# 3. Climate and surface water hydrology

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## 1. Introduction

Suriname is drained by seven rivers towards the Atlantic Ocean. Three main groups can be distinguished, when the extent and shape of the drainage areas are compared, see Fig. 1.

The larger Marowijne and Corantijn Rivers, with drainage areas of approximately 68,700 km² and 67,600 km² respectively, represent the first group, and together they drain almost 58% of the country. These rivers are border rivers respectively in the East and the West.

The Coppename River (approx. 21,700 km²) and the Suriname River (approx. 16,500 km²) represent the second group, and together they drain approximately 24% of the country.

The Nickerie River (approx. 10,100 km²), the Saramacca River (approx. 9,000 km²) and the Commewijne River (approx. 6,600 km²) represent the third group of rivers. These rivers together drain approximately 16% of the country.

It is obvious that the rivers of the first and second group mentioned above have a South-North flow, directly to the Atlantic Ocean. The rivers of the third group which are smaller ones deflect to the West on the Coastal Plain towards one of the larger rivers.

The courses of the rivers can be divided into two different parts, namely the courses through the hills and mountains of the Guiana Shield, and the estuaries traversing the Coastal Plain. Further intrusion of the tide is halted by the most seaward rapids, which mark the transition between the two parts. The Commewijne River and its tributary the Cottica River is the only river in Suriname which flows almost entirely through the Coastal Plain.

Hydrologically the country can be divided into three distinct areas. They are from the South to the North as follows, the Interior (Basement Area), the Savanna Belt, and the Coastal Plains. The largest one is the Interior covering 126,500 km² (Duba 1972) of the country, approximately South of 5° N Latitude. The infiltration and percolation in this area is comparatively small. As a consequence the surface run-off is relatively large, and the drainage density high.

*Paul E. Ouboter (ed.), Freshwater Ecosystems of Suriname, 29–51.*

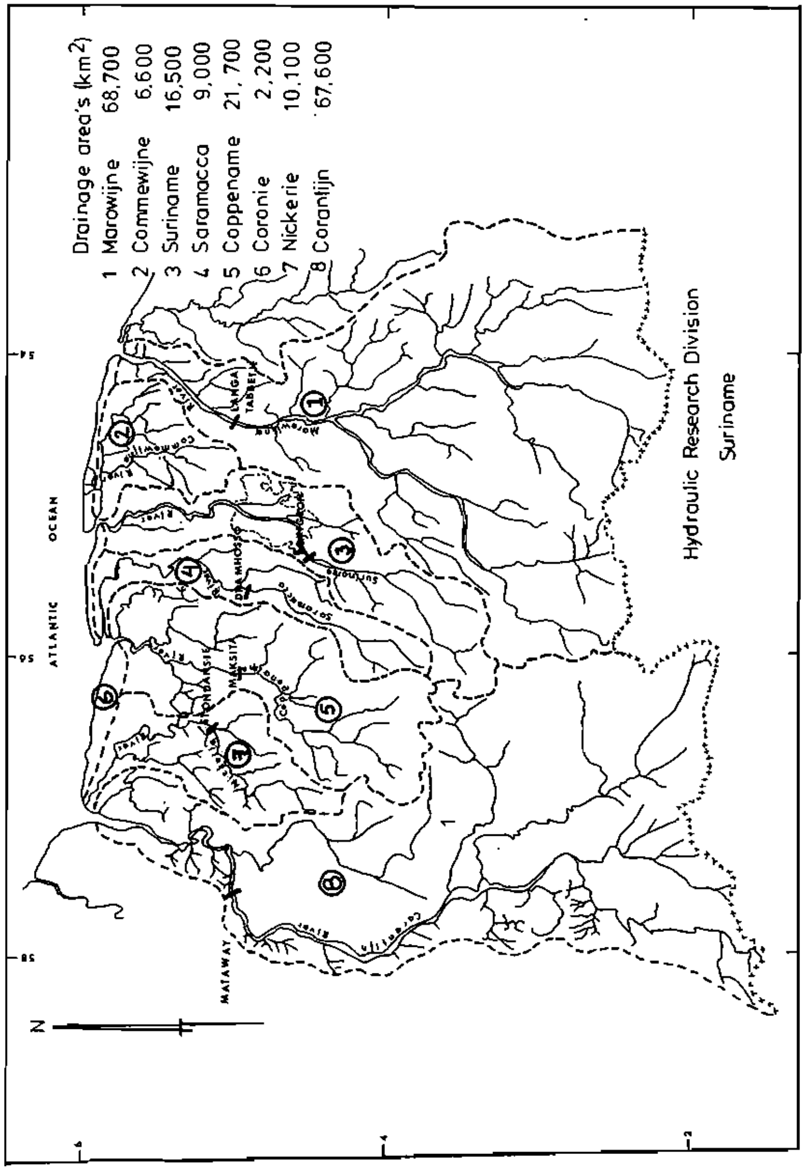


*Figure 1.* The main rivers of Suriname.



The Savanna Belt is the smallest of the three above-mentioned areas, with a total area of 8,500 km² (Duba 1972). This area is covered with coarse sands with interbedded sandy clay. One may expect that the infiltration and percolation is high, and the surface run-off small. The density of the drainage network of the Savanna Belt is less than the density of the drainage network of the Interior.

The Coastal Plains Area is spread over 21,000 km² (Duba 1972) of the country, and is low and flat. The surface run-off here is small, and the drainage network is not developed well. The water in the basin is stagnated and numerous swamps exist in this area. The major hydrological feature of this area is a vertical exchange of water via a rainfall – basin evapotranspiration mechanism. This results in a small run-off, and large input of water into and out of the Coastal Plains area.

At the upper reaches beyond the estuaries, where there is no tidal influence, the water level and currents in the rivers are influenced by the freshwater discharge. Consequently high waters correspond with peak flows, and low waters with low flows.

In the estuary the water level and currents are influenced by the tide, as well as by the freshwater discharge. Due to the tide, tidal inflow and outflow of seawater occur into and out of the estuary. The amount of water which moves into and out of the estuary is referred to as the tidal volume or tidal prism.

The tidal flow diminishes further upstream. Beyond a certain point upstream there is a continuous flow towards the lower reaches, and there is no reversal flow because of the freshwater discharge. This continuous flow varies in strength periodically, as far as the tide is noticeable. The location of the point at which the reverse tidal flow stops, depends upon the magnitudes of the freshwater discharge and the tidal range, and thus the tidal limit depends upon these two magnitudes.

The tide along the coast of Suriname is of the regular semi-diurnal type, having two high waters and two low waters during a tidal day (Nedeco 1968).

The tidal flow from the sea and the differences in density of the sea water and freshwater cause the salt-intrusion in the estuaries. On the other hand, the freshwater discharge of the rivers prevents further intrusion of the tide and saline waters. Tidal and salt-intrusion extend further landward, as the freshwater discharge decreases. So during periods of low flows (dry season) maximum intrusion occurs, and during peak flows (rainy seasons) minimum intrusion.

Silt originating from the Amazon basin is transported by the sea water along the coast of Suriname. These sediments are deposited at locations where the mixing of saline water and freshwater takes place (flocculation). As a result shallow banks and bars occur in the lower courses of the Surinamese rivers. On the other hand there is also a discharge of sediments, which originate from the Surinamese river-basins.

## 2. Climatological Aspects

### 2.1. General

Suriname lies in an area in which a North-East and South-East trade wind may occur. The Inter-Tropical Convergence Zone ("ITC-zone", also called the centre of the "Equatorial Trough") is the most decisive factor in creating the climate of Suriname. Two times a year the ITC-zone passes over Suriname, resulting in four seasons, namely

- the short dry season: early February to late April
- the long rainy season: late April to middle of August
- the long dry season: middle of August to early December
- the short rainy season: early December to early February.

The climate of Suriname is according to Köppen humid-tropical (Af), and has a mean monthly rainfall higher than 60 mm, during the driest months. However, the climate of a narrow strip along the coast, Coronie, and the South-West part of the country is drier. The long-term mean annual rainfall varies from about 1,450 mm (Coronie) to about 3,000 mm (Tafelberg) (National Planning Office of Suriname & Organization of American States 1988) (Fig. 2). The mean annual rainfall at Paramaribo, the capital of Suriname, which is located at about 10 km South of the coast, is about 2,200 mm. The maximum daily rainfall may rise up to 100–200 mm once every 2 or 3 years.

The mean temperature at Paramaribo is 27.1 °C. January is the coldest month with a mean temperature of 26.2 °C, while during the warmest months – September and October – the mean temperature is 28.2 °C. The mean of the daily maximum temperature is 30.5 °C and the mean daily minimum is 22.8 °C. Along the coast the daily fluctuations of the temperature is about 5 °C and is 10–12 °C in the Interior (National Planning Office of Suriname & Organization of American States 1988).

The mean windspeed is 1.3 on the scale of Beaufort. During the dry seasons the maximum windspeed occurs: a maximum of 1.6 Beaufort occurs in February, and a second peak in September and October. A minimum of 1.0 Beaufort occurs in January. During daytime windspeeds of 3–4 Beaufort generally occur, while in the evening and at night, especially in the Interior the windspeed drops (National Planning Office of Suriname & Organization of American States 1988).

### 2.2. Precipitation and Evapotranspiration

In the rainfall-run-off process the rainfall and evapotranspiration (= evaporation + plant transpiration) are important components. Four climatological stations are selected here where sufficient rainfall and pan-evaporation data are available, to give a rough idea of the precipitation and evapotranspiration over the whole country throughout the year. These stations



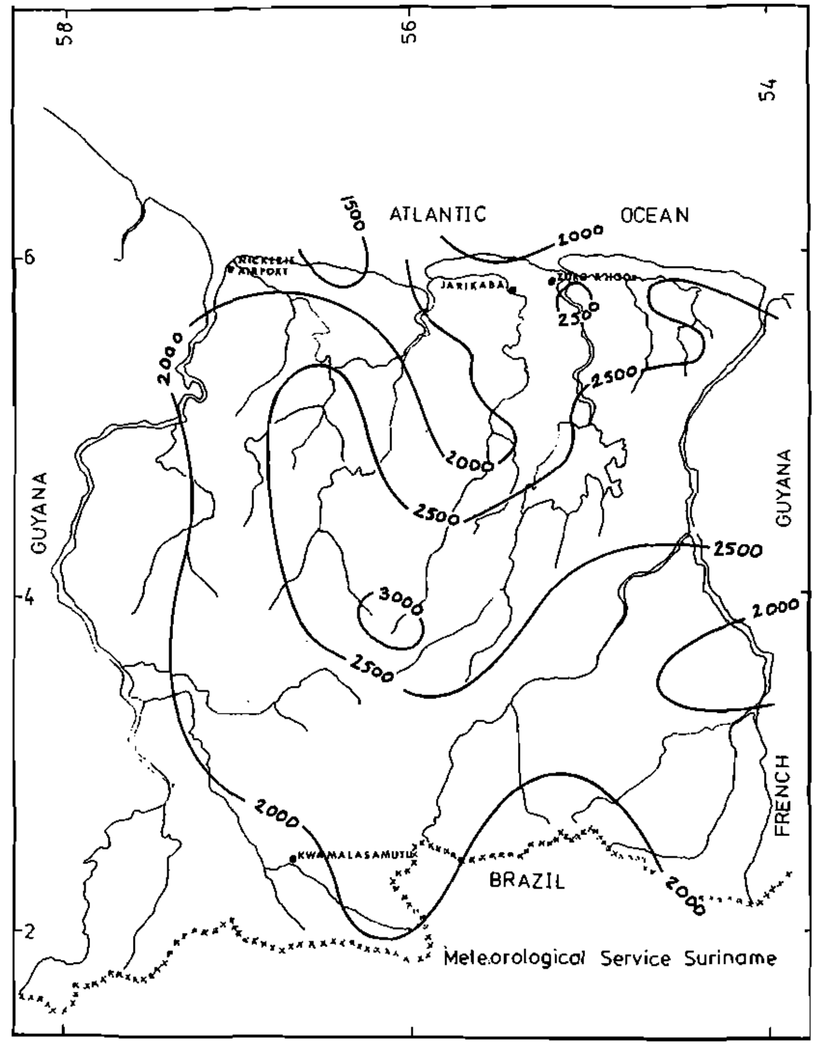


*Figure 2.* Average annual rainfall (in mm).

are Zorg & Hoop, Jarikaba, Nickerie Airport, and Kwamalasamutu. Zorg & Hoop is located near Paramaribo, Jarikaba about 20 km West of Paramaribo, and Nickerie Airport is near the outfall of the Nickerie River in North-West Suriname. Kwamalasamutu is located in the Southwestern part of the country, where the annual rainfall is less (see Fig. 2).

The long-term mean, maximum and minimum values, and the standard deviation of the monthly total and annual total rainfall of the above-mentioned stations are presented in Table 1.

According to recent analyses of rainfall data by C. Becker of the Meteorological Service of Suriname the precipitation in Suriname is decreasing at an average rate of about 4 mm a year since the past 100 years. Fig. 3 presents the trend of the annual precipitation of station Cultuurtuin in Paramaribo, as well as the 7-years moving average, and the years when the "El Niño" phenomenon occurred. It is obvious that in only approximately 20% of the years when the El Niño phenomenon occurred the annual rainfall was above the trend.

The long-term monthly total and annual total pan-evaporation are presented in Table 2. These values have been observed by means of a Class-A evaporation

*Table 1.* Longterm average, maximum and minimum precipitation totals (mm) at stations Kwamalasamutu, Nickerie Airport, Jarikaba and Zorg & Hoop.

Precipitation (mm) 1977-1990
Station: 144 Kwamalasamutu

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AVE | 116.8 | 103.9 | 224.6 | 254.0 | 389.7 | 302.1 | 233.1 | 151.8 | 78.3 | 52.8 | 40.4 | 78.5 | 1,729.6 |
| MAX | 216.0 | 166.3 | 370.7 | 340.7 | 528.2 | 547.0 | 512.0 | 317.6 | 135.3 | 95.5 | 125.9 | 135.9 | 2,481.7 |
| MIN | 40.7 | 21.9 | 34.1 | 100.5 | 131.8 | 94.6 | 26.0 | 23.3 | 25.1 | 15.5 | 2.1 | 26.3 | 908.0 |
| STDEV | 56.5 | 50.9 | 120.0 | 100.5 | 130.1 | 127.2 | 128.6 | 82.8 | 35.4 | 22.6 | 42.3 | 35.6 | 464.0 |

Precipitation (mm) 1965–1990
Station: 209 Nickerie Airport

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AVE | 167.2 | 93.7 | 98.8 | 173.3 | 246.1 | 264.1 | 229.2 | 166.1 | 83.2 | 58.7 | 83.4 | 156.0 | 1,754.1 |
| MAX | 427.1 | 297.1 | 258.4 | 454.0 | 480.0 | 396.0 | 381.9 | 281.9 | 342.8 | 181.8 | 224.0 | 329.5 | 2,215.8 |
| MIN | 37.3 | 15.7 | 2.6 | 20.0 | 50.4 | 192.5 | 130.6 | 35.6 | 10.4 | 0.5 | 6.1 | 28.9 | 1,366.5 |
| STDEV | 111.9 | 73.5 | 69.9 | 112.9 | 102.9 | 57.3 | 78.4 | 67.7 | 66.5 | 50.1 | 54.5 | 82.4 | 288.0 |

Precipitation (mm) 1969–1990
Station: 530 Jarikaba

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AVE | 193.7 | 137.2 | 136.2 | 210.8 | 295.7 | 289.1 | 230.7 | 158.2 | 103.1 | 103.7 | 140.3 | 199.9 | 2,138.1 |
| MAX | 445.6 | 317.1 | 271.7 | 516.2 | 579.2 | 423.3 | 336.9 | 317.1 | 263.8 | 340.1 | 459.8 | 372.7 | 2,891.8 |
| MIN | 33.7 | 10.8 | 10.7 | 35.5 | 75.6 | 180.8 | 132.9 | 44.4 | 0.7 | 0.0 | 31.4 | 93.4 | 1,194.5 |
| STDEV | 130.9 | 84.4 | 71.3 | 130.0 | 107.2 | 72.8 | 49.5 | 80.7 | 69.2 | 74.4 | 95.3 | 67.0 | 410.1 |

Precipitation (mm) 1965–1990
Station: 604 Zorg & Hoop

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AVE | 186.4 | 112.8 | 131.9 | 194.3 | 284.1 | 304.1 | 248.1 | 159.0 | 105.5 | 114.5 | 123.2 | 192.7 | 2,128.6 |
| MAX | 438.1 | 306.0 | 344.7 | 466.1 | 484.6 | 459.4 | 389.3 | 340.7 | 287.7 | 216.8 | 221.2 | 385.3 | 2,948.1 |
| MIN | 34.1 | 11.8 | 5.2 | 27.5 | 88.3 | 192.9 | 142.6 | 59.6 | 32.9 | 1.0 | 28.5 | 88.1 | 1,539.0 |
| STDEV | 127.0 | 72.7 | 76.1 | 112.7 | 96.4 | 74.5 | 67.6 | 72.5 | 58.3 | 64.2 | 54.8 | 72.6 | 348.6 |



*Table 2.* Long-term mean pan evaporation totals (mm) at stations Kwalasamutu, Nickerie Airport, Jarikaba and Zorg & Hoop.

Pan evaporation (mm) 1979–1986
Station: 144 Kwamalasamutu

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 108.2 | 78.0 | 72.4 | 71.1 | 131.8 | 142.3 | 107.2 | 85.8 | 54.7 | 53.2 | 45.7 | 62.8 | 1,013.2 |

Pan evaporation (mm) 1973–1990
Station: 209 Nickerie Airport

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 129.7 | 141.5 | 165.6 | 156.9 | 132.1 | 129.8 | 141.7 | 156.8 | 166.5 | 174.9 | 165.6 | 139.9 | 1,801.0 |

Pan evaporation (mm) 1975–1989
Station: 530 Jarikaba

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 119.3 | 109.1 | 112.1 | 128.3 | 114.9 | 87.3 | 123.0 | 143.0 | 145.8 | 119.4 | 108.1 | 115.3 | 1,425.6 |

Pan evaporation (mm) 1973–1990
Station: 604 Zorg & Hoop

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 93.3 | 97.6 | 126.8 | 118.6 | 128.2 | 118.4 | 132.4 | 140.1 | 119.9 | 104.2 | 101.7 | 123.8 | 1,405.0 |

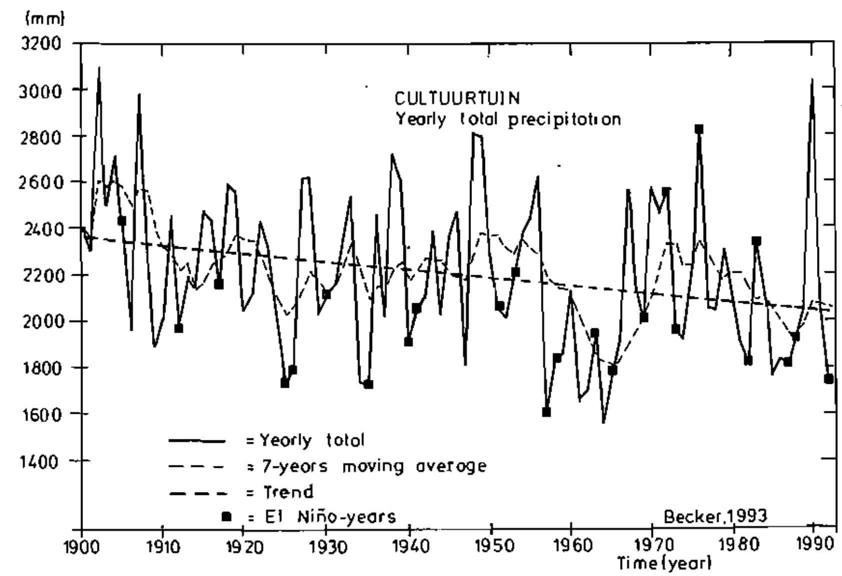


*Figure 3.* Yearly total precipitation at station Cultuurtuin.

pan, and give an idea of the evapotranspiration. One may estimate the potential evaporation by multiplying the pan-evaporation with the pan-coefficient, which is on average about 0.7 for the Class-A pan. Although the pan-evaporation does not give accurate estimates for the potential evapotranspiration (= maximum possible evapotranspiration in a given climatic condition, where the availability of water is not a limitation), one may conclude that the potential evapotranspiration in the Southwestern part of the country is less than the potential evapotranspiration in the Coastal Plain.

The precipitation surplus at the above-mentioned stations is presented by Figs. 4 and 5, and is equal to the total precipitation minus the potential evapotranspiration, assuming that the potential evapotranspiration here is equal to the potential evaporation. The precipitation surplus gives an indication of the availability of the precipitated water for the discharge. In Fig. 4 a pan-coefficient of 1.0 has been employed, and in Fig. 5 a pan-coefficient of 0.7. It should be mentioned that up to now only few investigations have been conducted in Suriname with regard to evapotranspiration.

Referring to Figs. 4 and 5 the precipitation surplus is the largest during the months of May, June and July, while during the months of September, October and November this parameter is the smallest. For the stations Zorg & Hoop and Jarikaba the values do not differ very much. For Nickerie Airport the values seem to be the smallest compared to the values of the other stations. For the first half year the values of the station Kwamalasamutu are larger than the values of the remaining stations.

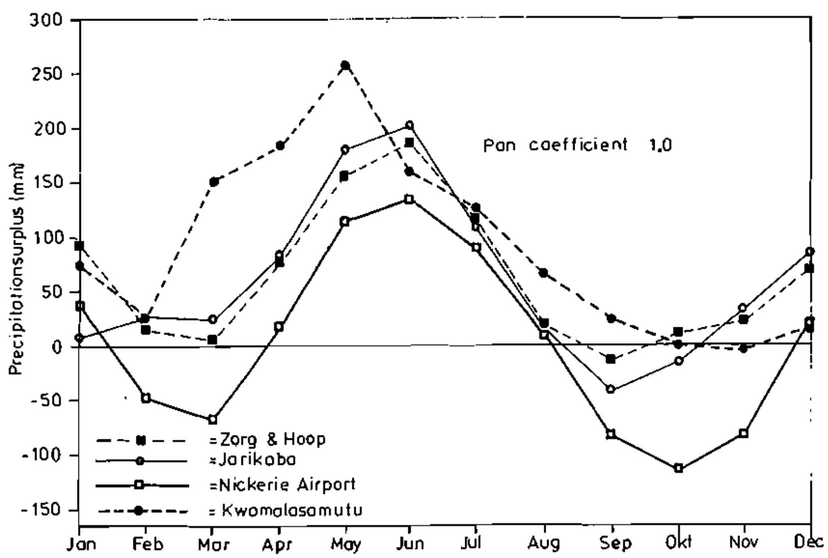


*Figure 4.* Precipitation surplus for four meteorological stations in Suriname, using a pan coefficient of 1.0.



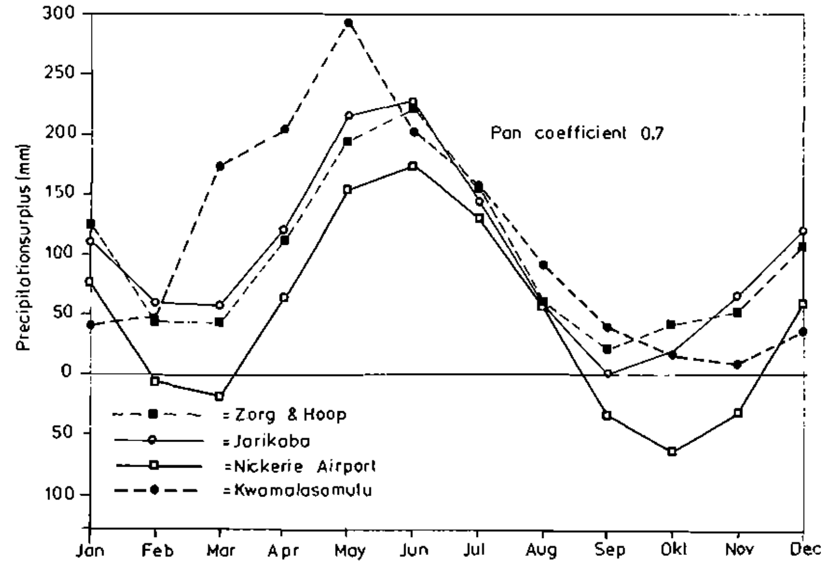


*Figure 5.* Precipitation surplus for four meteorological stations in Suriname, using a pan coefficient of 0.7.

## 3. The Rivers and Riverbasins

### *3.1. General*

In this part a description is given of the specific features of the different Surinamese rivers and river-basins.

The locations along the river courses are indicated by kilometres along the thalweg. The zeropoint is in the rivermouth, where the depth reaches 15 meters below low water spring (Nedeco 1968).

The considered discharge measurement stations are beyond the tidal limit, since it is complicated and laborious to measure the discharge continuously in the tidal reaches.

The limit of 300 mg Cl/l is considered here for the salt-intrusion, which is equivalent to 500 mg salt/l. This limit is used here, since most crops are tolerant to water with a salinity of less than 300 mg Cl/l. According to the available data there is a relationship between the freshwater discharge and the salt-intrusion.

The silt content is also influenced by the tide and the freshwater discharge, since most of the silt originates from the Amazon basin, and is transported by the sea water along the Surinamese coast.

*3.2. Marowijne River Basin*

The sources of the Marowijne River, and most important tributaries are in the mountain ranges which form the border with Brazil, and in the central highlands. The catchment area of this river is about 68,700 km², including the catchment area on the right bank in French Guiana (Hydraulic Research Division 1969). 99.45% is in the Interior, 0.05% in the Savanna Belt, and 0.5% in the Coastal Plains (Duba 1972). Many falls and rapids are situated along thc upper river courses and tributaries.

*3.2.1. Estuary*

The estuary of the Marowijne River is located downstream of the Armina Falls (km 114), about 90 km from the outfall. The mean tidal range is about 2 m in the rivermouth. The tidal volume of the Marowijne River is estimated at 200 million m³ and is less than the tidal volume of the Corantijn River (Nedeco 1968; Hydraulic Research Division 1969).

The salt-intrusion in the Marowijne estuary is less than the salt-intrusion in the Corantijn estuary. During wet periods the 300 mg Cl/l limit is, according to available data at the Hydraulic Research Division (HRD), close to km 37 in the Marowijne River, approx. 20 km downstream of Albina (km 57). During dry seasons this limit is near km 59, several km upstream of Albina.

*3.2.2. Freshwater Discharge*

The mean discharge at the outfall of the river was estimated at 2,100 m³/s. Peak discharges may exceed 9,000 m³/s, and minimum discharges may be as low as 100 m³/s (HRD 1969).

According to data collected over 29 years (1952–1980) the mean freshwater discharge of the Marowijne River at the station Langa Tabbetje (km 134) is 1,650 m³/s. The recorded maximum is 5,670 m³/s, which occurred in May 1976, and in November 1965 the minimum was recorded, namely 45 m³/s. The drainage area of the river upstream of Langa Tabbetje is about 63,500 km², which is about 92% of the total catchment area of the Marowijne River (HRD 1982). Assuming a mean discharge of 1,650 m³/s at Langa Tabbetje, and taking the catchment area into account, the mean discharge at the outfall is estimated here at 1,785 m³/s.

The exceedence frequency of the monthly freshwater discharge at Langa Tabbetje is presented in Fig. 6 (HRD 1982). One can conclude that peak flows and high waters occur around May-June, and low flows and low waters around November. These figures coincide more or less with the pattern of the precipitation surplus (Figs. 4 and 5). There is clearly a relationship between the precipitationsurplus and the discharge here, with some lag-time.



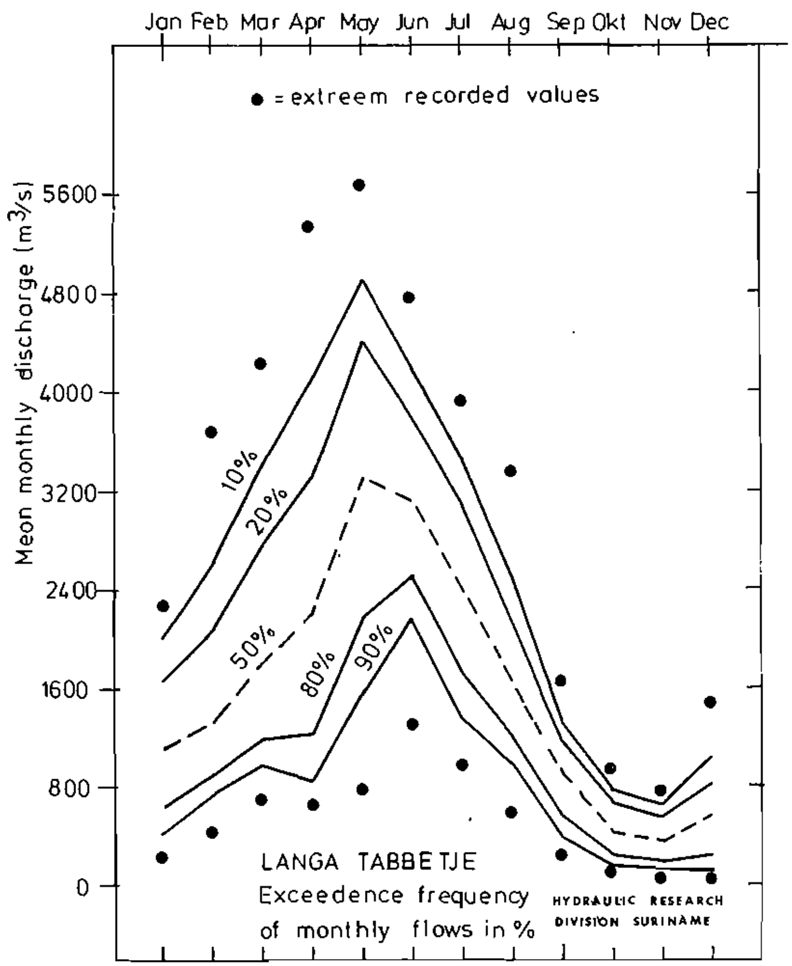


*Figure 6.* Exceedence frequency of the monthly freshwater discharge at Langa Tabbetje (Marowijne).

*3.2.3. Sediment Transport*

According to available data on silt content at the HRD, the silt content at Albina (km 57) varies from approx. 0.01 to 0.08 g/l, and it is expected that upstream the silt content decreases. Nedeco (1968) estimated the sediment discharge from the Marowijne River basin at 1.3 million tons per year.

*3.2.4. Depths*

The maximum depth along the thalweg at the lower reaches is approx. 21 m below the mean water level close to the French Guiana bank (km 47) and the minimum thalweg depth in this zone is approx. 4 m below mean sea level close to the outfall (km 15) (HRD 1969).

### *3.3. Commewijne River Basin*

The sources of the Commewijne River are in the Hok-A-Hing Mountains range near the Brokopondo Storage Lake. The catchment area of this river is about 6,600 km² (HRD 1972). 36.4% is in the Interior, 11.5% is in the Savanna Belt and 52.1% in the Coastal Plain (Duba 1972). Of the rivers treated here, the Commewijne River is the only one without rapids in its upper reaches.

*3.3.1. Estuary*

The tidal range in the outfall is about 1.9 m and the tidal volume is estimated at 40 million m³ (Nedeco 1968). The location of the tidal limit is not exactly known yet.

According to the available data at the HRD, during dry seasons the 300 mg Cl/l limit is located near km 150 in the Cottica River, approx. 10 km downstream from Tamarin. This limit is approx. 5 km upstream from Alkmaar during the wet season.

*3.3.2. Freshwater Discharge*

The discharge at the outfall of the Commewijne River was estimated at 120 m³/s by Ringma (1961). Only a few discharge measurements have been done in the Commewijne River. According to discharge measurements at Destombesburg (km 115) during the period 8–21 December 1979, the mean discharge at that station is 51.3 m³/s, and varies between 28 to 97 m³/s (HRD 1983).

*3.3.3. Sediment Transport*

The silt content at Alliance (km 67.2) varies according to data of the HRD between approx. 0.07 g/l to 20 g/l. Nedeco (1968) estimated the sediment discharge from the Commewijne River at 0.06 million tons per year.

*3.3.4. Depths*

The minimum depth of the thalweg is near the outfall, and is approx. 6.6 m with respect to the mean sea level. The maximum depth is approx. 31.0 m with respect to the mean water level, and is located near Post Sommelsdijk (km 71) (HRD 1972).



### *3.4. Suriname River Basin*

The sources of the Suriname River are in the Eilerts de Haan Mountain range. The length of this river is approx. 500 km, and the catchment area is approx. 16,500 km² (HRD 1988). 84.8% of the catchment is in the Interior, 4.5% in the Savanna Belt, and 10.7% in the Coastal Plain (Duba 1972). Along the upper river courses and tributaries, there are many falls and rapids. This is the only river in Suriname which is regulated. In 1964 a dam has been constructed for hydro-electric purposes at Afobaka (km 194). So an artificial lake, the Prof. van Blommenstein Storage Lake (Brokopondo Lake) exists between Afobaka and Pokigron (km 273), of which the area is about 1,600 km².

*3.4.1. Estuary*

The tidal intrusion depends upon the discharge from the Brokopondo Lake. Under normal discharge from the hydro-electric station, 250 m³/s, the tidal influence can reach as far as Berg en Dal (km 164), while the mean tidal range in the river mouth is approx. 1.8 m. The tidal volume of the Suriname River is approx. 125 million m³ (Nedeco 1968; HRD 1988).

The salt-intrusion also depends upon the discharge from the Brokopondo Lake. According to available data at the HRD the 300 mg Cl/l limit is near km 54, some kilometers downstream from Sluis Doorsteek during periods of peak flow; during periods of low flow this limit is near km 90, just upstream from Paranam.

*3.4.2. Freshwater Discharge*

The mean discharge at the outfall of the Suriname River was estimated at 440 m³/s. Peak flow may be as large as 1,800 m³/s and low flow as low as 220 m³/s (HRD 1970).

According to collected data over 27 years (1952–1978) the mean freshwater discharge of the Suriname River at station Pokigron (km 273), which flows into the Brokopondo Lake is 224 m³/s. The recorded maximum discharge at this station is 923 m³/s (May 1976), and the recorded minimum is 5.8 m³/s (December 1965) (HRD 1982).

The exceedence frequency of the monthly freshwater discharge at Pokigron (HRD 1982) shows that peak flows and high water occur around May–June and low flows and low water around November.

The average discharge at Afobaka (km 194) is 324 m³/s according to the collected data over a period of 12 years (1965–1980). The recorded minimum is 214 m³/s (July 1975), while the recorded maximum is 756 m³/s (June 1976). The drainage area upstream of the Afobaka station is approx. 12,550 km², which is approx. 76% of the total catchment area of the Suriname River (HRD 1982). Assuming a mean discharge of 324 m³/s, and taking the catchment area into account, the mean discharge at the outfall of the Suriname River is now estimated at 426 m³/s.

*3.4.3. Sediment Transport*
According to available data at the HRD, the silt content at Nieuw Amsterdam (km 40) varies between approx. 0.01 to 20.0 g/l, and at Domburg (km 68) this parameter varies between approx. 0.001 to 1.5 g/l. The sediment discharge from the Suriname River is estimated at 0.25 million tons per year by Nedeco (1968).

*3.4.4. Depths*
Near the rivermouth there are shallow spots along the thalweg, less than approx. 5 meters below mean sea level. Upstream up to Paranam the depth increases to approx. 17 meters with respect to the mean water level. Near km 130 several km downstream from Phedra, there are also shallow spots along the thalweg (HRD 1988).

*3.5. Saramacca River Basin*

The sources of the Saramacca River are in the central highlands of the country. The river emerges from the Emma Mountains in the South-West, and from the Van Asch van Wijk Mountains in the South-East. The length of the river is approx. 460 km and the catchment area is approx. 9,000 km² (HRD 1987). 74.1% of the drainage area is in the Interior, 3.1% in the Savanna Belt and 22.8% in the Coastal Plain (Duba 1972). Similar to the other rivers of Suriname, there are numerous falls and rapids along the upper courses of this river.

*3.5.1. Estuary*
During periods of low flows the tidal influence reaches much further than Kwakugron (km 220) (HRD 1987). The tidal prism is estimated at 50 million m³ by Nedeco (1968).

According to collected data by the HRD the limit of 300 mg Cl/l is near km 37, approx. 6 km downstream from Carl François during periods of peak flow, and during periods of low flow this limit is near km 89, approx. 5 km upstream of Groningen.

*3.5.2. Freshwater Discharge*
The mean discharge of the Saramacca River at the outfall was estimated at 240 m³/s by Ringma (1961).

The mean discharge of the Saramacca River is according to collected data over the period 1961–1978 (18 years) 100 m³/s at station Dramhoso (km 285). The observed maximum discharge of this station is 493 m³/s (May 1976), and a minimum of 1.8 m³/s occurred in November 1964. The drainage area upstream from the Dramhoso station is approx. 3,520 km², which is 39.1% of the total catchment area of the Saramacca River (HRD 1982). Assuming a mean discharge of 100 m³/s at the Dramhoso station, and taking into account the catchment area, the mean discharge at the outfall is estimated now at 225 m³/s..

Taking the exceedence frequency of the monthly discharge at Dramhoso (HRD 1982) into account, one may conclude that peak flows and high waters occur around May–June, and low flows and low waters around November.



*3.5.3. Sediment Transport*
According to the available data at the HRD the silt content at Huwelijkszorg (km 53) varies between approx. 0.003 and 1.3 g/l and at Uitkijk (km 104) between about 0.003 and 0.8 g/l. The sediment discharge from the Saramacca River is estimated at 0.13 million tons per year (Nedeco 1968).

*3.5.4. Depths*
The minimum depth along the thalweg is approx. 3 m with respect to the mean sea level, and is located near the outfall. The depth increases upstream, and there are depths of approx. 24 meters below mean water level near km 145, some kilometers downstream from Locus Creek (HRD 1987).

*3.6. Coppename River Basin*

The sources of the Coppename River are in the Wilhelmina Mountains in the central highlands. The catchment area is approx. 21,700 km² (HRD 1971). 65.5% is in the Interior, 9.2% in the Savanna Belt and 26.3% in the Coastal Plain (Duba 1972). Similar to most other rivers of Suriname there are numerous falls and rapids along the upper reaches.

*3.6.1. Estuary*
The tidal range in the outfall is about 2 m, while the tidal prism is estimated at 75 million m³ (Nedeco 1968). During periods of low flow the tidal influence can reach as far as Kwintikriki Falls (km 172) (HRD 1971).

According to data collected by the HRD the 300 mg Cl/l limit is near Boskamp (km 31) during periods of peak flow. During periods of low flow this limit is near km 83, about 12 km downstream from the outfall of the Wajambo River (km 95).

*3.6.2. Freshwater Discharge*
The mean discharge at the outfall was estimated at 490 m³/s. Peak flows may exceed 2,200 m³/s, and low flows may be as low as 6 m³/s (HRD 1971).

At discharge station Maksita (km 175) the mean discharge is 319 m³/s, based on available data over the period 1965–1980 (16 years). The maximum recorded discharge is 1,420 $m^3/s$ (May 1976), and the minimum recorded discharge is 4.4 $m^3/s$ (December 1969). The drainage area upstream from Maksita station is approx. 12,300 $km^2$, which is 57% of the total catchment area of the Coppename River (HRD 1982). Assuming a mean discharge of 319 $m^3/s$ at Maksita, and taking the catchment area into account the mean discharge at the outfall of the Coppename River is estimated here at 500 $m^3/s$.

According to the exceedence frequency of the monthly flow at Maksita (HRD 1982) it is expected that generally peak flows and high water occur around May–June, and low flows and low water around November.

#### *3.6.3. Sediment Transport*

The silt content at Boskamp (km 32) varies according to data collected by the HRD between approx. 0.03 and 50 g/l, and at the Tibiti outfall (km 68) between approx. 0.02 and 1.3 g/l. Nedeco (1968) estimated the sediment discharge from the river at 0.25 million tons a year.

#### *3.6.4. Depths*

The minimum depth along the natural channel at the lower reaches is near the rivermouth, and is about 3.7 m with respect to the mean sea level. The greatest depth is approx. 22 m below mean water level, and is located near km 82, 13 km downstream of the Wajambo outfall (HRD 1971).

### *3.7. Nickerie River Basin*

The source of the Nickerie River is situated in the Bakhuys Mountains. The catchment area of this river is approx. 10,100 $km^2$ (HRD 1970). Duba (1972) mentioned that 42.3% of the catchment is in the Interior, 23.6% in the Savanna Belt, and 34.1% in the Coastal Plains. Also in the upper reaches of this river there are numerous falls and rapids.

#### *3.7.1. Estuary*

During periods of low flow the tidal influence can be felt as far as Stondansie Falls (km 240) (HRD 1970). Nedeco (1968) mentioned that the tidal range is approx. 2.00 m at the outfall, and estimated the tidal prism at 10 million $m^3$.

According to data collected by the HRD the limit of 300 mg Cl/l may be further than the outfall of the Akwanza Creek during periods of low flow, while during periods of peak flow this limit is near Waterloo (km 28.2).



#### *3.7.2. Freshwater Discharge*

The mean discharge at the rivermouth was estimated at 160 $m^3/s$. The maximum discharge may exceed 500 $m^3/s$, while the minimum discharge may be as low as 2 $m^3/s$ (HRD 1970).

At station Stondansie (km 240) the mean discharge of the Nickerie River is 91 $m^3/s$, based on collected data over the period 1963–1980 (18 years). In July 1971 a maximum of 450 $m^3/s$ was recorded, and in May 1964 and February 1966 a minimum of 1.8 $m^3/s$ occurred. The drainage area upstream from station Stondansie is approx. 5,160 $km^2$, which is 51% of the total catchment area of the Nickerie River (HRD 1982). Taking the catchment area into account, and assuming a mean discharge of 91 $m^3/s$ at Stondansie the mean discharge at the rivermouth of the Nickerie River is estimated now at 178 $m^3/s$.

Peak flows and high water occur around June–July, while low flows and low water occur around November, according to the exceedence frequency of the monthly flow at Stondansie (HRD 1982).

#### *3.7.3. Sediment Transport*

According to data collected by the HRD the silt content at Klein Henar (km 52) varies between approx. 0.04 to 45 g/l. At Wageningen (km 73) it varies between approx. 0.03 to 6 g/l. The total annual sediment discharge from the Nickerie river is estimated at 0.1 million tons by Nedeco (1968).

#### *3.7.4. Depth*

A minimum depth of the natural channel of approx. 2.8 m with respect to the mean sea level is near the rivermouth. The greatest depth is approx. 17 m, and is recorded near Wageningen (km 73) (HRD 1970).

### *3.8. Corantijn River Basin*

The sources of the Corantijn River are located in the Acarai Mountains near the boundary with Brazil, and in the central highlands. The catchment of this river is about 67,600 $km^2$, including the catchment area on the left bank of the Corantijn River which is in Guyana (HRD 1969). According to Duba (1972) 90% is in the Interior, 4.6% in the Savanna Belt, and 5.4% in the Coastal Plain. Along the upper courses of this river there are numerous falls and rapids.

#### *3.8.1. Estuary*

The tidal range in the outfall is approx. 2 m, and the tidal volume is estimated at 300 million $m^3$ (Nedeco 1968). During periods of low flow the tidal influence is up to Cow Falls, which is located at a distance of about 210 km from the outfall (HRD 1969).

According to collected data by the HRD, during peak flows the 300 mg Cl/l limit is near km 40, some km upstream from Springland, and during periods of low flows this limit is near Oroprecaro Creek (km 82), near Baboon Island.

### *3.8.2. Freshwater Discharge*

The mean discharge at the outfall of the river was estimated at 1,800 m³/s. Peak flows may exceed 8,000 m³/s, and low flows can be as low as 30 m³/s (HRD 1969).

Based on collected data over the period 1966–1980 (15 years), the mean discharge at the station Mataway (km 243) is 1,200 m³/s. The maximum recorded discharge at this station is 5,370 m³/s (July 1971) and the minimum recorded discharge is 31 m³/s (January 1966). The catchment area of the Corantijn River upstream from this station is approx. 51,600 km², which is 76% of the total catchment area of the Corantijn River. Adopting a mean discharge of 1,200 m³/s at the station Mataway, and taking the catchment area into account, the mean discharge of the Corantijn River is estimated now at 1,572 m³/s.

According to the exceedence frequency of the monthly flow (HRD 1982), peak flows and high water occur during the months June–July, while low flows and low water occur during the months November–December.

### *3.8.3. Sediment Transport*

The silt content at Springland (km 36) varies according to the data collected by the HRD between approx. 0.04 to 10.0 g/l. At Kwie-Kwie Creek (km 68.5), some kilometers downstream of Mc Clemen, the silt content varies from approx. 0.02 to 4 g/l. Nedeco (1968) estimated the sediment discharge from the Corantijn River at 1.2 million tons a year.

### *3.8.4. Depths*

The minimum depth along the natural channel (4 m) is near the rivermouth. Further upstream it is deeper. The greatest depth is up to approx.30 m with respect to the mean water level, near Oreala (km 112) (HRD 1969).

## 4. The Water Balance and Climatic Impact

### *4.1. General*

In hydrology, calculations are made of the water quantities which enter and leave the system (catchment). A water balance study may be carried out to estimate the various components of the hydrological cycle, employing the water balance equation, which is based on the law of continuity and conservation.

Water balance studies of Suriname have been done in the past by Ringma (1961) and Duba (1972). Although a water balance study involves thorough



analyses, a simplified water balance of Suriname will be presented here to estimate the magnitude of the components of the hydrological cycle, and is limited to the long-term, mean annual water balance.

### *4.2. Areal precipitation*

Based on the isohyets presented in Fig. 2, the long-term areal mean annual precipitation for the whole of Suriname is estimated here at 2,300 mm (rounded). Salati and Marques (1984) mentioned that the average annual rainfall for the Amazon region is 2,300 mm. These two values, which are estimated independently, do not differ.

### *4.3. Areal Pan-evaporation*

The values of the long-term, mean annual pan-evaporation of the stations Zorg & Hoop, Jarikaba, Nickerie Airport and Kwamalasamutu are adopted here to estimate the long-term, mean annual pan-evaporation for the whole of Suriname. Here the weighted mean pan-evaporation of these stations is taken, where a weight of 0.17 (= 0.5/3) is given to the values of the stations Zorg & Hoop and Jarikaba, and a weight of 0.33 (=1/3) to the values of the stations Nickerie Airport and Kwamalasamutu. Thus, the long-term, mean annual pan-evaporation for Suriname is estimated at 1,279 mm.

### *4.4. Discharge*

Referring to section 3 of this Chapter, the estimated discharges at the outfall of the rivers are as follows:

| | |
|---|---|
| Marowijne River | 1,785 m³/s |
| Commewijne River | 120 m³/s |
| Suriname River | 426 m³/s |
| Saramacca River | 225 m³/s |
| Coppename River | 500 m³/s |
| Nickerie River | 178 m³/s |
| Corantijn River | 1,572 m³/s |

Adding all these values, the Surinamese rivers together drain on average approx. 4,806 m³/s freshwater into the Atlantic Ocean, which is equal to 757 mm/year.

### 4.5. *Water Balance of Suriname*

Neglecting the change in storage and all other components of the hydrological cycle which are not mentioned here, the long-term, mean annual actual evapotranspiration (= evapotranspiration which actually occurs) is equal to the residue long-term, areal mean annual precipitation (2,300 mm) minus the long-term annual discharge (757 mm). Thus the long-term, mean annual actual evapotranspiration is estimated here at 1.543 mm, which is about 1.2 times the long-term, mean annual pan-evaporation. Roche *et al.* (1991) mentioned that the actual evapotranspiration for Amazonian forests in French Guiana was evaluated at 1,470 mm a year. The difference between these two values for actual evapotranspiration is small (approx. 5%).

Referring to section 2.2 of this Chapter, one may conclude that for Surinamese conditions the potential evapotranspiration would be underestimated when a pan-coefficient of 0.7 is employed to convert the Class-A pan-evaporation to the potential evapotranspiration. A pan-coefficient for the Class-A pan of at least 1.2 should be employed for Surinamese conditions.

Approximately 67% of all the precipitated water on the Surinamese river basins returns to the atmosphere by evapotranspiration, and approx. 33% is drained off into the Atlantic Ocean. It should be noted that according to Salati and Marques (1984) for the Amazon region 46% of the precipitated water is discharged into the Atlantic Ocean, and 54% returns to the atmosphere by evapotranspiration. Moreover, it is agreed that the last mentioned ratio is between 60% and 65% for the continents (Roche *et al.* 1991).

### 4.6. *Climatic Impact*

It is concluded here that approx. 67% of the vapour forming precipitation on the Surinamese river-basins comes from evapotranspiration from the basin itself, and about 33% from the Atlantic Ocean by evaporation. Since the actual evapotranspiration is the greatest term of the water balance here, this term is very important for the hydrological cycle in Suriname.

Land-use and large scale deforestation in Suriname may affect the hydrological cycle and consequently the climate, since a great part of the precipitation on the Surinamese basins depends on the local evapotranspiration. Molion (1991) mentioned that large-scale land-use transformation from tropical humid forests to crop pasture fields reduce the evapotranspiration, and consequently the local rainfall. Run-off may also be reduced.

## Summary

The seven main rivers of Suriname can be classified into three groups, namely the larger rivers (Marowijne and Corantijn), which are border rivers, the second



largest rivers (Suriname and Coppename), and the smaller ones (Commewijne, Saramacca and Nickerie).

There are three hydrologically distinct areas, namely the Interior (approx. 126,550 km$^2$), the Savanna Belt (approx. 8,500 km$^2$), and the Coastal Plains (approx. 21,000 km$^2$).

The currents and water level in the upper reaches of the rivers are influenced by the freshwater discharge. In the estuary there is a combined influence of the tide and the freshwater discharge, upon which the currents and water level depend, as well as the salt-intrusion and transport of sediments.

The climate of Suriname is humid-tropic, with two rainy and two dry seasons per year. The long-term, mean annual rainfall varies from approx. 1,450 mm (Coronie) to approx. 3,000 mm (Tafelberg). At Paramaribo, the capital of the country, the mean temperature is 27.1 °C. The mean windspeed in the country is 1.3 on the scale of Beaufort.

The estimated precipitation surplus indicates that during the months of May-July much of the precipitated water is available for run-off, and during the months of September–October only little of the precipitated water is available.

The Marowijne River has the largest catchment area (approx. 68,700 km$^2$), the Corantijn River the second largest (approx. 67,600 km$^2$). The greatest part of the catchments of the rivers is in the Interior, except the catchments of the Commewijne and Nickerie Rivers. Of all the catchments only a small part (0.05% – 23.6%) is in the Savanna Belt.

In the West the tidal influence goes further landward, than in the East. The tidal range in the outfall of the main rivers is approx. 2.0 m. The Corantijn River has the greatest tidal prism (approx. 300 million m$^3$), the Marowijne River the second largest (approx. 200 million m$^3$), and the Nickerie River the smallest (approx. 10 million m$^3$). The tide is of the regular semi-diurnal type.

The minimum salt-intrusion is near km 30 – km 50 (about 10–30 kilometers upstream from the outfall), and occurs during periods of peak flows, while during periods of low flows, the maximum salt- intrusion occurs near km 60 – km 100 (about 40–80 kilometers upstream from the outfall).

The mean freshwater discharge at the outfall of the Marowijne River is the largest (approx. 1,785 $m^3/_s$), the second largest is at the outfall of the Corantijn River (approx. 1,572 $m^3/_s$), and the smallest at the outfall of the Commewijne River (approx. 120 $m^3/_s$). Peak flows and high water occur around June, and low flows and low water around November.

The silt content in the outfall of the main rivers is higher than further upstream, since sediments originating from the Amazon basin are transported by the sea water along the coast of Suriname. The sediment discharge from the Marowijne (approx. 1.3 million tons a year) and Corantijn basins (approx. 1.2 million tons a year) are the largest, and the sediment discharge from the Commewijne basin is the smallest (approx. 0.06 million tons a year).

The minimum depths along the thalweg are near the outfall of the main rivers, and vary from about 3 to 7 meters with respect to the mean sea level.

Further upstream the rivers are deeper. Maximum depths in the lower reaches vary between approx. 17 m to 30 m with respect to the mean water level.

About two thirds (± 67%) of the water which is precipitated on the Surinamese river basins, returns back to the atmosphere through evapotranspiration, and about one third (± 33%) is discharged into the Atlantic Ocean. Similar to the other river basins in the Amazon region, it is very likely that land-use and large-scale deforestation in Suriname could affect the climate significantly.


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## References


Adhin, H.S., 1982. Irrigation potential of Surinamese rivers. Proc. Congress Future of roads and rivers in Suriname and neighbouring region. University of Suriname and Delft University of Technology, Delft: 225–232.

Duba, D., 1972. Report on water balance studies, public water supplies and sewage, net-4, Suriname-2200. World Health Organization, 100 p.

Hydraulic Research Division, Ministry of Public Works, 1969. Hydrological data lower Marowijne river. Paramaribo, 85 p.

Hydraulic Research Division, Ministry of Public Works, 1969. Hydrological data lower Corantijn river. Paramaribo, 116 p.

Hydraulic Research Division, Ministry of Public Works, 1970. Hydrological data lower Suriname river. Paramaribo, 175 p.

Hydraulic Research Division, Ministry of Public Works, 1970. Hydrological data Nickerie river. Paramaribo, 140 p.

Hydraulic Research Division, Ministry of Public Works, 1971. Hydrological data lower Coppename river. Paramaribo, 122 p.

Hydraulic Research Division, Ministry of Public Works, 1972. Hydrological data Commewijne-Cottica river. Paramaribo, 88 p.

Hydraulic Research Division, Ministry of Public Works, 1982. Frequency analyses of revised monthly mean flows in the lower courses of the main rivers of Suriname. Paramaribo, 80 p.

Hydraulic Research Division, Ministry of Public Works, 1983. Onderzoek naar de irrigatiecapaciteit van de Commewijne en de Cottica. Nota 1: de metingen 1979/1980. Paramaribo, 70 p.

Hydraulic Research Division, Ministry of Public Works, 1987. Hydrological data lower Saramacca river (2nd ed.). Paramaribo, 147 p.

Hydraulic Research Division, Ministry of Public Works, 1988. Hydrological data lower Suriname river (2nd ed.). Paramaribo, 183 p.

Hydraulic Research Division, Ministry of Public Works. Hydrological annuals 1968–1980. Lower courses of the main rivers of Suriname. Paramaribo.





Molion, L.C.B., 1991. Climate variability and its effect on Amazonian hydrology. In: Water management of the Amazon basin. UNESCO/ROSTLAC, Montevideo: 261–274.

National Planning Office Suriname & Organization of American States, 1988. Suriname Plan Atlas. Washington, 51 p.

NEDECO, 1968. Suriname transportation study. Report on hydraulic investigations. The Hague, 293 p.

Ringma, S.A., 1961. Irrigatiecapaciteit van de Surinaamse rivieren. Bureau Landelijke Opbouw Suriname, Paramaribo, 82 p.

Roche, M.A. *et al.*, 1991. Water and salt balances of the Bolivian Amazon. In: Water management of the Amazon basin. UNESCO/ROSTLAC, Montevideo: 83–94.

Salati, E. and J. Marques, 1984. Climatology of the Amazon region. In: H. Sioli (ed.), The Amazon: limnology and landscape ecology of a mighty tropical river and its basin. Dr.W.Junk Publishers, Dordrecht: 85–226.

Shuttleworth, W.J. *et al.*, 1991. Post-deforestation Amazonian climate: Anglo-Brazilian research to improve prediction. In: Water management of the Amazon basin. UNESCO/ROSTLAC, Montevideo: 275–287.