Chapter 2: Landscapes: their formation and impact on the Basin.

Much of the Cuvelai-Etosha Basin is an extremely shallow and flat depression, which is surrounded by a rim of rocky, raised ground in the west and south. Beneath the Basin is a deep bowl which developed during the formation of the continent of Gondwana some 570 million years ago. Geologically, the bowl is known as the Owambo Basin. The southern and western rims of hills were also raised during Gondwana's formation.

Between the present surface and bed rock of the Owambo Basin lie hundreds of metres of sediments that gradually accumulated over tens of millions of years. During those many years, most sediments were deposited in the bowl by large rivers that drained higher ground in Angola and the southern and western rims of dolomites and limestone.

More arid conditions have prevailed during the last two million years and so most of the upper layers of sediments consist of windblown sands. However, rivers and drainage lines, such as the present *iishana*, have also deposited alluvial sediments in the Basin. And even during the rather dry last two million years there have also been wetter periods when the rainfall was two or three times what we measure today. Etosha Pan was then much larger and huge areas of the Cuvelai-Etosha Basin were then under water. Conversely, there were also much drier times during the last two million years when the Basin was covered largely by sand dunes, rather like the southern Kalahari Desert in southern Namibia and Botswana.

In essence, the Basin has had a history of alternating dry and wet periods during which respectively, sands and alluvial clays were laid down, steadily filling the deep Owambo Basin to form the even surface of the current Cuvelai-Etosha Basin.

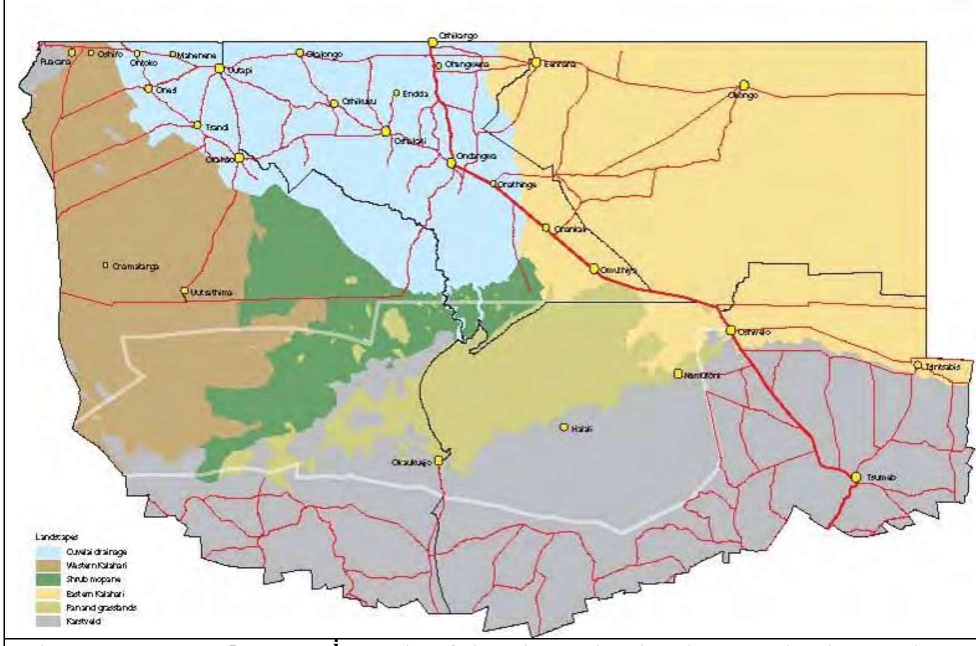
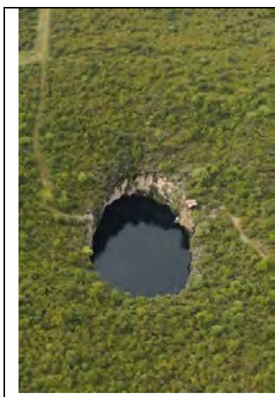
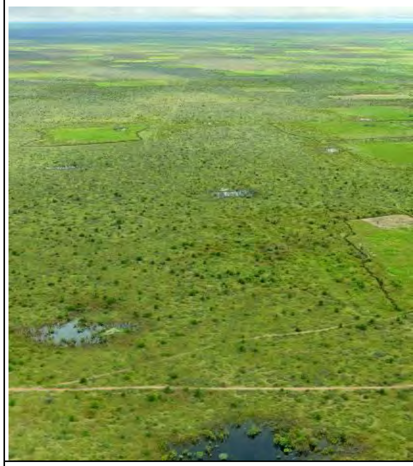


Figure 2.1 Landscapes [i]. Each of the six major landscapes in the Basin was formed from

different processes of erosion and deposition that have prevailed during dry and wet periods. In many areas, the soils and vegetation are characteristic of alluvial sediments, such as the pans and *iishana*. Elsewhere, particularly in the east and south-west, aeolian wind-borne sands predominate where they support plants and animals that characteristically prefer sandy substrates.

Within in anyone small area, there is often a mix of water and wind-borne sediments. This is most obvious where expanses of aeolian sand surround pans and iishana. Here, the lowest levels are clayey and often wet from local rain of from flows of water from the north. Just up from the *iishana* bottoms, the soils are more of a mix of sediments, while the highest ridges between the iishana often consist entirely of wind-borne sands. The most fertile and productive soils have formed where the sediments have been heavily mixed, and it is here that the majority of people live. Much of the mixing of sediments has done by prevailing easterly winds which have carried fine sediments out of the low-lying drainage lines and pans onto the surrounding sands.

 	On the surface the *Karstveld* consists largely of sediments derived from limestone and dolomite rocks, many of which remain as hills along the southern edges of the Basin. Water has dissolved these rocks to form large underground aquifer hollows from which water is pumped to supply irrigated crops. Rocks above these hollows have collapsed in some places, such as Lake Guinas (shown here) and Lake Oshikoto.
 	Much of the *Eastern Kalahari* consists of deep, infertile sands which hold little water. Tall woodlands grow on these sands which are not suited to crop production. However, there are many small pans which formed during much wetter times thousands of years ago. The soils around the pans are somewhat clayey, with higher nutrient contents and water holding capacity. It is on these soils that crops are grown and this is where most people live, in homes clustered as villages around the pans. Some pans, such as the one shown here, straddle the border and have fewer residents on the Angolan side. Old sand dunes remain visible in some areas, showing how this area has

	also been extremely arid in times past.
	The *Western Kalahari* is a drier version of the Eastern Kalahari, both having been formed from wind-blown sands. As a result of lower rainfall, there are fewer pans and arable soils, less water close to the surface, woodland is shorter and there are fewer people.. Most people in the west concentrate their efforts on cattle and goat farming.
	*Iishan*a: The great majority of people live in this landscape where there is a mix wind-blown sands on higher ground and water-borne clays in the low lying channels and pans. Particularly in the eastern areas, the clays and sands have been mixed and moulded to form the most fertile soils in the Basin, and this is why population densities are greatest here. The *iishana* are narrow in the east where water flows are relatively rapid, while the channels in the west are broad and saline because the slow flowing water often evaporates from the channels. Most of the channels converge in the south, forming the Omadhiya Lakes. Other channels have been covered over by wind-blown sands in these drier southern areas. As a result, these southern *iishana* areas are characterised by tens of thousands of small pans which are only filled by local rain.
Get appropriate photo	The *Shrub Mopane* landscape is a mix of alluvial clays and aeolian sands which generally salty as a consequence of high rates of evaporation. The surface soils are probably underlain by impermeable layers of rock formed from mineral precipitation. Roots are thus unable to reach nutrients and water beneath these layers and many

	of the plants remain stunted.
	*Pans and grasslands*: High concentrations of salt in Etosha and the many surrounding pans and grasslands are due to the evaporation of water that has flowed into these southern, dry areas of the Basin. The margins of most of the smaller pans are decorated by intricately shaped narrow drainage lines along which water may flow after the heaviest rain storms. The small pan shown here is Ngandjela Pan which has provided people in the Basin with salt for domestic use and trade for hundreds of years.

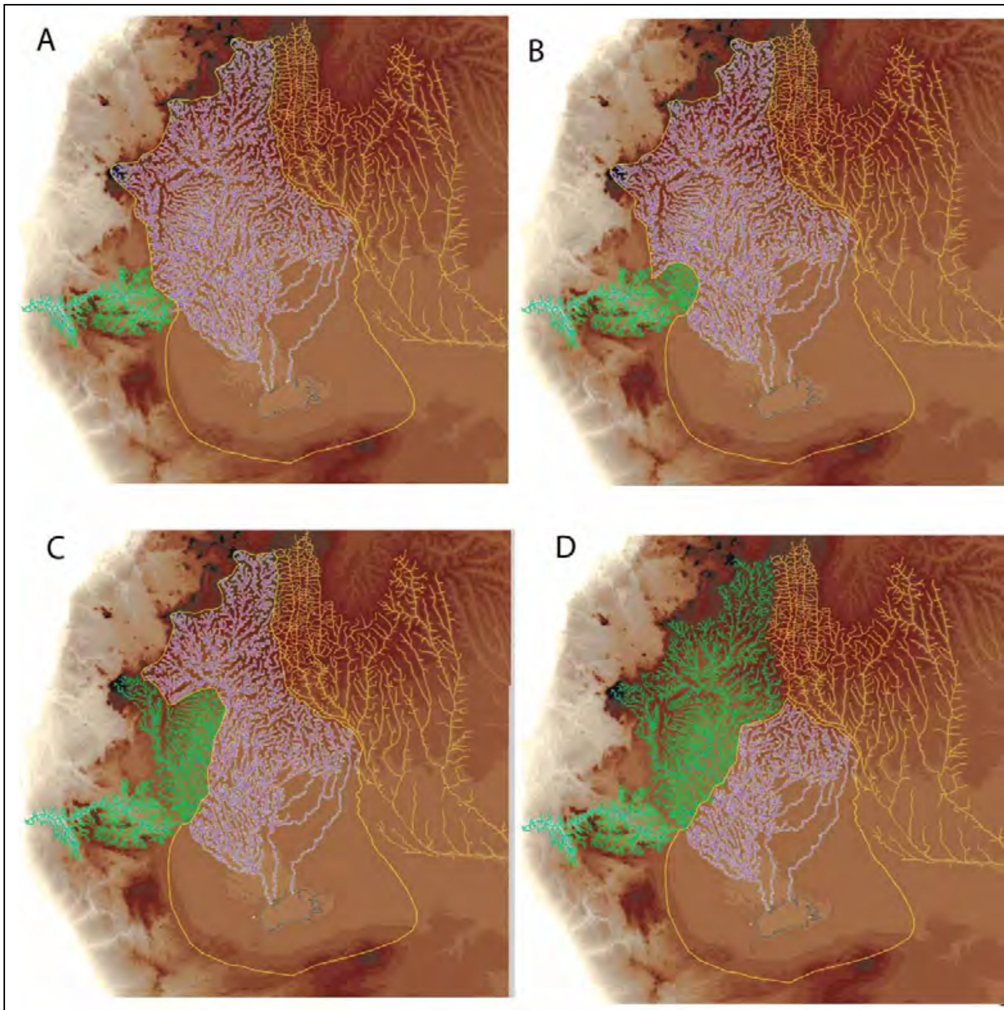


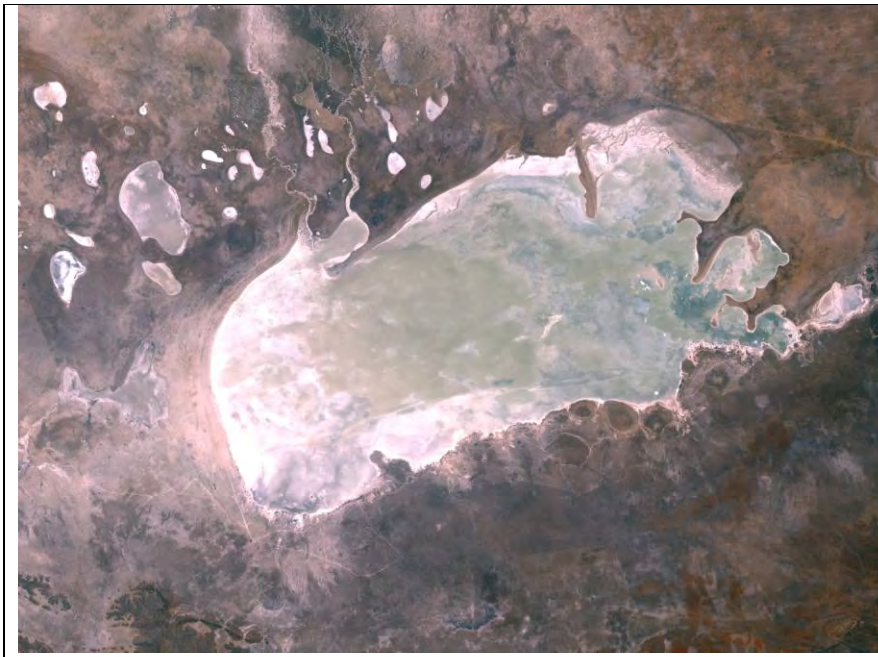
Figure 2.2. The deep bowl or Owambo Basin that formed some 570 million years ago has been progressively filled by sediments, most of them probably deposited by large rivers that drained the surrounding highlands. It is likely that the Cubango (known as the Okavango in Namibia) once flowed due south into the Basin before being diverted east towards Botswana and the Okavango Delta.

The Kunene River that drains the Angolan highlands probably also drained into the Basin before being captured by a western river that now flows to the coast. The western or coastal drainage system before the river capture began is shown in diagram **A** as a river flowing from about Ruacana to the Atlantic. The headwaters of that coastal drainage system then probably nibbled its way upstream, its nick-point progressively moving and capturing tributaries that flowed north-west to south-east into the Basin (**B** and **C**). The capture of each tributary reduced the overall volume of water reaching the Basin. Eventually, the river's headwaters cut back all the way up until it had captured the entire Kunene River (diagram **D**), thus leaving the Cuvelai-Etosha Basin with almost no sources of perennial flow (the small Mui and Cuvelai Rivers, continue to provide some water year-round, see page oo).

Following the suggestion that the Kunene was progressively captured and diverted to its present coastal mouth by a river progressively eroding upstream, as described above, most of the present *iishana* drainage lines are remnants of streams that once flowed from areas to the west of the Kunene's present course. This image shows the Kunene just south of Xangongo, and the broad drainage lines visible to the west of river are similar in structure to the *iishana* immediately to the east of the Kunene.

These *iishana* thus once flowed across this area before those that remain in the west were cut off by the Kunene from the *iishana* in the east. This helps explain why the headwaters of all the *iishana* immediately alongside the Kunene are broad rather than being narrow tributaries that widen downstream, as is true for all 'normal' rivers.

The progressive capture of *iishana* from south northwards means that those in the south of the Basin have been cut-off for longer than *iishana* in the north. One consequence of this is that the southern *iishana* should have the most saline soils in their beds because they have been deprived of freshwater flows for longest. *Iishana* to the north, by contrast, were cut-off from their western tributaries more recently. In essence, water has been evaporating off *iishana* in the south longer than off *iishana* in the north.


[ii]

Fossil and other evidence suggests that Etosha has been a pan or lake for the past six million years.[iii] At times, it was certainly a much greater expanse of water which perhaps covered much of the area up the present Angola border and even beyond. During drier times, the lake area shrank to perhaps something small like the present Adamanx Pan.

The floor of the pan or lake was covered in layers of calcrete and salt that formed during dry times as a result of evaporation, the calcrete being precipitates of calcium carbonate that had eroded out of the dolomite and limestone hills to the south. As the pan area dried, the layers of calcrete broke-up which allowed enabled strong easterly to blow away large volumes of fine sediments, resulting in the formation of the shallow depression that we see as pan today. The elevation of the pan varies very little, from 1,080 to 1,100 metres above sea level. Most of the present day inflow is from the Ekuma River in the north and, to a much lesser degree, from the Omurambo Owambo into Fischer's Pan next to Namutoni in the east.

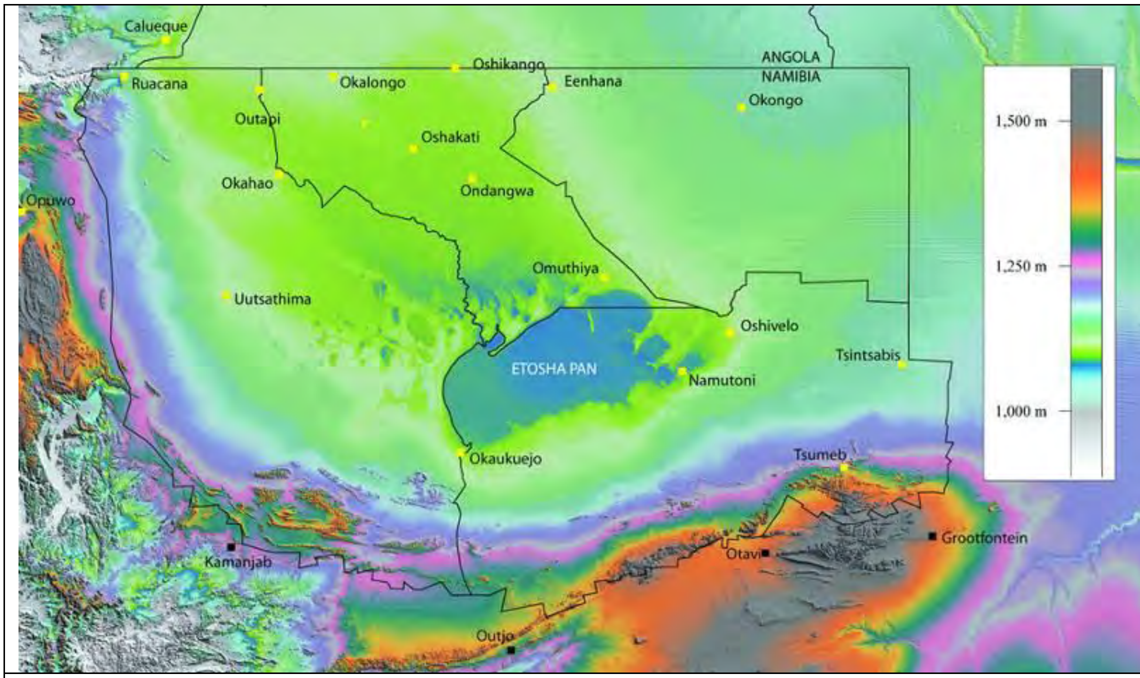


Figure 2.3 Elevations in the Basin. From the lowest altitudes of less than 1,100 metres above sea level in the Etosha Pan, elevations rise steeply to the south and west up the dolomite and limestone ridge that encircles the southern Basin. To the north, elevations are lowest in the *iishana* drainage area. For example, between Ruacana and Oshikango altitudes range between 1,120 and 1,110 metres above sea level and then rise gradually to about 1,160 metres at Okongo.

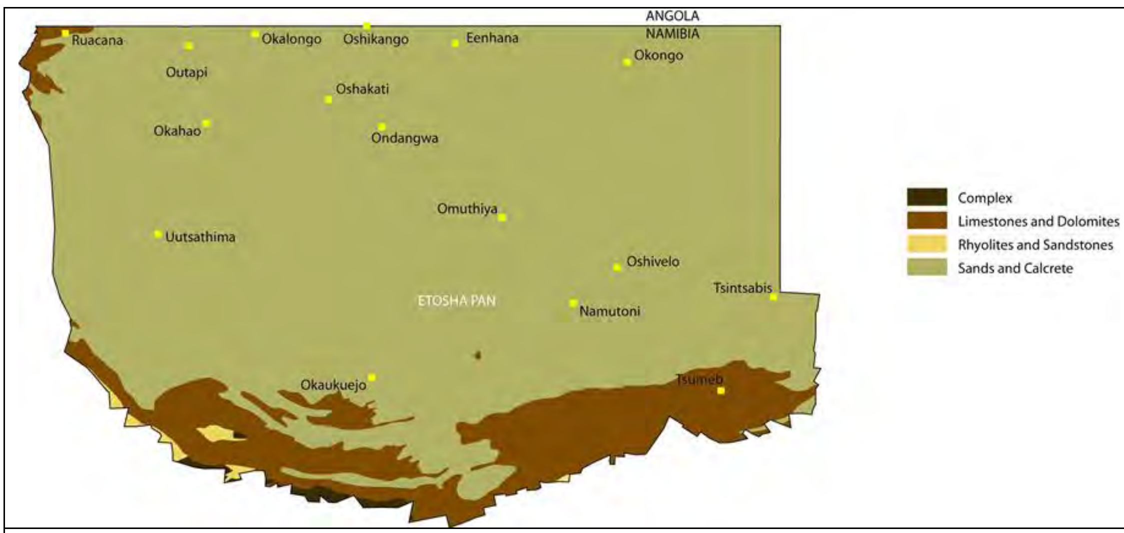


Figure 2.3 Geology of the Basin. Prior to about 1,000 million years ago, southern Africa was part of the continent of Rodinia. A few very old rocks formations – labeled here as Ancient complex formation – remain visible on the margins of the Basin. About 1,000 million years ago the continent began to break up and by 750 million years ago the Basin was submerged in an ocean. The land masses on either side of the ocean began to drift towards each other about 650 million years ago, and they eventually collided and

amalgamated to form the super-continent of Gondwana. Among a number of mountain ranges to lift up during the collision were those that now remain as the ridge of hills that encircle the south and west of the Basin.

The bowl or deep Owambo Basin then formed also as surface of the earth slumped down to the north of that ridge. This was 570 million years ago. Since then, successive periods of deposition have filled the Basin. One of these was started about 300 million years ago during an almost worldwide, period of glaciation. The deposits formed what are called the Karoo Sequence. Shales, sandstones and beds of organic material derived from plants were laid down in the Basin. Some of that organic material was later transformed into seams of coal and perhaps oil-bearing rock.

These seams are concealed below hundreds of metres sediments laid down during very wet periods by various rivers and during very dry periods by wind that carried and moulded vast quantities of sand into dunes that covered the Basin.

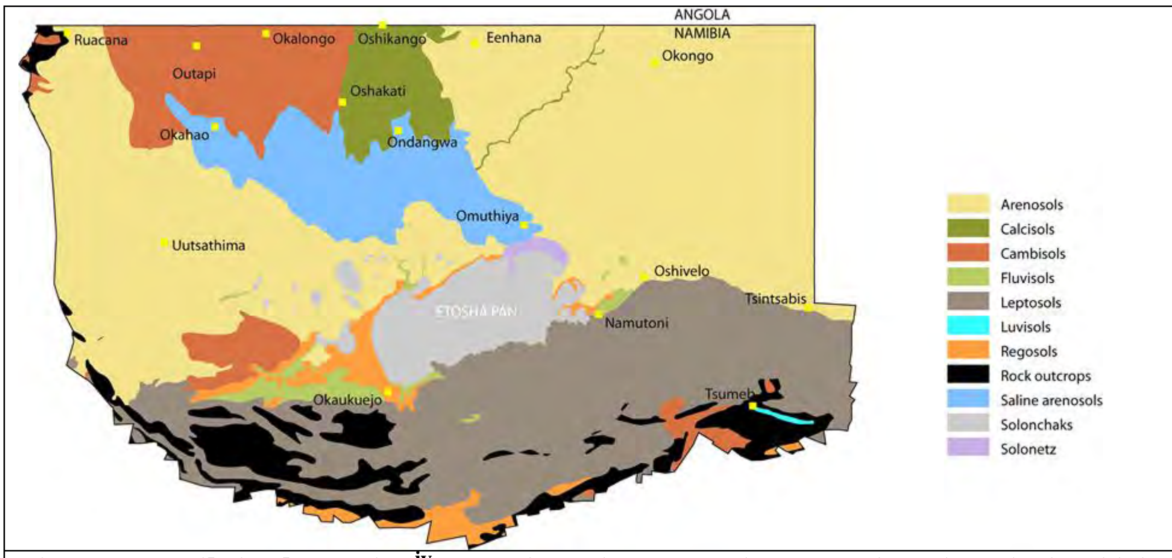


Figure 2.4 Soils in the Basin. [iv] Apart from the Leptosols, Regosols and Luvisols which formed from the erosion of Karstveld rocks (many of which remain as rock outcrops in the south), all other soils consist of sediments transported into the Basin by wind or water. The purest wind-blown soils are the Arenosols which cover much of the east and west. Soils which have high concentrations of salt are Saline Arenosols, Solonetzs and Solonchaks. Cambisols and especially calcisols, which are mixes of water- and wind-borne sediments are the most fertile soils, although there is much local variation depending on the predominance of alluvial or arenosol soils.

Photo of isolated patches of Kalahari woodland near Olushandja Dam

Figure 2.4 provides a perspective on the broad distribution of soils in the Basin. Within any one area, however, there is a great deal of local variation. In places where soils are suited to cultivation, farmers select patches of soils that have the highest fertility, and it is here that homes and their associated fields are located.

This image shows how about 20 homesteads are located in a circular arrangement around a central patch of Kalahari sands which have few nutrients and little capacity to hold water. Crops cannot be grown on the sands which are on the highest elevations, while the fields lie on the gentle slopes between the sands and the clayey, saline soils in the *iishana*. Note how the soils on the highest areas of the slopes are darkest, and become progressively lighter in colour at lower levels. (photo from EU RPRP project).

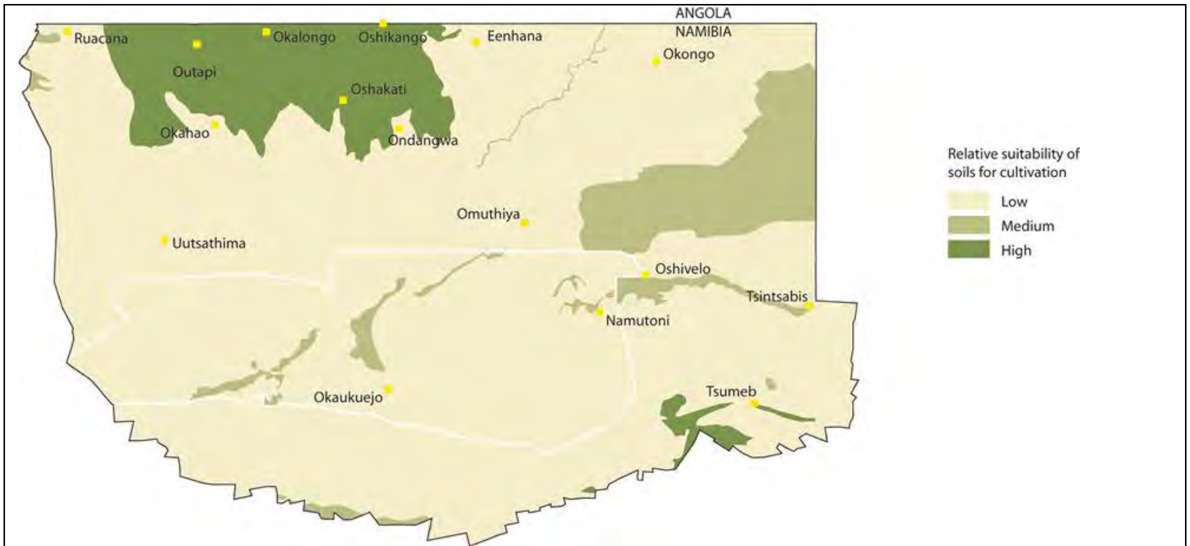


Figure 2.5 Potential for cultivation.[v] The soils in the northern area of the Basin are amongst the most fertile in Namibia. However, even in the fertile areas, there are many limitations to the potential for cultivation such as low and erratic rainfall, as well as soil characteristics such as organic content, salinity, water-holding capacity, chemical composition and depth. The calcisols and cambisols of the Cuvelai Drainage landscape around Oshakati and Outapi have the highest cultivation potential and this is reflected in the fact that these are the most densely populated areas in the Basin. In most of the rest of the Basin the potential for cultivation is low. The very sandy Western and Eastern Kalahari landscapes, with their arenosol soils, are nutrient-poor and have low water-holding capacity and trees which grow there need to have long roots. Crops can only be grown in those patches in the western areas where the soil has more clay because they retain moisture. In much of the rest of the Basin the soils are generally either too rocky or shallow (karstveld) or salty (pans and grasslands, shrub mopane) for crop cultivation.

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[i] Mendelsohn, J.M., el Obeid, S & Roberts, C.S. 2000. *A profile of north-central Namibia.* Gamsberg Macmillan, Windhoek.

[ii] Image from the Landsat 7 Team at NASA's Goddard Space Flight Center

[iii] Miller R, Pickford M, Senut B. 2010. The geology, palaeontology and evolution of the Etosha pan, Namibia: implications for terminal Kalahari deposition. *South African Journal of Geology*. 113: 307-334.

[iv] Adapted from Diniz CA. 1973. Características mesológicas de Angola. Missâo de Inquéritos Agricolas de Angola, Luanda; SINFIC, SARL. 2005. *Plano de Urbanização da Cidade de Ondjiva*. Report for Governo da Província do Kunene – Gabinete de Estudos, Planeamento e Estatística; and Mendelsohn, J.M., el Obeid, S & Roberts, C.S. 2000. *A profile of north-central Namibia.* Gamsberg Macmillan, Windhoek.

[v] Atlas of Namibia.