# SECTOR A

# GENERAL PHYSICAL CONDITIONS

The general physical condition described in this sector refers mainly to the Musi River Basin Study in 1989, updating the information and data.

## 1. TOPOGRAPHY

The Study Area covers a total of about 60,000 km$^2$ in the south of Sumatra Island between 2°17' and 4°58' South latitude and between 102°4' and 105°20' East Longitude, which includes the whole Musi River Basin. It covers most of South Sumatra Province, and only small parts of Bengkulu, Jambi and Lampung provinces as shown in the General Map.

**Table A1.1.1 Study Area** (km$^2$)

| Province and Regency | Musi River Basin |
|---|---|
| South Sumatra | |
| Ogan Komering Ulu*1 | 10,762 |
| Ogan Komering Ilir | 5,349 |
| Muaraenim | 8,909 |
| Lahat | 6,839 |
| Musirawas | 13,261 |
| Musibanyuasin | 12,212 |
| Palembang | 235 |
| Bengkulu | |
| Rejang Lebong | 2,130 |
| Jambi | |
| Batang Hari & Others | 245 |
| Total South Sumatra | 57,567 |
| Total Study Area | 59,942 |

*1 include Lampung Provice

### 1.1 Geomorphology

The recent geomorphological conditions, combined with hydro-climatic features have given 5 landscapes, which have determined human activities. They are from the southwest to the northeast, as listed below:

- Mountain Zone 15,700 km$^2$ 26%
- Piedmont Zone 8,200 km$^2$ 14%
- Central Plains 26,000 km$^2$ 43%
- Inland Swamps 6,900 km$^2$ 12%
- Coastal Plain 3,200 km$^2$ 5%

Geological map is illustrated in **Annex A1.1.1**.

#### 1.1.1 Mountain Zone

The mountain zone comprises the southern and south-western part of the Study Area. It is composed of valleys, highland plateaus and volcanic cones.

Valley of the Mountain Zone is most important for farm produce, thus, the agricultural areas are located in this Zone. Second to the valleys are the foot slopes of the young volcanoes used for the cultivation of dry land crops. The steeper slopes, which cover most of the Mountain Zone, are too steep for agriculture and normally covered by forest.

### 1.1.2 Piedmont Zone

The piedmont zone is an approximately 40 km wide transition belt between the mountain zone in the West and the plains in the East. It is an undulating to hilly area with some flat plains in between and flat alluvial terraces along the rivers. Its western border, which coincides more or less with the 150 m contour line, is well marked by the clearly visible rise of the mountain zone. Its eastern border towards the plains is hardly visible in the landscape, but the border roughly coincides with the 50 m contour line. The average elevation of the piedmont zone ranges between 50 m and 150 m above mean sea level. No swamps are found in the piedmont zone.

### 1.1.3 Central Plains

The Central Plains are located between the piedmont zone to the west and the swampy lowlands of the Coastal Plain to the East. The Central Plains are composed of three sections, uplands, flood plains and river levees.

The uplands of the Central Plains cover most of the area. Some of the upland parts are almost flat or gently undulating, but other parts, possibly the most extended, are hilly with short steep slopes, highly susceptible to erosion. The Central Plains are furthermore sharply dissected by a number of small rivers.

At the lower terraces on the Central Plain normally water meadows are found on both of the river two to the three meters above the riverbed. These are normally flooded one to several times during the rainy season, but not continuously. However, the floods can be of very large magnitude.

All the big rivers on the Central Plains are bordered by river levees. The formation of these river levees along the rivers in the middle and lower courses is a result of the sedimentation of eroded material from the Mountain Zone and to a certain extent also from the Piedmont Zone.

### 1.1.4 Inland Swamps

The inland swamps comprise the flood plains between the river levees and the upland of the Central Plains on either side of the lower and middle courses of the river Musi, Komering, Ogan and Lematang.

The Inland Swamps area is composed of natural river levees and back swamps. The back swamps are less elevated than the river level, flooded during the wet season and normally they rarely are desiccated during the dry season. The result has been the development of extended area of peat-covered swamps. The back swamps become increasingly wider downstream of the rivers, and they spread out to a width of several kilometers and cover an extensive area of thousand of hectares as the rivers approach Palembang.

The depth of water ranges from 30 cm to 2 m depending on the magnitude of the annual floods.

The types of inland swamps (lebak) can be distinguished as follows:

(a) Shallow transition zone between the river level and low lying areas, never continuously flooded,

(b) Medium transition zone flooded 2 to 3 months from December to January,

(c) Relatively low-lying areas away from the river, continuously flooded from November to June.

### 1.1.5 Coastal Plain

The tidal swamp area comprises the lowlands along the coast and the deltaic north eastern lowlands, naturally covered with peat swamp forest. They are characterized by an almost complete flat relief, their maximum elevation reaching five meters above sea level. As the name indicates daily tides occur, which makes the water level of the rivers oscillate up to three meters daily. The tidal range has significant influence on this area, as part of the area is continuously flooded and drained within a 24 hours cycle. The areas along the river levees are affected by the tides. Further inland, the tidal effect is negligible under natural conditions, but it is fundamental to improve the drainage.

During the wet season, the levees of the big rivers are often flooded to a depth of one meter. Outside the area influenced by rivers and canals (about 500 m) the water level in the natural swamp forest fluctuates a few centimeters only. The natural swamp forest is continuously flooded with 0.2 m to 0.3 m of water most of the year, this standing water containing large amount of acids.

The Coastal Plain can be divided into significant different parts, the more fertile alluvial levees along the rivers, composed of alluvial deposits and the island peat areas. In the inland area the peat can be up to several meters deep and because of the presence of alluvial and marine deposits in the subsoil, the inland peat soils are denominated potential sulphuric acid soil. The inland peat areas can be divided into two subgroups the area with shallow peat, which is best suited for agriculture, and the areas of deeper peat which have a very limited potential for agriculture.

## 1.2 River and Topography

The elevation in the upper part of the Musi/Lematang catchments reaches up to 3,200 m at Mt. Dempo in the Barisan Range, and the elevation of the upper catchment of the Musirawas reaches 2,202 m. The Musi River originates in the west - southwestern part of the catchment at the elevation of about 1,310 m, 40 km to the west of the City of Lubuk Linggau. The average slope of the Musi River ranges from 1/100 to 1/200 in the upper reaches, to 1/10,000 in the lower reaches upstream of Palembang. In Palembang the Musi River crosses a Miocene anticline and flows downstream through the Coastal Plain, which has a very smooth slope of about 1/20,000.

The river responds to that topographical change by building a straight channel, reducing its discharge velocity, enlarging its channel width and depositing bed load. There are several islands in the riverbed alternating with deeper and narrower sections up to the sea. At Boom Baru, the Port of Palembang where the river is relatively narrow, the lowest point is approximately 25 m below MSL, the smallest depth being around 8.5 m.

The total length of the Musi River from its source to Bangka Strait is about 640 km. The Musi River and other minor streams carved deep valleys in the continental shelf when the sea level was lowered by the last glacial period. When the climate got warmer the sea level rose as the ice melted and the Musi River, discharging large amounts of sediment was able to fill its estuary with sand and silt.

# 2. GEOLOGY

## 2.1 Plate Geology

According to modern interpretation, the Indian Ocean plate is presently sliding at a rate of 6 cm per year underneath the Island of Sumatra (see **Figure A2.1.1**). The movement started in the middle of the Tertiary period (Miocene). As the Barisan Range buckled upwards, the corresponding downward thrust formed a deep channel to the west of Sumatra.

There was an uplift of the continental shelf on the east coast and a down-lift movement on the opposite coast, outside the catchment area. This see-saw movement is still going on, as described below.

(1) The reduced size of the west coast plain, slowly sinking under the sea, by a subsidence movement.

(2) The reduced slope and the importance of the swamps in the east coast plain, by a tilt-up movement.

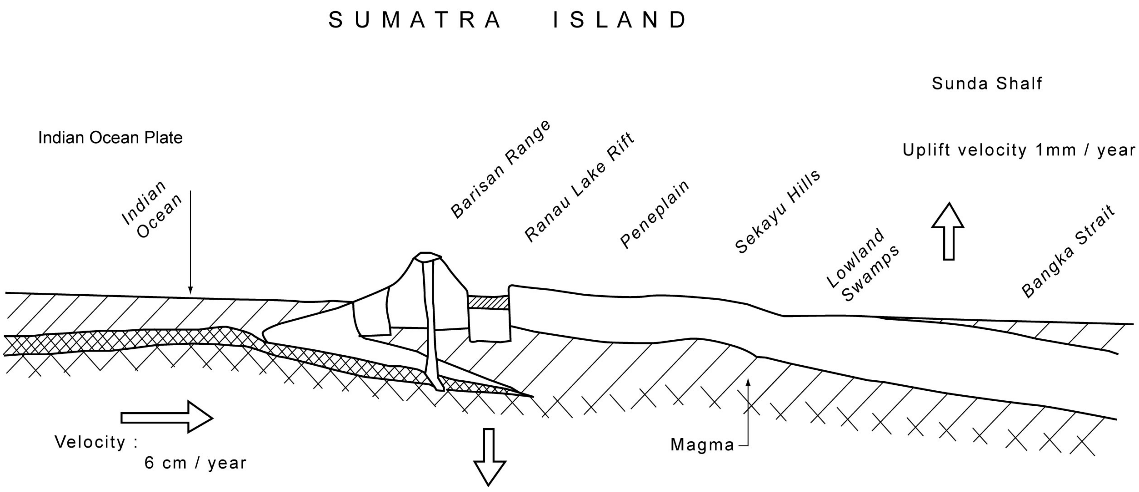


**Figure A2.1.1 Movement of Sumatra Island**

Full emergence of the Peneplain area occurred at the extreme end of the Tertiary, sheet wash produced a flat pediment by regressive erosion, up to the escarpment at the very beginning of the Quaternary (Villafranchien), sometimes producing a stone pavement. Pedological evaluation produced red-colored soils (latosols).

Buckling increased in the quaternary in the Barisan Range. A Northwest to Southeast rift opened through the Ranau Lake and follows the crest of the range. The movement is lateral, shearing Sumatra in two. Volcanic activity gained momentum through the quaternary and culminated with the explosion of the Ranau crater and the formation of breccia, lava outflows and ash tuffs.

Volcanic ashes were also blown on the Peneplain; the deposit covered the erosion pavement that can be observed, for instance, in cuts along the Trans-Sumatra Highway between Muararupit and Surulangun-Rawas. Pedological evaluation produced brown-colored soils during the quaternary, overlying the stone line and red layers already mentioned.

## 2.2 Regional Geology

The regional geology in the study area is a synopsis based on several sources of information. The Geological map is given in **Annex A2.2.1**.

### 2.2.1 Pre - Tertiary

The oldest rocks known to exist in the study area are a clastic limestone and various plutonic rocks of pre-tertiary age. The exposures cover only minor areas, mainly in the more elevated regions of the study area.

### 2.2.2 Tertiary - Recent

A transgression of the study area commended in Eocene time, culminated in Middle Miocene and terminated in Pleistocene. During this period, a thick series (reportedly up to 6,000 m) of sediments were deposited in the basin. Also a series of volcanic eruptions accompanied by tectonic disturbance took place.

### 2.2.3 Lahat Formation (Toml)

The oldest of these sediments presents in the study area is the Lahat Formation, which is upper and lower parts consist of coarse to fine tuff, tuffaceous breccia, and tuffaceous sandstone, while the intermediate tuff-free section comprises quartz-conglomerates, quartz-sandstone and clay.

### 2.2.4 Old Volcanics (Tomv)

Simultaneous to the deposition of the lower Lahat beds, andesitic volcanism occurred in the area. The rocks formed, known as “old andesites”, includes breccia, tuff, clayey tuff, araneceous tuff and sandstone.

### 2.2.5 Telisa Formation (Tmt)

The next sediments to be deposited were the Telisa Formation (marks, 1956). This package consists of sanstones, siltstones, claystones and shales. Generally the lower parts of the formation are more coarsegrained than the upper parts, indicative of increasingly deeper (marine) depositional environment as time progressed.

### 2.2.6 Baturaja Limestone (Tmb)

In places, the Baturaja limestone is found within the above formation. It consists of coral-limestone, arenaceous limestone and marl. The transgressive phase had culminated during the deposition of the latest sediments of the Telisa Formation. Through the following regression period, a new series of sediments were deposited with a generally increasing grain size.

### 2.2.7 Lower Palembang Formation (Tmp)

The Lower Palembang series commences as a dense calcareous claystone, somewhat shaly with intercalations of tuffaceous siltstones. The middle part is as alternation of dense to soft claystones, with intercalations of dense calcareous claystone, while the upper part is composed of siltstone and finegrained sandstones, which are often laminated. The age of Lower Palembang is Middle to Late Miocene.

### 2.2.8 Middle Palembang Formation (Tmpp)

The middle Palembang commences as sandstone and tuffaceous siltstone with intercalations of carbonaceous siltstone and coalseams. It developes in the middle part into coarse to medium-grained tuffaceous sandstone and tuffaceous siltstones with coal intercalations. The upper part is again more finegrained and consists of tuffaceous clay/silstones with intercalations of quartz siltstone and coalseams. The age of middle Palembang is Late Miocene to Pliocene.

### 2.2.9 Upper Palembang Formation (QTpv)

Upper Palembang consists of tuff, sandy tuff and tuffaceous sandstone, often containing pumice. Occasionally thin lenses of coal are found. The age of upper Palembang is assumed to be Plio-Pleistocene.

### 2.2.10 Young Volcanics (Qhv)

During Plio-Pleistocene time, a series of volcanic eruptions took place in the area now known as Barisan Mountains. Three main units of volcanic comprise Rhyolitic/Dacitic/Andesitic tuffs, lavas and breccias.

### 2.2.11 Swamp Sediments (Qs)

At the western parts of the study area, the accumulation of organic matter, peat soils, estuarine and marine sediments were deposited. These sediments are mainly silts and clays, occasionally with a high content of sulfides.

### 2.2.12 Alluvial (Qal):

Alluvial sediments have been deposited along the river-courses where they form elongated bodies of clay, silt, sand and gravel, in places partly overlying, partly underlying the swamp sediments.

# 3. METEOROLOGY

## 3.1 General Condition

The meteorological conditions in the Musi River Basin are affected by tropical monsoon, which give hot and humid climate through the year to this area. The Meteorological condition is shown in **Figure A3.1.1**.

Mean annual rainfall varies between less than 2,000 mm in the coastal plain and 3,500 mm in Lahat located in the eastern foot of the Barisan Range; it is everywhere higher than the annual potential evapotranspiration, which is in the range of 1,200 mm to 1,500 mm (Evapotranspiration is estimated in the Musi River Basin Study, 1989). Rainfall is in excess of evapotranpiration during most of the year.

Relative humidity is high throughout the year between 60% and 90%. Mean daily temperature shows little seasonal variation, around 28°C with a mean minimum of about 20°C and a mean maximum of 35°C at altitude lower than 150 m above sea level. Day duration varies little from 12 hours all the year long in relation to the low latitude.

South-easterly winds prevail during the dry season which normally occurs from May to October and westerly winds during the rainy season which normally occurs from November to April.

The meteorological data concerning temperature, relative humidity and wind speed/direction at Palembang between 1986 and 2001 are summarized in **Annex A3.1.1.**

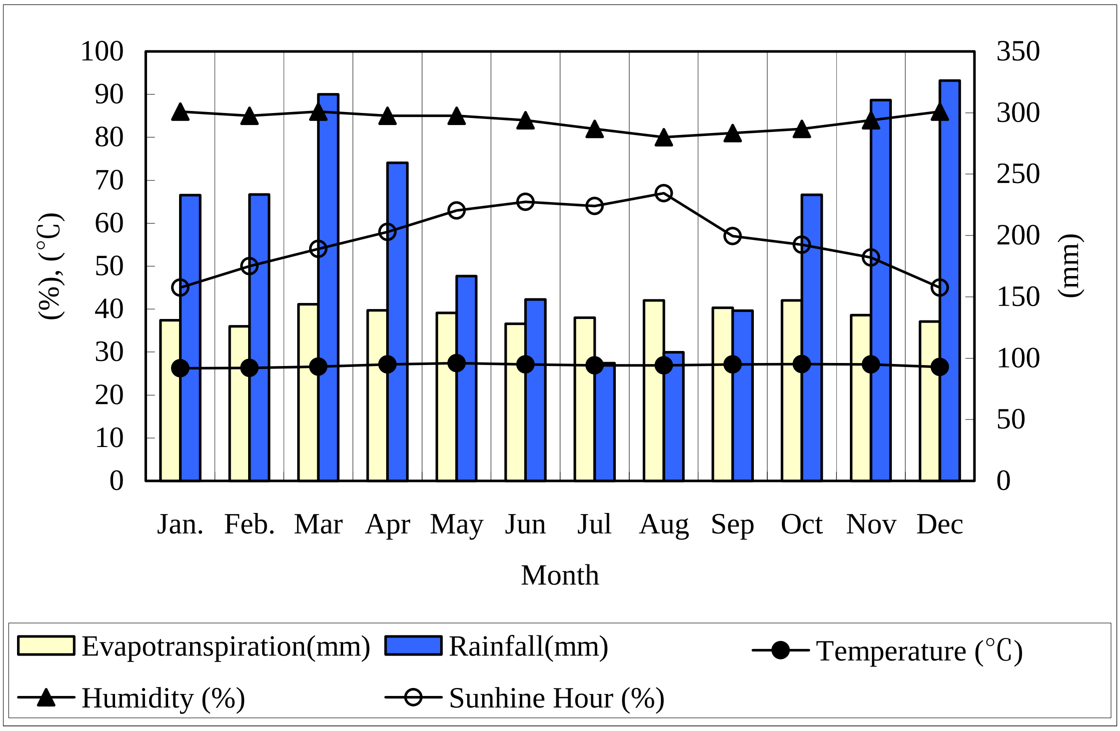


**Figure A3.1.1 Meteorological Condition at Palembang**

## 3.2 Station Location

Climatological data have been obtained from BMG. The stations are listed in **Table A3.2.1** and presented in **Annex A3.2.1**.

**Table A3.2.1 Climatological Stations**

| No. | BMG No. | Station Name | Location | | Data Available |
|---|---|---|---|---|---|
| | | | South | East | |
| 1 | 191a | Tl. Betutu (Palembang) | 02 ° 52’ | 104 ° 41’ | T, S, W, RH |
| 2 | 200 | Sekayu | 02 ° 51’ | 103 ° 49’ | T, S, RH |
| 3 | 214c | Belitang | 04 ° 06’ | 104 ° 38’ | T, S, W, RH |
| 4 | 175b | Jambi | 01 ° 35’ | 103 ° 38’ | T, S, W, RH |

T: Temperature, S: Sunshine hours, W: Wind speed, RH: Relative humidity

## 3.3 Climatic Characteristics of Study Area

### 3.3.1 Temperature

The average monthly temperature is given in **Table A3.3.1** for the four stations. Temperature at stations is almost constant throughout the year. Additionally, since the stations are located at elevations between 6 m and 33 m, there is no significant variation in the average monthly temperature.

**Table A3.3.1 (1) Average Monthly Temperature (℃)**

| Station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Talang Betutu | 26.2 | 26.3 | 26.6 | 27.1 | 27.4 | 27.1 | 26.9 | 26.9 | 27.1 | 27.2 | 27.1 | 26.5 |
| Sekay u | 26.1 | 26.9 | 27.1 | 27.4 | 27.5 | 27.3 | 27.2 | 27.2 | 27.3 | 27.3 | 27.2 | 26.8 |
| Belitang | 26.2 | 26.4 | 26.6 | 27.2 | 27.3 | 27.0 | 26.7 | 27.0 | 26.8 | 27.0 | 26.9 | 26.4 |
| Jambi | 25.8 | 26.0 | 26.3 | 26.5 | 26.7 | 26.7 | 26.3 | 26.6 | 26.2 | 26.5 | 26.2 | 25.9 |

**Table A3.3.1 (2) Minimum and Maximum at Palembang (℃)**

| Station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum | 32.6 | 32.3 | 32.6 | 33.2 | 34.0 | 33.0 | 32.9 | 33.5 | 34.4 | 34.6 | 34.4 | 32.5 |
| Minimum | 23.4 | 23.5 | 23.4 | 23.9 | 24.1 | 23.7 | 23.3 | 23.1 | 23.1 | 23.4 | 23.5 | 24.1 |

**Table A3.3.1 (3) Minimum and Maximum Temperature at Sekayu (℃)**

| Station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Maximum | 32.1 | 32.2 | 32.8 | 33.5 | 33.4 | 33.2 | 32.9 | 33.2 | 34.0 | 34.4 | 34.2 | 38.8 |
| Minimum | 20.2 | 20.8 | 21.0 | 21.0 | 21.8 | 23.1 | 22.8 | 22.7 | 18.8 | 19.5 | 18.9 | 21.1 |

### 3.3.2 Sunshine Hours

The average actual sunshine hours, expressed as the percentage of the maximum possible sunshine hours, are given below for the four stations. The sunshine hours seems to be synchronized with the season (Rainy and Dry season).

**Table A3.3.2 Average Monthly Sunshine Hours (% of Max)**

| Station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Talang Betutu | 45 | 50 | 54 | 58 | 63 | 65 | 64 | 67 | 57 | 55 | 52 | 45 |
| Sekayu | 49 | 49 | 56 | 56 | 57 | 58 | 59 | 60 | 60 | 55 | 52 | 50 |
| Belitang | 41 | 48 | 52 | 61 | 65 | 61 | 59 | 65 | 56 | 54 | 53 | 49 |
| Jambi | 45 | 49 | 48 | 51 | 55 | 59 | 61 | 61 | 47 | 44 | 44 | 43 |

### 3.3.3 Wind Speed

The average wind speed at elevations 2 m and 10 m are given below for the four stations. The wind speed at Belitang Station always exceeds those at the other stations.

**Table A3.3.3 (1) Average Monthly Wind speed (m/s) - Elevation 10m -**

| Station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Talang Betutu | 2.23 | 1.96 | 1.76 | 1.53 | 1.59 | 1.77 | 2.04 | 2.20 | 2.07 | 1.82 | 1.61 | 1.85 |
| Sekayu | - | - | - | - | - | - | - | - | - | - | - | - |
| Belitang | 3.72 | 3.03 | 2.98 | 2.59 | 2.61 | 2.87 | 3.09 | 3.42 | 3.58 | 3.58 | 2.75 | 3.06 |
| Jambi | 1.13 | 1.09 | 0.80 | 0.75 | 0.80 | 0.96 | 1.14 | 1.31 | 1.05 | 0.76 | 0.72 | 0.98 |

**Table A3.3.3 (2) Average Monthly Wind speed (m/s) - Elevation 2m -**

| Station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Talang Betutu | 0.67 | 0.59 | 0.53 | 0.46 | 0.48 | 0.53 | 0.61 | 0.66 | 0.63 | 0.55 | 0.49 | 0.56 |
| Sekayu | - | - | - | - | - | - | - | - | - | - | - | - |
| Belitang | 1.12 | 0.91 | 0.90 | 0.78 | 0.79 | 0.86 | 0.93 | 1.03 | 1.08 | 1.08 | 0.83 | 0.92 |
| Jambi | 0.34 | 0.33 | 0.24 | 0.22 | 0.24 | 0.29 | 0.34 | 0.39 | 0.32 | 0.23 | 0.22 | 0.30 |

### 3.3.4 Relative Humidity

The average relative humidity is given below for the four stations. Humidity of the Study Area little varies throughout the year. Further, there is no significant variation in the average monthly temperature among the stations.

**Table A3.3.4 Relative Humidity (%)**

| Station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Talang Betutu | 86 | 85 | 86 | 85 | 85 | 84 | 82 | 80 | 81 | 82 | 84 | 86 |
| Sekayu | 86 | 85 | 85 | 86 | 85 | 84 | 84 | 82 | 83 | 83 | 85 | 85 |
| Belitang | 85 | 85 | 84 | 84 | 83 | 82 | 81 | 80 | 80 | 82 | 83 | 84 |
| Jambi | 85 | 85 | 85 | 85 | 85 | 83 | 83 | 81 | 83 | 83 | 85 | 86 |

# 4. HYDROLOGY

## 4.1 General

The mean annual rainfall ranges from 2,000 mm in Palembang and the coastal area, and up to 3,500 mm in Lahat. Rainfall is higher in the western part of the catchment area than in the eastern part where a relatively dry belt can be observed. An isohyetal map of mean annual rainfall is given in **Annex A4.1.1**.

As for the flow regime, the lower Musi River, downstream stretch from the confluence of the Komering River has an average flow of about 2,500 $m^3/s$ with fluctuations in dry and wet seasons between 1,400 and 4,200 $m^3/s$. Normally, the flow of the Musi River and its tributaries has highest between February and March, and lowest between July and September. The flow regime is described in more detail in Sector H.

The water level of the Musi River at Palembang in 2000 is illustrated in **Figure A4.1.1**. According to this figure, the water level of the Musi River is +1.2 m above mean sea level as the highest and +0.0 m as the mean in the dry season. In the rainy season, the water level of the Musi River is +1.8 m above mean sea level as the highest and +1.0 m as the mean. The maximum spring tide level could reach +3.3 m at the Talang Buyut Station at the Musi River estuary. Generally, maximum spring tides occur in December and June and lower spring tides occur in March and September.

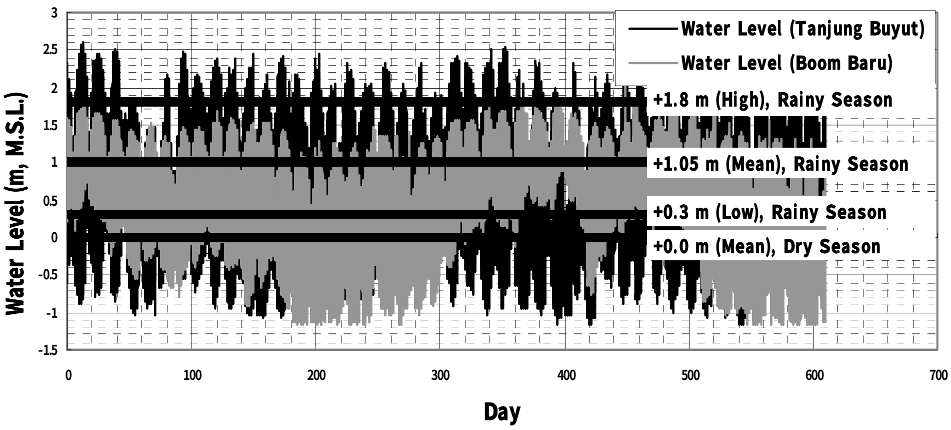


**Figure A4.1.1 Water Level of Musi River at Palembang**

## 4.2 Drought

A significant drought problem occurs especially in the middle reaches of the Komering River Basin. The drought problem is caused by the existence of the natural channel (Randu, Arisan, Jambu, Sigonang, and Anyar channels) from the Komering River to the Ogan River. In order to solve the drought problem, a control structure was build at the

Randu channel; however, this structure has not solved the problem effectively. In mid-2000, improvement works were implemented to mitigate the problem in the Randu channel through weir development and dredging of sediment along the Komering River for about 8 km from the Sukabumi Village of OKU District to the downstream.

## 4.3 Flood

### 4.3.1 Flood Scale and Cause

The area affected by inundation is approximately 114,100 ha. Since the flooding problems remain complex with enormous physical damages, a comprehensive river basin study needs to be done in this particular area. Some factors that influence the flooding are listed below.

- Decline of hydrological function due to devastation of forests in the Upper Musi River Basin.
- Meandering configuration of river.
- Degradation of flow capacity due to aggradation of riverbed.
- Tidal level, which slows down river flow.

### 4.3.2 Flood Condition

At the middle and lower reaches between Sekayu and Palembang, the Musi inland swamps are being transformed into lakes in rainy season. The sediment discharged from the Organ-Komering river network is slowly plugging the middle reach of Musi River, increasing the flooding problem in the inland swamp between Sekayu and Palembang due to the rise of backwater. Moreover, in the downstream of the Organ River, especially, between Kayu Agung and Palembang, there are many swamp areas flooded for several months a year.

The Rawas, Lakitang, Lematang, Kelingi river basins are inundated due to over-spilling from the natural bank. Especially, at the confluences with the Musi River, inundations frequently occur when floods peak at both the tributaries and the Musi main stream simultaneously. The floods often damage roads nearby the rivers. Additionally, the villages along the upstream of tributaries are always under the menace of flush floods and debris flow.

In the past, flood inundations were not very significant in Palembang City. However, during the recent economic development, residential areas have expanded to the low-lying areas and the houses in those areas suffer from frequent inundation. Major problems caused by flood inundation are property damage, interruption of traffic and the outbreak of infectious diseases. Since Sekayu City is also located in a low-lying area, it suffers from frequent inundation during the rainy season.

## 4.4 Sedimentation

The discharged sediment consists of bed load, because the upper watershed is covered with sandy soils produced by landslide and sheet erosion due to deforestation. At the upper reach the erosion deepening process is still going on and, without any countermeasure, all sandy bed loads go further downstream.

Therefore, the Lower Musi River Basin has been silted up due to the deposition of sediment caused mainly by erosion in the upper catchments as mentioned above. The rise of riverbed has resulted not only in the reduction of discharge capacity causing floods, but also in the extension of back-swamp areas.

There is a serious sedimentation problem in the middle and lower reaches of the Komering River. The river flow downstream of Perjaya Dam has not been stable because of sedimentation, which caused bifurcation of the Komering River. The riverbed between Menanga and Cempaka has risen due to sedimentation, and no water flow can be observed during the dry season.

# 5. GROUNDWATER

## 5.1 Availability of Groundwater

In the Barisan Mountain Range an unknown but presumably substantial potential groundwater exists for new and extended schemes exploiting spring sources and shallow aquifers. An additional potential relying on deep fracture zones to be verified in terms of quality and quantity.

In the Piedmont zone groundwater potential seems to be less significant. Detailed survey should be directed towards spring sources and shallow aquifers. Deep aquifers are less likely to bear any major potential for groundwater exploitation. The Pre-pleistocene Peneplains including the surroundings of Palembang are in general not suited for groundwater exploitation from deep formations due to poor aquifer characteristics in terms of both quantity and quality. In this area the major potential for groundwater abstraction is limited to shallow aquifers exploitable by shallow drilled and handdug wells.

In the Pleistocene Peneplains the groundwater prospects are generally good for shallow as well as for deep aquifers.

In the tidal lowlands of the Coastal Plain the shallow formations have poor aquifer characteristics. Acidic, saline, and brackish conditions prevail over large areas.

Prospective aquifers may be present at deeper levels, either in older alluvial deposits or in the upper Palembang formation. Any opportunities have to be investigated by intensive receptivity prospecting, followed by drilling and through testing of test production wells.

## 5.2 Groundwater Development

There is not a very long tradition of groundwater abstraction of deep aquifers in the study area, which means that adverse effects of such exploitation have not yet developed. The experience related to technical aspects is very limited. It is recommended to refrain the development of small to intermediate groundwater abstraction schemes applied for domestic water supply for minor towns.

The application of groundwater for major irrigation schemes does not seem feasible, as the areas with the highest potential for deep groundwater do not fit for irrigation due to low fertility and high infiltration losses.

# 6. SOILS

## 6.1 Soil Classification

Six soil units that are separated in the Musi River Basin (see **Annex A6.1.1**) are described as follows:

### 6.1.1 Organosol

Organosols are formed on deposits of peat and are distinguished by depth and decomposition of the peat. Weakly decomposed peat deposits, consisting of clearly recognizable plant remains are classified as Fibric Organosols; those deposits consisting of more decomposed materials, in which plant remains are only partly recognizable are classified as Hemic Organosols and deposits which are completely decomposed are classified as Sapric Organosols.

### 6.1.2 Regosol

Regosol are soils having no diagnostic horizons or none other than an horizon (topsoil) which is pale in color and contains little organic matter. The largest continuous extent of Regosols occurs in the Belitang area in the Southeastern part of the Study Area. These soils are formed in sediments of volcanic origin, recently deposited, probably as mixed alluvial and mass-movement deposits. Although they have, in general, a high watertable now, these soils are probably relatively rich in primary minerals, reaching them a fertility considered above average.

### 6.1.3 Alluvial

Alluvial soils are formed on recent alluvial deposits and are therefore associated with the courses of rivers and streams and also with coastal areas; all such areas are liable to regular folding. These soils are primarily classified according to the nature of the alluvial materials and major types recognized include those consisting of sulphidic of calcareous materials. Sulphidic materials are normally associated with coastal deposits and are extensive in the Musi Delta.

### 6.1.4 Rendzina

The Rendzinas normally have surface soils, which are high in organic matter and calcareous material, overlying marble in varying stages of weathering. Because of the small areas they cover, the Rendzinas are not shown on the soil map. In the Musi River basin they occur on the karsitic hills of marble in the Kalung area, where they are dominant in association with Mediterranean soils; on the karstic mountain ridges over marble in the Mt. Gadang and on the hillocky plains over marble in the Aeknabontair area, where they are subordinate to Mediterranean soils.

### 6.1.5 Podzolic

Podzolic soils are the most widespread soils in the catchment area, because they result from the dominant soil forming process on dryland sites at low elevations, i.e. the leaching of clay and its translocation to lower parts of the soil to form argillic horizons. Such horizons show an increase in clay content when compared with surface horizons.

### 6.1.6 Andosol

Andosols are recent volcanic soils generally with weakly developed surface horizons and cambial horizons overlying volcanic materials, either consisting of more than 60 % of volcanic materials such as volcanic ash, cinders and ash including glass, or materials of very low bulk density. Andosols occur on the steep upper slopes of the young strato-volcanoes of basic to intermediate composition include in the Tanggamus area and of the small, young basic to intermediate volcanic cones of the Batu Ajan area.

## 6.2 Soil Suitability for Agriculture

The soil suitability for agriculture depends on texture, structure, permeability, acidity and nutrient status.

### 6.2.1 For Wetland Paddy

For wetland paddy the soil type is of lesser importance, due to the special reducing soil conditions in the wetland paddy fields, which limit soil acidity and make nutrients more available to the plants. The only problematic soils are the potential acid sulphate soils in the tidal swamp area which possess toxic compounds for the rice plants. A more limiting soil factor for wetland paddy is the water holding capacity and permeability. If the percolation, in light to medium textured soils is high, irrigation might be restricted. The light to medium textured soils are the Regosols, Alluvial, Andosols and Podzolic soils. On the other hand it must be noted that if a light textured is being irrigated, the percolation will be considerably reduced, after a few years, by the sediment brought into the field by the irrigation water, the accumulation of organic matter and the formation of a pan by the continued puddling process.

### 6.2.2 For Dry Land Crops

Only few of the soils possess an intrinsic fertility high for dryland crops, such as the alluvial, the Andosols and the Rendzinas. Moderately to marginally fertile are the Regosols, the Lithosols and the Oxisols. Infertile are the Podzolic Soils, the Gleysols and the Organosols, these soils cannot be used for agricultural purposes without major inputs. These soils are, however, better suitable for tree crops where there is sufficient drainage.

### 6.2.3 For Tree Crops Only

There is wide variety of soils, in the study area, suitable for tree crops in addition to those recommended for dry land food crops. Coffee can be grown in great variety of soils from deeply weathered tropical latosols to those associated with coastal sandy loams. Soils have to be deep and well drained. Rubber is also suited to a variety of different soils from shallow to deep clays, gravels and lateritic soils. Oil palm gives the better yields in deep, friable and well drained soils. The oil palm trees adaptability opens up large areas of the flood plain to possible expansion, including peat, providing there is a regular flushing out of the acid ions, and acid subsoil is deep enough. Drainage is the limiting factor. For account trees the most suitable locations are the alluvial soils of river valleys and flood plains provided drainage is satisfactory.