shape suggesting that they formed at the same time and by similar processes (R. Swart pers. comm.). Most are now vegetated and perhaps relatively inactive, but a small number are active (e.g., at Lake Tchanssengwe (18.64 East, 12.42 South); at 19.32 East, 11.80 South; and at 18.99 East, 12.22 South; and in the city of Luena (Fig. 2.6)). The amphitheatres probably form where impermeable layers force water to flow horizontally and out of the ground, which may cause unconsolidated sands on slopes to slump.

2.4 Water Chemistry

A fundamental feature of water in the four catchments is its extreme clarity (Fig. 2.7) due to low concentrations of suspended solids. Water draining the catchments of deep sands have the greatest clarity, while water in the upper Cubango is often more opaque. All the rivers become somewhat murky once the first summer rains carry ash from the many bush fires into the river water. The fires are widespread and frequent across south-eastern Angola (Stellmes et al. 2013; Mendelsohn and Martins 2018).

Expeditions of the National Geographic Okavango Wilderness Project (NGOWP) collected water quality measurements at daily stops from May to June 2017 on the Cubango river, and May to July 2018 on the Cuando river (NGOWP 2020a, b). In addition, measurements were taken in May 2018 in lakes at the sources of the Cuito and Cuanavale rivers (von Brandis and Boyes 2017).

Total dissolved solids (TDS), salinity and conductivity are similar parameters of water quality, largely measuring the dissolved salt or ion content of water. Unsurprisingly, the three measures varied in similar ways along the Cuando. The lowest levels were close to the sources of the Cuando and Kembo (a major tributary nearby (Fig. 2.16)), while the highest values were downstream in the lower catchment area of the Cuando and close to Zambia. Similar trends were observed along the Cubango, but with two exceptions. First, levels of salts and dissolved solids between the uppermost and middle reaches of the river rose more rapidly than along the Cuando. Second, levels also declined somewhat in the middle reaches south of Cuvango town, perhaps because of the diluting effects of water added by the Cacuchi, Cuelei, Cuebe and Cuatir rivers. These four rivers drain large areas of sandy substrates (like those of the Cuando and Cuito) and

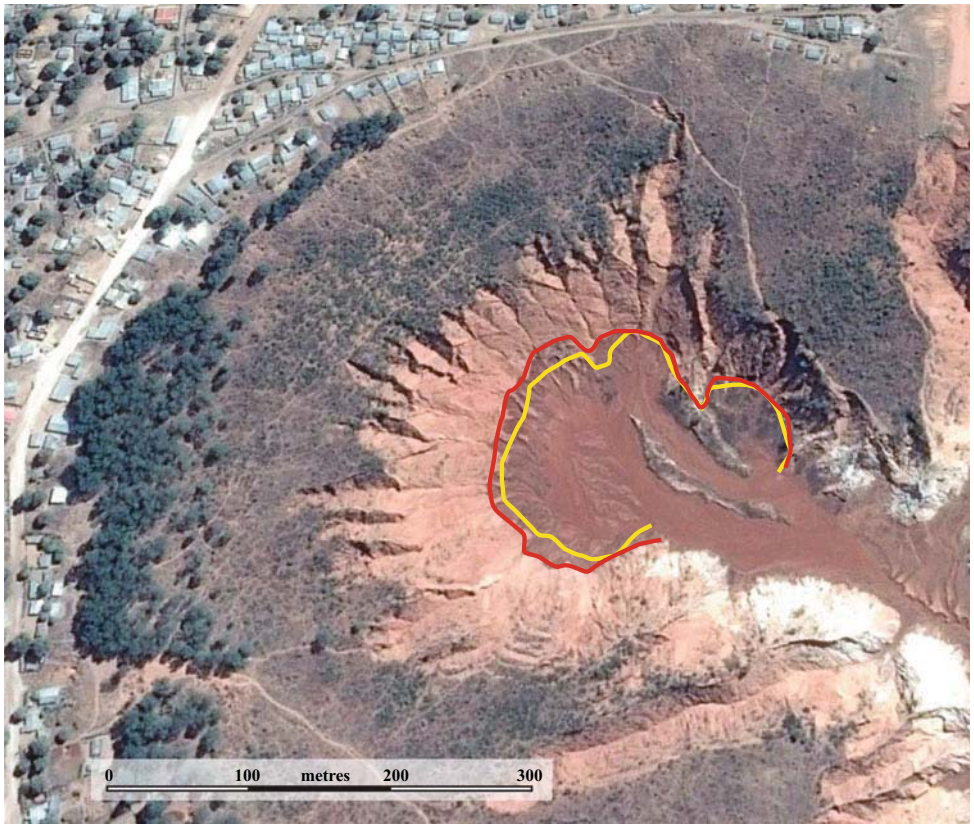

Fig. 2.6 Amphitheatre valley at Luena (19.93 East, 11.78 South). The image was taken in July 2013. The red line marks the top of the dark, saturated zone of sand in July 2013, while the yellow line is the top of the saturated zone 4 m lower in September 2011. The saturated zone lies about 60 m below the surrounding plateau. Image from Google Earth

Fig. 2.7 Meander along the Cuito river near the town of Rito. Note the clear water, white sands and dry woodland above the under-cut river bank (Photograph: Helge Denker)

their waters are thus also likely to carry fewer salts and dissolved solids.

Even the higher values of salinity recorded in these waters are low. For example, they are about 1,500 times lower than in sea water, much lower than those in most fresh waters, and indeed comparable to those found in purified water.

Oxygen saturation levels were found to vary little along the Cubango, generally exceeding 90%. In contrast, there were major fluctuations along the Cuando and Kembo. Low saturation levels were measured close to the sources, but down the river, percentages rose rapidly to above 90% before progressively dropping again to less than 70% along

parts of the river dominated by broad floodplains of phragmites reeds. Why oxygen levels should rise and fall so much along the Cuando's rivers is not clear.

Soils in the headwaters of the Cuando (and doubtless the Cuito, Zambezi and even the Cuebe, Cuelei and Cuatir) are acidic with low base cation contents, as is true for rivers in most parts of south-eastern Angola. In contrast, water in the upper Cubango (at least north of Cuvango town) was only marginally acidic (NGOWP 2020a).

2.5 Rivers of Northern Botswana

2.5.1 Cubango River

The Cubango catchment is divided between two groups of rivers (Fig. 2.8). The first is to the west, and farthest north, from where the Cubango, Cutato Nganguela, Cuchi and Cacuchi rivers flow south in parallel. They originate from the highest elevations at about 1,700 masl (Fig. 2.3) from areas underlain by granitic, gneissic and meta-sedimentary sequences which were subsequently weathered into gently rolling hills (de Carvalho 1981; De Araújo and Guimarães 1992; McCourt et al. 2013). Most soils are derived either from these rocks—and are thus old, weathered and leached—or are more recent sandy sediments, likely of aeolian origin.

The four rivers have comparatively steep gradients, with flows that accelerate in places where the rivers tumble down rapids or small waterfalls (Fig. 2.9). Of these, the Cubango's flow is most even, generally following a straight course. However, the rivers meander through sizeable beds of phragmites reeds in places (Fig. 2.10) which are most extensive along the Cutato Nganguela and Cuchi. Observations suggest that the reeds may filter the water since both rivers appear murkier in their upper than their lower reaches. The extent to which they may reduce pollutants and nutrient levels in these rivers requires study.

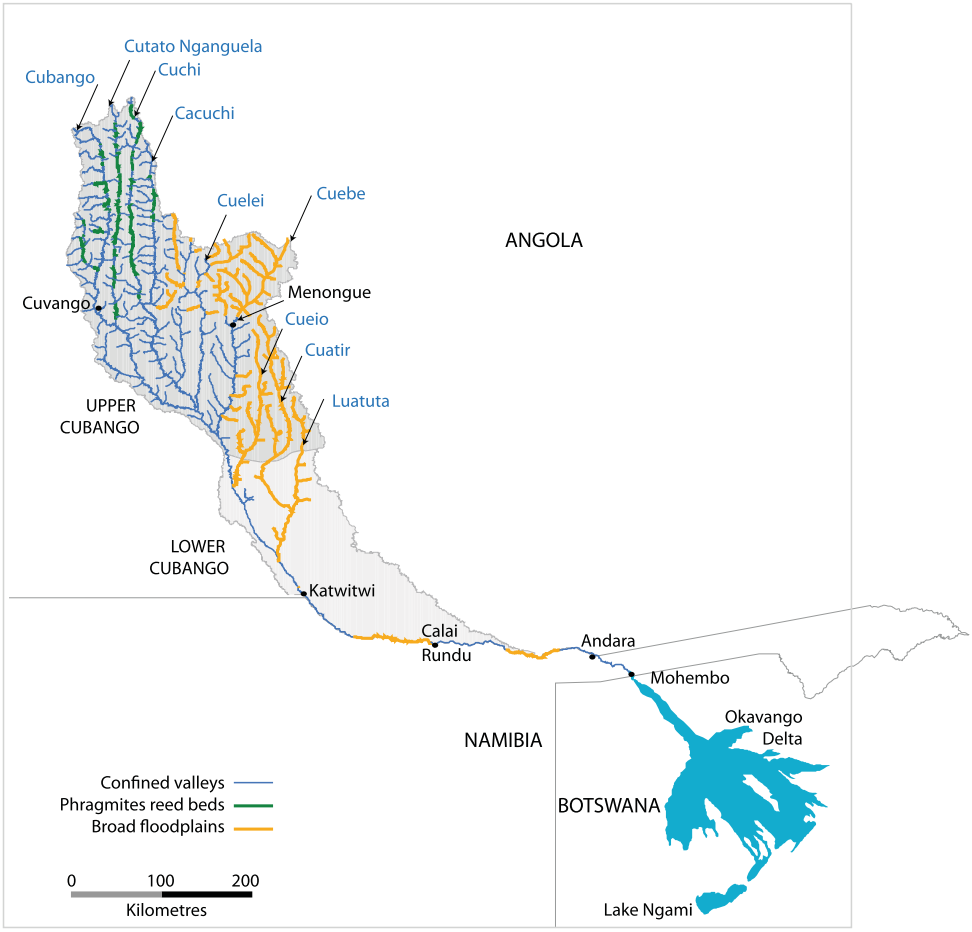

Fig. 2.8 Rivers of the Cubango catchment

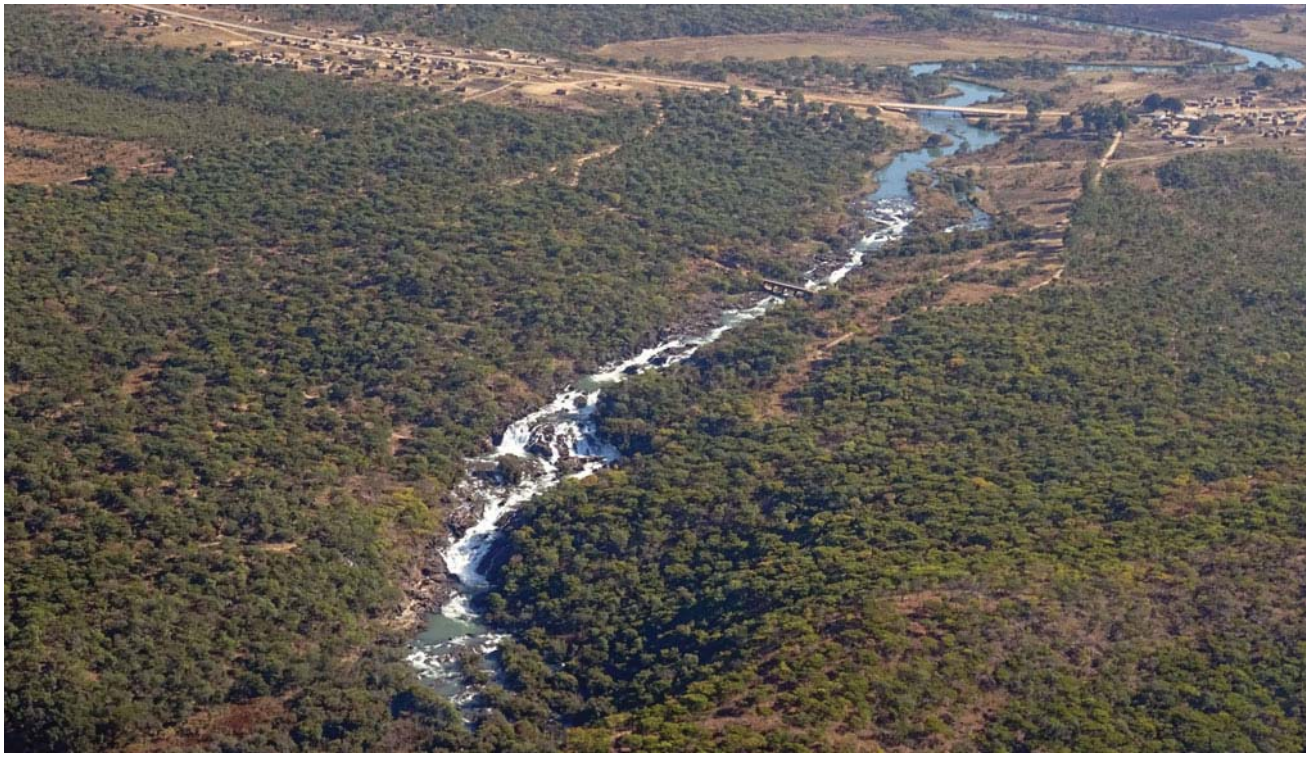

Fig. 2.9 Waterfall and rapids on the Cutato Nganguela river just downstream of the town of Cutato (Photograph: John Mendelsohn)

Fig. 2.10 Phragmites marshes, meanders and oxbows on the Cutato Nganguela river (Photograph: Helge Denker)

Fig. 2.11 Broad floodplains along the Cuebe river, with its very clear water. Brown areas close to the river are moist and peaty, while grey areas further away are drier grasslands. Miombo forest flanks the floodplains. Black fire scars and a cloud shadow are also visible (Photograph: John Mendelsohn)

The second group of rivers are to the east: the Cuelei, Cuebe, Cueio, Cuatir and Luatuta, shown in orange in Fig. 2.8. All five largely drain sandy substrates, and their courses are often flanked by broad floodplains of grasslands and some beds of peat close to the actual river lines (Fig. 2.11). Water flows are slower and seasonally more stable than those of the north-western group.

The two groups of rivers also provide complementary supplies of water. From the north-west, fast, episodic flows, probably with more minerals; and from the sandier eastern areas, cleaner, slower and more stable flows. Water leaving Angola in the Cubango in the rainy, summer months is likely dominated by discharges of the western group, while slower, later flows from the eastern group of rivers probably make up much of the water in the dry season.

On a larger scale, flows from the upper Cubango complement those from the Cuito in ways that add much value to the Okavango Delta, which broadly consists of three wetland environments: permanent swamps, seasonal floodplains and occasional floodplains. The permanent swamps provide stable habitats for plants and animals, which live there from year to year with little new production. The steady flows of the Cuito river do much to maintain these permanent waters and the life they support, especially in the dry season when the Cubango's levels are low. But it is following good rains in its upper catchment that the Cubango delivers pulses of floodwaters which trigger flourishes of production in the Delta's seasonal and occasional floodplains. Plants germinate and grow, the dormant eggs of aquatic animals hatch, frogs emerge from beneath the ground, fish swim in to

spawn, birds arrive to feed and nest, and herbivorous mammals move into a feast, fatten and breed. It is indeed during these periodic floods that much of the Delta's rich biodiversity is produced (Cronberg et al. 1996; McCarthy et al. 2000; Hogberg et al. 2002; Krah et al. 2006; Lindholm et al. 2007; Mendelsohn et al. 2010). This abundance of life would not be generated in the absence of floodwaters coming from the western upper Cubango catchment. Arguably, this catchment is the most important supplier of productive water to the Okavango Delta.

2.5.2 Cuito River

The Cuito and Cuanavale's sources are around 1,400 masl (Fig. 2.3). The two rivers flow south in parallel to their confluence at the town of Cuito Cuanavale, which lies at 1,250 masl. From there, the Cuito continues southwards for 140 kms to Nankova where it is joined by the Longa, carrying water from the upstream Luassinga and Cuiriri rivers (Fig. 2.12). After Nankova, no regular or substantial tributaries flow into the Cuito. Close to Dirico, the Cuito river joins the Cubango on the Namibian border (Fig. 2.13).

The entire Cuito catchment is underlain by aeolian, highly permeable sands. Except for a few small waterfalls in the northern reaches of the Cuito and Cuanavale and close to the Namibian border, all its rivers meander across flat, grassy floodplains (Fig. 2.14). These are often underlain by peat close to the drainage courses. As elevations rise, swathes of grassland that extend away from the rivers become increasingly shrubby and woody, mainly with the so-called underground trees or geoxylic suffrutices (Zigelski et al. 2019). These grasslands are located mainly in the upper catchment and are probably maintained largely by frequent fires and hardpans or aquitards which keep the upper soil layers saturated during wet periods.

Fig. 2.12 Confluence of the Longa and Cuito Rivers near the town of Nankova (Photograph: Helge Denker)

Fig. 2.13 The upper and lower catchments of the Cuito river and its major tributaries

Six major source lakes have been identified in the uppermost catchment areas: the Cuito (Fig. 2.15), Cuanavale, Limpulo, Mbambi, Cunde and Calua lakes (Von Brandis and Boyes 2017) (Fig. 2.16).

2.5.3 Cuando River

The Cuando is the most undisturbed and enigmatic river in southern Africa, perhaps in all of Africa. Its lowest reaches straddle the Namibia/Botswana border where they form an inland delta (Nkasa Ruparo) and terminal swamp (Linyanti) which are major attractions to wildlife and tourists. Its active catchment lies entirely within Angola (because the Zambian border runs along the eastern edge of Cuando's floodplain). There are only four significant towns on the Cuando river: Cangamba, Cangombe and Rivungo in Angola, and Shangombo on the Zambian side opposite Rivungo. Lake Saliakembo (on the Kembo river) is the only major lake known in the upper Cuando. A substantial and recent compendium of information on the Cuando was compiled by the National Geographic Okavango Wilderness Project (2020b).

Perhaps the most unusual aspect of the Cuando is its structure and hydrological functioning. Average flow rates at Kongola (the only place where water flows are measured) are 33.9 cubic metres/second, equivalent to just over one billion cubic metres per year. No flows of any significance enter the Cuando below Kongola; thus all the water in the Cuando represented by these figures comes from Angola (Fig. 2.17).

Of all the rivers in Angola, the Cuando has the broadest floodplain, which is 5–15 km wide for much of its length, an expanse easily seen in satellite images (Fig. 2.18). The floodplain extends over about 3,450 km^2 from where it first widens in the north, approximately at the confluence of the Kembo and Cuando, to where it narrows sharply on Angola's southern border. Apart from its narrow channels of open water, the entire floodplain is covered in macrophytes of tall grasses, phragmites reeds and papyrus (which are seen only in limited patches on the Cubango and Cuito and the Barotse floodplain of the Zambezi). Where the substantial nutrient supplies needed to support thousands of square kilometres of macrophytes come from, is a puzzle, given that soils throughout the Cuando's catchment are so infertile. One possibility is that the nutrients were derived from basaltic rocks upstream along the Cuando, Kembo, Cubangui and Cussivi rivers where there are outcrops of Calondo metasediments. In northern Angola, these rocks are associated with rivers rich in alluvial diamonds which probably accompany nutrients from kimberlites. In addition, other rich sources of nutrients may lie west of the main Cuando, for example along the Cueio and Lomba rivers where there are alluvial diamonds which might also be derived from local kimberlites.

2.5.4 Zambezi River

Although the upper Zambezi is often assumed to be in Zambia, its western upper catchment in Angola is large and probably has significant impacts on the downstream functioning of the Zambezi. First, the sandy highlands of the Western Zambezi operate like a giant sponge that stores and gradually releases steady flows into its major rivers, such as the Luena, Lungue-Bungo and Luanguinga

Fig. 2.14 The confluence of the Cuito and Cubango rivers on the border between Angola and Namibia. The sluggish, meandering Cuito is flanked by multiple scroll bars and oxbows, unlike the Cubango with its faster, more direct flow (image from Microsoft Bing Maps Imagery Services)

(Figs. 2.19 and 2.20) that later feed the Zambezi. It is not known how much water these rivers contribute to the upper Zambezi, but the flows may be significant, especially in the dry season when water from Angola may do much to support perennial wetlands along the Zambezi, such as the Barotse floodplains. Three source lakes have been identified in the Western Zambezi catchment: Lakes Tchanssengwe, Dala and Sapua.

The second feature is the contribution of the Western Zambezi catchment to the seasonal inundation of the Bulozi floodplain (Fig. 2.21) when it becomes an enormous wetland and breeding ground for fish in the upper Zambezi. The

Fig. 2.15 The lake and source of the Cuito river. Most lakes in the catchments appear to form behind narrowed sections of the river valleys (Photograph: John Mendelsohn)

western rivers may also maintain year-round water levels in refugia for adult fish within this flat nutrient-rich expanse. The Bulozi floodplain is effectively the lower catchment of the Western Zambezi (Mendelsohn and Weber 2015; Zigelski et al. 2018).

2.6 Recharge and Discharge

Comparatively little is known about mechanisms of recharge and discharge in the catchments of all the rivers in south-east Angola. Water levels and flows have only been measured for any reasonable time at Rundu (for the Cubango), at Andara and Mohembo (for the Okavango/Cubango as it enters its Delta) and at Kongola (for the Cuando) in recent times. Because no tributaries join the Cubango downstream of Rundu or after its confluence with the Cuito, the Cuito's discharges can be estimated by subtracting measures at Andara/Mohembo from those at Rundu. To my knowledge, no flow measurements are available for the Zambezi's tributaries in Angola.

Rivers in the upper western Cubango catchment are recharged comparatively rapidly by rainfall because rock surfaces are exposed in places, and many soils are shallow and less permeable than in other sandier areas. These surges of water are also apparent from the large seasonal changes in discharges on the Cubango. Recharge is slower elsewhere where almost all rain sinks into the ground. How much rainwater emerges later as seepage into tributaries is unknown. Likewise, how long it takes rainwater to emerge as seepage is unknown, but this is certain to vary in relation to the depth and nature of sediments.

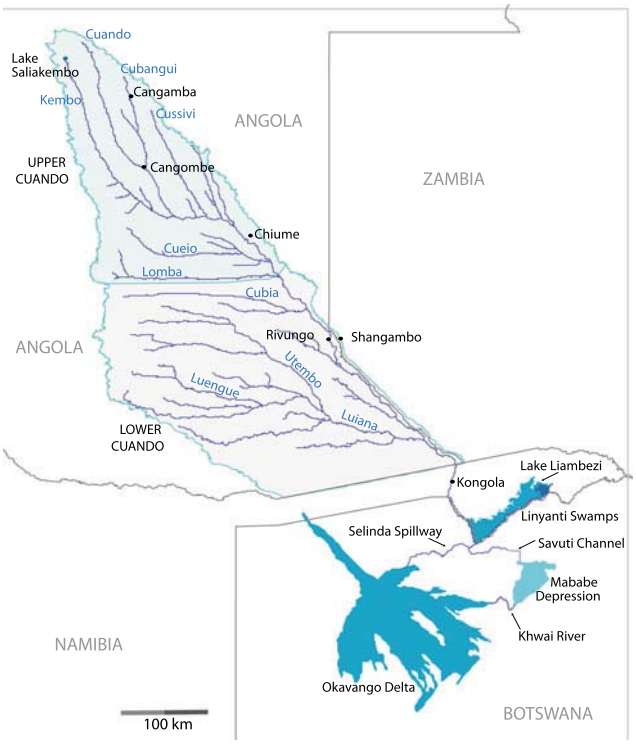

Fig. 2.16 Rivers and sub-catchments of the Cuando

There are major differences in the volumes and timing of discharge between the Cubango, Cuito and the Cuando. For example, the Cubango supplies about 55% of all the water flowing into the Okavango Delta, with the remaining 45% coming from the Cuito. However, these proportions vary during the year. Thus, the Cubango supplies about double the Cuito's volume water between January and June, whereas the reverse holds from July to December when the Cubango discharges are lowest and about half those of the Cuito (Mendelsohn et al. 2010).

The Cuito's annual discharge is almost four times higher than that of the Cuando's total of 1.068 billion cubic metres (Fig. 2.22). This is surprising because their catchments are similar in size and lie side by side, sharing apparently the same upper topography, soils, rainfall and geomorphology. However, they differ greatly in their lower catchment areas: the Cuito meanders across short grassy floodplains that are seldom wider than one or two kilometres, while the Cuando's meandering path is across a floodplain that is generally ten or more kilometres wide (Figs. 2.17 and 2.18). Moreover, the Cuando's floodplain supports vast areas of phragmites reeds, papyrus and tall grasses. Losses of water due to evaporation and transpiration from the Cuando must

Fig. 2.17 The Cuando river and its 10-km-wide floodplain near its confluence with the Lomba river (Photograph: John Mendelsohn)

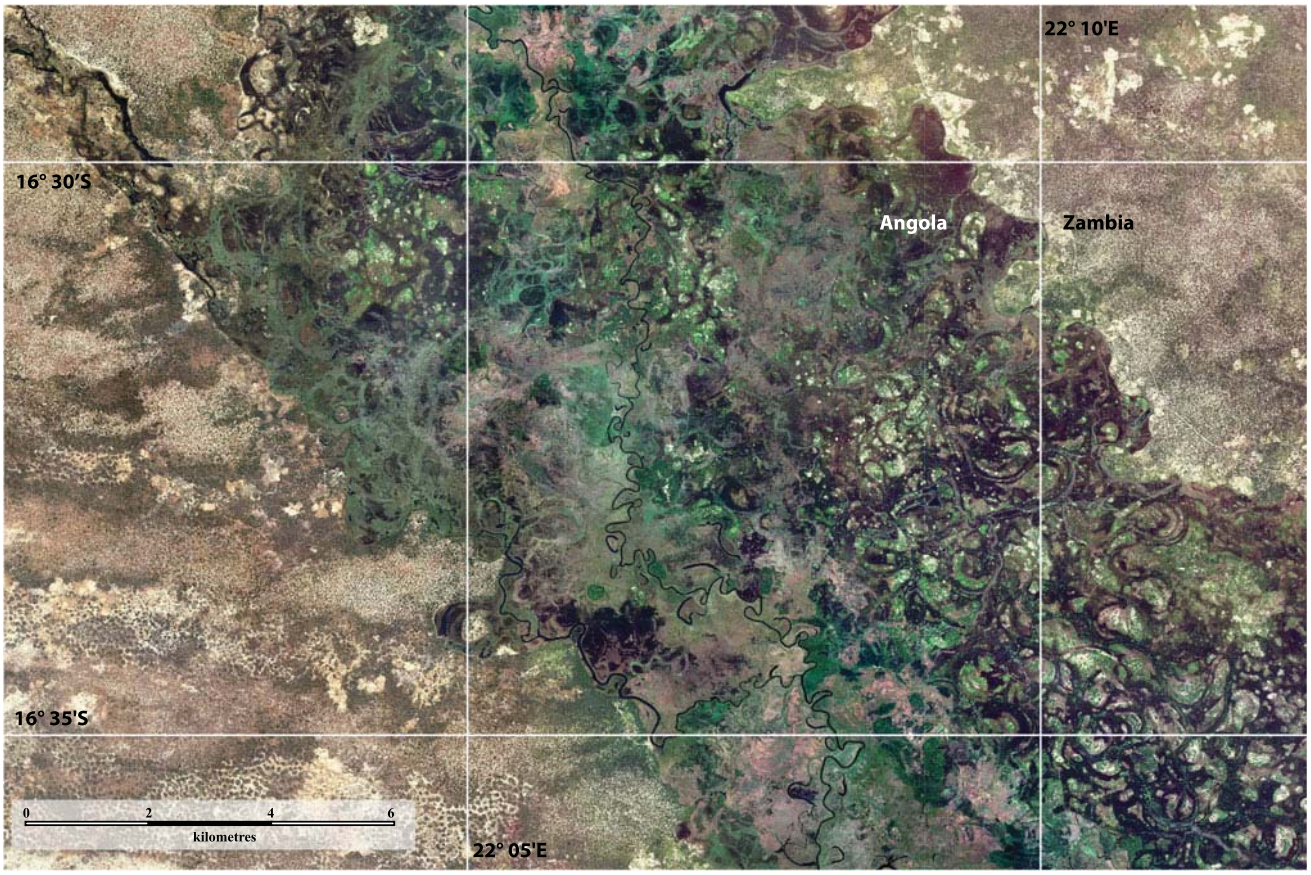

Fig. 2.18 The Cuando river and its broad floodplain south of Rivungo and Shangombo. The main channel is 10–20 m wide in most places (image from Microsoft Bing Maps Imagery Services)

therefore be greater than from the Cuito, and this may explain the great differences in discharge between the two rivers.

The Cuando's flows are also slower than those of the Cuito, and very much slower than those of the Cubango. Peak discharges along the Cubango reach the southern border of Angola in April and May, one or two months after high rainfall in the upper catchment of the Cubango. Those of the Cuito reach the border between May and July, and thus two to five months after rain in the upper catchment of the Cuito (Fig. 2.23).

The highest flows on the Cuando at Kongola are usually measured in July and August, but discharges vary considerably from year to year, as shown over 22 years when its flows were measured consistently (Fig. 2.23). Discharges sometimes peaked at the end of the year, suggesting that rainwater that fell in the upper catchment during the previous summer may have taken much of the year to reach the gauging station at Kongola. In other years, flows peaked towards the end of summer, perhaps as a result of local rains adding to river flows in the Kongola area.

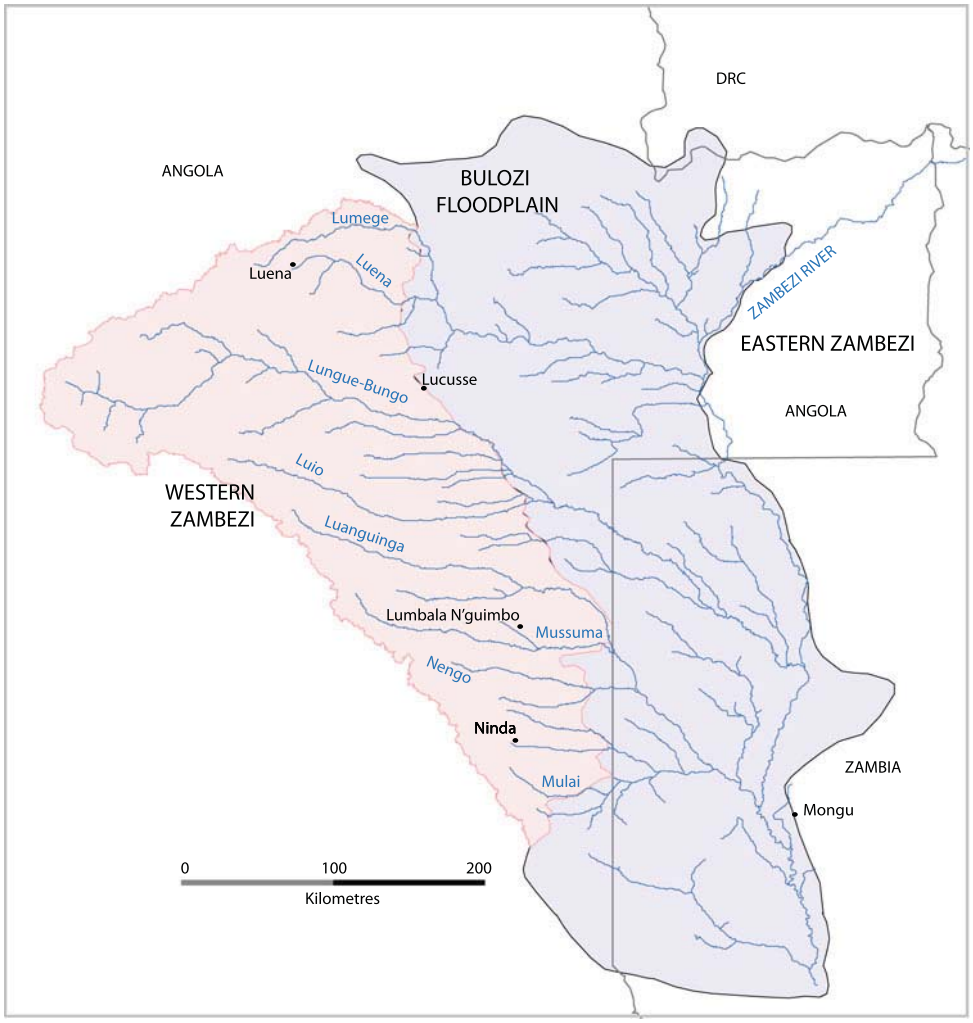

Fig. 2.19 Rivers and the catchment of the Western Zambezi in Angola, as well as the Bulozi floodplain

Although the main Cubango, Cuito and Cuando rivers have many tributaries in their lower catchments, none of these watercourses delivers much, or any water. While rainfall is somewhat lower than in the upper catchments, the watercourses are dry mainly because the lower catchments are extremely flat with soils of highly permeable sands (Fig. 2.4). Most rain, therefore, seeps away, leaving no water to flow on the surface.

2.7 Mixing Water

The Cubango/Cuito, Cuando and Zambezi are discrete bodies of water in their Angolan catchments. But they can connect with each other when water levels are high, in north-eastern Namibia and north-eastern Botswana (Fig. 2.24). Thus, when water levels are high in the

Fig. 2.20 The Lungue-Bungo is the largest river meandering off the Western Zambezi catchment (Photograph: John Mendelsohn)

Zambezi, some of its water flows westwards along the Chobe river and via the Bukalo Channel into Lake Liambezi. The Linyanti Swamps which are fed by the Cuando may also merge with Lake Liambezi when water levels are high. Water from the Cuando and Zambezi thus mix from time to time in these wetlands, and some of the wetland's mixed water can later flow into the Zambezi when it drops, causing the Chobe to reverse and flow eastwards.

Furthermore, Cubango/Cuito water in the Okavango Delta may reach the Cuando and Linyanti Swamps via the Selinda Spillway. When high, water from both the Cuando and Okavango Delta can flow into the Mababe Depression, the former via the Savuti Channel and the latter along the Khwai river. Thus, water collected from across the broad Angolan catchments can later be spread across other broad areas in northern Botswana, including into Lake Xau via the Boteti river. High water conditions which permit these connections have been recorded sporadically in recent years, such as in the early and late 1960s and again between 2008 and 2012. But river flows have also been low, indeed so low that Lake Liambezi and Lake Ngami were dry from the mid-1980s until 2004.

Fig. 2.21 Flows from the Western Zambezi in Angola and the Eastern Zambezi flowing out of Zambia's north-western province merge in the massive expanse of the Bulozi floodplains which straddle the border of Zambia and Angola. The floodplains cover approximately 400 kms north to south and up to 200 kms west to east (Photograph: Rich Beilfuss)

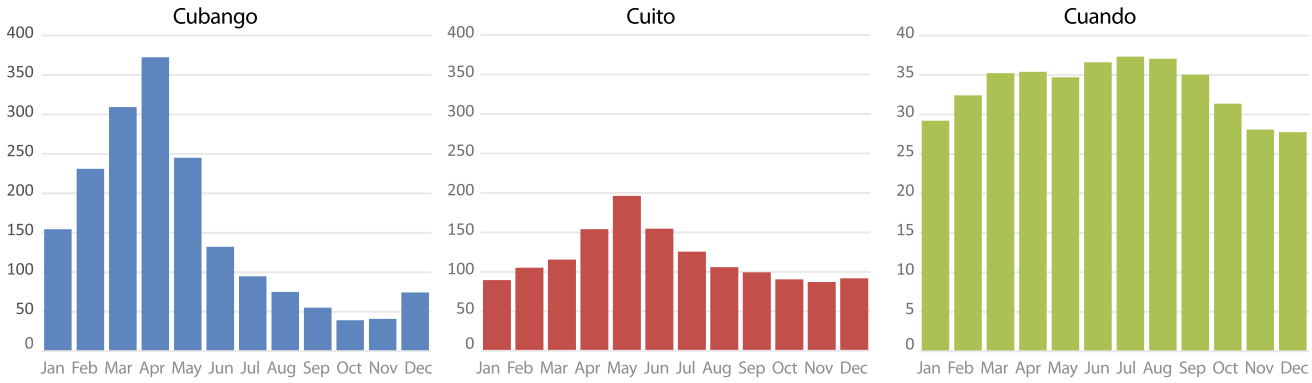

Fig. 2.22 Average monthly discharges in cubic metres per second along the Cubango (at Rundu), the Cuito (at Dirico) and Cuando (at Kongola). Note how Cubango flows vary much more than those of the Cuito, which, in turn, are much more variable than flows along the Cuando. Note the different scale for Cuando's y-axis. Data kindly supplied by the Hydrology Division, Ministry of Agriculture, Water and Forestry, Namibia. Averages for the Cubango and Cuito cover the period 1972–2007; those for the Cuando from 1972 to 2016

Fig. 2.23 Discharges in cubic metres per second along the Cubango (at Rundu), the Cuito (at Dirico) and Cuando (at Kongola) between 1981 and 2002, and average monthly rainfall in their upper catchments. Note the different scales of the y-axis. Each year runs from January to December. Discharge data kindly supplied by the Hydrology Division, Ministry of Agriculture, Water and Forestry, Namibia. Rainfall estimates from CHIRPS data (https://iridl.ldeo.columbia.edu/SOURCES/.UCSB/.CHIRPS/.v2p0/.monthly/.global/.precipitation/)

2.8 Conclusion

Most river flows are from the upper catchments because of their elevated and dissected topography and relatively high rainfall. Seepage into the upper catchment rivers and their tributaries is slow, acidic and almost totally free of minerals or suspended solids. In contrast, most rainwater seeps away in the flat lower, southern catchment areas, probably to levels beneath any rivers, and deep into the Kalahari Basin. The lower catchments thus only provide limited supplementary flows during extremely wet periods.

The north-western catchment of the Cubango differs from the other sandy upper catchments due to its geological foundations of granitic, gneissic and meta-sedimentary sequences, its higher elevation and consolidated soils. These conditions together with substantial falls of rain lead to rapid pulses of discharge during the summer months that bring periodic floodwaters and bouts of biological production to the Okavango Delta. These pulses complement the steadier flows of the Cuito which deliver most water to the Delta during the dry season.

Other complementary flows come from the Western Zambezi catchment and the eastern catchments in Zambia; and from the north-western and eastern rivers within the upper Cubango catchments.

The slowest flows are along the Cuando, an enigmatic river which seemingly loses much of its discharge to evapotranspiration from reeds and papyrus covering the very broad floodplains that flank the main channel along much of its journey south.

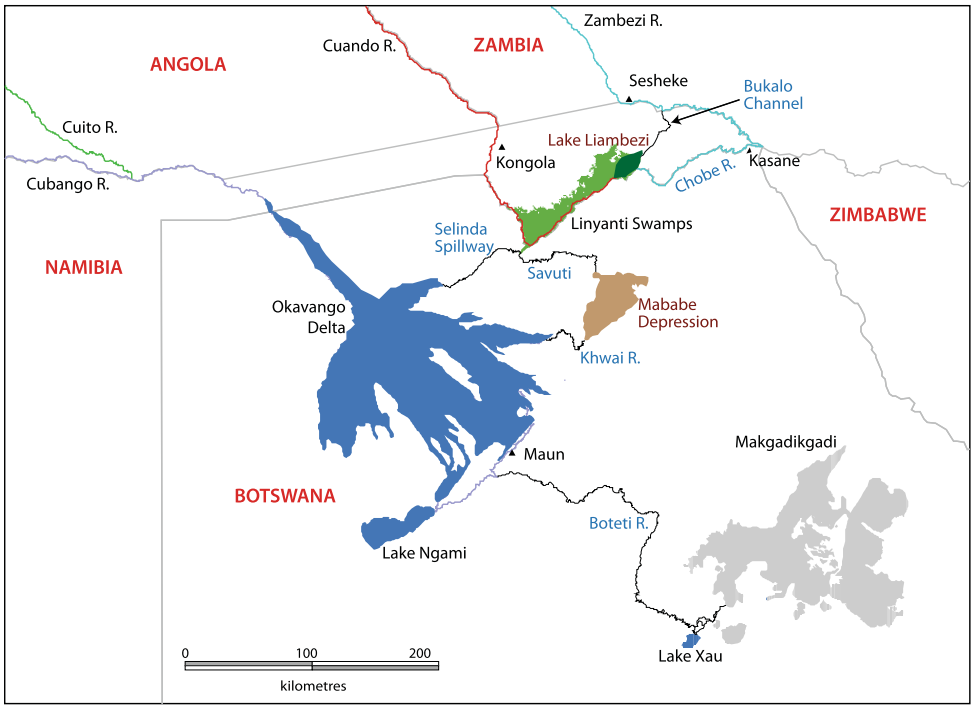

Fig. 2.24 The complex of interconnected wetlands formed from flows down the Okavango, Cuito, Cuando and Zambezi rivers in north-eastern Namibia and northern Botswana and include the Okavango Delta (Chap. 3), Lake Ngami and Mababe Depression (Chap. 4), Makgadikgadi (Chap. 5), Chobe enclave (Chap. 6) and Chobe-Zambezi floodplain (Chap. 7)

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