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PHYSICAL RESOURCES AND INFRASTRUCTURE

Dick Foeken

ABSTRACT

This chapter describes the main physical characteristics as well as the main physical and social infrastructure features of Kenya's coastal region. Physical resources include relief, soils, rainfall, agro-ecological zones and natural resources. Aspects of the physical infrastructure discussed are the hierarchy of centres and the communication networks (railway lines, roads, water facilities, etc.). The social infrastructure includes health and educational facilities. The general conclusion is that except for its touristic resources such as the game parks, the coral reefs and the beaches, the coastal region is in most respects poorly endowed and poorly developed.

INTRODUCTION

The aim of this chapter is twofold. First, the data presented offer the general context for many of the topics dealt with in the following chapters. Second, the chapter is meant to unfold the limitations set by the physical and infrastructural environments with respect to the development potential of the region.[1]

The region concerned is Kenya's Coast Province with the exception of the largest part of 'inland' Tana River District. Hence, it comprises the districts of Taita Taveta[2], Kwale, Mombasa, Kilifi, Malindi[3] and Lamu, as well as the south-eastern part of Tana River (Garsen Division; see Figure 1.1, p. 4).[4]

1 Some of the aspects presented in this chapter are discussed in much more detail in some of the following chapters, notably 4 (Marine resources), 5 (Current environmental problems) and 23 (Water resources).

2 As regards Taita Taveta, 62% of this district is occupied by Tsavo (East and West) National Parks (Kenya 1989e). With the exception of some rocky hills in the northern part of Tsavo West National Park, the whole area (more than 10,000 km^2) is a relatively flat plain, with low rainfall and consequently has no potential for rain-fed farming. Moreover, human habitation and agriculture are forbidden there. Hence, the parks are excluded in this chapter and on the maps.

3 Up to the mid-1990s, Malindi District was part of Kilifi District. Where possible, data on the two districts will be presented separately. Otherwise, they will be treated as one, notably Kilifi District.

4 Strictly speaking, the coastal region also includes the southeastern tip of Garissa District in North-Eastern Province. This area comprises largely of Boni National Reserve

PHYSICAL CHARACTERISTICS

Relief

The general contour lines show a gradual rise from the shoreline to the interior (see Figure 27.3, p. 424). On a smaller scale, however, there are some morphological features which greatly influence the agricultural potential.

In Kwale, Kilifi and Malindi Districts, four topographical zones can be distinguished: the Coastal Plain, the Foot Plateau, the Coastal Range or Uplands and the Nyika Plateau (Kenya 1989a-b). The *Coastal Plain* is a narrow belt along the coast, with a maximum altitude of about 60 metres.[5] This zone extends to 10 km inland in the area stretching from the Tanzanian border in the south to the town of Kilifi in the north. North of Kilifi town, the plain widens until it reaches some 30 km inland off Malindi. The *Foot Plateau* is the western extension of the Coastal Plain and has an altitude of some 60 to 135 metres, although it is characterised by a relatively flat surface, alternated with a number of hills. The *Coastal Range* or *Coastal Uplands* rise rather steeply inland from the Foot Plateau. The zone lies at an altitude of 150 to 460 metres and includes hill complexes such as the Shimba Hills in Kwale District and the hilly country between the towns of Mazeras and Kaloleni, as well as various isolated hills south of the Shimba Hills and north of Kilifi town. This zone has good rainfall and fertile soils, with a fairly high potential for agriculture. West of the Coastal Range, the terrain drops steeply to the *Nyika Plateau*, which has a gently rolling relief and gradually rises further inland to about 300 metres.

Further inland, off Kwale District, some conspicuous hills such as Kilibashi (840 m) and Kasigau (1630 m), and hill complexes like the Sagala Hills (up to 1510 m) and the famous Taita Hills (highest peak 2150 m) dominate the landscape of Taita Taveta District. These hills are relatively wet 'islands' in a semi-arid and arid 'sea'.

North of Malindi District, no topographical zones can be distinguished. The Coastal Plain widens and covers the whole of south-eastern Tana River and Lamu Districts. Both districts are less than 100 m above sea level, most of it even lower than 50 metres.

Soils and soil fertility

Soils in Kwale, Kilifi and Malindi Districts broadly correspond with the topographical division described above (Jaetzold and Schmidt 1983). In the Coastal Plain, soils have developed on coastal sands and coral limestone and are generally well-drained but vary in depth and structure. Their fertility — or topsoil physical performance — is moderate to low. The soils of the Foot Plateau are deep and well-drained, but also with moderate to low fertility. Soil units in the Coastal Range vary greatly. Depending on the ways in which they were formed and the type of parent material, they range from well-drained, deep, sandy and clayey soils with varying degrees of fertility, to shallow, coarse, sandy soils which are prone to erosion, especially on the steeper slopes of the hills and hill complexes. Finally, the soils of the Nyika Plateau are sandy and clayey in nature. In general, their fertility is low although in certain places fertile soils occur. Many soil units in this zone are degraded because of erosion.

This broad East-West pattern is intersected by the Sabaki (Galana) River and the Tana River. Along both rivers as well as along their tributaries, extensive alluvial plains with well-drained, deep, loamy soils occur. These are areas of relatively high fertility. The Tana delta consists of a deep, firm, cracking clay, with a saline and sodic or sulfidic deeper subsoil. As a result, most of the delta is less fertile than

5 The Coastal Plain should not be confused with the 'coastal strip'. The former is a physical-geographical category, while the latter is a political-geographical unit, notably the area from the sea shore up to ten nautical miles inland (see Chapter 1).

the rest of the river banks.

The soils in the Taita Hills are dominated by relatively well-drained, fairly deep soil types, consisting of stony, sandy clay loam. Their fertility is relatively high. The lower slopes of the hills consist of well-drained, very deep soils, but with a low fertility. The remainder, lower part of the district is dominated by soils which consist of well-drained, deep, friable sandy clay, with a low fertility.

Figure 27.4 (p. 425) offers a rough picture of the soil fertility in the study area. Based on a more detailed classification by Jaetzold and Schmidt (1983), three categories are distinguished, 'high', 'moderate' and 'low' fertility. The figure shows that less fertile soils — i.e. with moderate to low fertility — are predominant. Relatively fertile soils are mainly found along the Sabaki and Tana rivers, the uplands in Kilifi, the inland plateau in Kwale, the Taita Hills, and the Taveta area (at the foot of the Kilimanjaro). As will become clear in the following section, a combination of fertile soils and relatively high rainfall is quite rare and is only found in the Kilifi Uplands and the Taita Hills.

It should be noted that Figure 27.4 (p. 425) gives only a generalised picture of soil fertility in the region. Due to differences in such soil-forming factors as parent material (rock), topography, age, climate, hydrology, soil fauna and human activity, soils differ greatly locally, both in type and in fertility. For instance, 13 major soil classes occur in a relatively small area such as in Kilifi between the towns of Kilifi and Bamba in the north and Mtwapa and Mazeras in the south (De Meester & Smaling 1987). In the same area, seven fertility classes could be distinguished, but generally fertility is quite low (Smaling & Janssen 1987).

Rainfall

Generally, rainfall diminishes as one goes inland. However, due to the direction of the trade-winds (south-east and north-east) and the differences in relief, rainfall does not show a perfect east-west gradient (see Figure 27.5, p. 426). Rainfall is highest in the south-eastern part of Kwale District. The Coastal Uplands also catch a fair amount of rainfall, which is visible as 'wet strips' in the figure. Further inland, rainfall quickly diminishes. In Kwale and Kilifi, the 700 mm isohyet can be found at 40 to 50 km from the sea, after which semi-arid conditions start, only interrupted by the higher rain catchment areas in Taita Taveta. In Lamu, the amount of rainfall during the long rains decreases at a rate of about 100 mm per 5 km going inland.

On average, annual evapotranspiration is much higher than annual rainfall, starting at about 2,000 mm near the coast and increasing further inland (Michieka, Van der Pouw & Vleeshouwer 1978). This means that on a yearly basis there is a considerable water deficit. In the cooler Coastal Uplands and the hills in Taita Taveta, evapotranspiration is less. But, while evaporation is fairly equally distributed throughout the year, rainfall is not. There is "a pronounced concentration of rainfall at the beginning of the April-June rains, particularly in the hinterland" (Smaling & Boxem 1987: 14). This means that there is a water surplus in the soil during relatively short periods of time only. This determines the length of the growing periods, which are generally short in Coast Province.

In general, three patterns of climatic seasonality are distinguished: (i) with no real dry season; (ii) bimodal with two rainy and two dry seasons; and (iii) unimodal or monomodal with one wet and one dry season (Walsh 1981). In Kenya, only the two latter types occur, although in some parts of the country rainfall is fairly equally distributed throughout the year (Braun 1985). The distinction between bimodal and unimodal climates is an important one because, potentially, in a bimodal climate two harvests per year are possible and in a unimodal climate

only one. Thus, provided rains are 'normal', in a bimodal climate not only the time-gap between harvests is reduced, but also storage problems and possibly food shortages.

Along the coastline, a unimodal climate prevails. It is unimodal because there is only one rainy season — the long rains in April, May and June. The rains are not immediately followed by total dryness, but by a period of so-called intermediate rains, lasting until November or even December. The real dry months are January and February. Further inland, at a distance of about 15-25 km from the coast, this (weakly) unimodal climatic regime gradually tends towards a more bimodal climate. However, the period between the first (or long) rains and the second (or short) rains is not entirely dry. Going further inland, bimodality is more pronounced, particularly in Taita Taveta. In this zone, the second rains of November-December are at least as important as the first rains in March-April; in some places, such as Chakama in eastern Kilifi and in the lower parts of Taita Taveta, they are even more important.

The distribution of rainfall throughout the year can be measured in a single figure, the so-called Degree of Rainfall Seasonality (DRS; see Foeken 1994), whereby DRS is higher as more rainfall is concentrated in relatively short periods. The highest DRS values can be found in the most pronounced unimodal regimes, of which Lamu (DRS = 67%) is an example. The rainfall stations in the more outspoken bimodal climates have fairly high values as well, such as Taveta (DRS = 51%) and Voi (DRS = 54%). The lowest values occur in the weakly bimodal zone, Lunga Lunga in southern Kwale (DRS = 39%) and Ngao in Tana River (DRS = 36%) being good examples.

The coastal region is characterised by a high degree of rainfall variability between years, between the same months in different years, and between places. As regards annual rainfall fluctuations, deviations of 30-40% of the annual mean are quite normal (Hoorweg, Foeken & Klaver 1995). Moreover, the coastal region is known for frequent droughts. Herlehy (1983) lists ten more or less serious famines that occurred in the Mazeras-Kaloleni-Mariakani area between 1880 and 1960. Six of these lasted for three years or more. Lack of rainfall was usually the prime cause, often accompanied by epidemics and plagues of insects. After 1960, several more periods of serious food shortages occurred: 1964-65, 1969-70, 1973-76, 1979-80, and 1982-84. In most cases, inadequate long rains and/or completely failing short rains were the main causes.

Rainfall distribution within years can fluctuate strongly. An average amount of annual rainfall does not guarantee a distribution according to monthly averages. As shown elsewhere, years with the same amount of rainfall can show highly different monthly distributions (Foeken 1994). Even in years with 'normal' or 'above-normal' rainfall, the monthly distribution does not necessarily coincide with the needs of the agrarian cycle. Some of the famines mentioned above were not so much caused by a shortage of rain but by the erratic distribution throughout the year, making the farmers' timing of planting very problematic and forcing them to do several replantings of maize. In other years, excessive rains, causing water logging of the soil, destroyed many crops. Generally speaking, the drier hinterland is harder hit by droughts than the coastal strip. There are examples of years in which hardly any pasture and water was to be found, forcing many livestock owners to sell their cattle, if the animals survived at all.

Finally, there also exist important spatial fluctuations. Showers tend to be very localised and a 'good' year in one place does not mean a 'good' year some 25 km further away (for a coastal example, see Foeken 1994). In short, it is very uncertain when the rains will start, how much rain will fall, where it will

fall and how the rain will be distributed over the seasons. Since rainfall determines the agricultural calendar, this makes the crop cycle equally uncertain.

Agro-ecological zones

Agro-ecological (or agro-climatic) zonation provides a tool for assessing which areas are climatically suitable for various land use alternatives, with particular emphasis on the suitability for crop cultivation. In Kenya, two approaches for defining agro-climatic or agro-ecological zones are used (Smaling & Boxem 1987). The first one is based on annual averages of rainfall, potential evaporation and temperature. This is the classification used by the Kenya Soil Survey (Sombroek, Braun & Van der Pouw 1982). The second zonation is based on zones of temperature and moisture availability, more or less following the first method, but in addition 'length of growing period' is taken into account, i.e. the seasonal variation in rainfall and evapotranspiration (Jaetzold & Schmidt 1983: 9).[6]

The five districts bordering the Indian Ocean belong to one temperature belt or *zone group* with mean annual temperature higher than 24°C and mean maximum temperature lower than 31°C. This zone group is denoted as Coastal Lowlands (CL), with cashew nuts and coconuts being the characteristic main crops. The lower parts of Taita Taveta also belong to this temperature belt. The higher parts of Taita Taveta belong to three cooler belts: Lower Midlands (annual mean temperature 21-24°C), Upper Midlands (18-21°C) and a small area of Lower Highlands (15-18°C).

Within these zone groups, *main zones* are distinguished by mean annual rainfall, i.e. by "their probability of meeting the temperature and water requirements of the main leading crops". Five main agro-ecological zones exist in the coastal districts, ranging from CL3 (where '3' stands for 'semi-humid') to LM6 (where 6 stands for 'arid'), each characterised by certain crops and/or agricultural activities. The spatial distribution of the main zones is shown in Figure 27.6 (p. 427) and the major characteristics of the main zones are listed in Table 3.1.

The five most important agro-ecological zones can be briefly characterised as follows:

- CL3. The *Coconut-Cassava Zone* has a medium potential for agricultural activities and covers 6.5% of the arable land. The annual precipitation ranges from 1,000 to about 1,300 mm, but the short rains do not allow for cultivation of a wide range of annual crops. Coconuts form the principal crop in this zone, demanding at least 1,050 mm of rainfall in order to be reasonably productive (coconut palms can also be found in drier zones, but productivity is quite low there; moreover, slow growth increases the danger of pests and diseases). Unfortunately, in Kwale District the zone coincides with a large area with relatively infertile soils. In Kilifi District, the CL3 potential is higher. Large stretches of the soil in the Tana River CL3 zone are not suitable for the leading CL3 crops, due to seasonal flooding and water logging. In Lamu District, soils are also often not suitable for the leading crops of the zone, because they are prone to water logging in many places or, near Hindi, are too heavy in nature.
- CL4. The *Cashewnut-Cassava Zone* covers 19% of the arable land and has a low to medium potential for cropping. Rainfall ranges from about 800 to about 1,100 mm annually, but only in six out of ten years are the amount and distribution of the long rains adequate for the production of annual crops. Cultivation of annual crops during the period of the short rains is normally not possible. Sisal is doing

6 Growing periods are defined as "seasons with enough moisture in the soil to grow most crops, starting with a supply for plants to transpirate more than $0.4E_0$ (i.e., >40% of the open water evaporation), coming up to $>E_0$ (in the ideal case) during the time of peak demand, and then falling down in the maturity phase again."

Table 3.1 Agro-ecological zones: main characteristics

Agro-ecological zone*		approximate altitude (m)	annual mean temperature (°C)	annual rainfall (mm)
CL2	Lowland Marginal Sugarcane Zone	1-60	24-31	>1300
CL3	Coconut-Cassava Zone	1-450	24-31	1000-1300
CL4	Cashewnut-Cassava Zone	1-300	24-31	800-1100
CL5	Lowland Livestock-Millet Zone	1-800	24-31	600-900
CL6	Lowland Ranching Zone	50-700	24-31	<700
LM6	Lower Midland Ranching Zone	600-900	21-24	<500
LM5	Lower Midland Livestock-Millet Zone	800-1000	21-24	500-700
LM4	Marginal Cotton Zone	900-1200	21-24	600-800
UM4	Sunflower-Maize Zone	1200-1500	18-21	700-900
UM3	Marginal Coffee Zone	1350-1700	18-21	900-1200
LH2	Wheat/Maize-Pyrethrum Zone	>1600	15-18	>1200

* CL = Coastal Lowland; LM = Lower Midland; UM = Upper Midland; LH = Lower Highland
2 = sub-humid; 3 = semi-humid; 4 = transitional; 5 = semi-arid; 6 = arid
Source: Jaetzold & Schmidt 1983.

well in this zone; the Vipingo sisal estates in Kilifi are located in this zone. In Lamu, the boundaries of the CL4 zone can only tentatively be established, due to the small number of rainfall stations in the district. The real extent of the zone is important to know to decide the settlement prospects in this sparsely populated area.

- CL5. The *Lowland Livestock-Millet Zone* (25% of the arable land) is characterised by an average annual rainfall of about 600 mm to 900 mm and unreliable rains. Due to the short duration of the long rains, crop production in this zone should be restricted to drought-resistant crops. In general, the CL5 zone is more suitable for ranching than for crop cultivation. In Kwale District, and to a lesser extent also in Kilifi District, some CL5 strips can be seen in CL6. This is caused by the fact that, after descending beyond the Coastal Uplands, the air rises again, cools off and, therefore, loses some moisture.
- CL6. The *Lowland Ranching Zone* is the largest in size (41% of the agricultural land) but has virtually no potential for arable agriculture. Annual precipitation is less than 700 mm on average and is extremely unreliable. Agricultural activities are restricted to non-intensive types of livestock rearing. It is the largest of the different agro-ecological zones in the region, covering almost 14,000 km^2.
- LM6. The *Lower Midland Ranching Zone* is only found in Taita Taveta and accounts for 4% of the land. Rainfall is less than 500 mm annually, making it, like CL6, only suitable for extensive grazing.

Table 3.2 offers an overview of the respective agro-ecological zones in each of the districts. If the whole area is considered it is clear that high potential areas (zones 2-3) are quite small covering about 8% of the land. Some 20% can be classified as medium (zone 4) and the remaining 72% as low potential (zones 5-6). According to official estimates, Coast Province has the highest proportion of low potential land of all provinces, with the exception of North Eastern Province (Kenya 1991: 93). There are important differences between the districts although

Table 3.2 Agro-ecological zones by district[a]

	Kilifi		Kwale		Lamu		Malindi		Mombasa		Taita T.[c]		Tana R.[d]		Total	
AEZ[b]	km²	%	km²	%	km²	%	km²	%	km²	%	km²	%	km²	%	km²	%
CL2			235	3.2											235	0.7
CL3	352	9.2	953	13.0	511	9.3	61	1.9	30	21.4			280	3.3	2,187	6.4
CL4	1,143	30.0	897	12.3	3,376	61.2	855	27.0	100	71.4			138	1.6	6,509	19.0
CL5	1,217	32.0	2,342	32.0	1,606	29.1	1,431	45.2	10	7.1	1,029	17.6	970	11.3	8,605	25.1
CL6	1,097	28.8	2,886	39.5	24	0.4	817	25.8			1,943	33.3	7,162	83.8	13,929	40.6
LM6											1,405	24.0			1,405	4.1
LM5											762	13.0			762	2.2
LM4											442	7.6			442	1.3
UM4											103	1.8			103	0.3
UM3											118	2.0			118	0.3
LH2											40	0.7			40	0.1
Total	3,809	100	7,313	100	5,517	100	3,164	100	140	100	5,842	100	8,550	100	34,335	100

Notes: a. Land surfaces concern agricultural land only, i.e. excluding unsuitable steep slopes, forest reserves, mangrove forests, lakes, swamps, rivers, roads, homesteads, etc.
b. CL = Coastal Lowland; LM = Lower Midland; UM = Upper Midland; LH = Lower Highland
2 = sub-humid; 3 = semi-humid; 4 = transitional; 5 = semi-arid; 6 = arid
c. Tsavo East and Tsavo West National Parks are excluded.
d. Garsen Division only.
Source: Jaetzold & Schmidt 1983.

the low potential area is always largest, particularly in Tana River and Taita-Taveta (Lamu is the exception because the District does not extend far inland and has virtually no really arid land). In addition, as already mentioned, in most of the high potential areas the physical performance of the soil is rather poor. Hence, in general, crop performance is also poor. For instance, in the central part of Kilifi District (which is mainly CL3 and CL4 zones) yields of the major food crop (maize) tend to be very low. The main causes are too much, too little or inadequately distributed rainfall and low soil fertility (Waaijenberg 1987).

Natural resources

Further natural resources that will be discussed are minerals, forests, water, wildlife, and marine resources.[7] A large variety of ***minerals*** is found in the region, particularly in Taita Taveta and Kilifi Districts, be it not in large quantities. Examples include asbestos graphite, kaolin, kyanite, gemstones, iron ore, limestone, zinc, manganese, nepheline, copper, lead, barium, gypsum, titanium and salt. Although several of these are known to be present in exploitable reserve deposits, few are actually mined. In 1952, the exploitation of asbestos started in Taita Taveta, but due to high production costs mining was abandoned nine years later (Kenya 1989e). At present, the only ongoing mining activities concern gemstones (Taita Taveta), iron ore (Kwale), lead (Kilifi), barium (Kilifi) and salt ponds (Malindi and Tana River). Building stones, coral limestone, sand

7 The data are mainly derived from the respective District Development Plans 1989-1993 (Kenya 1989a-f) and 1994-1996 (Kenya 1994b-g).

and clay are important for the building industry. The main constraints to the exploitation of the minerals in Kenya's coastal region are "low levels of technical know-how, lack of adequate investible funds, inadequate research to explore the reserve deposits and discovery of new market channels, conflict with other existing natural resources especially forests and arable land, risks of erosion and poor supportive infrastructure in terms of passable roads during rains, unavailability of electricity and telephone services" (Kenya 1989a: 9).

Forests are of great importance for a number of reasons, notably the conservation and improvement of water supplies, the prevention of soil erosion, nature conservation, as well as the needs of the local people in terms of wood fuel, building poles and timber. In the early 1980s, there were more than 5,000 km^2 of forest in the Coast region, mainly in Kilifi (Jaetzold & Schmidt 1983). The largest of these is Arabuko-Sokoke forest, covering about 420 km^2 (Hoorweg 1998). It is well-known for its large array of rare and endemic wildlife species (Bennum 1995). In Taita Taveta, nearly 110 km^2 of protected forest reserves exist. In Tana River, forest areas are concentrated in the coastal strip and some small patches along the river banks. The latter are the only true representatives in East Africa of a type of riverine forest found in West Africa, containing a large number of plant and animal species (Butynski 1995). Finally, in Lamu some smaller forests exist such as the Witu Forest Reserve and the Lungi and Boni forests. The latter two forests are apparently threatened by the local slash and burn agriculture (Kenya 1989c). Forests in Kilifi are threatened because of poor exploitation and re-afforestation techniques (Kenya 1989a). Some riverine forests in Tana River are endangered due to overexploitation for fuelwood (Kenya 1989f). The mangrove forests along the coast perform a vital function in the coastal ecosystem. They supply inshore waters with nutrients from their leaves and provide food for fish. They also provide poles, which are used for building and to a lesser extent on boats, and as fuelwood, as well as tannin which is extracted from the bark (Kenya 1989b). Although mangrove forests can be found in all the districts bordering the Indian Ocean, most of it is situated in Lamu, where it probably covers about 400 km^2 (Hoorweg 1998).

Water is an important development input anywhere. It is needed for crop cultivation, for domestic stock, for human consumption and for industrial processing. In general, the provision of potable water is a major problem in the coastal region (for a more extensive discussion, see Chapter 23). Apart from the rivers Sabaki (Galana) and Tana there are few permanent streams; most rivers are seasonal. Particularly in the drier hinterland and in Lamu District, both surface water and underground water is scarce. This poses problems for many communities because women have to walk long distances to fetch (often unsafe) water from dams in the long dry season. Moreover, due to the unreliable rainfall, dams often do not fill up during the rains and suffer from serious silting. The latter also applies to many wells. The river Tana is a major source of water for local use and irrigation but it also forms a serious threat because of annual floods, while the terrain around it is susceptible to soil erosion. On the other hand, the river provides fish for human consumption (Kenya 1989f). Lamu has hardly any surface fresh water sources for humans and livestock and this is considered a major constraint to economic development (Kenya 1989c). The major sources of drinking water are traditional water catchments (*djiabas*) which are scattered over the district. However, many of these groundwater sources are shallow. There are a number of small fresh water lakes in the district, Lake Kenyatta and Lake Amu being the most important ones.

Wildlife is of importance for tourism, which is

the main source of foreign exchange for the country (see Sindiga, Chapter 15). As mentioned, over 60% of the land surface of Taita Taveta District consists of the Tsavo National Parks. The number of visitors — on average 95,000 per year in Tsavo West and 113,000 in Tsavo East in the 1988-1991 period (Kenya 1993) — can be considered as an indication of the economic importance of the parks. Although the Shimba Hills Game Reserve attracts fewer visitors (on average 34,100 in 1988-1991), it is, nevertheless, an important source of income for the district. The other land protection area is Dodori National Reserve. Due to its peripheral location and lack of infrastructure provisions, however, it attracts almost no tourists. The same applies to Boni National Reserve in the extreme southeastern corner of Garissa District. In Tana River, abundant wildlife, both game and birds, can be found in the river delta, offering a substantial tourist potential.

A major problem is to find a balance between wildlife protection, on the one hand, and human settlement, on the other. In Taita Taveta, many cattle ranches and agricultural farms border the Tsavo National Parks. Livestock is regularly taken by predators such as lions and cheetahs while elephants, wild pigs and baboons regularly devastate farms (Kenya 1994f). On the other hand, farmers encroach on reserves and parks. Shimba Hills National Reserve is surrounded by small farmers whose crops suffer serious damage, particularly from elephants. The farming families have to guard their crops day and night (Kenya 1989b). In Lamu, wildlife, particularly elephants, were threatened by poaching and by cutting and burning scrub for human settlement (Kenya 1989c). It is in these areas as well as in the Tana River delta, that questions regarding the balance between wildlife protection and human settlement are most pressing. In Gede, Malindi District, the Kipepeo Project started in 1993 in an attempt to combine local community development and nature conservation. Using leaves from forest trees, villagers living adjacent to Arabuko-Sokoke forest produce butterfly pupae which are exported to the live exhibit industry in Europe and America (Gordon 1995).

Marine resources consist of living resources (fish and mollusk shells) and non-living resources (fossil coral rocks and sandy beaches; see Aloo, Chapter 4). Fishing is widespread along the coast, from Vanga in the extreme south to Kiunga in the extreme north. In Lamu, fishing is the mainstay of the district's economy (Kenya 1989c). In general, the artisanal fisher uses traditional methods with small boats and simple methods. Moreover, the various creek sites along the Kilifi coast "offer excellent potential for aqua and marine culture which is virtually untapped, due to lack of technical know-how and poor infrastructure" (Kenya 1989a: 8).

INFRASTRUCTURE

Hierarchy of centres

Officially, four types of service centres are distinguished according to the number of people to be served: urban centres (120,000 or more), rural centres (40,000), market centres (15,000) and local centres (5,000). Figure 27.7 (p. 428) shows the spatial distribution of the first two categories.

Most of the centres of the first two categories, urban centres and rural centres, are situated in rural areas that are relatively densely populated. These are also the areas with a high agricultural potential. Some other centres have sprung up because of the existence of factories or mining activities such as Gongoni and Fundisha (both in Malindi). Moreover, the centres tend to be located in areas with electricity, a relatively good road network and water. In the more marginal zones, urban and rural centres are rare (Kenya 1989a).

Table 3.3 shows the number of urban, rural and market service centres in the different districts (the

local centres have been left out because their status is often unclear). The right-hand column shows the average number of people per centre (different categories taken together). This is a crude estimation, since on the one hand some centres serve people from more than one district (Mariakani is an example) while, on the other hand, centres within the same category can differ substantially regarding the number and types of services they provide. Nevertheless, the figures suggest important differences in 'service levels' between the districts.

Strengthening smaller urban centres in order to reduce the rural-urban gap is a major government objective (Obudho & Aduwo 1990) but centres differ greatly regarding their service potential, even within categories. Taita Taveta District may serve as an example (Table 3.4). The district has four major service centres, notably Wundanyi, Voi, Taveta and Mwatate (Kenya 1994f: 18). Each centre serves more or less the population of the division with the same name, although Wundanyi, being the district capital, also has a district function. The market centre of Mwatate serves a population that is not smaller than the other (urban) centres, but in 1989 it had only 49 businesses (Kenya 1989e: 19-20). On the other hand, the number of businesses in Taveta, which was only recently turned from a market centre into an urban centre, was three times higher than in the district capital Wundanyi. This fairly low service level in a district capital can also be found in Kwale town, which in 1989 had "less than twenty shops, complemented by numerous kiosks mainly selling essential commodities" (Kenya 1989b: 16). In short, as a policy objective, the population figures attached to each category of service centre are far from being achieved (Kenya 1984).

Physical infrastructure

The coastal region is transected by two ***railway lines***, but only the smaller one (Voi-Taveta) has a local function. The Mombasa-Nairobi rail link serves mainly for the transport of goods from and to the seaport of Mombasa, and to a lesser extent for passenger traffic between the two major cities of the country. The Voi-Taveta line is only in use on market days in Taveta (twice a week), for both passengers and goods.

The ***road network*** is heavily concentrated in the coastal belt, the coastal range and the Taita Hills (Figure 27.7, p. 428). This coincides with the areas of relatively high agricultural potential, tourist hotels and population concentration. Only a few roads are bitumenized, namely the international trunk roads (Mombasa-Nairobi, Mombasa-Tanzanian border,

Table 3.3 Service centres

District	population (1989)	urban centres	rural centres	market centres	population per centre*
Kilifi	591,903	3	4	24	9,865
Kwale	383,053	2	2	8	12,768
Lamu	56,783	1	2**	10**	2,366
Mombasa	461,753	2	1	-	24,303
Taita Taveta	207,273	3	-	9	6,281
Tana River (SE)	47,206	-	1	2**	9,441
Total	1,747,971	11	10	53	10,222

* Centres of different categories are taken together here, in the sense that 1 urban centre = 8 market centres and 1 rural centre = 3 market centres.

** Estimations.

Sources: Kenya, 1989a-f; 1994a; 1994b-g.

Table 3.4 Taita Taveta District: major service centres

Centre	category*	population**	businesses	popul./ business
Wundanyi	u.c.	54,223	94	577
Voi	u.c.	52,673	221	238
Taveta	u.c.	41,515	273	152
Mwatate	m.c.	56,137	49	1,146

* u.c. = urban centre, m.c. = market centre
** This concerns the 1989 population of the four divisions in which the centres are located.
Sources: Kenya, 1989e: 14, 19-20; 1994a; 1994f: 18.

and Voi-Taveta for the first 30 km), the national trunk road between Mombasa and Malindi (and recently extended to Garsen, half-way completed in mid-1998), and three relatively short branches leading to district centres (Wundanyi and Kwale town) and an important agricultural centre (Kaloleni). Most other roads are made of gravel or earth and are impassable during the rainy seasons. Moreover, large areas, particularly the hinterland of the coastal districts, have hardly been opened up. For instance, the western part of Kwale District is mainly served by unclassified and poorly maintained tracks (Kenya 1989b). According to the Kilifi District Development Plan, "during the wet season, all activities in the marginal areas such as Ganze, Magarini, Kaloleni and inward Malindi, come to a standstill as roads are impassable [while] other places are even never accessible by any motor transport" (Kenya 1989a: 25). This was spectacularly demonstrated by the collapse of the road network in these areas during the El Niño rains of 1997. The road network in Mombasa District suffers from two handicaps. First, most roads are in poor condition, some being even unusable. Second, some roads are too narrow for the many heavy commercial vehicles coming from or going to the port (Kenya 1989d).

There is an international *airport* in Port Reitz, Mombasa. Malindi has a national airport, which is important for transportation of tourists. Minor landing strips are scattered over the region. The largest concentration is found in Tsavo West National Park (Figure 27.7, p. 428), serving the tourist lodges. The hinterland of both Kwale and Kilifi Districts hardly accessible by road are also not accessible by air.

As mentioned earlier, *water* and *electricity supply* are major constraints in the coastal region. Because of the scarcity of drinking water, the city of Mombasa has to draw its water from quite far away (see Chapter 23). Of the four sources, two — the Marere River and the Tiwi Boreholes, both in Kwale District — are some 20 km away and two are much further away – the Sabaki River 100 km north, and the Mzima Springs 200 km inland. The city still experiences a serious shortage of water, due to the high demand of the increasing population, industries and tourist facilities (Kenya 1994e). In Kwale, there were 27 large-scale water supplies in 1989, most of them located in the eastern half of the district. At the same time, twenty of these were in operation or under construction, the others were not in use. In the coastal strip, unprotected wells are an important source of water supply, but are also liable to contamination due to rope and water buckets for drawing the water (Kenya 1989b). Kilifi District had some 527 km of water pipelines in 1989 while another 64 km were under construction (Kenya, 1989a). In Tana River, each of the four divisional headquarters, including Garsen, has its own water supply system, which are, however, inadequate. Along the river, various protected wells have been constructed by the Ministry of Health. In some places, there are surface dams, but they are threatened by siltation (Kenya, 1989f).

Electricity is supplied by various sources. Mombasa and the centres along the tarmac roads to Voi and to Malindi are connected to the national grid. In addition, there is a diesel power generating plant in Kipevu, Mombasa. At the time of writing this chapter (1997), both sources had serious capacity prob-

lems. In recent years daily rationing of power lasting six hours had become normal practice in Mombasa and its immediate surroundings, reaching a climax in the course of 1996 when rationing lasted twelve hours or more (*The Daily Nation*, 25 October 1996: "Power crisis hits the Coast"). As a result, many businesses found themselves in serious trouble or even had to close down completely. Outside the 'tarmac zones' electricity supplied by means of generators is only available in a few places (although many private houses in the coastal strip have their own generators), usually the district headquarters and other main market centres.

Social infrastructure

Table 3.5 offers an overview of different categories of ***health facilities*** in each of the districts. In the whole study area there was on average approximately one facility per 8,500 persons in 1989. These figures differ considerably between the districts. In Kwale and Kilifi Districts, the ratio of facilities is much lower than in the other districts. The situation in Lamu seems to be most favourable. Still, the picture is probably distorted. For instance, in Mombasa, facilities are much better than in all other districts while the distance to each facility is comparatively small. In Lamu, large areas are quite sparsely populated; hence, people have to walk great distances to the nearest health facility, even with the risk of being attacked by bandits. Moreover, quite a number of refugees from nearby Somalia have arrived in recent years, causing overutilization of several health centres (Kenya 1994d). With 159 hospital beds and cots per 100,000 inhabitants in 1993, Coast Province ranked second in the country after Nairobi (Kenya 1994h). However, the provincial figure is biased because of the facilities in Mombasa. For instance, in Kwale only 72 beds were available in 1993 (Kenya 1994c), which is about half the national average. In Taita Taveta, on the other hand, the situation was better, notably 142 beds per 100,000 inhabitants (Kenya 1994f).

As regards the ***educational facilities*** in the region, the number and distribution of secondary schools is taken into consideration. Table 3.6 gives the number of secondary schools per district in 1989, as well as the size of the so-called secondary school cohort, i.e. the population of the age group, 14-17 years of age. The right-hand column shows that in the whole area, there is one secondary school per approximately 1,250 potential pupils. But in Taita Taveta and Lamu, for the same number of pupils two schools are available. A major constraint for most schools (including primary schools) are their

Table 3.5 Health facilities, 1989

District	hospitals[a]	health centres[b]	clinics	dispensaries	other	total	population per facility[c]
Kilifi	5	6	-	34	2	47	15,149
Kwale	3	5	-	33	1	42	10,168
Lamu	1	7	5	12	-	25	2,692
Mombasa	10	15	14	27	8	74	7,866
Taita Taveta	3	5	-	22	16	46	4,922
Tana River (SE)	1	2	1	8	-	12	4,517
Total	23	40	20	136	27	246	8,411

Notes: a. Includes District Hospitals, Sub-District Hospitals and Provincial Hospital (Mombasa).
b. Includes Health Centres and Sub-Health Centres.
c. Based on the 1993 population projections.

Sources: Kenya, 1989a-f; 1994b-g.

Table 3.6 Secondary schools

District	nr. of secondary schools (1992)	nr. of 14-17 yrs old (1993)*	nr. of 14-17 yrs. old per secondary school
Kilifi	39	69,000	1,769
Kwale	22	33,755	1,534
Lamu	6	3,414	569
Mombasa	32	44,240	1,383
T. Taveta	39	21,213	544
Tana River**	11	16,942	1,540
Total	149	188,564	1,266

* Population projections.
** Since the 14-17 years population projection for Garsen Division were not available, the Tana River figures concern the whole district.
Sources: Kenya, 1994b-g.

poor facilities due to poor maintenance of the buildings, lack of equipment, lack of desks and lack of teachers' houses, among others. Secondary schools are usually confronted with lack of dormitories, workshops and laboratories, and electricity, especially in the marginal areas (Kenya 1989a).

Conclusion

Compared with other parts of the country, Kenya's coastal region is not favoured in terms of physical resources. The agricultural potential is relatively low, which is due to the limited amount of precipitation, the high level of rainfall variability and the lack of fertile soils. Droughts are quite common. Moreover, it is only in a few areas that sufficient rainfall and fertile soils go together. As a result, crop performance is generally poor.

Various minerals, some in exploitable deposits, are present in the area but few are actually being mined, and mostly at a modest scale. There are still substantial forest reserves, but in various parts of the region these are threatened by human activities. Water supply is a major problem, since there are very few permanent streams. People in rural areas often have to walk long distances to the nearest water source. Mombasa suffers from a chronic water shortage. In the national parks and reserves, wildlife abounds. This is important for tourism, but the local population hardly benefits from it. Finally, marine resources are perhaps the most important resource of the region, as the beaches and the coral reefs attract many tourists from all over the world. The tourist sector, in turn, influences the distribution of coastal infrastructure. It is mostly in the limited areas where the tourist hotels are located that infrastructural provisions like roads, water facilities and electricity exist. These are also the areas where quite a number of relatively well developed service centres can be found. In the major part of the region, the physical infrastructure is poorly developed. Finally, although quite a number of health and educational facilities can be found all over the area, they are generally too few and most of them are under-equipped. In conclusion, in terms of physical resources and infrastructure, most of Kenya's coastal region can be characterised as poorly endowed and poorly developed.

References

BENNUM L. (1995). Arabuko again ... *Swara*, 18(5), 22-23.

BRAUN H.M.H. (1985). *Average monthly rainfall as a percentage of the annual rainfall in Kenya and Tanzania, with particular reference to the Kenyan Coast*. Nairobi: Ministry of Agriculture, Kenya Soil Survey.

BUTYNSKI T. (1995). Primates and hydropower. *Swara*, 18(5), 28-30.

DE MEESTER T. & SMALING E.M.A. (1987). The soils. In H.W. Boxem, T. de Meester & E.M.A. Smaling eds., *Soils of the Kilifi area, Kenya* (pp. 48-109). Wageningen: PUDOC.

FOEKEN D. (1994). Climatic seasonality in Kenya, with special reference to Coast province. *Eastern and Southern African Geographical Journal*, 5(1), 28-43.

FOEKEN D. & HOORWEG J. (1988). *Seasonality in the Coastal Lowlands of Kenya, Part 2: Introduction to seasonality.* Nairobi / Leiden: Ministry of Planning and National Development / African Studies Centre, Food and Nutrition Studies Programme, Report Nr. 28.

GORDON I. (1995). The Kipepeo Project. Butterflies of Arabuko Sokoke help protect the forest. *Swara*, 18(6), 15-17.

HERLEHEY T.J. (1983). *An historical dimension of the food crisis in Africa: surveying famines along the Kenyan Coast, ca. 1880-1980.* Boston: Harvard University (Thesis).

HOORWEG J. (1998). Introduction. In J. Hoorweg ed., *Dunes, groundwater, mangroves and birdlife in coastal Kenya* (pp. 1-16). Nairobi: Acts Press.

JAETZOLD R. & SCHMIDT H. (1983). *Farm management handbook of Kenya, Volume II: Natural conditions and farm management information. Part C: East Kenya.* Nairobi: Ministry of Agriculture.

KENYA, REPUBLIC OF (1984). *Kwale District environmental assessment report.* Nairobi: Ministry of Environment and Natural Resources, National Environment and Human Settlements Secretariat.

KENYA, REPUBLIC OF (1989a). *Kilifi District development plan 1989-1993.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1989b). *Kwale District development plan 1989-1993.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1989c). *Lamu District development plan 1989-1993.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1989d). *Mombasa District development plan 1989-1993.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1989e). *Taita Taveta District development plan 1989-1993.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1989f). *Tana River District development plan 1989-1993.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1991). *Statistical abstract 1991.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1993). *Economic survey 1993.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1994a). *Kenya population census 1989, Volume I.* Government Printer.

KENYA, REPUBLIC OF (1994b). *Kilifi District development plan 1994-1996.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1994c). *Kwale District development plan 1994-1996.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1994d). *Lamu District development plan 1994-1996.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1994e). *Mombasa District development plan 1994-1996.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1994f). *Taita Taveta District development plan 1994-1996.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1994g). *Tana River District development plan 1994-1996.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1994h). *Statistical abstract 1994.* Nairobi: Government Printer.

KENYA, REPUBLIC OF (1995). *Economic survey 1995.* Nairobi: Government Printer.

MICHIEKA D.O., VAN DER POUW B.J.A. & VLEESHOUWER J.J. (1978). *Soils of the Kwale-Mombasa-Lungalunga Area, Volume I and II and Soilmaps 1 : 100,000.* Nairobi: Ministry of Agriculture, Kenya Soil Survey.

MUKUI J.T. (1994). *Kenya: Poverty profiles, 1982-92.* Nairobi: Office of the Vice-President and Ministry of Planning and National Development.

OBUDHO R.A. & ADUWO G.O. (1990). Small urban centres and the spatial planning of Kenya. In J. Baker ed., *Small town Africa. Studies in rural-urban interaction* (pp. 51-68). Uppsala: The Scandinavian Institute of African Studies.

SMALING E.M.A. & BOXEM H.W. (1987). Climate and agroclimatic zonation. In H.W. Boxem, T. de Meester & E.M.A. Smaling eds., *Soils of the Kilifi Area, Kenya* (pp. 9-20). Wageningen: PUDOC.

SMALING E.M.A. & JANSSEN B.H. (1987). Soil fertility. In H.W. Boxem, T. de Meester & E.M.A. Smaling eds., *Soils of the Kilifi Area, Kenya* (pp. 109-117). Wageningen: PUDOC.

SOMBROEK W.G., BRAUN H.M.H. & VAN DER POUW B.J.A. (1982). *Exploratory soil map and agro-climatic zone map of Kenya 1980, scale 1 : 1,000,000.* Nairobi: Ministry of Agriculture, Kenya Soil Survey, Report No. E1.

WAAIJENBERG H. (1987). Agriculture in the Kilifi area (Mapsheet 198), Kenya. In H.W. Boxem, T. de Meester & E.M.A. Smaling eds., *Soils of the Kilifi area, Kenya* (pp. 195-247). Wageningen: PUDOC.

WALSH R.P.D. (1981). The nature of climatic seasonality. In R. Chambers, R. Longhurst & A. Pacey eds., *Seasonal dimensions of rural poverty* (pp. 11-21). London: Frances Pinter (Publishers) Ltd.