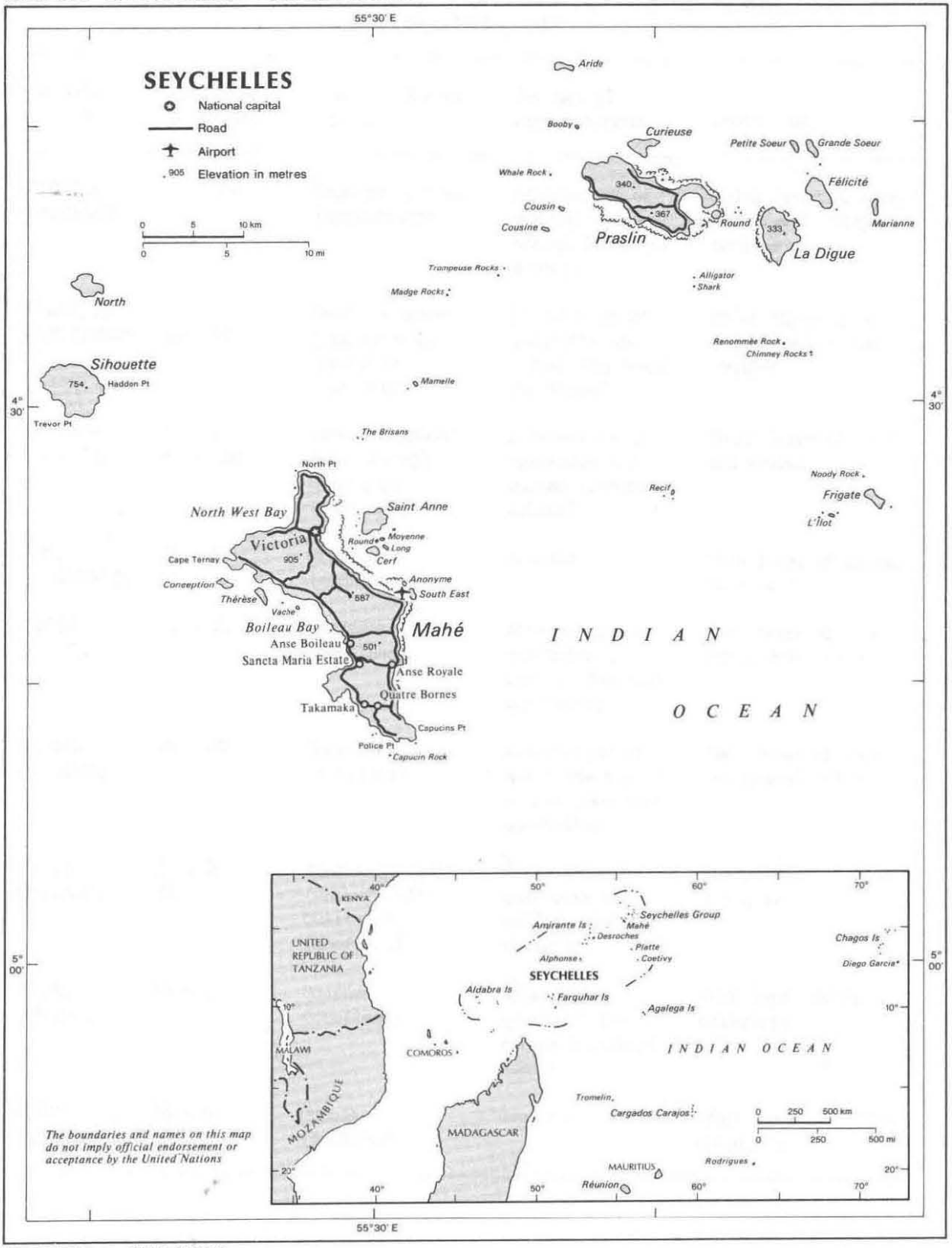
MAP 23. SEYCHELLES — GENERAL MAP



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SEYCHELLES

Area: 453 km^2
Population: 60,000

I. BACKGROUND

The Seychelles archipelago in the Indian Ocean numbers about 100 islands situated around latitude 3° south and about 1,500 km from the east coast of Africa. Almost all (98 %) of the population lives in the Mahé-Praslin group of granitic islands which makes up about 50 % of the archipelago's land area. Most of the islands take the form of fairly high plateaus (up to 900 m) dominating narrow coastal plains. They consist of recent Precambrian granites with intrusions of Cenozoic dolerites and syenites. In some places the granite is altered into clays or "tropical red earth". The other outlying islands consist of coral atolls and sand banks.

Climate

The climate is of the wet tropical (equatorial) type with little variation of temperature (27 °C) and humidity (80 %) during the year. The climate is dominated by the pattern of the monsoons. The south-east monsoon from May to October brings cool winds but little rainfall (dry season); the north-west monsoon from November to April brings variable gentle winds, low clouds and heavy rainfall (wet season). The monsoons themselves are determined by the position of the inter-tropical convergence zone (ITCZ) which sweeps the island twice a year. During the wet season the ITCZ is located at about latitude 15° south and the imbalance of this unstable air causes heavy rains. During the dry season the ITCZ is situated at latitude 15° north and therefore has no influence on the weather of the Seychelles.

The heaviest rains occur on Mahé, where the amount depends mainly on the altitude. The central plateaus can receive up to 3,500 mm of rainfall a year but the south of the island less than 1,800 mm. The heaviest rainfall occurs in the outlying islands, but little data is available for them. In contrast, there have been up to 40 pluviometric stations on Mahé, of which 30 are still operating and six are equipped with automatic recording instruments.

Several other stations are also in operation on Mahé, Praslin, La Digue and Aldabra.

Some data on the rainfall (in millimetres) are given below:

Station	Annual Average	Typical range	Maximum	Minimum
Mahé	2,370	630	6,176	956
Praslin	1,990	490	3,206	872
La Digue	1,620	390	2,450	974
Outlying islands	1,290	390	2,486	541

The average annual evaporation from a free surface measured at Mahé airport is 2,063 mm; (the value of 1,748 mm is obtained by calculation).

Surface water

The granitic islands have many small steep watercourses which flow swiftly over pebble beds. They have incised deep V-shaped or Y-shaped valleys. Most of the watercourses have only ephemeral flows. There is a small number of perennial watercourses; in the dry season they have only a tiny flow through the mass of pebbles which is visible only close to the banks. The collection of flow data was begun in 1960 by means of triangular channels, some of which have been abandoned but others were improved in 1976 with the installation of recording instruments. In addition, estimates have been made of the low water flows of the minor watercourses on Mahé, Praslin and La Digue.

II. GEOLOGY

Granitic islands

The granitic islands have high relief consisting of the tips of a large granitic mass underlying the Seychelles banks. The granites are about 600 million years old. They are of calc-alkaline composition, usually with alkaline feldspaths, plagioclases and hornblende quartz. These granites are mostly coarse-grained and traversed by dykes. They are intensely altered but still rise to heights of up to 900 m. With the exception of the small coastal plateaus, the granitic islands have a rugged relief resulting from the different degrees of erosion along the less resistant dykes, which thus control the hydrographic network. At the summit of the hills and along the high ground the granite is exposed in the form of blocks and large pebbles, and vertical rocky walls are the rule at all altitudes.

Coral islands

Recent deposits of sands are found on the outlying islands, which are surrounded by very deep water. With the exception of two of them, these islands consist exclusively of limestone.

Their bedrock is probably of volcanic origin. Two types are distinguished:

(i) The commonest type consists of sand and gravel debris detached from the base and carried up above sea level by the action of the waves: the islands are barely more than four metres above sea level;

(ii) The second type also consists of coral and algae limestone but these islands were raised in a body. Their present altitude is 9 m; it must have been higher in the past. Geologists estimate in fact that Aldabra once rose to a height of 16 m, but its present altitude is under 5 m; this implies 11 m of erosion by mechanical action or dissolution. It was also thought that these islands emerged as a result of a drop in the level of the sea and that they reached their maximum height during the second interglacial period about 40,000 years ago.

Sedimentary rocks are confined to the Recent deposits found along the coastline and on the outlying islands. These deposits include sands and gravels produced from limestone corals and algae, with varying amounts of shell fragments. Sandstone strata with limestone or calcium phosphate cement are sometimes found in these formations. The action of the waves broke down the reefs and the currents shifted

the fragments, forming offshore bars and beaches. The plateaus along the coast are very young and it is probable that the oldest deposits are no more than 6,000 years old. As the plateaus are actually table-shaped, the surface flow is slow, the sediment charge is deposited and swampy areas have thus been formed at the foot of the hills. As stated above, the coastal plateaus occupy only a small area, the largest of them being found on Praslin and La Digue.

The surface of the limestone islands is irregular and fragmented. There are many caves with channels and cavities which may communicate with the sea. The ground water is therefore saline and affected by the tides. The sand banks are different. They are flat and their edges are at the mercy of the ocean currents, but owing to the protection of the reefs change is slow.

All the southern islands of whatever type contain sand dunes which can be up to 31 m high, mainly in the south-east coastal zones. The monsoons have perhaps helped to form these dunes. They consist of calcareous sand of uniform calibre and are more or less stabilized.

III. GROUND WATER

The Water and Sewerage Division of the Public Utilities Corporation is responsible for all matters relating to water resources throughout the Seychelles. However, owing to the lack of regular boat services, it has not been possible to make regular periodic measurements on the outlying islands.

The hydrogeological studies have been concerned mainly with the coastal aquifers of the four islands of the Mahé-Praslin group. The coastal plains are narrow (a maximum of 1,000 m wide on the higher coast) and consist of altered granite overlain with gravels and quartzitic and feldspathic sands, shell sands and debris of coral reefs, with clays and soil.

The aquifers are unconfined and the water table is close to the surface (1 metre deep, i.e. 1 to 2 metres above sea level), producing undrained swampy areas. The hydraulic grade slopes gently towards the sea but its shape can change during the year. The transmissivity coefficient is fairly high and the storage coefficient is around 10 % on average.

The following studies have been made of ground water:

Mahé island

1977. Study of the coastal swamp of Anse de l'Intendance. Here the ground water is saline except in the vicinity of a small estuary.

1978. Val Mer estate - Electrical geophysical study.

1978. Three boreholes drilled near a State farm (Anse à la Mouche). They yield 2 l/s intermittently and are used for sprinkler-irrigation of vegetables.

1987. Eight boreholes drilled in the coastal plain of Anse Royale, with test pumping in wet and dry seasons. This pumping seems to have causes sea-water intrusion. The observation are continuing.

Ste. Anne island

1980. Detailed study of a small coastal clay aquifer. The yields are too small for exploitation to be considered.

Praslin

1977-1978. At l'Amitié - Study of the largest coastal aquifer in the Seychelles (2 km^2). A productive borehole was drilled.

1977-1978. At Pasquière and Plaine Hollandaise: thin aquifer with poor permeability.

1981-1983. Coastal zone - Côte d'or. Here the ground water proved to be saline.

La Digue island

1977. A large drilling programme was carried out in a relatively large coastal zone (almost 2 km^2) with great success in a very permeable stratum of quartzy gravel with no fine elements.

The piezometric levels are monitored regularly on Mahé, Praslin and La Digue. The water quality is checked exclusively by measurement of conductivity. Apart from the exploitation wells on La Digue where a number of physical, chemical and bacteriological properties are measured monthly, checks are made at other points on request.

The following table presents the results of some of the ground-water studies.

Situation	Depth of aquifer (m)	Depth of borehole (m)	Specific yield (l/s/m)	Hydrogeological properties: Permeability K (m^2/day)	Hydrogeological properties: Transmissivity T (m^2/day)	Hydrogeological properties: Storage S (%)
Mahé island						
1. Anse Int. 3 boreholes	22	8-25	7.0	22.7	500	10
2. Val Mer 2 boreholes	15	15-20	11.5	57.3	860	11
3. Anse Royale 8 boreholes	12	10-23	7.0	16.7	200	8
Praslin island						
1. L'Amitié 4 boreholes	6	8-21	2.5	66.7	400	8
2. Pasquière 1 borehole	7	15	1.5	10	70	10

Situation	Depth of aquifer (m)	Depth of borehole (m)	Specific yield (l/s/m)	Hydrogeological properties: Permeability K (m^2/day)	Hydrogeological properties: Transmissivity T (m^2/day)	Hydrogeological properties: Storage S (%)
3. Plaine Hollandaise						
2 boreholes	1.5	10	1.5	106.7	160	0.1
4. Côte d'or						
17 boreholes	11	4-19	5.0	27.3	300	4
La Digue island						
10 boreholes	15	7-32	5.5	50	750	8

Water quality

When it is not contaminated by sea-water intrusion, the ground water of the Seychelles is fit for drinking. However, concentrations of hydrogen sulfide in excess of 1 mg/l have been found in the swampy areas, giving the water an unpleasant odour - which can be considerably reduced by aeration. The nitrate content is acceptable but the presence of ammonia seems to indicate pollution of organic origin. Traces of fluorine and iron have also been found. Owing to the filtering effect of the unconsolidated deposits, the ground water is of better bacteriological quality than the surface water.

The interface between sweet and sea water cannot be definitely established. There is an area of ionic diffusion at least 50 m thick which results from the seasonal and daily fluctuations (due to the tides) of the water level and penetrates inland.

In some cases the saline water may be associated with the presence of large swampy areas, the undeveloped remains of ancient lagoons where the salt water has still not been washed out by rain and drainage. The salt may also have been retained by the underlying clay of the main aquifer.

The dry residue of the ground water ranges from 450-550 mg/l in the wet season to 680-1,150 mg/l in the dry season. The temperature averages 27 °C (29 °C in the swamps). The measurements of electrical conductivity indicate a stratum with poor conductivity 16-17 m below ground level, associated with the presence of clay-free quartz grains and gravels.

Need for additional studies

(i) In several rural areas of Mahé, Praslin and La Digue it would be useful to have ground water available for irrigation, but this would require a minimum of geophysical studies, drilling and pumping;

(ii) The variations in the annual recharge and its effects on the position of the underlying salt water must be monitored in order to prevent sea-water contamination due to excessive pumping in years of insufficient rainfall.

This will require measurements over long periods in observation wells equipped with limnigraphs. A mathematical model of the aquifer should also be constructed;

(iii) The reaction of the interface of sweet and salt water to various levels of exploitation must also be determined;

(iv) A study should also be made of the ground water of the fracture zones in the higher granitic rocks, with a view to supplying water to the villages situated above the present limit of the existing networks;

(v) A general hydrogeological study should be made and hydrometeorological observation posts established on the outlying islands where ground-water development is envisaged. Preliminary studies have shown that the lense of sweet water is distorted in the direction of the swampy zones on the coral islands.

If all this is to be done, considerable external aid will be required in the form of financing, personnel training and technical assistance.

A project proposal has been prepared with a view to improvement of the water supply on La Digue through the drilling of additional boreholes. Test boreholes might also be drilled, with an eye to irrigation.

IV. EXPLOITATION OF THE GROUND WATER

The water resources section of the Water and Sewerage Division of the Public Utilities Corporation is responsible for all ground-water development operations in the country, including studies, in co-operation with specialized firms of consultants. This section has five technicians, including a computer technician, and up to 1985 it had the services of a hydrogeologist from the United Kingdom. The water resources section needs technical aid in the form of specialist advice and training.

The service has two light cable drilling rigs (Edeco DR1 and Pilcon Wayfarer 1500) which have been used in the drilling of almost all the country's existing boreholes. They are used on request. The Division has laboratory facilities for chemical analysis of the water.

Most of the inhabitants of La Digue take their water supplies from the ground-water aquifer exploited by a single well on the coastal plateau. The hydrogeological studies carried out in 1977-1978 demonstrated that the pumped yield should not exceed the safe limit, but this limit is exceeded in periods of prolonged drought. However, in the long term (one month to one year) the volume of water drawn off is below the safe limit.

The water is treated and aerated. The average consumption is 4,760 m^3 per month - 3,000 m^3 for domestic use and the remainder for commercial use, including tourism and industry. The demand is expected to triple in the years to come. The output must therefore be increased considerably and new pumping stations installed. On La Digue the ground water is also used for irrigation and to water livestock.

On Mahé and Praslin the population uses surface water, which is more abundant on these islands. However, here too the demand is showing a considerable increase.

Hardly anything is yet known about the exploitation of the ground water of the coral islands with respect either to the quantities drawn off or to their quality. It would be very useful to determine this potential, for it is the most important determinant of population size.

There is a serious problem which must be emphasized, one common to small islands: the amounts of water available are closely linked to the weather - be it watercourses which react immediately to rainfall, or ground water which is very vulnerable to contamination by sea water when it is overexploited or during droughts. Since the aquifers are unconfined and very permeable and the ground water is close to the surface, the resource is very vulnerable to pollution, especially when latrines with cesspools penetrate the water-bearing stratum.

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