Ground elevation of the Study Area ranges from 0 m to 120 m. The highest spot with an altitude of 120 m is located in the Bukit Badung of the southern peninsula.

The land of the Denpasar area gently declines toward south to the Benoa Bay, from an elevation of 75 m to 0 m. The ground level of the central Denpasar is 20 m.

Topographic map with contour lines of the Study Area is shown in Fig. A.6.2.

## 6.3 Geology

According to the "Geological Map, Bali" published by the Geological Survey of Indonesia in 1971, the Study Area is covered by three (3) stratigraphies of Bujan-Bratan/Batur Tuffs and Lahar Deposits, Alluvial Deposits and Selatan Formation as described below (See, Fig. A.6.3).

### Bujan-Bratan/Batur Tuff and Lahar Deposits

Most of the Study Area is underlain by the Quaternary volcanics derived from Bujang-Bratan and Batur mountains. These rocks are highly heterogeneous, including lava flows of variable composition (basalt to trachy-andesite), breccias, unconsolidated volcanic sand and gravel, volcanic dust and lahar, pumice, clay, and tuff. Most of the material is pyroclastic in origin, and much has undergone water sorting. There are rapid lateral changes in lithology and few strata can be correlated to any great distance.

### Alluvial Deposits

The low-lying part of the Study Area is covered by the Alluvial Deposits. Alluvial Deposits are found along river and coast as a form of river deposit, sand beach, sand dune, tombolos and spit. They are composed of three (3) kinds of clastic materials ; volcanic rock origin, clastic rock origin, and coral and coral limestone origin.

Selatan Formation

The Selatan Formation is Miocene to Plioçene in age. This formation, which is mainly made up of coral limestone, is distributed in the southern peninsula and Nusa Penida. The age of this formation is confirmed by the fossils in the coral limestone. The Selatan Formation forms the foundations of the Bali Island along with the Ulakan and Sorga Formations.

Table A.2.1 (1) Existing Population and Population Density by Kelurahan/Desa in 1990

| Code Number | Name of Kelurahan/Desa & Kecamatan | Area (ha) | Residential Area (ha) | Population | Population Density (Person/ha) | Net Population Density (person/ha) |
|---|---|---|---|---|---|---|
| 101 | Dauh Puri | 60 | 21.0 | 10,751 | 179.2 | 512.0 |
| 102 | Dauh Puri Kaja | 109 | 25.4 | 10,234 | 93.9 | 402.9 |
| 103 | Dauh Puri Kauh | 190 | 87.7 | 12,919 | 68.0 | 147.3 |
| 104 | Dauh Puri Kangin | 59 | 23.6 | 5,279 | 89.5 | 223.7 |
| 105 | Dauh Puri Kelod | 188 | 53.4 | 14,719 | 78.3 | 275.6 |
| 106 | Pemecutan | 194 | 118.8 | 19,830 | 102.2 | 166.9 |
| 107 | Pemecutan Kaja | 385 | 64.5 | 21,355 | 55.5 | 331.1 |
| 108 | Pemecutan Kelod | 450 | 99.1 | 17,721 | 39.4 | 178.8 |
| 109 | Peguyangan | 644 | 36.5 | 6,852 | 10.6 | 187.7 |
| 110 | Peguyangan Kaja | 536 | 31.1 | 2,780 | 5.2 | 89.4 |
| 111 | Peguyangan Kangin | 416 | 47.1 | 4,699 | 11.3 | 99.8 |
| 112 | Padang Sambian | 401 | 70.3 | 8,532 | 21.3 | 121.4 |
| 113 | Padang Sambian Kaja | 409 | 43.2 | 4,592 | 11.2 | 106.3 |
| 114 | Padang Sambian Kelod | 412 | 31.6 | 6,911 | 16.8 | 218.7 |
| 115 | Ubung | 103 | 40.2 | 6,928 | 67.3 | 172.3 |
| 116 | Ubung Kaja | 400 | 17.6 | 7,386 | 18.5 | 419.7 |
| 117 | Tegal Kerta | 24 | 22.4 | 6,472 | 269.7 | 288.9 |
| 118 | Tegal Harum | 26 | 20.8 | 5,772 | 222.0 | 277.5 |
| 100 | DENPASAR BARAT | 5,006 | 854.3 | 173,732 | 34.7 | 203.4 |
| 201 | Dangin Puri | 65 | 20.9 | 9,721 | 149.6 | 465.1 |
| 202 | Dangin Puri Kauh | 72 | 23.4 | 4,503 | 62.5 | 192.4 |
| 203 | Dangin Puri Kaja | 142 | 38.3 | 11,125 | 78.3 | 290.5 |
| 204 | Dangin Puri Kangin | 75 | 21.0 | 10,754 | 143.4 | 512.1 |
| 205 | Dangin Puri Kelod | 142 | 58.9 | 12,052 | 84.9 | 204.6 |
| 206 | Sumerta | 52 | 28.7 | 7,422 | 142.7 | 258.6 |
| 207 | Sumerta Kauh | 89 | 44.2 | 7,090 | 79.7 | 160.4 |
| 208 | Sumerta Kaja | 73 | 35.1 | 7,456 | 102.1 | 212.4 |
| 209 | Sumerta Kelod | 271 | 70.0 | 9,200 | 33.9 | 131.4 |
| 210 | Kesiman | 266 | 31.4 | 6,561 | 24.7 | 208.9 |
| 211 | Kesiman Petilan | 290 | 30.5 | 6,282 | 21.7 | 206.0 |
| 212 | Kesiman Kertalangu | 405 | 63.5 | 10,107 | 25.0 | 159.2 |
| 213 | Tonja | 230 | 43.6 | 9,257 | 40.2 | 212.3 |
| 214 | Penatih | 281 | 41.3 | 4,774 | 17.0 | 115.6 |
| 215 | Penatih Dangin Puri | 320 | 28.8 | 2,579 | 8.1 | 89.5 |
| 200 | DENPASAR TIMUR | 2,773 | 579.6 | 118,883 | 42.9 | 205.1 |

Source : PENDUDUK BALI HASIL SENSUS PENDUDUK 1990
PENDUDUK KABUPATEN BADUNG 1990
RENCANA UMUM TATA RUANG KOTA DENPASAR, KUTA

Note: Net population density means population density in residential area.

Table A.2.1 (2) Existing Population and Population Density by Kelurahan/Desa in 1990

| Code Number | Name of Kelurahan/Desa & Kecamatan | Area (ha) | Residential Arae (ha) | Population | Population Density (Person/ha) | Net Population Density (person/ha) |
|---|---|---|---|---|---|---|
| 301 | Sanur Kaja | 269 | 43.1 | 6,684 | 24.8 | 155.1 |
| 302 | Sanur | 402 | 71.7 | 10,978 | 27.3 | 153.1 |
| 303 | Sanur Kauh | 386 | 24.0 | 6,657 | 17.2 | 277.4 |
| 304 | Renon | 254 | 32.4 | 6,484 | 25.5 | 200.1 |
| 305 | Panjer | 359 | 68.8 | 14,846 | 41.4 | 215.8 |
| 306 | Sesetan | 739 | 86.4 | 20,741 | 28.1 | 240.1 |
| 307 | Sidakarya | 389 | 28.9 | 7,191 | 18.5 | 248.8 |
| 308 | Pedungan | 749 | 75.7 | 10,836 | 14.5 | 143.1 |
| 309 | Pemogan | 971 | 47.2 | 8,879 | 9.1 | 188.1 |
| 310 | Serangan | 101 | 6.5 | 2,533 | 25.1 | 389.7 |
| 300 | **DENPASAR SELATAN** | 4,619 | 484.7 | 95,829 | 20.7 | 197.7 |
| 401 | Dalung | 615 | 52.9 | 5,514 | 9.0 | 104.2 |
| 402 | Canggu | 1,173 | 82.2 | 8,341 | 7.1 | 101.5 |
| 403 | Kerobokan | 1,598 | 131.9 | 15,144 | 9.5 | 114.8 |
| 404 | Kuta | 1,293 | 243.1 | 17,422 | 13.5 | 71.7 |
| 405 | Tuban | 459 | 64.0 | 14,687 | 32.0 | 229.5 |
| 406 | Jimbaran | 3,050 | 72.8 | 12,000 | 3.9 | 164.8 |
| 407 | Benoa | 3,067 | 316.3 | 15,885 | 5.2 | 50.2 |
| 400 | **KUTA** | 11,255 | 963.2 | 88,993 | 7.9 | 92.4 |
| | **Total** | 23,653 | 2,881.8 | 477,437 | 20.2 | 165.7 |

Source : PENDUDUK BALI HASIL SENSUS PENDUDUK 1990
PENDUDUK KABUPATEN BADUNG 1990
RENCANA UMUM TATA RUANG KOTA DENPASAR, KUTA

Note : Net population density means population density in residential area.

Table A.2.2(1) Future Population and Population Density by Kelurahan/Desa in 2010

| Code Number | Name of Kelurahan/Desa & Kecamatan | Area (ha) | Residential Area (ha) | Population | Population Density (Person/ha) | Net Population Density (person/ha) |
|---|---|---|---|---|---|---|
| 101 | Dauh Puri | 60 | 36.0 | 10,800 | 180.0 | 300.0 |
| 102 | Dauh Puri Kaja | 109 | 65.4 | 15,200 | 139.4 | 232.4 |
| 103 | Dauh Puri Kauh | 190 | 114.0 | 25,000 | 131.6 | 219.3 |
| 104 | Dauh Puri Kangin | 59 | 35.4 | 7,800 | 132.2 | 220.3 |
| 105 | Dauh Puri Kelod | 188 | 112.8 | 27,100 | 144.1 | 240.2 |
| 106 | Pemecutan | 194 | 118.8 | 29,500 | 152.1 | 248.3 |
| 107 | Pemecutan Kaja | 385 | 115.5 | 25,900 | 67.3 | 224.2 |
| 108 | Pemecutan Kelod | 450 | 135.0 | 26,300 | 58.4 | 194.8 |
| 109 | Peguyangan | 644 | 96.6 | 10,200 | 15.8 | 105.6 |
| 110 | Peguyangan Kaja | 536 | 80.4 | 4,100 | 7.6 | 51.0 |
| 111 | Peguyangan Kangin | 416 | 62.4 | 7,000 | 16.8 | 112.2 |
| 112 | Padang Sambian | 401 | 120.3 | 25,300 | 63.1 | 210.3 |
| 113 | Padang Sambian Kaja | 409 | 61.4 | 6,800 | 16.6 | 110.7 |
| 114 | Padang Sambian Kelod | 412 | 61.8 | 7,700 | 18.7 | 124.6 |
| 115 | Ubung | 103 | 40.2 | 9,100 | 88.3 | 226.4 |
| 116 | Ubung Kaja | 400 | 60.0 | 7,500 | 18.8 | 125.0 |
| 117 | Tegal Kerta | 24 | 22.4 | 6,700 | 279.2 | 299.1 |
| 118 | Tegal Harum | 26 | 20.8 | 6,200 | 238.5 | 298.1 |
| 100 | DENPASAR BARAT | 5,006 | 1,359.2 | 258,200 | 51.6 | 190.0 |
| 201 | Dangin Puri | 65 | 39.0 | 11,700 | 180.0 | 300.0 |
| 202 | Dangin Puri Kauh | 72 | 43.2 | 9,400 | 130.6 | 217.6 |
| 203 | Dangin Puri Kaja | 142 | 85.2 | 19,000 | 133.8 | 223.0 |
| 204 | Dangin Puri Kangin | 75 | 45.0 | 13,500 | 180.0 | 300.0 |
| 205 | Dangin Puri Kelod | 142 | 85.2 | 17,900 | 126.1 | 210.1 |
| 206 | Sumerta | 52 | 31.2 | 9,300 | 178.8 | 298.1 |
| 207 | Sumerta Kauh | 89 | 53.4 | 12,200 | 137.1 | 228.5 |
| 208 | Sumerta Kaja | 73 | 43.8 | 11,100 | 152.1 | 253.4 |
| 209 | Sumerta Kelod | 271 | 81.3 | 13,700 | 50.6 | 168.5 |
| 210 | Kesiman | 266 | 79.8 | 9,700 | 36.5 | 121.6 |
| 211 | Kesiman Petilan | 290 | 87.0 | 9,300 | 32.1 | 106.9 |
| 212 | Kesiman Kertalangu | 405 | 121.5 | 15,000 | 37.0 | 123.5 |
| 213 | Tonja | 230 | 69.0 | 13,800 | 60.0 | 200.0 |
| 214 | Penatih | 281 | 42.2 | 5,300 | 18.9 | 125.6 |
| 215 | Penatih Dangin Puri | 320 | 48.0 | 5,600 | 17.5 | 116.7 |
| 200 | DENPASAR TIMUR | 2,773 | 954.8 | 176,500 | 63.6 | 184.9 |

Source : JICA

Note : Net population density means population density in residential area.

Table A.2.2(2) Future Population and Population Density by Kelurahan/Desa in 2010

| Code Number | Name of Kelurahan/Desa & Kecamatan | Area (ha) | Residential Area (ha) | Population | Population Density (Person/ha) | Net Population Density (person/ha) |
|---|---|---|---|---|---|---|
| 301 | Sanur Kaja | 269 | 80.7 | 9,900 | 36.8 | 122.7 |
| 302 | Sanur | 402 | 120.6 | 19,000 | 47.3 | 157.5 |
| 303 | Sanur Kauh | 386 | 57.9 | 7,200 | 18.7 | 124.4 |
| 304 | Renon | 254 | 76.2 | 9,600 | 37.8 | 126.0 |
| 305 | Panjer | 359 | 107.7 | 22,100 | 61.6 | 205.2 |
| 306 | Sesetan | 739 | 221.7 | 30,800 | 41.7 | 138.9 |
| 307 | Sidakarya | 389 | 58.4 | 7,300 | 18.8 | 125.0 |
| 308 | Pedungan | 749 | 112.4 | 16,100 | 21.5 | 143.2 |
| 309 | Pemogan | 971 | 145.7 | 16,600 | 17.1 | 113.9 |
| 310 | Serangan | 101 | 30.3 | 3,800 | 37.6 | 125.4 |
| 300 | **DENPASAR SELATAN** | 4,619 | 1,011.6 | 142,400 | 30.8 | 140.8 |
| 401 | Dalung | 615 | 92.3 | 8,200 | 13.3 | 88.8 |
| 402 | Canggu | 1,173 | 176.0 | 12,400 | 10.6 | 70.5 |
| 403 | Kerobokan | 1,598 | 239.7 | 22,500 | 14.1 | 93.9 |
| 404 | Kuta | 1,293 | 243.1 | 25,900 | 20.0 | 106.5 |
| 405 | Tuban | 459 | 68.9 | 21,800 | 47.5 | 316.4 |
| 406 | Jimbaran | 3,050 | 457.5 | 17,800 | 5.8 | 38.9 |
| 407 | Benoa | 3,067 | 460.1 | 23,600 | 7.7 | 51.3 |
| 400 | **KUTA** | 11,255 | 1,737.6 | 132,200 | 11.7 | 76.1 |
| | **Total** | 23,653 | 5,063.2 | 709,300 | 30.0 | 140.1 |

Source : JICA

Note : Net population density means population density in residential area.

Table A.3.1(1) Existing Land Use Condition by Kelurahan/Desa in 1989

(Unit : ha)

| Code Number | Name of Kelurahan/Desa & Kecamatan | Residencial | Commercial & Institutional | Tourism | Industry | Others | Total |
|---|---|---|---|---|---|---|---|
| 101 | Dauh Puri | 21.0 | 9.9 | 1.7 | 0.8 | 26.6 | 60.0 |
| 102 | Dauh Puri Kaja | 25.4 | 15.0 | 0.0 | 0.0 | 68.6 | 109.0 |
| 103 | Dauh Puri Kauh | 87.7 | 6.6 | 0.5 | 1.0 | 94.2 | 190.0 |
| 104 | Dauh Puri Kangin | 23.6 | 6.9 | 1.4 | 0.0 | 27.1 | 59.0 |
| 105 | Dauh Puri Kelod | 53.4 | 20.9 | 2.8 | 1.1 | 109.8 | 188.0 |
| 106 | Pemecutan | 118.8 | 26.0 | 0.9 | 1.1 | 47.2 | 194.0 |
| 107 | Pemecutan Kaja | 64.5 | 11.1 | 0.0 | 1.6 | 307.8 | 385.0 |
| 108 | Pemecutan Kelod | 99.1 | 8.3 | 1.3 | 4.6 | 336.7 | 450.0 |
| 109 | Peguyangan | 36.5 | 0.8 | 0.0 | 0.1 | 606.6 | 644.0 |
| 110 | Peguyangan Kaja | 31.1 | 1.4 | 0.0 | 0.2 | 503.3 | 536.0 |
| 111 | Peguyangan Kangin | 47.1 | 1.3 | 0.0 | 0.2 | 367.4 | 416.0 |
| 112 | Padang Sambian | 70.3 | 2.4 | 0.0 | 1.7 | 326.6 | 401.0 |
| 113 | Padang Sambian Kaja | 43.2 | 4.5 | 0.0 | 1.5 | 359.8 | 409.0 |
| 114 | Padang Sambian Kelod | 31.6 | 1.8 | 0.0 | 1.1 | 377.5 | 412.0 |
| 115 | Ubung | 40.2 | 12.5 | 0.0 | 1.9 | 48.4 | 103.0 |
| 116 | Ubung Kaja | 17.6 | 3.6 | 0.0 | 0.7 | 378.1 | 400.0 |
| 117 | Tegal Kerta | 22.4 | 0.5 | 0.0 | 0.0 | 1.1 | 24.0 |
| 118 | Tegal Harum | 20.8 | 0.7 | 0.0 | 0.0 | 4.5 | 26.0 |
| 100 | **DENPASAR BARAT** | 854.3 | 134.2 | 8.6 | 17.6 | 3,991.3 | 5,006.0 |
| 201 | Dangin Puri | 20.9 | 7.1 | 0.2 | 0.0 | 36.8 | 65.0 |
| 202 | Dangin Puri Kauh | 23.4 | 3.8 | 0.8 | 0.0 | 44.0 | 72.0 |
| 203 | Dangin Puri Kaja | 38.3 | 1.9 | 0.9 | 0.2 | 100.7 | 142.0 |
| 204 | Dangin Puri Kangin | 21 | 9.9 | 1.7 | 0.8 | 41.6 | 75.0 |
| 205 | Dangin Puri Kelod | 58.9 | 28.2 | 0.0 | 0.0 | 54.9 | 142.0 |
| 206 | Sumerta | 28.7 | 4.4 | 0.0 | 0.5 | 18.4 | 52.0 |
| 207 | Sumerta Kauh | 44.2 | 4.9 | 0.0 | 0.0 | 39.9 | 89.0 |
| 208 | Sumerta Kaja | 35.1 | 2.5 | 0.6 | 0.3 | 34.5 | 73.0 |
| 209 | Sumerta Kelod | 70.0 | 39.8 | 0.6 | 0.5 | 160.1 | 271.0 |
| 210 | Kesiman | 31.4 | 3.4 | 0.0 | 0.2 | 231.0 | 266.0 |
| 211 | Kesiman Petilan | 30.5 | 1.7 | 0.0 | 0.4 | 257.4 | 290.0 |
| 212 | Kesiman Kertalangu | 63.5 | 7.9 | 1.5 | 4.3 | 327.8 | 405.0 |
| 213 | Tonja | 43.6 | 1.5 | 0.0 | 0.0 | 184.9 | 230.0 |
| 214 | Penatih | 41.3 | 4.0 | 0.0 | 0.3 | 235.4 | 281.0 |
| 215 | Penatih Dangin Puri | 28.8 | 1.4 | 0.0 | 0.1 | 289.7 | 320.0 |
| 200 | **DENPASAR TIMUR** | 579.6 | 122.4 | 6.3 | 7.6 | 2,057.1 | 2,773.0 |

Source : RENCANA UMUM TATA RUANG KOTA DENPASAR

Table A.3.1(2) Existing Land Use Condition by Kelurahan/Desa in 1989

(Unit : ha)

| Code Number | Name of Kelurahan/Desa & Kecamatan | Residencial | Commercial & Institutional | Tourism | Industry | Others | Total |
|---|---|---|---|---|---|---|---|
| 301 | Sanur Kaja | 43.1 | 2.7 | 21.7 | 0.7 | 200.8 | 269.0 |
| 302 | Sanur | 71.7 | 15.6 | 48.0 | 4.2 | 262.5 | 402.0 |
| 303 | Sanur Kauh | 24.0 | 3.4 | 16.8 | 0.9 | 340.9 | 386.0 |
| 304 | Renon | 32.4 | 3.3 | 0.0 | 0.4 | 217.9 | 254.0 |
| 305 | Panjer | 68.8 | 3.1 | 0.0 | 0.2 | 286.9 | 359.0 |
| 306 | Sesetan | 86.4 | 13.7 | 0.0 | 1.0 | 637.9 | 739.0 |
| 307 | Sidakarya | 28.9 | 4.8 | 0.0 | 0.0 | 355.3 | 389.0 |
| 308 | Pedungan | 75.7 | 19.3 | 0.0 | 6.2 | 647.8 | 749.0 |
| 309 | Pemogan | 47.2 | 6.9 | 0.0 | 4.6 | 912.3 | 971.0 |
| 310 | Serangan | 6.5 | 1.5 | 0.0 | 0.0 | 93.0 | 101.0 |
| 300 | **DENPASAR SELATAN** | 484.7 | 74.3 | 86.5 | 18.2 | 3,955.3 | 4,619.0 |
| 401 | Dalung | 52.9 | 5.6 | 0.0 | 0.0 | 556.5 | 615.0 |
| 402 | Canggu | 82.2 | 12.3 | 7.0 | 2.9 | 1,068.6 | 1,173.0 |
| 403 | Kerobokan | 131.9 | 8.2 | 5.9 | 8.9 | 1,443.1 | 1,598.0 |
| 404 | Kuta | 186.4 | 144.6 *1 | 147.2 | 14.5 | 800.3 | 1,293.0 |
| 405 | Tuban | 64.0 | 230.6 *2 | 0.0 | 1.0 | 163.4 | 459.0 |
| 406 | Jimbaran | 72.8 | 184.8 *3 | 23.6 | 0.0 | 2,768.8 | 3,050.0 |
| 407 | Benoa | 316.3 | 29.0 | 144.8 | 0.0 | 2,576.9 | 3,067.0 |
| 400 | **KUTA** | 906.5 | 615.1 | 328.5 | 27.3 | 9,377.6 | 11,255.0 |
| | **Total** | 2,825.1 | 946.0 | 429.9 | 70.7 | 19,381.3 | 23,653.0 |

Source : RENCANA UMUM TATA RUANG KOTA DENPASAR

Note : *1 Airport area of 69.4 ha is included.

*2 Airport area of 222.6 ha is included.

*3 Udayana Univ. of 170 ha is included.

Table A.3.2 (1) Future Land Use Condition by Kelurahan/Desa in 2010

(Unit:ha)

| Code Number | Name of Kelurahan/Desa & Kecamatan | Residencial | Commercial and Institutional | Tourism | Industry | Others | Total |
|---|---|---|---|---|---|---|---|
| 101 | Dauh Puri | 36.0 | 20.5 | 2.7 | 0.8 | 0.0 | 60.0 |
| 102 | Dauh Puri Kaja | 65.4 | 15.0 | 1.1 | 0.1 | 27.4 | 109.0 |
| 103 | Dauh Puri Kauh | 114.0 | 7.4 | 0.5 | 1.0 | 67.1 | 190.0 |
| 104 | Dauh Puri Kangin | 35.4 | 13.0 | 1.4 | 0.0 | 9.2 | 59.0 |
| 105 | Dauh Puri Kelod | 112.8 | 23.8 | 4.9 | 1.1 | 45.4 | 188.0 |
| 106 | Pemecutan | 118.8 | 26.0 | 0.9 | 1.1 | 47.2 | 194.0 |
| 107 | Pemecutan Kaja | 115.5 | 11.1 | 0.0 | 2.2 | 256.2 | 385.0 |
| 108 | Pemecutan Kelod | 135.0 | 8.3 | 1.3 | 4.6 | 300.8 | 450.0 |
| 109 | Peguyangan | 96.6 | 0.8 | 0.0 | 0.2 | 546.4 | 644.0 |
| 110 | Peguyangan Kaja | 80.4 | 1.4 | 0.0 | 0.3 | 453.9 | 536.0 |
| 111 | Peguyangan Kangin | 62.4 | 1.3 | 0.0 | 0.2 | 352.1 | 416.0 |
| 112 | Padang Sambian | 120.3 | 11.5 | 0.0 | 2.1 | 267.1 | 401.0 |
| 113 | Padang Sambian Kaja | 61.4 | 9.6 | 3.2 | 1.5 | 333.3 | 409.0 |
| 114 | Padang Sambian Kelod | 61.8 | 1.8 | 0.0 | 1.1 | 347.3 | 412.0 |
| 115 | Ubung | 40.2 | 12.5 | 0.0 | 1.9 | 48.4 | 103.0 |
| 116 | Ubung Kaja | 60.0 | 11.8 | 0.0 | 0.7 | 327.5 | 400.0 |
| 117 | Tegal Kerta | 22.4 | 0.7 | 0.0 | 0.0 | 0.9 | 24.0 |
| 118 | Tegal Harum | 20.8 | 2.3 | 0.0 | 0.0 | 2.9 | 26.0 |
| 100 | DENPASAR BARAT | 1,359.2 | 178.8 | 16.0 | 18.9 | 3,433.1 | 5,006.0 |
| 201 | Dangin Puri | 39.0 | 8.9 | 0.2 | 0.0 | 16.9 | 65.0 |
| 202 | Dangin Puri Kauh | 43.2 | 4.9 | 0.9 | 0.0 | 23.0 | 72.0 |
| 203 | Dangin Puri Kaja | 85.2 | 3.6 | 0.9 | 0.7 | 51.6 | 142.0 |
| 204 | Dangin Puri Kangin | 45.0 | 11.2 | 1.7 | 0.8 | 16.3 | 75.0 |
| 205 | Dangin Puri Kelod | 85.2 | 28.2 | 0.0 | 0.0 | 28.6 | 142.0 |
| 206 | Sumerta | 31.2 | 4.4 | 0.0 | 0.5 | 15.9 | 52.0 |
| 207 | Sumerta Kauh | 53.4 | 5.0 | 0.0 | 0.0 | 30.6 | 89.0 |
| 208 | Sumerta Kaja | 43.8 | 2.5 | 0.7 | 0.3 | 25.7 | 73.0 |
| 209 | Sumerta Kelod | 81.3 | 39.8 | 0.6 | 0.5 | 148.8 | 271.0 |
| 210 | Kesiman | 79.8 | 3.4 | 0.0 | 0.2 | 182.6 | 266.0 |
| 211 | Kesiman Petilan | 87.0 | 2.1 | 6.5 | 0.4 | 194.0 | 290.0 |
| 212 | Kesiman Kertalangu | 121.5 | 8.4 | 18.2 | 4.3 | 252.6 | 405.0 |
| 213 | Tonja | 69.0 | 3.7 | 0.0 | 0.0 | 157.3 | 230.0 |
| 214 | Penatih | 42.2 | 4.0 | 0.0 | 0.3 | 234.5 | 281.0 |
| 215 | Penatih Dangin Puri | 48.0 | 1.4 | 0.0 | 0.1 | 270.5 | 320.0 |
| 200 | DENPASAR TIMUR | 954.8 | 131.5 | 29.7 | 8.1 | 1,648.9 | 2,773.0 |

Source : JICA

Table A.3.2 (2) Future Land Use Condition by Kelurahan/Desa in 2010

(Unit:ha)

| Code Number | Name of Kelurahan/Desa & Kecamatan | Residencial | Commercial and Institutional | Tourism | Industry | Others | Total |
|---|---|---|---|---|---|---|---|
| 301 | Sanur Kaja | 80.7 | 2.7 | 51.6 | 0.8 | 133.2 | 269.0 |
| 302 | Sanur | 120.6 | 15.6 | 82.2 | 4.2 | 179.4 | 402.0 |
| 303 | Sanur Kauh | 57.9 | 3.4 | 30.5 | 0.9 | 293.3 | 386.0 |
| 304 | Renon | 76.2 | 3.3 | 0.0 | 0.4 | 174.1 | 254.0 |
| 305 | Panjer | 107.7 | 8.0 | 0.0 | 0.2 | 243.1 | 359.0 |
| 306 | Sesetan | 221.7 | 13.7 | 2.6 | 1.0 | 500.0 | 739.0 |
| 307 | Sidakarya | 58.4 | 6.0 | 0.0 | 0.0 | 324.6 | 389.0 |
| 308 | Pedungan | 112.4 | 22.4 | 0.0 | 6.2 | 608.0 | 749.0 |
| 309 | Pemogan | 145.7 | 7.7 | 0.0 | 4.6 | 813.0 | 971.0 |
| 310 | Serangan | 30.3 | 1.5 | 11.0 | 0.0 | 58.2 | 101.0 |
| 300 | **DENPASAR SELATAN** | 1,011.6 | 84.3 | 177.9 | 18.3 | 3,326.9 | 4,619.0 |
| 401 | Dalung | 92.3 | 5.6 | 0.0 | 0.0 | 517.1 | 615.0 |
| 402 | Canggu | 176.0 | 117.3 | 138.1 | 2.9 | 738.7 | 1,173.0 |
| 403 | Kerobokan | 239.7 | 102.7 | 98.8 | 8.9 | 1,147.9 | 1,598.0 |
| 404 | Kuta | 239.6 | *1 166.1 | 189.2 | 14.5 | 683.6 | 1,293.0 |
| 405 | Tuban | 68.9 | *2 231.8 | 21.0 | 1.0 | 136.3 | 459.0 |
| 406 | Jimbaran | 457.5 | *3 259.6 | 241.3 | 0.0 | 2,091.6 | 3,050.0 |
| 407 | Benoa | 460.1 | 29.0 | 746.8 | 0.0 | 1,831.1 | 3,067.0 |
| 400 | **KUTA** | 1,734.1 | 912.1 | 1,435.2 | 27.3 | 7,146.3 | 11,255.0 |
| | **Total** | 5,059.7 | 1,306.7 | 1,658.8 | 72.6 | 15,555.2 | 23,653.0 |

Source : JICA

Note : *1 Airport area of 69.4 ha is included.

*2 Airport area of 222.6 ha is included.

*3 Udayana Univ. of 170 ha is included.

Table A.3.3 Existing and Future Land Use Pattern by Kecamatan

| Name of Kecamatan / Land Use | Residential | | Commercial & Institutional | | Tourism | | Industry | | Others | | Total (ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Existing (ha) | Future (ha) | Existing (ha) | Future (ha) | Existing (ha) | Future (ha) | Existing (ha) | Future (ha) | Existing (ha) | Future (ha) | |
| Denpasar Barat | 854.3 (17.0%) | 1,359.2 (27.2%) | 134.2 (2.7%) | 178.8 (3.6%) | 8.6 (0.2%) | 16.0 (0.3%) | 17.6 (0.4%) | 18.9 (0.4%) | 3,991.3 (79.7%) | 3,433.1 (68.5%) | 5,006.0 |
| Denpasar Timur | 579.6 (20.9%) | 954.8 (34.4%) | 122.4 (4.4%) | 131.5 (4.7%) | 6.3 (0.2%) | 29.7 (1.1%) | 7.6 (0.3%) | 8.1 (0.3%) | 2,057.1 (74.2%) | 1,648.9 (59.5%) | 2,773.0 |
| Denpasar Selatan | 487.7 (10.6%) | 1,011.6 (21.9%) | 74.3 (1.6%) | 84.3 (1.8%) | 86.5 (1.9%) | 177.9 (3.9%) | 18.2 (0.4%) | 18.3 (0.4%) | 3,955.3 (85.5%) | 3,326.9 (72.0%) | 4,619.0 |
| Kuta | 963.2 (8.6%) | 1,734.1 (15.4%) | 615.1 (5.5%) | 912.1 (8.1%) | 328.5 (2.9%) | 1,435.2 (12.8%) | 27.3 (0.2%) | 27.3 (0.2%) | 9,320.9 (82.8%) | 7,146.3 (63.5%) | 11,255.0 |
| Total | 2,881.8 (12.2%) | 5,059.7 (21.4%) | 946.0 (4.0%) | 1,306.7 (5.5%) | 429.9 (1.8%) | 1,658.8 (7.0%) | 70.7 (0.3%) | 72.6 (0.3%) | 19,324.6 (81.7%) | 15,555.2 (65.8%) | 23,653.0 |

Table A.4.1 Gross Regional Domestic Product (GRDP) by Sector and Per Capita GRDP of the Study Area in 1990 and 2010

| Item | 1990 | 2010 |
|---|---|---|
| I. GRDP by Sector (Rp. million at 1990 prices) | | |
| 1. Agriculture | 152,169 | 134,022 |
| 2. Mining and Quarrying | 1,060 | 618 |
| 3. Industry | 38,328 | 224,775 |
| 4. Electricity, Gas and Water Supply | 17,044 | 108,964 |
| 5. Construction | 69,153 | 186,296 |
| 6. Trade, Hotels and Restaurants | 207,704 | 931,514 |
| 7. Transport and Communications | 168,561 | 958,197 |
| 8. Banking and Other Financial Institutions | 42,731 | 364,129 |
| 9. House Rent | 3,425 | 9,790 |
| 10. Government and Defence | 54,148 | 101,002 |
| 11. Services | 61,161 | 444,003 |
| Total | 815,484 | 3,463,310 |
| II. Per Capita GRDP | | |
| 1. Population | 477,437 | 709,300 |
| 2. GRDP per Capita (Rp.) | 1,708,045 | 4,882,715 |

Sources : 1) Indikator Economi Badung 1990
2) Badung dalam Angka 1990
3) Pendapatan Regional (Kabupaten Daerah Tingkat II Badung) 1983-1987
4) Produk Domestik Regional Bruto, Propinsi Daerah Tingkat I Bali 1969-1978, 1979-1984 and 1985-1989
5) JICA

Table A.4.2 Definition of Income Classes by Type of Houses

| | |
|---|---|
| High Income Class | Luxurious, permanent house. Big size. Has many rooms. Made of good materials. Has a car or more, a spacious garden and well-tended walls/fences. Occupied by rich people. |
| Middle Income Class | Ordinary, permanent house. Medium size. Made of ordinary materials. May or may not have a car. Has a small garden. May have mediocre fences. Neither rich, nor poor. |
| Low Income Class | Semi-permanent or temporary house. Small size. Has few rooms. Made of inferior, make-shift materials. May have no garden, nor fences. Occupied by poor people. |

Source : JICA

Table A.4.3(1) Composition of Population by Income Class in 1991

( Unit : % )

| Code Number | Name of Kelurahan/Desa & Kecamatan | Income Class | | |
|---|---|---|---|---|
| | | High | Middle | Low |
| 101 | Dauh Puri | 4.5 | 75.1 | 20.4 |
| 102 | Dauh Puri Kaja | 4.1 | 80.2 | 15.7 |
| 103 | Dauh Puri Kauh | 2.4 | 73.6 | 24.0 |
| 104 | Dauh Puri Kangin | 4.7 | 69.7 | 25.6 |
| 105 | Dauh Puri Kelod | 5.0 | 72.3 | 22.7 |
| 106 | Pemecutan | 3.8 | 53.5 | 42.7 |
| 107 | Pemecutan Kaja | 2.5 | 46.4 | 51.1 |
| 108 | Pemecutan Kelod | 2.5 | 57.5 | 40.0 |
| 109 | Peguyangan | 2.8 | 44.4 | 52.8 |
| 110 | Peguyangan Kaja | 2.0 | 53.9 | 44.1 |
| 111 | Peguyangan Kangin | 1.1 | 25.4 | 73.5 |
| 112 | Padang Sambian | 2.5 | 33.9 | 63.6 |
| 113 | Padang Sambian Kaja | 0.8 | 47.8 | 51.4 |
| 114 | Padang Sambian Kelod | 0.8 | 42.3 | 56.9 |
| 115 | Ubung | 0.8 | 25.2 | 74.0 |
| 116 | Ubung Kaja | 2.4 | 23.4 | 74.2 |
| 117 | Tegal Kerta | 3.7 | 52.8 | 43.5 |
| 118 | Tegal Harum | 6.4 | 69.1 | 24.5 |
| 100 | **DENPASAR BARAT** | 3.1 | 54.9 | 42.0 |
| 201 | Dangin Puri | 6.6 | 69.9 | 23.5 |
| 202 | Dangin Puri Kauh | 6.4 | 73.2 | 20.4 |
| 203 | Dangin Puri Kaja | 6.9 | 78.7 | 14.4 |
| 204 | Dangin Puri Kangin | 6.7 | 70.8 | 22.5 |
| 205 | Dangin Puri Kelod | 6.5 | 84.7 | 8.8 |
| 206 | Sumerta | 3.2 | 51.4 | 45.4 |
| 207 | Sumerta Kauh | 6.1 | 62.0 | 31.9 |
| 208 | Sumerta Kaja | 3.5 | 38.5 | 58.0 |
| 209 | Sumerta Kelod | 3.7 | 52.8 | 43.5 |
| 210 | Kesiman | 1.4 | 48.8 | 49.8 |
| 211 | Kesiman Petilan | 1.4 | 46.7 | 51.9 |
| 212 | Kesiman Kertalangu | 0.8 | 42.3 | 56.9 |
| 213 | Tonja | 0.4 | 35.9 | 63.7 |
| 214 | Penatih | 0.5 | 32.8 | 66.7 |
| 215 | Penatih Dangin Puri | 0.4 | 27.9 | 71.7 |
| 200 | **DENPASAR TIMUR** | 4.1 | 57.7 | 38.2 |

Table A.4.3(2) Composition of Population by Income Class in 1991

( Unit : % )

| Code Number | Name of Kelurahan/Desa & Kecamatan | Income Class | | |
|---|---|---|---|---|
| | | High | Middle | Low |
| 301 | Sanur Kaja | 4.5 | 46.3 | 49.2 |
| 302 | Sanur | 4.2 | 44.1 | 51.7 |
| 303 | Sanur Kauh | 2.9 | 46.8 | 50.3 |
| 304 | Renon | 0.4 | 32.5 | 67.1 |
| 305 | Panjer | 0.8 | 39.0 | 60.2 |
| 306 | Sesetan | 2.0 | 47.1 | 50.9 |
| 307 | Sidakarya | 2.2 | 42.9 | 54.9 |
| 308 | Pedungan | 2.1 | 34.2 | 63.7 |
| 309 | Pemogan | 1.1 | 31.6 | 67.3 |
| 310 | Serangan | 0.1 | 10.1 | 89.8 |
| 300 | **DENPASAR SELATAN** | 2.1 | 40.2 | 57.7 |
| 401 | Dalung | 1.7 | 38.3 | 60.0 |
| 402 | Canggu | 1.5 | 36.8 | 61.7 |
| 403 | Kerobokan | 1.0 | 50.3 | 48.7 |
| 404 | Kuta | 5.1 | 47.7 | 47.2 |
| 405 | Tuban | 5.4 | 51.6 | 43.0 |
| 406 | Jimbaran | 2.1 | 35.3 | 62.6 |
| 407 | Benoa | 3.7 | 51.6 | 44.7 |
| 400 | **KUTA** | 3.3 | 46.2 | 50.5 |
| | **Total** | 3.2 | 51.0 | 45.8 |

Source : JICA

Table A.4.4 Per Capita Per Month Income by Kelurahan/Desa in 1991

( Unit : Rp )

| Code Number | Name of Kelurahan/Desa & Kecamatan | Income |
|---|---|---|
| 101 | Dauh Puri | 57,000 |
| 102 | Dauh Puri Kaja | 57,300 |
| 103 | Dauh Puri Kauh | 54,100 |
| 104 | Dauh Puri Kangin | 56,400 |
| 105 | Dauh Puri Kelod | 57,200 |
| 106 | Pemecutan | 52,700 |
| 107 | Pemecutan Kaja | 50,000 |
| 108 | Pemecutan Kelod | 51,700 |
| 109 | Peguyangan | 50,100 |
| 110 | Peguyangan Kaja | 50,500 |
| 111 | Peguyangan Kangin | 44,900 |
| 112 | Padang Sambian | 48,000 |
| 113 | Padang Sambian Kaja | 48,100 |
| 114 | Padang Sambian Kelod | 47,200 |
| 115 | Ubung | 44,500 |
| 116 | Ubung Kaja | 46,300 |
| 117 | Tegal Kerta | 52,500 |
| 118 | Tegal Harum | 58,400 |
| 100 | **DENPASAR BARAT** | 52,100 |
| 201 | Dangin Puri | 58,800 |
| 202 | Dangin Puri Kauh | 59,100 |
| 203 | Dangin Puri Kaja | 60,600 |
| 204 | Dangin Puri Kangin | 59,100 |
| 205 | Dangin Puri Kelod | 61,000 |
| 206 | Sumerta | 51,700 |
| 207 | Sumerta Kauh | 57,000 |
| 208 | Sumerta Kaja | 50,000 |
| 209 | Sumerta Kelod | 52,500 |
| 210 | Kesiman | 49,000 |
| 211 | Kesiman Petilan | 48,600 |
| 212 | Kesiman Kertalangu | 47,200 |
| 213 | Tonja | 45,700 |
| 214 | Penatih | 45,300 |
| 215 | Penatih Dangin Puri | 44,500 |
| 200 | **DENPASAR TIMUR** | 53,700 |
| 301 | Sanur Kaja | 52,500 |
| 302 | Sanur | 51,800 |
| 303 | Sanur Kauh | 50,600 |
| 304 | Renon | 45,200 |
| 305 | Panjer | 46,700 |
| 306 | Sesetan | 49,500 |
| 307 | Sidakarya | 49,100 |
| 308 | Pedungan | 47,600 |
| 309 | Pemogan | 45,900 |
| 310 | Serangan | 41,300 |
| 300 | **DENPASAR SELATAN** | 48,500 |
| 401 | Dalung | 47,700 |
| 402 | Canggu | 47,200 |
| 403 | Kerobokan | 48,700 |
| 404 | Kuta | 53,500 |
| 405 | Tuban | 54,500 |
| 406 | Jimbaran | 47,800 |
| 407 | Benoa | 52,300 |
| 400 | **KUTA** | 50,900 |
| | **Total** | 51,500 |

Note : Results of the sampling questionnaire survey.
The No. of samples was 750.

Source : JICA

Table A.4.5(1) Composition of Population by Income Class in 2010

( Unit : % )

| Code Number | Name of Kelurahan/Desa & Kecamatan | Income Class | | |
|---|---|---|---|---|
| | | High | Middle | Low |
| 101 | Dauh Puri | 22.9 | 64.8 | 12.3 |
| 102 | Dauh Puri Kaja | 23.2 | 67.4 | 9.4 |
| 103 | Dauh Puri Kauh | 20.8 | 64.8 | 14.4 |
| 104 | Dauh Puri Kangin | 22.4 | 62.2 | 15.4 |
| 105 | Dauh Puri Kelod | 23.0 | 63.3 | 13.7 |
| 106 | Pemecutan | 19.8 | 54.6 | 25.6 |
| 107 | Pemecutan Kaja | 17.7 | 51.6 | 30.7 |
| 108 | Pemecutan Kelod | 19.0 | 57.0 | 24.0 |
| 109 | Peguyangan | 17.7 | 50.6 | 31.7 |
| 110 | Peguyangan Kaja | 18.2 | 55.4 | 26.4 |
| 111 | Peguyangan Kangin | 14.0 | 41.9 | 44.1 |
| 112 | Padang Sambian | 16.2 | 45.6 | 38.2 |
| 113 | Padang Sambian Kaja | 16.4 | 52.8 | 30.8 |
| 114 | Padang Sambian Kelod | 15.7 | 50.1 | 34.2 |
| 115 | Ubung | 13.7 | 41.9 | 44.4 |
| 116 | Ubung Kaja | 14.9 | 40.6 | 44.5 |
| 117 | Tegal Kerta | 19.6 | 54.3 | 26.1 |
| 118 | Tegal Harum | 23.9 | 61.4 | 14.7 |
| 100 | **DENPASAR BARAT** | 19.3 | 55.6 | 25.1 |
| 201 | Dangin Puri | 24.2 | 61.7 | 14.1 |
| 202 | Dangin Puri Kauh | 24.4 | 63.4 | 12.2 |
| 203 | Dangin Puri Kaja | 25.5 | 65.9 | 8.6 |
| 204 | Dangin Puri Kangin | 24.4 | 62.1 | 13.5 |
| 205 | Dangin Puri Kelod | 25.8 | 68.9 | 5.3 |
| 206 | Sumerta | 18.9 | 53.8 | 27.3 |
| 207 | Sumerta Kauh | 22.8 | 58.1 | 19.1 |
| 208 | Sumerta Kaja | 17.7 | 47.5 | 34.8 |
| 209 | Sumerta Kelod | 19.6 | 54.3 | 26.1 |
| 210 | Kesiman | 17.0 | 53.1 | 29.9 |
| 211 | Kesiman Petilan | 16.8 | 52.1 | 31.1 |
| 212 | Kesiman Kertalangu | 15.7 | 50.1 | 34.2 |
| 213 | Tonja | 14.6 | 47.2 | 38.2 |
| 214 | Penatih | 14.3 | 45.7 | 40.0 |
| 215 | Penatih Dangin Puri | 13.7 | 43.3 | 43.0 |
| 200 | **DENPASAR TIMUR** | 20.5 | 56.7 | 22.8 |

Table A.4.5(2) Composition of Population by Income Class in 2010

( Unit : % )

| Code Number | Name of Kelurahan/Desa & Kecamatan | Income Class | | |
|---|---|---|---|---|
| | | High | Middle | Low |
| 301 | Sanur Kaja | 19.5 | 51.0 | 29.5 |
| 302 | Sanur | 19.0 | 50.0 | 31.0 |
| 303 | Sanur Kauh | 18.1 | 51.7 | 30.2 |
| 304 | Renon | 14.2 | 45.5 | 40.3 |
| 305 | Panjer | 15.3 | 48.6 | 36.1 |
| 306 | Sesetan | 17.3 | 52.1 | 30.6 |
| 307 | Sidakarya | 17.0 | 50.0 | 33.0 |
| 308 | Pedungan | 15.9 | 45.9 | 38.2 |
| 309 | Pemogan | 14.7 | 44.9 | 40.4 |
| 310 | Serangan | 11.3 | 34.8 | 53.9 |
| 300 | **DENPASAR SELATAN** | 16.6 | 48.6 | 34.8 |
| 401 | Dalung | 16.0 | 47.9 | 36.1 |
| 402 | Canggu | 15.7 | 47.3 | 37.0 |
| 403 | Kerobokan | 16.8 | 53.9 | 29.3 |
| 404 | Kuta | 20.2 | 51.5 | 28.3 |
| 405 | Tuban | 20.9 | 53.2 | 25.9 |
| 406 | Jimbaran | 16.0 | 46.4 | 37.6 |
| 407 | Benoa | 19.4 | 53.8 | 26.8 |
| 400 | **KUTA** | 18.3 | 51.3 | 30.4 |
| | **Total** | 18.8 | 53.7 | 27.5 |

Source : JICA

Table A.4.6 Per Capita Per Month Income by Kelurahan/Desa in 2010

( Unit : Rp )

| Code Number | Name of Kelurahan/Desa & Kecamatan | Income |
|---|---|---|
| 101 | Dauh Puri | 153,600 |
| 102 | Dauh Puri Kaja | 155,000 |
| 103 | Dauh Puri Kauh | 148,200 |
| 104 | Dauh Puri Kangin | 151,700 |
| 105 | Dauh Puri Kelod | 153,500 |
| 106 | Pemecutan | 142,300 |
| 107 | Pemecutan Kaja | 136,200 |
| 108 | Pemecutan Kelod | 141,200 |
| 109 | Peguyangan | 136,000 |
| 110 | Peguyangan Kaja | 138,400 |
| 111 | Peguyangan Kangin | 123,600 |
| 112 | Padang Sambian | 130,600 |
| 113 | Padang Sambian Kaja | 133,000 |
| 114 | Padang Sambian Kelod | 130,500 |
| 115 | Ubung | 122,800 |
| 116 | Ubung Kaja | 125,600 |
| 117 | Tegal Kerta | 141,800 |
| 118 | Tegal Harum | 155,200 |
| 100 | **DENPASAR BARAT** | 141,500 |
| 201 | Dangin Puri | 156,000 |
| 202 | Dangin Puri Kauh | 157,100 |
| 203 | Dangin Puri Kaja | 160,700 |
| 204 | Dangin Puri Kangin | 156,700 |
| 205 | Dangin Puri Kelod | 162,500 |
| 206 | Sumerta | 140,000 |
| 207 | Sumerta Kauh | 151,400 |
| 208 | Sumerta Kaja | 134,900 |
| 209 | Sumerta Kelod | 141,800 |
| 210 | Kesiman | 134,800 |
| 211 | Kesiman Petilan | 134,000 |
| 212 | Kesiman Kertalangu | 130,500 |
| 213 | Tonja | 126,700 |
| 214 | Penatih | 125,600 |
| 215 | Penatih Dangin Puri | 123,100 |
| 200 | **DENPASAR TIMUR** | 144,900 |
| 301 | Sanur Kaja | 140,700 |
| 302 | Sanur | 139,000 |
| 303 | Sanur Kauh | 137,300 |
| 304 | Renon | 125,200 |
| 305 | Panjer | 129,000 |
| 306 | Sesetan | 135,400 |
| 307 | Sidakarya | 134,000 |
| 308 | Pedungan | 129,800 |
| 309 | Pemogan | 126,400 |
| 310 | Serangan | 114,400 |
| 300 | **DENPASAR SELATAN** | 132,300 |
| 401 | Dalung | 130,800 |
| 402 | Canggu | 129,600 |
| 403 | Kerobokan | 134,600 |
| 404 | Kuta | 142,700 |
| 405 | Tuban | 145,100 |
| 406 | Jimbaran | 130,300 |
| 407 | Benoa | 141,300 |
| 400 | **KUTA** | 137,800 |
| | **Total** | 139,800 |

Source : JICA

Table A.5.1 Projection of Tourist Arrivals in Bali

(Unit : No. of Tourists)

| Year | Air | Sea | Overland | Total | Regression Equations Used |
|---|---|---|---|---|---|
| 1. Actual Figures | | | | | 1) Air Passengers |
| 1980 | 421,474 | 11,438 | 802,831 | 1,235,743 | log y = 10.71225 + 1.358982 log t |
| 1981 | 454,636 | 9,121 | 803,155 | 1,266,912 | where, y : passengers |
| 1982 | 431,915 | 3,443 | 758,186 | 1,193,544 | t : year (1980 = 1) |
| 1983 | 423,503 | 8,358 | 738,138 | 1,169,999 | |
| 1984 | 497,492 | 3,816 | 877,962 | 1,379,270 | base period : 1985 - 1990 |
| 1985 | 525,965 | 9,452 | 948,374 | 1,483,791 | correl. coef.: 0.9982482 |
| 1986 | 615,221 | 5,592 | 1,040,064 | 1,660,877 | T-value : 33.74386 |
| 1987 | 751,266 | 9,115 | 1,223,821 | 1,984,202 | |
| 1988 | 881,970 | 8,095 | 1,347,533 | 2,237,598 | |
| 1989 | 1,038,189 | 10,368 | 1,448,796 | 2,497,353 | 2) Sea Passengers |
| 1990 | 1,176,395 | 8,503 | 1,367,837 | 2,552,735 | log y = 8.451689 + 0.2409894 log t |
| 2. Forecasts | | | | | where, y : passengers |
| 1991 | 1,314,793 | 8,523 | 1,473,999 | 2,797,315 | t : year (1980 = 1) |
| 1992 | 1,465,880 | 8,689 | 1,578,093 | 3,052,662 | |
| 1993 | 1,621,201 | 8,846 | 1,680,315 | 3,310,362 | base period : 1981 - 1990 |
| 1994 | 1,780,561 | 8,994 | 1,780,823 | 3,570,378 | correl. coef.: 0.3396752 |
| 1995 | 1,943,779 | 9,135 | 1,879,764 | 3,832,678 | T-value : 1.021481 |
| 1996 | 2,110,704 | 9,269 | 1,977,254 | 4,097,227 | |
| 1997 | 2,281,193 | 9,398 | 2,073,399 | 4,363,990 | |
| 1998 | 2,455,119 | 9,521 | 2,168,294 | 4,632,934 | 3) Overland Passengers |
| 1999 | 2,632,362 | 9,640 | 2,262,018 | 4,904,020 | log yo = 12.41792 + 0.7640801 log t |
| 2000 | 2,812,817 | 9,754 | 2,354,638 | 5,177,209 | y = yo - 176,497 |
| 2001 | 2,996,389 | 9,864 | 2,446,226 | 5,452,479 | where, y : passengers |
| 2002 | 3,182,978 | 9,970 | 2,536,834 | 5,729,782 | t : year (1980 = 1) |
| 2003 | 3,372,499 | 10,073 | 2,626,523 | 6,009,095 | |
| 2004 | 3,564,882 | 10,172 | 2,715,332 | 6,290,386 | base period : 1984 - 1989 |
| 2005 | 3,760,038 | 10,269 | 2,803,304 | 6,573,611 | correl. coef.: 0.9876201 |
| 2006 | 3,957,921 | 10,363 | 2,890,480 | 6,858,764 | T-value : 12.59197 |
| 2007 | 4,158,448 | 10,454 | 2,976,902 | 7,145,804 | |
| 2008 | 4,361,563 | 10,543 | 3,062,593 | 7,434,699 | |
| 2009 | 4,567,208 | 10,629 | 3,147,593 | 7,725,430 | |
| 2010 | 4,775,327 | 10,713 | 3,231,929 | 8,017,969 | |

Sources : Buku Data Kepariwisataan TH 1990 and JICA

Table A.5.2 Projection of No. of International and Domestic Tourists Coming to Bali

(Unit : No. of Tourists)

| Year | International | | | | Domestic | | | Total |
|---|---|---|---|---|---|---|---|---|
| | Air | Sea | Overland | Sub-Total | Air | Overland | Sub-Total | |
| 1986 | 426,769 | 5,592 | 20,801 | 453,162 | 188,452 | 1,019,263 | 1,207,715 | 1,660,877 |
| 1987 | 533,896 | 9,115 | 24,476 | 567,487 | 217,370 | 1,199,345 | 1,416,715 | 1,984,202 |
| 1988 | 632,679 | 8,095 | 26,951 | 667,725 | 249,291 | 1,320,582 | 1,569,873 | 2,237,598 |
| 1989 | 748,267 | 10,368 | 28,976 | 787,611 | 289,922 | 1,419,820 | 1,709,742 | 2,497,353 |
| 1990 | 831,716 | 8,503 | 27,357 | 867,576 | 344,679 | 1,340,480 | 1,685,159 | 2,552,735 |
| 1991 | 934,592 | 8,523 | 29,480 | 972,595 | 380,201 | 1,444,519 | 1,824,720 | 2,797,315 |
| 1992 | 1,047,248 | 8,689 | 31,562 | 1,087,499 | 418,632 | 1,546,531 | 1,965,163 | 3,052,662 |
| 1993 | 1,164,029 | 8,846 | 33,606 | 1,206,481 | 457,172 | 1,646,709 | 2,103,881 | 3,310,362 |
| 1994 | 1,284,839 | 8,994 | 35,616 | 1,329,449 | 495,722 | 1,745,207 | 2,240,929 | 3,570,378 |
| 1995 | 1,409,590 | 9,135 | 37,595 | 1,456,320 | 534,189 | 1,842,169 | 2,376,358 | 3,832,678 |
| 1996 | 1,538,214 | 9,269 | 39,545 | 1,587,028 | 572,491 | 1,937,709 | 2,510,200 | 4,097,228 |
| 1997 | 1,670,645 | 9,398 | 41,468 | 1,721,511 | 610,548 | 2,031,931 | 2,642,479 | 4,363,990 |
| 1998 | 1,806,830 | 9,521 | 43,366 | 1,859,717 | 648,289 | 2,124,928 | 2,773,217 | 4,632,934 |
| 1999 | 1,946,716 | 9,640 | 45,240 | 2,001,596 | 685,646 | 2,216,778 | 2,902,424 | 4,904,020 |
| 2000 | 2,090,261 | 9,754 | 47,093 | 2,147,108 | 722,556 | 2,307,545 | 3,030,101 | 5,177,209 |
| 2001 | 2,237,428 | 9,864 | 48,925 | 2,296,217 | 758,961 | 2,397,302 | 3,156,263 | 5,452,480 |
| 2002 | 2,388,176 | 9,970 | 50,737 | 2,448,883 | 794,802 | 2,486,097 | 3,280,899 | 5,729,782 |
| 2003 | 2,542,473 | 10,073 | 52,530 | 2,605,076 | 830,026 | 2,573,993 | 3,404,019 | 6,009,095 |
| 2004 | 2,700,298 | 10,172 | 54,307 | 2,764,777 | 864,584 | 2,661,026 | 3,525,610 | 6,290,387 |
| 2005 | 2,861,615 | 10,269 | 56,066 | 2,927,950 | 898,424 | 2,747,238 | 3,645,662 | 6,573,612 |
| 2006 | 3,026,416 | 10,363 | 57,810 | 3,094,589 | 931,505 | 2,832,671 | 3,764,176 | 6,858,765 |
| 2007 | 3,194,670 | 10,454 | 59,538 | 3,264,662 | 963,779 | 2,917,364 | 3,881,143 | 7,145,805 |
| 2008 | 3,366,359 | 10,543 | 61,252 | 3,438,154 | 995,204 | 3,001,341 | 3,996,545 | 7,434,699 |
| 2009 | 3,541,468 | 10,629 | 62,952 | 3,615,049 | 1,025,740 | 3,084,641 | 4,110,381 | 7,725,430 |
| 2010 | 3,719,980 | 10,713 | 64,639 | 3,795,332 | 1,055,347 | 3,167,291 | 4,222,637 | 8,017,969 |

Sources : 1) Buku Data Kepariwisataan TH 1990

2) JICA

Table A.5.3 Projection of No. of Tourists to Stay in the Study Area by Class of Accommodations

(Unit : No. of Tourists)

| Year | Classified Hotels | | | Non-Classified Hotels & Other Accommodations | | | Total |
|---|---|---|---|---|---|---|---|
| | International Tourists | Domestic Tourists | Sub-Total | International Tourists | Domestic Tourists | Sub-Total | |
| 1986 | 328,242 | 98,443 | 426,685 | 54,654 | 741,544 | 796,198 | 1,222,883 |
| 1987 | 412,246 | 113,549 | 525,795 | 67,544 | 871,329 | 938,873 | 1,464,668 |
| 1988 | 486,466 | 130,223 | 616,689 | 78,418 | 962,202 | 1,040,620 | 1,657,309 |
| 1989 | 575,945 | 151,448 | 727,393 | 90,889 | 1,040,659 | 1,131,548 | 1,858,941 |
| 1990 | 637,881 | 180,052 | 817,933 | 97,511 | 1,002,438 | 1,099,949 | 1,917,882 |
| 1991 | 715,999 | 198,608 | 914,607 | 108,635 | 1,082,703 | 1,191,338 | 2,105,945 |
| 1992 | 801,652 | 218,683 | 1,020,335 | 120,669 | 1,162,417 | 1,283,086 | 2,303,421 |
| 1993 | 890,429 | 238,815 | 1,129,244 | 133,066 | 1,240,921 | 1,373,987 | 2,503,231 |
| 1994 | 982,258 | 258,953 | 1,241,211 | 145,820 | 1,318,294 | 1,464,114 | 2,705,325 |
| 1995 | 1,077,075 | 279,047 | 1,356,122 | 158,924 | 1,394,606 | 1,553,530 | 2,909,652 |
| 1996 | 1,174,826 | 299,055 | 1,473,881 | 172,374 | 1,469,911 | 1,642,285 | 3,116,166 |
| 1997 | 1,275,464 | 318,935 | 1,594,399 | 186,164 | 1,544,256 | 1,730,420 | 3,324,819 |
| 1998 | 1,378,947 | 338,650 | 1,717,597 | 200,292 | 1,617,685 | 1,817,977 | 3,535,574 |
| 1999 | 1,485,236 | 358,164 | 1,843,400 | 214,753 | 1,690,232 | 1,904,985 | 3,748,385 |
| 2000 | 1,594,300 | 377,445 | 1,971,745 | 229,544 | 1,761,921 | 1,991,465 | 3,963,210 |
| 2001 | 1,706,110 | 396,462 | 2,102,572 | 244,663 | 1,832,785 | 2,077,448 | 4,180,020 |
| 2002 | 1,820,636 | 415,185 | 2,235,821 | 260,106 | 1,902,842 | 2,162,948 | 4,398,769 |
| 2003 | 1,937,855 | 433,585 | 2,371,440 | 275,872 | 1,972,118 | 2,247,990 | 4,619,430 |
| 2004 | 2,057,749 | 451,637 | 2,509,386 | 291,959 | 2,040,624 | 2,332,583 | 4,841,969 |
| 2005 | 2,180,291 | 469,314 | 2,649,605 | 308,363 | 2,108,373 | 2,416,736 | 5,066,341 |
| 2006 | 2,305,477 | 486,595 | 2,792,072 | 325,086 | 2,175,383 | 2,500,469 | 5,292,541 |
| 2007 | 2,433,282 | 503,454 | 2,936,736 | 342,124 | 2,241,667 | 2,583,791 | 5,520,527 |
| 2008 | 2,563,694 | 519,870 | 3,083,564 | 359,477 | 2,307,228 | 2,666,705 | 5,750,269 |
| 2009 | 2,696,699 | 535,821 | 3,232,520 | 377,143 | 2,372,082 | 2,749,225 | 5,981,745 |
| 2010 | 2,832,286 | 551,287 | 3,383,573 | 395,121 | 2,436,236 | 2,831,357 | 6,214,930 |

Sources : 1) Buku Data Kepariwisataan TH 1990

2) Survey Kepariwisataan Tahun 1990 di Bali

3) Badung dalam Angka 1990

4) JICA

Table A.5.4 Projection of No. of Rooms to be Occupied by Tourists in the Study Area by Class of Accommodations

(Unit : No. of Rooms)

| Year | Classified Hotels | | | Non-Classified Hotels & Other Accommodations | | | Total |
|---|---|---|---|---|---|---|---|
| | International Tourists | Domestic Tourists | Sub-Total | International Tourists | Domestic Tourists | Sub-Total | |
| 1986 | 162,496 | 48,734 | 211,230 | 27,057 | 367,101 | 394,158 | 605,388 |
| 1987 | 204,082 | 56,212 | 260,294 | 33,438 | 431,351 | 464,789 | 725,083 |
| 1988 | 240,825 | 64,467 | 305,292 | 38,821 | 476,338 | 515,159 | 820,451 |
| 1989 | 285,121 | 74,974 | 360,095 | 44,995 | 515,178 | 560,173 | 920,268 |
| 1990 | 315,783 | 89,135 | 404,918 | 48,273 | 496,256 | 544,529 | 949,447 |
| 1991 | 354,455 | 98,321 | 452,776 | 53,780 | 535,992 | 589,772 | 1,042,548 |
| 1992 | 396,857 | 108,259 | 505,116 | 59,737 | 575,454 | 635,191 | 1,140,307 |
| 1993 | 440,806 | 118,225 | 559,031 | 65,874 | 614,317 | 680,191 | 1,239,222 |
| 1994 | 486,266 | 128,195 | 614,461 | 72,188 | 652,621 | 724,809 | 1,339,270 |
| 1995 | 533,205 | 138,142 | 671,347 | 78,675 | 690,399 | 769,074 | 1,440,421 |
| 1996 | 581,597 | 148,047 | 729,644 | 85,333 | 727,679 | 813,012 | 1,542,656 |
| 1997 | 631,418 | 157,889 | 789,307 | 92,161 | 764,483 | 856,644 | 1,645,951 |
| 1998 | 682,647 | 167,648 | 850,295 | 99,154 | 800,834 | 899,988 | 1,750,283 |
| 1999 | 735,265 | 177,309 | 912,574 | 106,313 | 836,748 | 943,061 | 1,855,635 |
| 2000 | 789,257 | 186,854 | 976,111 | 113,636 | 872,238 | 985,874 | 1,961,985 |
| 2001 | 844,609 | 196,269 | 1,040,878 | 121,120 | 907,320 | 1,028,440 | 2,069,318 |
| 2002 | 901,305 | 205,537 | 1,106,842 | 128,765 | 942,001 | 1,070,766 | 2,177,608 |
| 2003 | 959,334 | 214,646 | 1,173,980 | 136,570 | 976,296 | 1,112,866 | 2,286,846 |
| 2004 | 1,018,687 | 223,583 | 1,242,270 | 144,534 | 1,010,210 | 1,154,744 | 2,397,014 |
| 2005 | 1,079,352 | 232,334 | 1,311,686 | 152,655 | 1,043,749 | 1,196,404 | 2,508,090 |
| 2006 | 1,141,325 | 240,888 | 1,382,213 | 160,934 | 1,076,922 | 1,237,856 | 2,620,069 |
| 2007 | 1,204,595 | 249,235 | 1,453,830 | 169,369 | 1,109,736 | 1,279,105 | 2,732,935 |
| 2008 | 1,269,155 | 257,361 | 1,526,516 | 177,959 | 1,142,192 | 1,320,151 | 2,846,667 |
| 2009 | 1,334,999 | 265,258 | 1,600,257 | 186,704 | 1,174,298 | 1,361,002 | 2,961,259 |
| 2010 | 1,402,122 | 272,914 | 1,675,036 | 195,604 | 1,206,057 | 1,401,661 | 3,076,697 |

Sources : 1) Buku Data Kepariwisataan TH 1990

2) Survey Kepariwisataan Tahun 1990 di Bali

3) Badung dalam Angka 1990

4) JICA

Table A.5.5 Projection of Room Nights to be Realized by Tourists in the Study Area by Class of Accommodations

(Unit : Room Nights)

| Year | Classified Hotels | | | Non-Classified Hotels & Other Accommodations | | | Total |
|---|---|---|---|---|---|---|---|
| | International Tourists | Domestic Tourists | Sub-Total | International Tourists | Domestic Tourists | Sub-Total | |
| 1986 | 698,732 | 151,076 | 849,808 | 102,815 | 844,332 | 947,147 | 1,796,955 |
| 1987 | 877,553 | 174,258 | 1,051,811 | 127,063 | 992,107 | 1,119,170 | 2,170,981 |
| 1988 | 1,035,547 | 199,848 | 1,235,395 | 147,519 | 1,095,577 | 1,243,096 | 2,478,491 |
| 1989 | 1,226,021 | 232,420 | 1,458,441 | 170,980 | 1,184,909 | 1,355,889 | 2,814,330 |
| 1990 | 1,357,866 | 276,317 | 1,634,183 | 183,436 | 1,141,389 | 1,324,825 | 2,959,008 |
| 1991 | 1,524,155 | 304,794 | 1,828,949 | 204,363 | 1,232,781 | 1,437,144 | 3,266,093 |
| 1992 | 1,706,486 | 335,602 | 2,042,088 | 227,001 | 1,323,544 | 1,550,545 | 3,592,633 |
| 1993 | 1,895,468 | 366,499 | 2,261,967 | 250,322 | 1,412,930 | 1,663,252 | 3,925,219 |
| 1994 | 2,090,946 | 397,403 | 2,488,349 | 274,314 | 1,501,028 | 1,775,342 | 4,263,691 |
| 1995 | 2,292,783 | 428,241 | 2,721,024 | 298,966 | 1,587,918 | 1,886,884 | 4,607,908 |
| 1996 | 2,500,867 | 458,945 | 2,959,812 | 324,267 | 1,673,661 | 1,997,928 | 4,957,740 |
| 1997 | 2,715,096 | 489,454 | 3,204,550 | 350,210 | 1,758,312 | 2,108,522 | 5,313,072 |
| 1998 | 2,935,382 | 519,710 | 3,455,092 | 376,787 | 1,841,919 | 2,218,706 | 5,673,798 |
| 1999 | 3,161,642 | 549,658 | 3,711,300 | 403,991 | 1,924,521 | 2,328,512 | 6,039,812 |
| 2000 | 3,393,806 | 579,248 | 3,973,054 | 431,815 | 2,006,148 | 2,437,963 | 6,411,017 |
| 2001 | 3,631,819 | 608,432 | 4,240,251 | 460,257 | 2,086,835 | 2,547,092 | 6,787,343 |
| 2002 | 3,875,612 | 637,165 | 4,512,777 | 489,309 | 2,166,603 | 2,655,912 | 7,168,689 |
| 2003 | 4,125,137 | 665,402 | 4,790,539 | 518,967 | 2,245,481 | 2,764,448 | 7,554,987 |
| 2004 | 4,380,356 | 693,106 | 5,073,462 | 549,229 | 2,323,482 | 2,872,711 | 7,946,173 |
| 2005 | 4,641,213 | 720,234 | 5,361,447 | 580,089 | 2,400,623 | 2,980,712 | 8,342,159 |
| 2006 | 4,907,700 | 746,754 | 5,654,454 | 611,548 | 2,476,921 | 3,088,469 | 8,742,923 |
| 2007 | 5,179,758 | 772,627 | 5,952,385 | 643,600 | 2,552,393 | 3,195,993 | 9,148,378 |
| 2008 | 5,457,368 | 797,820 | 6,255,188 | 676,244 | 2,627,042 | 3,303,286 | 9,558,474 |
| 2009 | 5,740,498 | 822,300 | 6,562,798 | 709,477 | 2,700,886 | 3,410,363 | 9,973,161 |
| 2010 | 6,029,124 | 846,034 | 6,875,158 | 743,296 | 2,773,932 | 3,517,228 | 10,392,386 |

Sources : 1) Buku Data Kepariwisataan TH 1990

2) Survey Kepariwisataan Tahun 1990 di Bali

3) Badung dalam Angka 1990

4) JICA

Table A.5.6 Projection of Room Occupancy Rate in the Study Area by Class of Accommodations

(Unit : %)

| Year | Classified Hotels | Non-Classified Hotels & Other Accommodations | Total |
|---|---|---|---|
| 1986 | 53.1 | 52.5 | 52.8 |
| 1987 | 67.3 | 60.9 | 64.1 |
| 1988 | 73.6 | 66.9 | 70.1 |
| 1989 | 74.1 | 67.3 | 70.4 |
| 1990 | 71.3 | 45.6 | 57.1 |
| 1991 | 43.9 | 50.4 | 46.5 |
| 1992 | 45.1 | 52.1 | 47.9 |
| 1993 | 46.3 | 53.7 | 49.2 |
| 1994 | 47.4 | 55.1 | 50.4 |
| 1995 | 48.6 | 56.4 | 51.5 |
| 1996 | 49.7 | 57.6 | 52.6 |
| 1997 | 50.7 | 58.7 | 53.6 |
| 1998 | 51.7 | 59.7 | 54.6 |
| 1999 | 52.8 | 60.6 | 55.5 |
| 2000 | 53.7 | 61.5 | 56.4 |
| 2001 | 54.7 | 62.3 | 57.3 |
| 2002 | 55.6 | 63.0 | 58.2 |
| 2003 | 56.6 | 63.7 | 59.0 |
| 2004 | 57.5 | 64.4 | 59.8 |
| 2005 | 58.4 | 65.0 | 60.6 |
| 2006 | 59.3 | 65.6 | 61.4 |
| 2007 | 60.1 | 66.1 | 62.1 |
| 2008 | 61.0 | 66.7 | 62.8 |
| 2009 | 61.8 | 67.1 | 63.5 |
| 2010 | 62.6 | 67.6 | 64.2 |

Sources : 1) Buku Data Kepariwisataan TH 1990
2) Survey Kepariwisataan Tahun 1990 di Bali
3) Badung dalam Angka 1990
4) JICA

Table A.5.7 Projection of Bed Nights to be Realized by Tourists in the Study Area by Class of Accommodations

(Unit : Bed Nights)

| Year | Classified Hotels | | | Non-Classified Hotels & Other Accommodations | | | Total |
|---|---|---|---|---|---|---|---|
| | International Tourists | Domestic Tourists | Sub-Total | International Tourists | Domestic Tourists | Sub-Total | |
| 1986 | 1,411,439 | 305,173 | 1,716,612 | 207,687 | 1,705,550 | 1,913,237 | 3,629,849 |
| 1987 | 1,772,656 | 352,001 | 2,124,657 | 256,667 | 2,004,056 | 2,260,723 | 4,385,380 |
| 1988 | 2,091,805 | 403,692 | 2,495,497 | 297,988 | 2,213,065 | 2,511,053 | 5,006,550 |
| 1989 | 2,476,562 | 469,488 | 2,946,050 | 345,380 | 2,393,517 | 2,738,897 | 5,684,947 |
| 1990 | 2,742,890 | 558,161 | 3,301,051 | 370,540 | 2,305,607 | 2,676,147 | 5,977,198 |
| 1991 | 3,078,794 | 615,684 | 3,694,478 | 412,813 | 2,490,217 | 2,903,030 | 6,597,508 |
| 1992 | 3,447,102 | 677,917 | 4,125,019 | 458,542 | 2,673,558 | 3,132,100 | 7,257,119 |
| 1993 | 3,828,845 | 740,327 | 4,569,172 | 505,651 | 2,854,119 | 3,359,770 | 7,928,942 |
| 1994 | 4,223,711 | 802,754 | 5,026,465 | 554,115 | 3,032,076 | 3,586,191 | 8,612,656 |
| 1995 | 4,631,421 | 865,046 | 5,496,467 | 603,911 | 3,207,594 | 3,811,505 | 9,307,972 |
| 1996 | 5,051,750 | 927,070 | 5,978,820 | 655,020 | 3,380,795 | 4,035,815 | 10,014,635 |
| 1997 | 5,484,494 | 988,698 | 6,473,192 | 707,424 | 3,551,789 | 4,259,213 | 10,732,405 |
| 1998 | 5,929,471 | 1,049,815 | 6,979,286 | 761,109 | 3,720,676 | 4,481,785 | 11,461,071 |
| 1999 | 6,386,516 | 1,110,309 | 7,496,825 | 816,061 | 3,887,532 | 4,703,593 | 12,200,418 |
| 2000 | 6,855,488 | 1,170,081 | 8,025,569 | 872,267 | 4,052,418 | 4,924,685 | 12,950,254 |
| 2001 | 7,336,274 | 1,229,033 | 8,565,307 | 929,719 | 4,215,406 | 5,145,125 | 13,710,432 |
| 2002 | 7,828,736 | 1,287,073 | 9,115,809 | 988,403 | 4,376,538 | 5,364,941 | 14,480,750 |
| 2003 | 8,332,776 | 1,344,113 | 9,676,889 | 1,048,313 | 4,535,871 | 5,584,184 | 15,261,073 |
| 2004 | 8,848,319 | 1,400,074 | 10,248,393 | 1,109,443 | 4,693,434 | 5,802,877 | 16,051,270 |
| 2005 | 9,375,250 | 1,454,873 | 10,830,123 | 1,171,781 | 4,849,259 | 6,021,040 | 16,851,163 |
| 2006 | 9,913,553 | 1,508,444 | 11,421,997 | 1,235,328 | 5,003,381 | 6,238,709 | 17,660,706 |
| 2007 | 10,463,110 | 1,560,707 | 12,023,817 | 1,300,073 | 5,155,833 | 6,455,906 | 18,479,723 |
| 2008 | 11,023,880 | 1,611,596 | 12,635,476 | 1,366,013 | 5,306,624 | 6,672,637 | 19,308,113 |
| 2009 | 11,595,810 | 1,661,045 | 13,256,855 | 1,433,143 | 5,455,789 | 6,888,932 | 20,145,787 |
| 2010 | 12,178,830 | 1,708,989 | 13,887,819 | 1,501,459 | 5,603,343 | 7,104,802 | 20,992,621 |

Sources : 1) Buku Data Kepariwisataan TH 1990

2) Survey Kepariwisataan Tahun 1990 di Bali

3) Badung dalam Angka 1990

4) JICA

Table A.5.8 Projection of Tourists' Expenditures in the Study Area by Class of Accommodations

(Unit : Rp. Million)

| Year | Classified Hotels | | | Non-Classified Hotels & Other Accommodations | | | Total |
|---|---|---|---|---|---|---|---|
| | International Tourists | Domestic Tourists | Sub-Total | International Tourists | Domestic Tourists | Sub-Total | |
| 1986 | 211,716 | 30,517 | 242,233 | 15,576 | 85,278 | 100,854 | 343,087 |
| 1987 | 265,898 | 35,200 | 301,098 | 19,250 | 100,203 | 119,453 | 420,551 |
| 1988 | 313,771 | 40,369 | 354,140 | 22,349 | 110,653 | 133,002 | 487,142 |
| 1989 | 371,484 | 46,949 | 418,433 | 25,903 | 119,676 | 145,579 | 564,012 |
| 1990 | 411,434 | 55,816 | 467,250 | 27,791 | 115,280 | 143,071 | 610,321 |
| 1991 | 461,819 | 61,568 | 523,387 | 30,961 | 124,511 | 155,472 | 678,859 |
| 1992 | 517,065 | 67,792 | 584,857 | 34,391 | 133,678 | 168,069 | 752,926 |
| 1993 | 574,327 | 74,033 | 648,360 | 37,924 | 142,706 | 180,630 | 828,990 |
| 1994 | 633,557 | 80,275 | 713,832 | 41,559 | 151,604 | 193,163 | 906,995 |
| 1995 | 694,713 | 86,505 | 781,218 | 45,293 | 160,380 | 205,673 | 986,891 |
| 1996 | 757,763 | 92,707 | 850,470 | 49,126 | 169,040 | 218,166 | 1,068,636 |
| 1997 | 822,674 | 98,870 | 921,544 | 53,057 | 177,589 | 230,646 | 1,152,190 |
| 1998 | 889,421 | 104,981 | 994,402 | 57,083 | 186,034 | 243,117 | 1,237,519 |
| 1999 | 957,977 | 111,031 | 1,069,008 | 61,205 | 194,377 | 255,582 | 1,324,590 |
| 2000 | 1,028,323 | 117,008 | 1,145,331 | 65,420 | 202,621 | 268,041 | 1,413,372 |
| 2001 | 1,100,441 | 122,903 | 1,223,344 | 69,729 | 210,770 | 280,499 | 1,503,843 |
| 2002 | 1,174,310 | 128,707 | 1,303,017 | 74,130 | 218,827 | 292,957 | 1,595,974 |
| 2003 | 1,249,916 | 134,411 | 1,384,327 | 78,624 | 226,794 | 305,418 | 1,689,745 |
| 2004 | 1,327,248 | 140,007 | 1,467,255 | 83,208 | 234,672 | 317,880 | 1,785,135 |
| 2005 | 1,406,288 | 145,487 | 1,551,775 | 87,884 | 242,463 | 330,347 | 1,882,122 |
| 2006 | 1,487,033 | 150,844 | 1,637,877 | 92,650 | 250,169 | 342,819 | 1,980,696 |
| 2007 | 1,569,467 | 156,071 | 1,725,538 | 97,505 | 257,792 | 355,297 | 2,080,835 |
| 2008 | 1,653,583 | 161,160 | 1,814,743 | 102,451 | 265,331 | 367,782 | 2,182,525 |
| 2009 | 1,739,371 | 166,105 | 1,905,476 | 107,486 | 272,789 | 380,275 | 2,285,751 |
| 2010 | 1,826,825 | 170,899 | 1,997,724 | 112,609 | 280,167 | 392,776 | 2,390,500 |

Sources : 1) Buku Data Kepariwisataan TH 1990
2) Survey Kepariwisataan Tahun 1990 di Bali
3) Badung dalam Angka 1990
4) JICA

Table A.6.1 Temperature, Humidity and Rainfall of the Study Area

Monthly Average Temperature

(°C)

| Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27.7 | 27.8 | 27.7 | 27.6 | 27.2 | 26.7 | 26.0 | 26.0 | 26.6 | 27.5 | 28.0 | 28.0 | 27.2 |

Monthly Average Humidity

(%)

| Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80.6 | 80.5 | 81.1 | 81.1 | 80.6 | 79.8 | 78.9 | 78.2 | 78.4 | 77.5 | 78.7 | 79.6 | 79.6 |

Monthly Rainfall

(mm)

| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 617 | 293 | 31 | 7 | 63 | 116 | 327 | 40 | 90 | 79 | 361 | 355 | 2,379 |
| 1982 | 335 | 195 | 131 | 164 | 2 | 1 | 0 | 5 | 0 | 1 | 8 | 513 | 1,355 |
| 1983 | 147 | 88 | 134 | 179 | 290 | 3 | 45 | 1 | 3 | 138 | 321 | 456 | 1,805 |
| 1984 | 461 | 430 | 706 | 84 | 169 | 19 | 515 | 61 | 165 | 78 | 115 | 362 | 3,165 |
| 1985 | 221 | 336 | 261 | 32 | 11 | 116 | 224 | 22 | 8 | 4 | 239 | 134 | 1,608 |
| 1986 | 407 | 257 | 62 | 138 | 35 | 73 | 8 | 73 | 53 | 10 | 232 | 160 | 1,508 |
| 1987 | 477 | 258 | 39 | 3 | 75 | 73 | 140 | 10 | 2 | 1 | 197 | 365 | 1,640 |
| 1988 | 469 | 186 | 135 | 99 | 12 | 30 | 4 | 98 | 22 | 68 | 192 | 339 | 1,654 |
| 1989 | 408 | 396 | 379 | 208 | 30 | 197 | 123 | 111 | 0 | 116 | 33 | 83 | 2,084 |
| 1990 | 594 | 42 | 330 | 63 | 141 | 14 | 72 | 21 | 29 | 34 | 4 | 346 | 1,690 |
| Ave. | 414 | 248 | 221 | 99 | 83 | 64 | 146 | 44 | 37 | 53 | 170 | 311 | 1,890 |

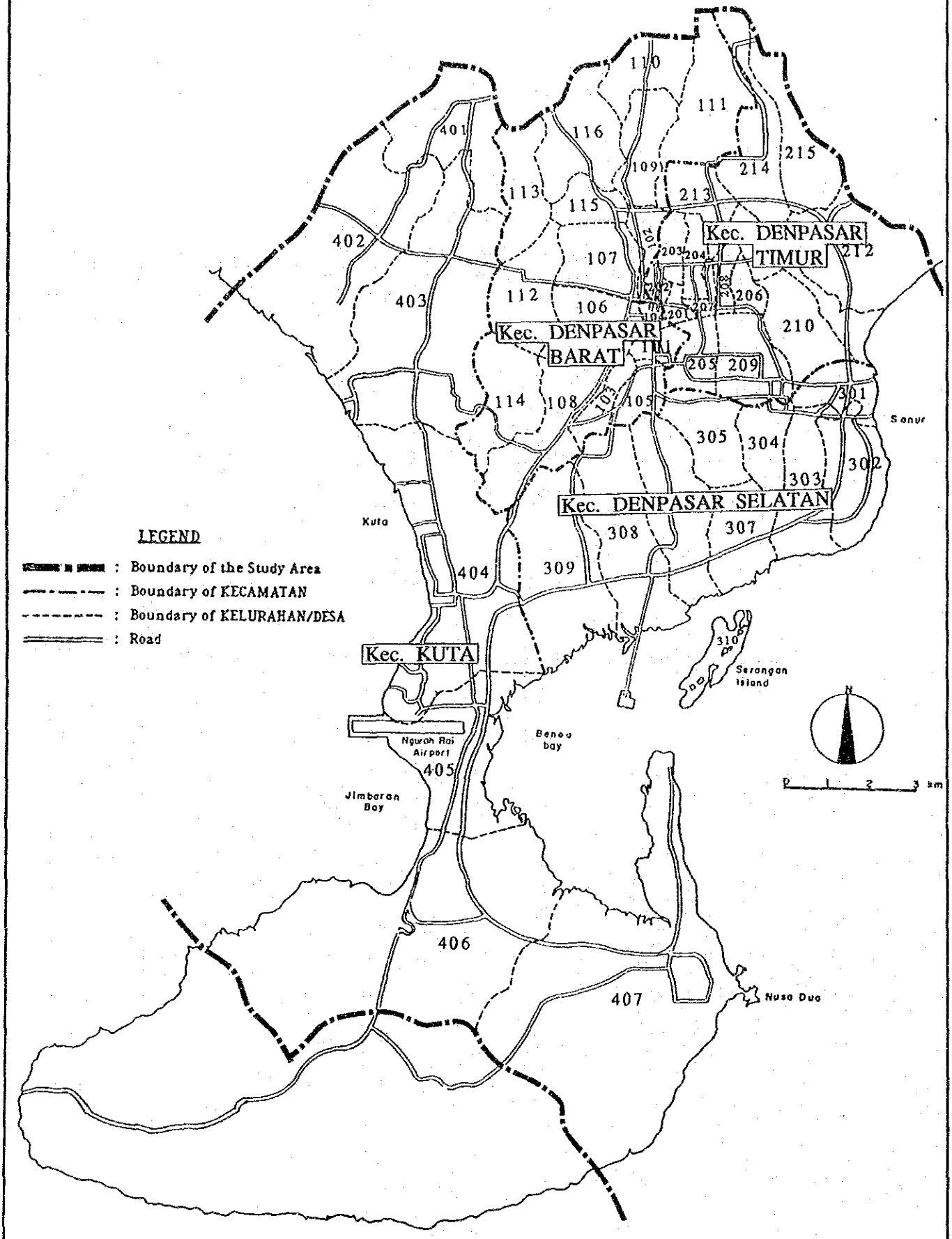



**FIG. A.1.1** ADMINISTRATIVE BOUNDARY

**THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR**

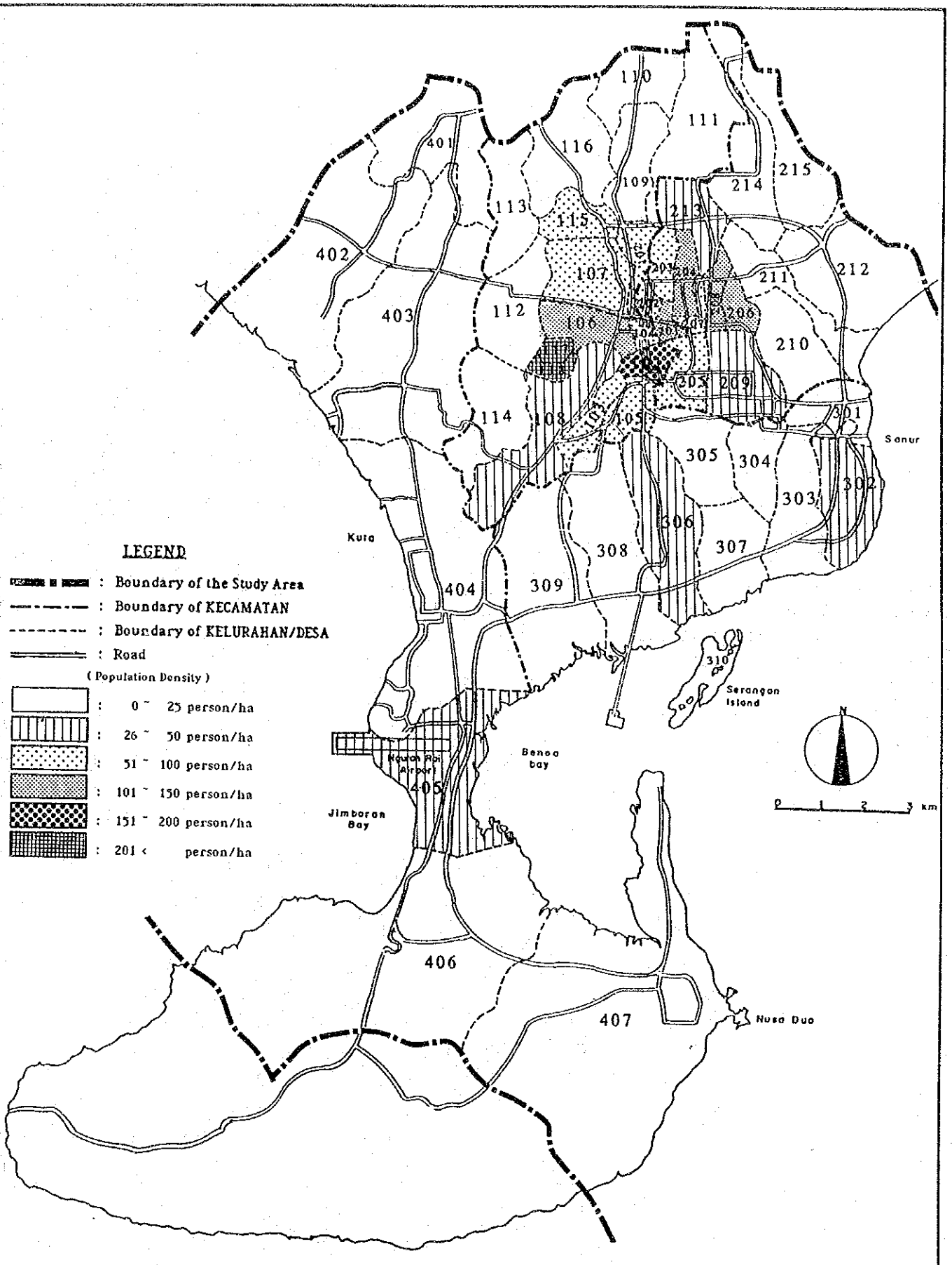



**FIG. A.2.1** EXISTING POPULATION DENSITY BY KELURAHAN/DESA (1990)

**THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR**

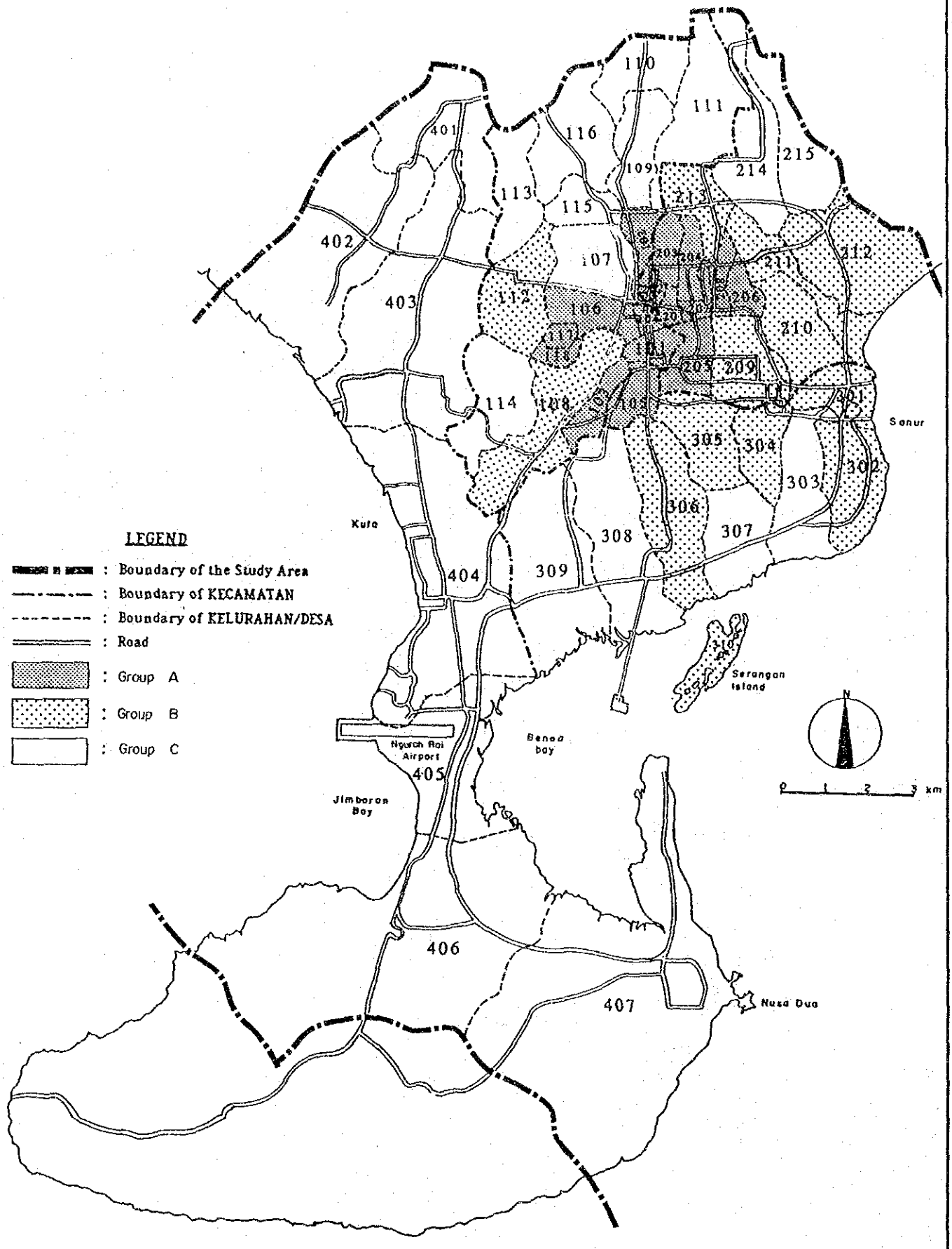



**FIG.** A.2.2 CLASSIFICATION OF KELURAHAN/DESA BY LOCATION AND POPULATION DENSITY

**THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR**

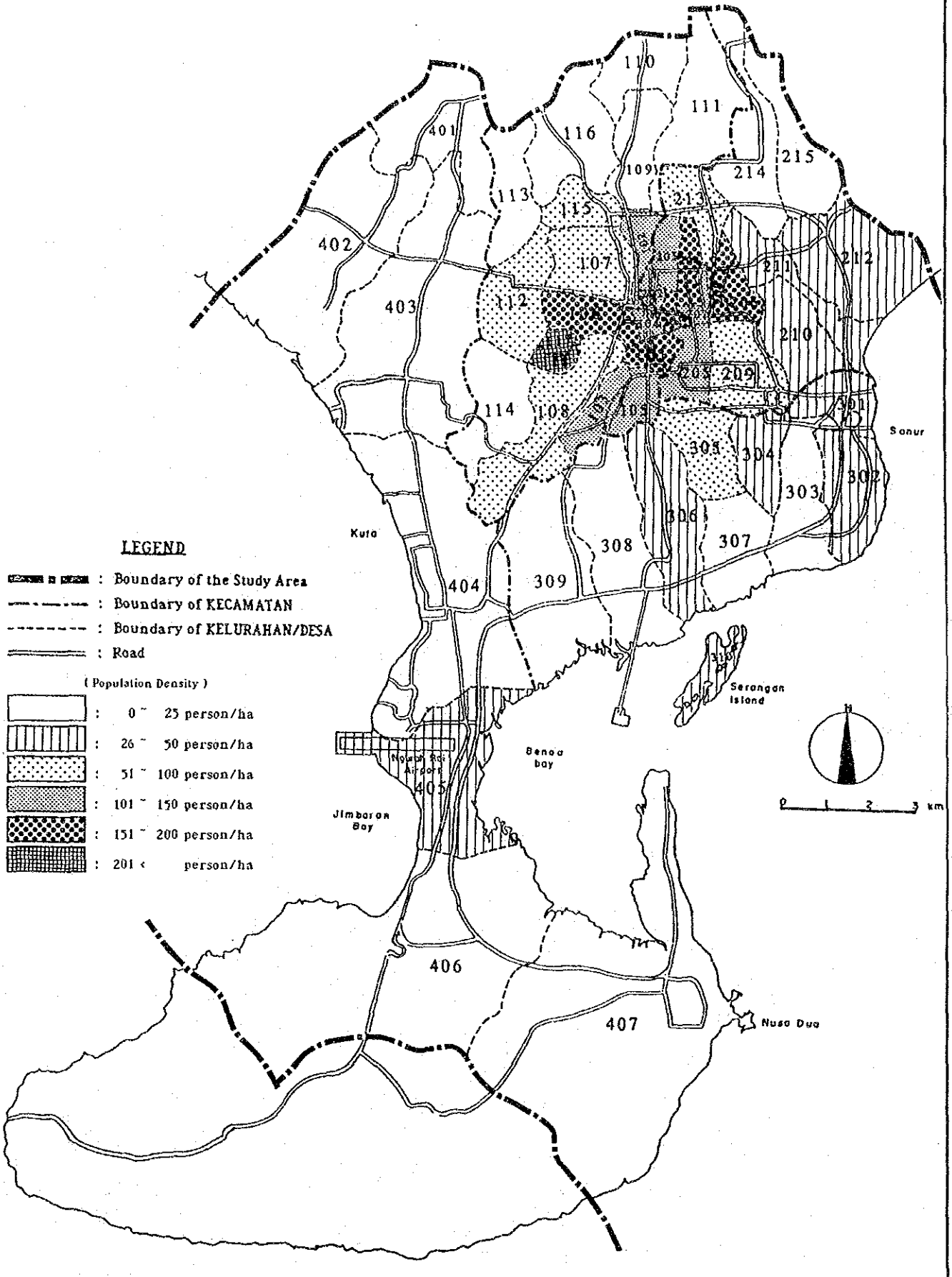



**FIG.** A.2.3 FUTURE POPULATION DENSITY BY KELURAHAN/DESA (2010)

**THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR**

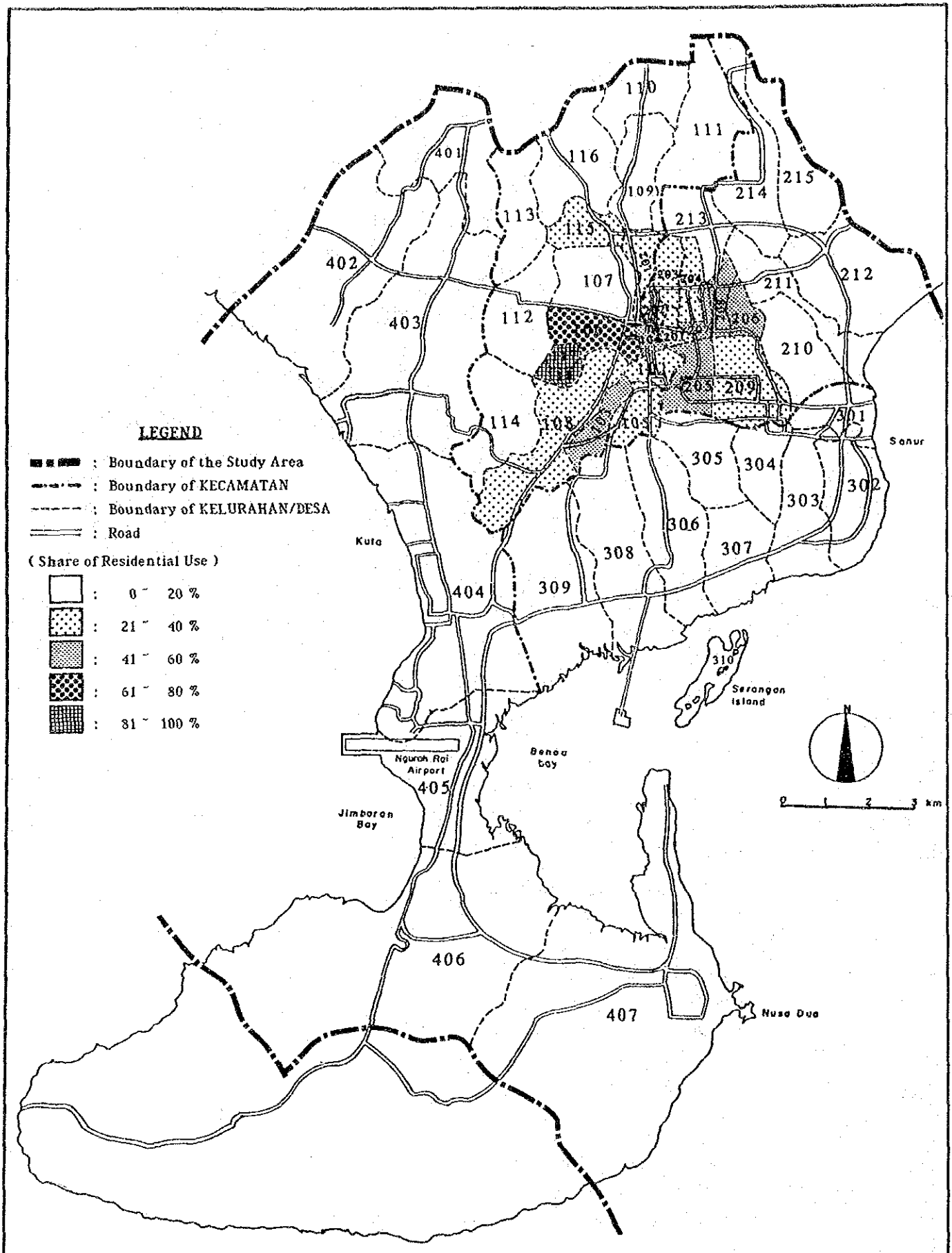



**FIG.** A.3.1 SHARE OF EXISTING RESIDENTIAL USE BY KELURAHAN/DESA

**THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR**

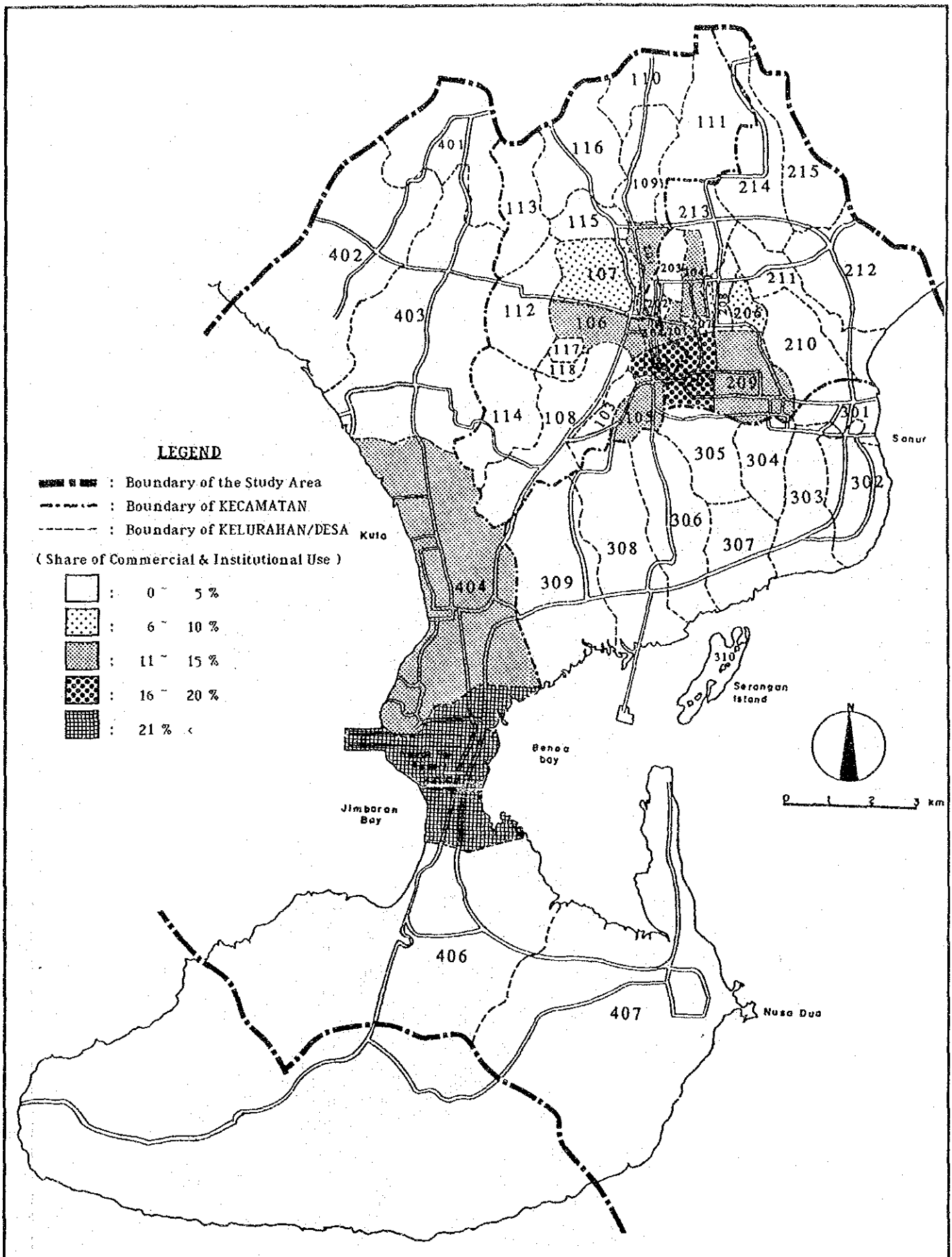



**FIG.** A.3.2 SHARE OF EXISTING COMMERCIAL & INSTITUTIONAL USE BY KELURAHAN/DESA

**THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR**

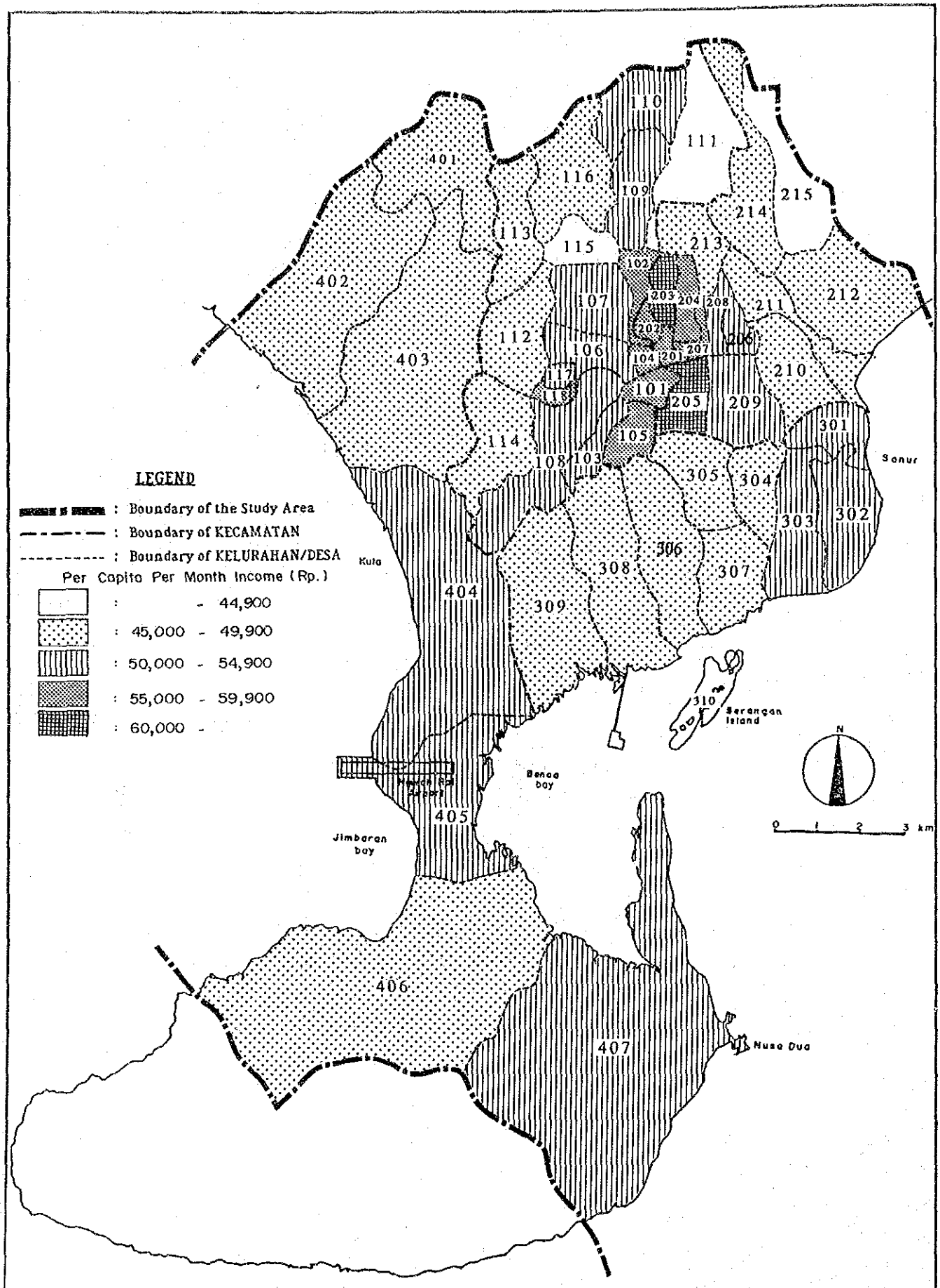



FIG. A.4.1 PER CAPITA PER MONTH HOUSEHOLD INCOME BY KELURAHAN/DESA IN 1991

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

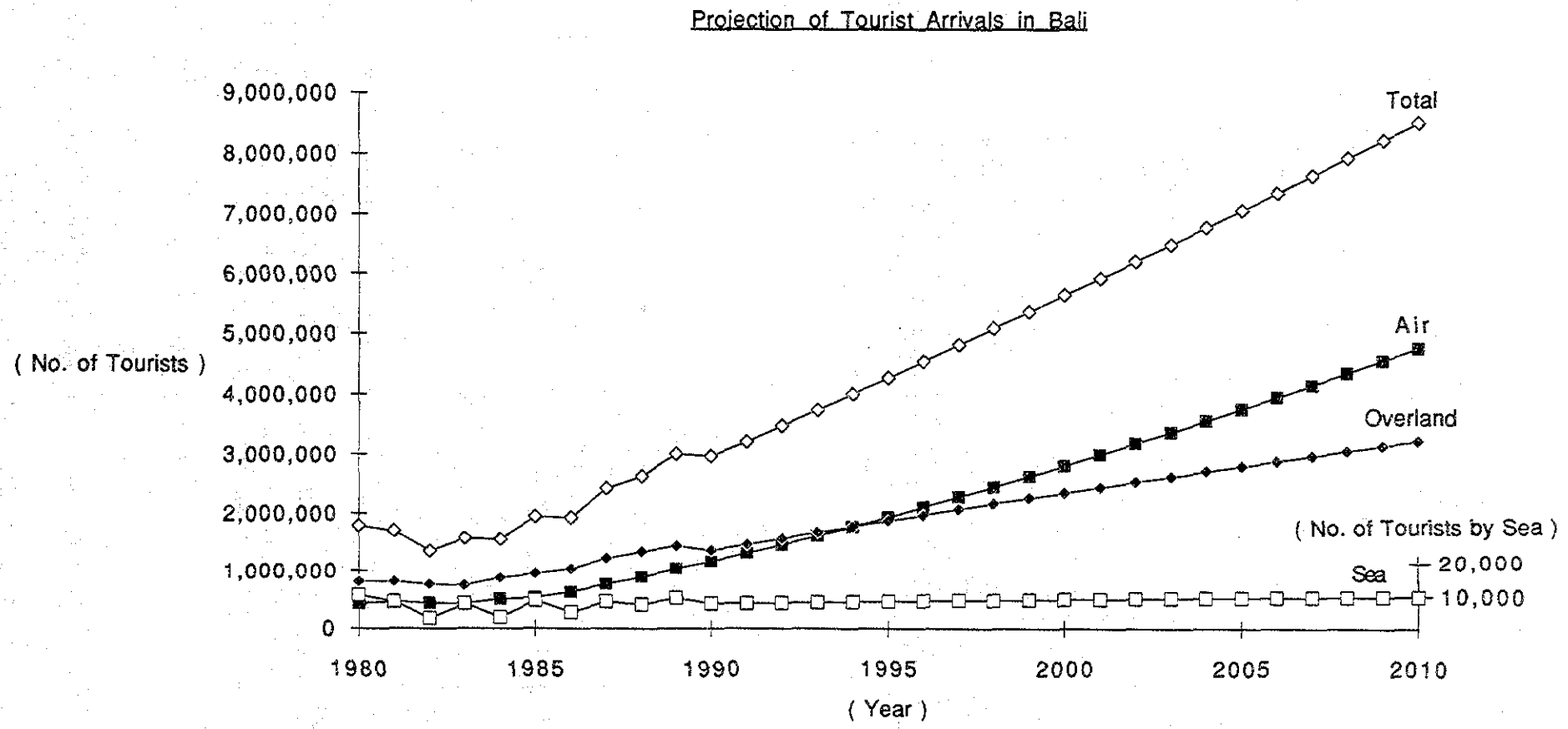
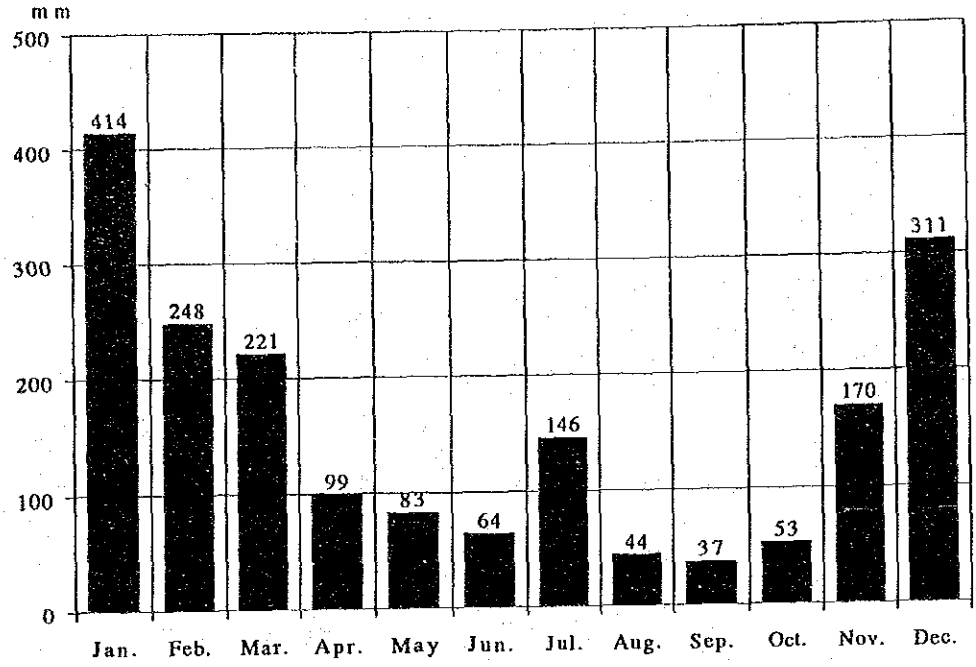



**FIG.** A.5.1 PROJECTION OF TOURIST ARRIVALS IN BALI

**THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR**

Average Monthly Raifall Depth




Average Monthly Rainy Days

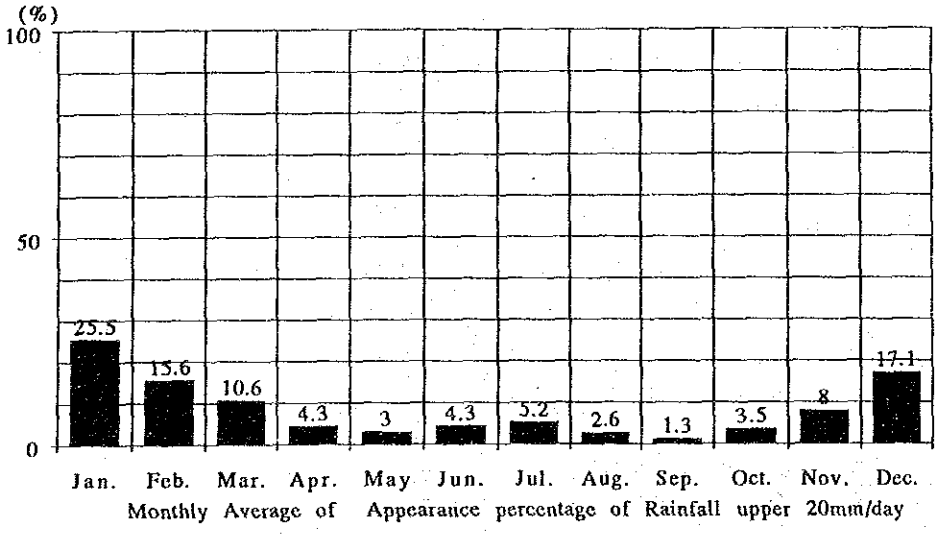



**FIG. A.6.1** AVERAGE MONTHLY RAINFALL DEPTH AND RAINY DAYS

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

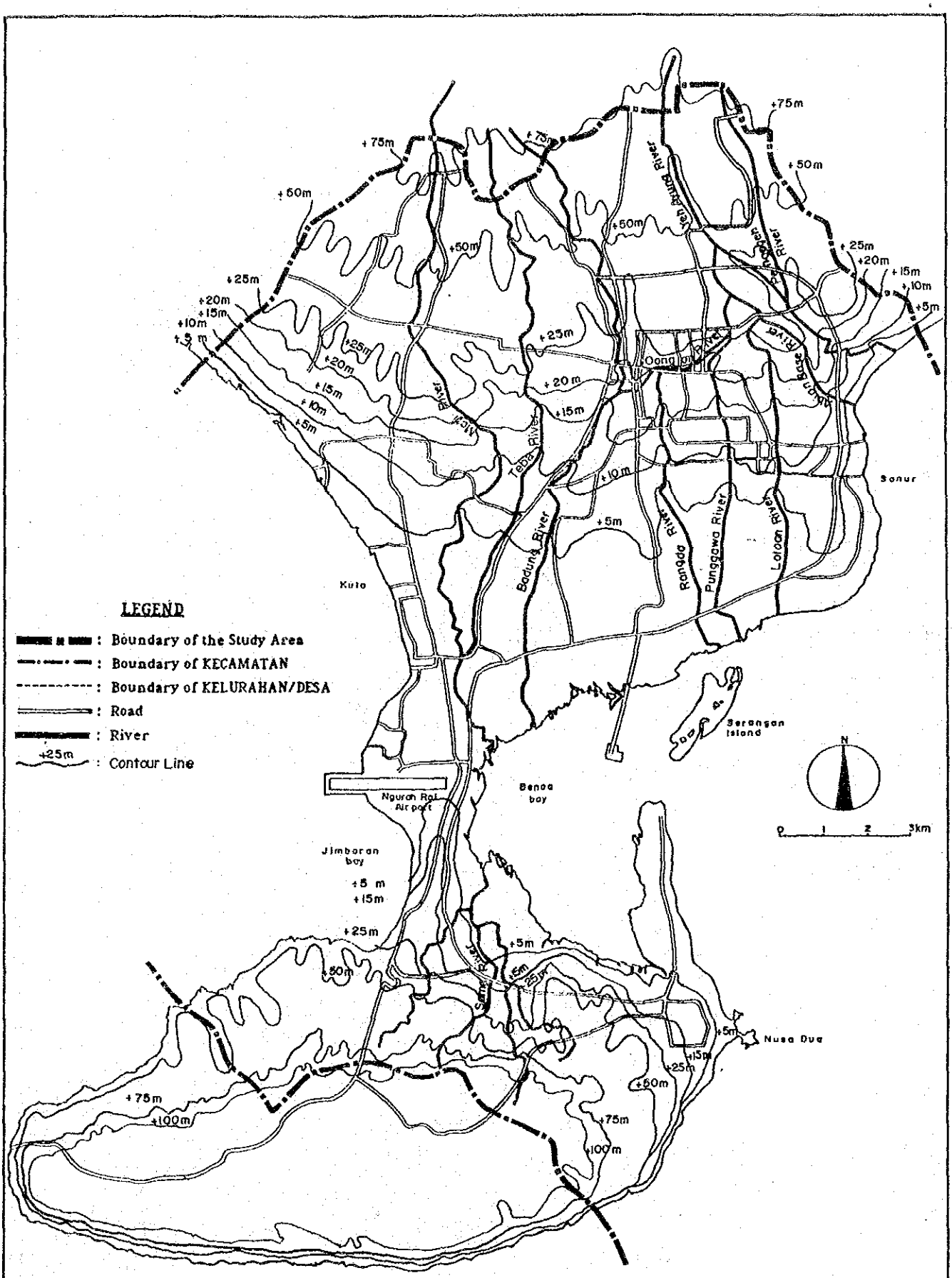
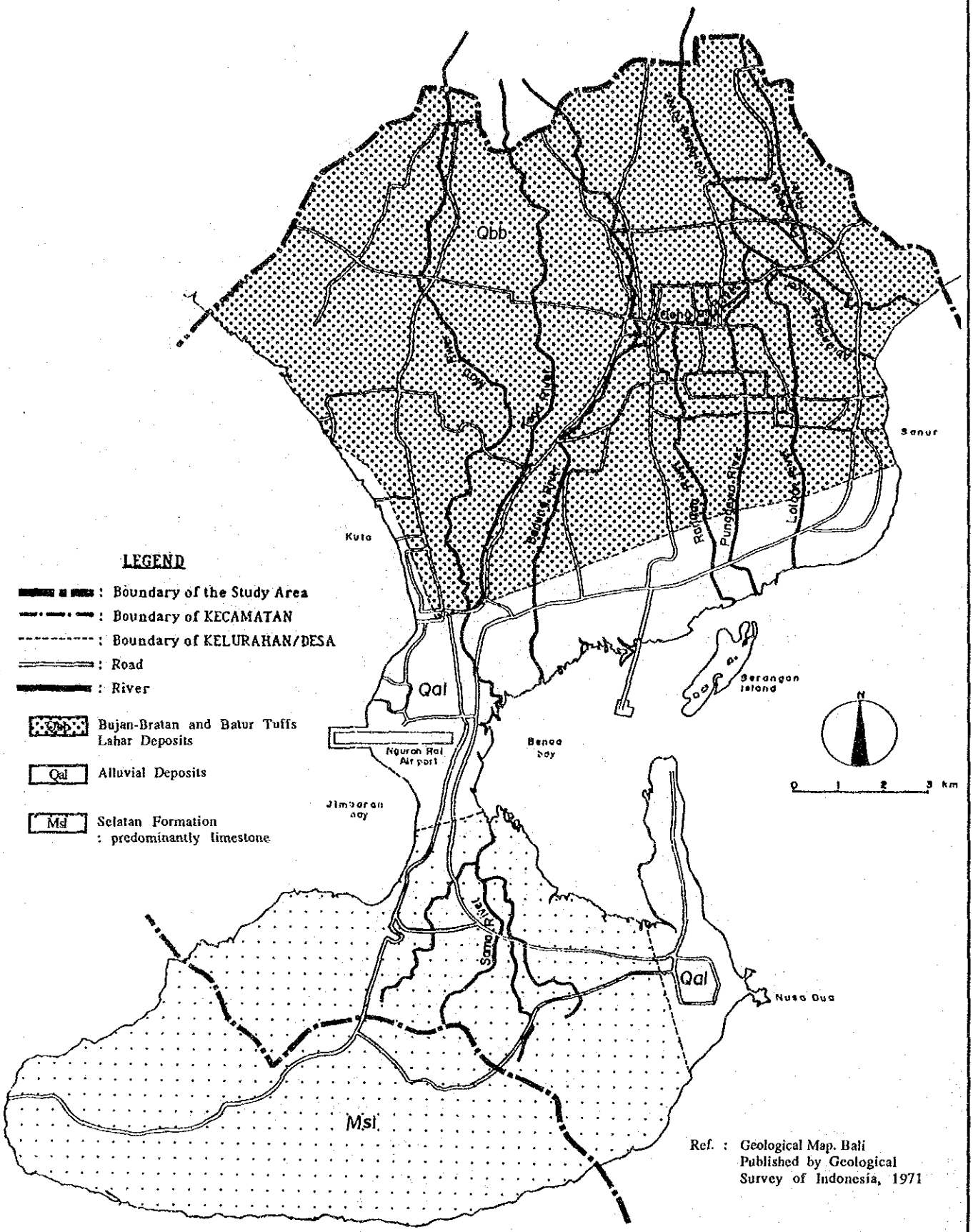



FIG. A.6.2 TOPOGRAPHIC MAP OF STUDY AREA

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR




Ref. : Geological Map. Bali Published by Geological Survey of Indonesia, 1971

**FIG. A.6.3** GEOLOGICAL MAP

**THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR**

# APPENDIX B

# WATER ENVIRONMENTS

# APPENDIX B WATER ENVIRONMENTS

## 1. River Networks

The Study Area is mainly drained by the following 11 rivers.

- Pengegeh, Yeh Ayung, Abian Base, Loloan, Punggawa, Oongan, Rangda, Badung, Teba, Mati and Sama

Yeh Ayung River drains the northern part of Denpasar along with its tributary of Pengegeh River into the north Sanur Beach.

Badung River and its tributary of Oongan discharges the central part of Denpasar into the north Benoa Bay. Oongan River is connected with Yeh Ayung River and withdraws irrigation water from Yeh Ayung River. The taken irrigation water is distributed to the farm lands in the eastern and southern Denpasar areas through Abian Base, Loloan, Punggawa and Rangda rivers.

Mati River including its tributary of Teba River collects the western part of Denpasar and part of Kuta into the north Benoa Bay.

Abian Base River drains a part of eastern Denpasar into the north Sanur Beach. Loloan, Punggawa and Rangda rivers discharges the southern part of Denpasar into the south Sanur Beach.

Sama River drains part of the northern hilly areas of Bukit Badung into the south Benoa Bay.

The above river networks are shown in Fig. B.1.1.

A major portion of 161.9 $km^2$ or 68.4% in the Study Area is drained through the above 11 rivers. While, the remaining area of 74.6 $km^2$ is directly discharged to the sea. The catchment area of 161.9 $km^2$ is broken down into 11 rivers as shown in Table B.1.1. While, the hydrological catchment areas of Yeh Ayung, Badung and Mati Rivers are not limited within the Study Area. They covers also the upstream outside of the Study Area. Total catchment area of the rivers are as follows.

- Yeh Ayung : 285.4 km$^2$, Badung : 37.7 km$^2$, Mati : 41.5 km$^2$

Total length of the 11 rivers within the Study Area is measured to be 63.0 km. Break-down by river is also given in Table B.1.1.

## 2. River Water Quality and Use

### 2.1 River Discharge

#### 2.1.1 Available Data

River discharge records in the Study Area are available at five (5) irrigation water intake sites of Mambal, Peraupan and Oongan of Yeh Ayung River, and Merta Gangga and Tukad Badung of Badung River along with irrigation water intake volume for the recent five (5) years from 1986 to 1990.

Location of the intake sites and their commanding irrigation areas are shown in Fig. B.2.1.

Monthly river discharge and intake volume at each intake during 1986 to 1990 are shown in Table B.2.1(1) - B.2.1(5). Average monthly river discharge before and after irrigation water intake during the five (5) years at each intake site are compared as shown in Table B.2.2 and Fig. B.2.2.

River discharge before intake usually records its peak in January to March and gradually decreases, reaching the lowest in September to October. River discharge after intake shows the pattern of variation since the irrigation intake volume are nearly constant through the year. River discharge at each intake site are summarized below.

( Unit : $m^3/s$ )

| Intake Site | Before Intake | | After Intake | |
|---|---|---|---|---|
| | Range | Average | Range | Average |
| Mambal | 4.4-7.2 | 5.8 | 1.3-2.8 | 2.0 |
| Peraupan | 1.6-5.7 | 3.3 | 1.0-5.1 | 2.7 |
| Oongan | 1.7-5.9 | 3.5 | 0.0-2.2 | 1.0 |
| Merta Gangga | 1.0-2.4 | 1.4 | 0.4-1.7 | 0.7 |
| Tukad Badung | 0.7-2.4 | 1.3 | 0.0-0.8 | 0.2 |

### 2.1.2 JICA Observation

The JICA Study Team conducted a river flow measurement at 25 sites within the Study Area in both dry season of 1991 and rainy season of 1992 along with a river water quality survey. Location of the measurement points are shown in Fig. B.2.3. The observed river discharge in both dry and rainy seasons are summarized in Table B.2.3.

Based on the JICA observation, water balance of the Denpasar area of 123.0 $km^2$ is calculated for the dry season of 1991 and rainy season of 1992. Inflow to the Denpasar area is obtained by summing up the river flow at five (5) stations (No.1, No.2, No.16, No.20, No.22) of Pengegeh, Yeh Ayung, Badung, Teba and Mati rivers. While, outflow from the area is estimated by totalling the river discharge at seven points (No.4, No.7, No.9, No.12, No.15, No.19, No.24) of Yeh Ayung, Abian Base, Loloan, Punggawa, Rangda, Badung and Mati rivers.

The calculated water balance is shown below.

| | Dry Season | Rainy Season |
|---|---|---|
| Outflow ($m^3/d$) | 447,600 | 789,600 |
| In flow ($m^3/d$) | 638,600 | 626,400 |
| Balance | -191,000 | +163,200 |

## 2.2 River Water Quality

### (1) Observed Water Quality in 1987

The Study on the Development of Water Supply System based on Estuary Reservoirs had conducted the river water quality analysis at three (3) points in the Study Area in August, 1987. The location of sampling points are shown in Fig. B.2.4. The observed water quality parameters are as follows.

- $BOD_5$, COD, SS, $NH_4$-N, $NO_3$-N, $NO_2$-N, $Cl^-$, Fe, Mn, KMnO4, Alkalinity, Total-Hardness, Ca-Hardness, Turbidity, Phosphate

The results are shown in Table B.2.4.

Another Study on wastewater disposal system for Denpasar was carried out by a local consultant in 1988. This study also conducted the river water quality analysis at 11 points in the Study Area in December, 1987. The sampling points are also shown in Fig. B.2.4. The samples were taken four (4) times at six (6) hour interval at each location. The observed water quality parameters are as follows.

- $BOD_5$, $COD_{cr}$, DO, pH, Conductivity, Coliform, SS, Phosphate, Chloride, E.Coliform

The results are shown in Table B.2.5.

### (2) JICA observation

The JICA Study Team conducted two (2) river water quality observations at 25 points of the Study Area in the dry season of 1991 (October 29 , 1991) and in rainy season of 1992 (January 14, 1992). The locations of sampling points are shown in Fig. B.2.5. The observation points were selected covering the whole Study Area with following points of view :

- Five (5) points of No.1, No.2, No.16, No.20 and No.22 were selected for estimation of pollution load inflow from outside the Study Area

- Five (5) points of No.3, No.5, No.6, No.21, and No.23 were selected at both upper and lower streams of river diversion points

- Seven (7) points of No.8, No.10, No.11, No.13, No.14, No.17 and No.18 were selected at inside and downstream of central part of Denpasar

- Eight (8) points of No.4, No.7, No.9, No.12, No.15, No.19, No.24 and No.25 were selected to estimate the amount of pollution load discharge to the sea.

The observed water quality parameters are as follows.

- $BOD_5$, $COD_{cr}$, DO, SS, T-N, $NH_4$-N, $NO_3$-N, $NO_2$-N, T-P, pH, Air Temperature, Water Temperature, Fecal Coliform, Transparency and n-Hexan extracts

The results are shown in Table B.2.6 (dry season) and in Table B.2.7 (rainy season), and Fig. B.2.6(1) ~ B.2.6(13).

## 2.3 Existing Water Quality by Section

### 2.3.1 Regional Distribution of River Water Quality

The regional distribution of DO, $BOD_5$, $COD_{cr}$, $NH_4$-N and others are established based on the observed water quality by JICA Study Team in 1991 and are shown in Fig. B.2.6(1) ~ Fig. B.2.6(13) for both dry and rainy season.

Dry Season

(1) $BOD_5$

The regional variation of $BOD_5$ in the Study Area is wide ranging from 3.1 mg/l to 50.4 mg/l. The maximum value was observed in the Oongan River, while the minimum was observed in the uppermost reach of the Teba River.

High $BOD_5$ were observed in the river reaches extending from upstream to downstream of Oongan, middle and lower reaches of Loloan, Badung, Punggawa and Rangda, and mid-stream of Teba. The

$BOD_5$ concentration exceeds 20 mg/l at ten (10) observation points in the above mentioned rivers.

Most of the above rivers are affected mainly by domestic and commercial wastewater while flowing through the urbanized area of Denpasar. However, the major pollution source of the Teba River is the industrial wastes from the batik factories. The other rivers of Pengegeh, Yeh Ayung, Abian Base and Mati that are flowing mainly through rural areas, are still less polluted with $BOD_5$ concentration of less than 10 mg/l.

The lower Punggawa, Rangda and Mati streams respectively mark lower $BOD_5$ concentration of 24 mg/l, 24 mg/l and 11.6 mg/l than their upstream of 29.2 mg/l, 35.2 mg/l and 25.3 mg/l. These three (3) rivers are mainly used for irrigation purpose and even polluted water is drawn to the paddy fields in dry season. The paddy fields may also act as oxidation ponds while the irrigated water is retained in them, thereby improving the drainage water quality to a certain level.

The water qualities of all the uppermost river reaches in the Study Area are still very good with $BOD_5$ concentration of less than 5 mg/l. The whole reaches of the Yeh Ayung are also still clear, recording low $BOD_5$ concentration of 5 mg/l or less.

(2) $COD_{cr}$

The maximum $COD_{cr}$ was observed at Oongan with 80.2 mg/l, while the minimum was 5.0 mg/l in upstream of Yeh Ayung.

High $COD_{cr}$ of about 50 mg/l or more were observed in central parts of Denpasar in downstream of Oongan and upperstreams of Punggawa and Rangda, in middle to downstream of Badung and in downstream of Loloan.

The rivers located in the eastern parts of Study Area, Yeh Ayung, Pengegeh and Abian Base, are not much polluted with $COD_{cr}$ of 12.2 to 15.2 mg/l, except in the downstream of Yeh Ayung with 24.8 mg/l.

Badung is heavily polluted with 80 to 50 mg COD/l from the middle to downstream.

A recovery of CODcr while flowing from the middle to downstream was observed in three (3) rivers of Punggawa, Rangda and Teba. This is considered to have happened due to irrigation use. However two (2) rivers of Loloan and Mati deteriorate in COD, as they flow from upstream to downstream.

(3) Nitrogen

Four (4) different nitrogens were analyzed : $NH_4$-N, $NO_2$-N, $NO_3$-N and Total-N.

$NH_4$-N is found where human and animal wastes are the directly discharged. The maximum $NH_4$-N was observed in the downstream of Loloan river with 6.8 mg/l, while there were many stations observed with 0 mg/l of $NH_4$-N. This means that they are not polluted by human and animal wastes.

$NO_3$-N is the final product of nitrification from organic nitrogen through $NH_4$-N and $NO_2$-N. $NO_2$-N is a middle product in the nitrification, and is usually found in a low concentration.

The maximum $NO_2$-N was observed in the upstream of Oongan river with 0.165 mg/l, while many stations had no concentration of $NO_2$-N.

The maximum $NO_3$-N was observed in the downstream of Yeh Ayung river having 33.7 mg/l. The second and third ones were found in Mati (14.6 mg/l) and Punggawa (10.7 mg/l) respectively. There were nine (9) stations where no $NO_3$-N was observed.

The maximum total nitrogen of 40.45 mg/l was observed in Yeh Ayung, where the maximum $NO_3$-N was also found.

(4) Phosphorus

The Study Team analyzed total-P and found that the results were in the order of 0.01 to 0.53 mg/l. The maximum of 0.53 mg/l was observed in the upstream of Yeh Ayung, while the minimum of 0.01 mg/l was found in Sama river. In the center of Denpasar, where most pollution were found, the level of total-p was in the ranges of 0.05 to 0.15 mg/l.

(5) n-Hexan Extracts

There were six (6) stations where n-Hexan extracts were found. The maximum of 9.4 mg/l was observed in Sama river whic seemed to be extreme due to something like oil leakage, while the minimum of 0 mg/l was found in a total of 19 stations.

(6) Fecal Coliform

E.Coli is an indicator of bacteriological pollution. High figures in the range of 110,000 to 2,800,000 per 100 ml were found in the center of Denpasar.

The maximum was observed at No.13 Station in Oongan river, while the minimum of 3,900 ml was found in the upper-most stream of Yeh Ayung.

Rainy Season

(1) $BOD_5$

The highest $BOD_5$ of 50.5 mg/l was found in Oongan, the center of Denpasar, while the lowest one was found in Sama having 2.7 mg/l. The highest figure was found at the point, where the highest was found in dry season. Generally speaking the rivers located in eastern parts of the Study Area were not much polluted having $BOD_5$ upto about 15 mg/l.

There were eight (8) stations where $BOD_5$ exceeded 20 mg/l. The pollution trends were almost the same as in dry season.

(2) $COD_{cr}$

The pollution trends by COD in wet season were almost the same as in dry season. The maximum of 94.5 mg/l was found at No.13 station in Oongan the center of Denpasar, where the maximum BOD of 50.5 mg/l was also found.

Naturally the upstreams of rivers were less polluted, but the pollution levels, exceeding 10 mg/l, were roughly about 20 mg/l. As the rivers flow through the city center, they are further polluted to the level of about 100 mg/l. After the river waters were used for irrigation, they undergo a kind of purification or dilution to be improved to a level of about 30 mg/l.

(3) Nitrogen

$NH_4$-N ranged between 0.75 to 9.00 mg/l. The maximum of 9.00 mg/l was observed at two (2) stations, No.14 and No.21, in Rangda and Teba rivers. $NO_2$-N ranged between 0.007 to 0.028 mg/l. The maximum of 0.028 mg/l was found at two (2) stations of No.7 and No.8 in Abian Base.

$NO_3$-N ranged between 0.25 to 1.75 mg/l. The maximum of 1.75 mg/l was observed at No.11 station in Punggawa river, while the minimum of 0.25 mg/l was found at two (2) stations in Oongan and Rangda rivers.

Total-N ranged between 2.12 to 12.13 mg/l. The maximum of 12.13 mg/l was observed at No. 14 station in Rangda river, while the minimum of 2.12 mg/l was found at No.6 station in Abian Base river.

(4) Phosphorus

Total-P ranged between 0.009 to 0.938 mg/l. The highest figure of 0.938 mg/l was observed at No.21 station in Teba river, while the lowest one of 0.009 mg/l was found at No.25 station in Sama river.

(5) n-Hexan Extracts

There were as many as 17 stations where n-Hexan extracts were not found. The maximum figure was 17.2 mg/l at No.21 station in Teba river. The second one was found with 3.2 mg/l at downstream of Abian Base and middle stream of Loloan river.

(6) Fecal coliform

The bacteriological pollution trends in wet season were almost the same as in dry season, while the upstreams are less polluted, but as the rivers flow through urbanized areas, they are more and more polluted, because more and more pollutants are discharged into rivers in the center of Denpasar. The maximum of 490,000/100 ml was found at No.14 station in Rangda river, while the minimum of 5,700/100 ml was found at the same station as in dry season.

However there are noticeable capacity of purification in the down streams due to irrigation or others.

Generally speaking the bacteriological pollution level in rainy season is slightly lower than in dry season.

2.3.2 Classification of River Stretches by Water Quality

The existing water quality of rivers in the Study Area is classified into five (5) classes in terms of $BOD_5$ concentration as shown below.

| Class | BOD (mg/l) | Water Quality Condition |
|---|---|---|
| I | BOD ≤ 5 | Pristine |
| II | 5 < BOD ≤ 10 | Clean |
| III | 10 < BOD ≤ 20 | Slightly polluted |
| IV | 20 < BOD ≤ 30 | Significantly polluted |
| V | 30 < BOD | Heavily polluted |

The river stretches of the Study Area are classified based on the river water quality in dry season as shown in Fig. B.2.7. Similarly, the river classification for rainy season is shown in Fig. B.2.8.

### 2.3.3 Color and Odour of River Water based on Questionnaire Survey

The JICA Study Team visited each of 50 Kelurahan/Desa offices and asked the chairman of a Kelurahan/Desa about the name of the rivers or canals flowing across the Kelurahan/Desa, and water colors and smells of those rivers/canals. He was asked to choose one (1) out of five (5) colors, i.e. Green & Clear, Light Brown, Dark Brown, Gray and Black, and also to choose one (1) out of three (3) smells, i.e. No Smell, Slight Smell and Strong Smell regarding a particular river/canal. The questionnaire survey was conducted in January, 1992.

The results are shown in Table B.2.8, Table B.2.9, Fig. B.2.9, Fig. B.2.10 and Fig. B.2.11.

Table B.2.8 shows colors and smells of river water by Kelurahan/Desa. It also shows their summary by Kecamatan and for the Study Area. In Denpasar Barat water color of 35% of rivers can be said to be light brown, 27% dark brown, 15% green & clear, 15% black and 8% gray. In Denpasar Timur water color of 53% of rivers is green & clear, 40% light brown and 7% gray. In Denpasar Selatan water color of 60% of rivers is gray, 40% black and 10% green & clear. In Kuta 60% of rivers are green & clear and 40% light brown. Summing up, it can be said that rivers/canals flowing across Denpasar Selatan have the darkest water color, followed by Denpasar Barat, while in Kuta the color of river water is the lightest, followed by Denpasar Timur. Across the Study Area water color of 30% of rivers is light brown, 27% green & clear, 16% gray, 14% black and 13% dark brown. Fig. B.2.9 visualizes the colors of river water by Kelurahan/Desa.

In Denpasar Barat water of 50% of rivers can be said to have slight smell, 27% no smell and 23% strong smell. In Denpasar Timur water of 60% of rivers has slight smell and 40% no smell. In Denpasar Selatan water of 80% of rivers has slight smell, 10% no smell and 10% strong smell. In Kuta 60% of rivers have no smell and 40% slight smell. Summing up, river water in Denpasar Selatan smells the hardest, followed by Denpasar Barat, while in

Kuta smell of river water is the lightest, followed by Denpasar Timur. Across the Study Area water of 57% of rivers has slight smell, 20% no smell and 13% strong smell. Fig. B.2.10 visualizes the smells of river water by Kelurahan/Desa.

Table B.2.9 shows colors and smells of river water by river. 11 Major rivers were subjected to the observation of the chairmen of Kelurahan/Desa.

Water color of the River Abian Base is green & clear. Water color of 50% of the River Badung is light brown, 42% black and 8% gray. Water color of 50% of the River Loloan is gray, 25% green & clear and 25% black. Water color of 38% of the River Mati is light brown, 38% dark brown and 24% green & clear. Water color of 50% of the River Oongan is light brown, 33% green & clear and 17% black. Water color of the River Pengegeh is green & clear. 50% of the River Punggawa is green & clear and 50% gray. 75% of the River Rangda is gray and 25% light brown. 43% of the River Teba is dark brown, 29% light brown, 14% green & clear and 14% gray. Water color of 60% the River Yeh Ayung is green & clear and 40% light brown. Water color of 67% of the River Yeh Poh is green & clear and 33% light brown.

Summing up, it can be said that 7 rivers, namely Badung, Loloan, Oongan, Rangda, Punggawa, Teba and Mati have darker water colors and the remaining 4 rivers, namely Abian Base, Pengegeh, Yeh Poh and Yeh Ayung have lighter water colors. Fig. B.2.11 graphically shows the water colors of the 11 rivers.

Water of the River Abian Base has no smell. Water of 50% of the River Badung has slight smell, 25% no smell and 25% strong smell. Water of the River Loloan has slight smell. Water of 63% of the River Mati has slight smell, 25% no smell and 12% strong smell. 83% of the River Oongan has slight smell and 17% no smell. The River Pengegeh has no smell. 75% of the River Punggawa has slight smell and 25% no smell. The River Rangda has slight smell. Water of 43% of the River Teba has slight smell, 43% strong smell and 14% no smell. Water of 80% of the River Yeh Ayung has no smell and 20% slight smell. Water of 67% of the River Yeh Poh has no smell and 33% slight smell.

Summing up, it can be said that 7 rivers, namely Teba, Badung, Mati, Loloan, Rangda, Oongan and Punggawa have harder water smells, while the remaining 4 rivers, namely Abian Base, Pengegeh, Yeh Ayung and Yeh Poh have lighter water smells. Fig. B.2.11 graphically illustrates water smells of 11 rivers.

## 2.4 Existing Water Use by Section

### 2.4.1 Macro View

#### (1) General

In the Study Area, river water are mostly used for irrigation water. Therefore, intake sites, canals and diversion works are established everywhere. All irrigation water in the Study Area is provided from Ayung river through five (5) intake sites.

Fig. B.2.1 shows irrigable area from each intake site. According to Fig. B.2.1, the east area in the Study Area is provided from four (4) intake works in the Study Area and the west area is provided from Mambal Intake Work located in the north of the Study Area.

Table B.2.1(1) ~ B.2.1(5) show average monthly discharge at each intake sites. Irrigation water is constantly provided all over the seasons. Other water uses are derived by using this irrigation water.

Besides the use of river water for irrigation, washing and bathing are generally practised. These water uses are observed in the upstream areas where good water quality is maintained and intake sites and diversion works are often used.

#### (2) Field Survey

The JICA Study Team conducted a questionnaire survey towards the chairmen of the 50 Kelurahan/Desa in the Study Area about the existing uses of rivers/canals flowing across their own Kelurahan/Desa. The survey was done in January, 1992. The chairman of a Kelurahan/Desa was asked about the name of rivers/canals taking a course inside the Kelurahan/Desa and the uses of each of those rivers/canals.

The uses of rivers/canals were classified as follows :

Transport, Washing, Bathing, Drinking/Cooking, Agriculture, Industrial Water, Recreation (Swimming, Fishing, etc.), Fisheries, Wastewater/Refuse Disposal, Garbage Dumping and No Use.

The results of the survey are shown in Table B.2.10, Table B.2.11, Fig. B.2.12, Fig. B.2.13, Fig. B.2.14 and Fig. B.2.15.

Table B.2.10 shows the existing uses of rivers/canals by Kelurahan/Desa. It also shows their summary by Kecamatan and for the Study Area.

According to the table 69% of the rivers flowing within the boundaries of Denpasar Barat are used for wastewater/refuse disposal, 65% for washing, 62% for agriculture, 54% for bathing, 38% for recreation, 12% for fisheries, 4% for industrial water and 4% for nothing. No response was obtained regarding the uses for transport, drinking/cooking and garbage dumping.

75% of the rivers in Denpasar Timur are used for agriculture, 67% for washing, 60% for bathing, 33% for wastewater/refuse disposal, 20% for recreation, 7% for fisheries and 7% for nothing. No response was gotten regarding the uses for transport, drinking/cooking and industrial water.

90% of the rivers in Denpasar Selatan are used for agriculture, 70% for wastewater/refuse disposal, 50% for recreation, 40% for washing, 30% for bathing, 30% for fisheries and 10% for nothing. No response was gotten regarding the uses for transport, drinking/cooking, industrial water and garbage dumping.

The entire length of the rivers flowing within the boundaries of Kuta are used for bathing, agriculture and recreation. 80% of them are also used for washing, 60% wastewater/refuse disposal and 10% for fisheries. No response was obtained regarding the uses for transport, drinking/cooking, industrial water, garbage dumping and nothing.

It can be said from the above that in Denpasar Selatan negative uses of rivers are most marked, followed by Denpasar Barat, while in Kuta positive uses of rivers are the most widely recognized, followed by Denpasar Timur.

Over the whole Study Area 73% of the rivers/canals crisscrossing the area are used for agriculture, 62% for washing, 59% for wastewater/refuse disposal, 55% for bathing, 41% for recreation, 14% for fisheries, 6% for nothing, 3% for garbage dumping and 2% for industrial water. Rivers/canals in the Study Area are not used for transport and drinking/cooking.

Fig. B.2.12, Fig. B.2.13 and Fig. B.2.14 show the distribution of Kelurahan/Desa where rivers/canals are used for washing/bathing, agriculture and wastewater/refuse disposal, respectively.

Table B.2.11 shows the existing uses of rivers/canals by river. The entire length of the River Abian Base is used for washing and bathing. 83% of the River Badung is used for wastewater/refuse disposal, 67% for washing, 58% for bathing, 50% for agriculture, 42% for recreation and 17% for fisheries. The entire length of the River Loloan is used for agriculture, 75% of the length for washing, 50% for bathing, 50% for wastewater/refuse disposal, 25% for recreation, fisheries and garbage dumping.

75% of the River Mati is used for agriculture and recreation, 63% for washing and bathing, 50% for wastewater/refuse disposal, 25% for fisheries and 13% for garbage dumping. 83% of the River Oongan is used for agriculture, 67% for washing, 50% for bathing and wastewater/refuse disposal and 17% for garbage dumping and nothing. The entire length of the River Pengegeh is used for washing, bathing and agriculture and 50% of the length for recreation and wastewater/refuse disposal.

The River Punggawa is entirely used for agriculture, 50% of it for washing and wastewater/refuse disposal and 25% for bathing, recreation and fisheries. 50% of the River Rangda is used for agriculture, wastewater/refuse disposal and garbage dumping and 25% for recreation. 71% of the River Teba is used for agriculture and wastewater/refuse disposal, 57% for washing, 43% for bathing, 29% for recreation and 14% for fisheries.

80% of the River Yeh Ayung is used for bathing and agriculture, 60% for washing and recreation and 20% for industrial water, fisheries and wastewater/refuse disposal. The entire length of the River Yeh Poh is used

for washing, bathing, agriculture and recreation and 67% of it for wastewater/refuse disposal.

Summing up, it can said that negative uses are more marked in 7 rivers, namely Badung, Teba, Rangda, Punggawa, Loloan, Oongan and Mati, while positive uses are more widely recognized in 3 rivers, namely Abian Base, Yeh Poh and Yeh Ayung. Fig. B.2.15 graphically depicts the existing uses of rivers by river.

Along with the questionnaire survey towards the chairmen of Kelurahan/Desa, on-site field inspection survey was conducted. Based on these surveys the following facts are obtained :

(1) In most of the Study Area river/canal water is used for irrigation. In fact, intake sites, canals and diversion works are established everywhere. Th existence of these facilities shows agricultural water is used in general.

(2) In the upstreams of the Study Area good water quality is maintained. Washing and bathing are often observed especially at intake sites, diversion works and canals.

(3) The uses of rivers/canals for transportation and drinking/cooking are not recognized.

(4) But, wastewater/refuse disposal and garbage dumping are widely observed in the Study Area. Especially in the downstreams of Denpasar water pollution and garbage dumping are recognized everywhere.

The existing major positive uses (irrigation and washing & bathing) of river water by river section are summarized as shown in Fig. B.2.16.

### 2.4.2 Irrigation Water Use

The largest water use in the Study Area is irrigation use. Technical irrigation systems including intake, canal and diversion device are provided for a large part of the Study Area with an area of 9,602 ha. Irrigation water is withdrawn from five (5) intakes of Mambal, Peraupan

and Oongan in Yeh Ayung River, and Merta Gangga and Tukad Badung in Badung River. The withdrawn water is distributed to the respective irrigation areas through well deviced irrigation networks.

Location of the intakes and their commanding irrigation areas are shown in Fig. B.2.1.

Average monthly intake volume by season by intake site are calculated from the data in Table B.2.1(1) - B.2.1(5) as given in Table B.2.12. Those are summarized below.

| Intake No. | Name | Irrigation Area (ha) | Dry Season ($m^3/s$) | Rainy Season ($m^3/s$) | Average ($m^3/s$) |
|---|---|---|---|---|---|
| 1. | Mambal | 5,963 | 3.5 | 4.1 | 3.8 |
| 2. | Peraupan | 230 | 0.6 | 0.5 | 0.6 |
| 3. | Oongan | 1,781 | 2.0 | 3.0 | 2.5 |
| 4. | Merta Gangga | 380 | 0.7 | 0.7 | 0.7 |
| 5. | Tukad badung | 1,248 | 1.0 | 1.3 | 1.1 |
| | Total | 9,602 | 7.7 | 9.6 | 8.7 |

Average irrigation water requirement of the Study Area in dry season and rainy season are 7.0 mm/day and 8.6 mm/day.

## 3. Sea Water Quality and Use

### 3.1 Observed Water Quality

#### (1) Observed Sea Water Quality in 1987

The Study on Wastewater Disposal for Denpasar had conducted the sea water quality observation at five (5) points in Sanur, Nusa Dua and Kuta in 1987. The location of sampling points are shown in Fig. B.3.1. The observed water quality parameters are as follows.

- $BOD_5$, $COD_{cr}$, DO, SS, $NH_4$-N, $NO_3$-N, $NO_2$-N, T-P, pH, Air Temperature, Water Temperature, Conductivity, Coliform, E.Coliform, n-Hexan extracts, Chloride

The results are shown in Table B.3.1.

The Feasibility Study on the Urgent Bali Beach Conservation Project conducted by JICA in 1988 had also analyzed the sea water quality at 13 points in Sanur, Nusa Dua and Kuta. The sampling location is shown in Fig. B.3.1. The observed water quality parameters are as follows.

- $BOD_5$, $COD_{cr}$, DO, SS, T-P, T-N, pH, E.Coliform

The results are shown in Table B.3.2.

#### (2) JICA Observation

The JICA Study Team conducted the sea water quality observation at 52 points in Sanur, Nusa Dua and Kuta in dry season 1991 (November 5 ~ 7 and 12, 1991). It also conducted the sea water quality observation at the same locations in rainy season of 1992 (January 23 ~ February 6, 1992). The locations of sampling points are shown in Fig. B.3.2. The observation water quality parameters are as follows.

- $COD_{cr}$, DO, SS, $NO_3$-N, $NO_2$-N, T-P, T-N, pH, Air Temperature, Water Temperature, Transparency, Fecal Coliform, n-Hexan extracts.

The results are shown in Table B.3.3(1) ~ (2) (dry season) and Table 3.4(1) ~ (2) (rainy season), and Fig. B.3.3(1) ~ (9).

The JICA Study Team also conducted the sea water quality observations by a portable analyzer in the same period of dry season of 1991. This was to confirm the results by the laboratory analysis. All together 51 locations were selected for this purpose, as shown in Fig. 3.2. The observed water quality parameters are as follows :

- $COD_{Mn}$, SS, DO, pH, Phenol and Fecal Coliform.

The results are shown in Table B.3.5.

## 3.2 Existing Water Quality by Area

### 3.2.1 Regional Distribution of Sea Water Quality

The regional distribution of DO, $COD_{cr}$, SS and other parameters are established based on the observed water quality by JICA Study Team in November, 1991 and January, 1992 and are shown in Fig. 3.3 (1) ~ (9).

Dry Season

(1) DO

No significant regional variation of DO was found out in the coastal sea of the Study Area. DO ranged from 6.8 mg/l as the lowest to 7.8 mg/l as the highest with an average of 7.3 mg/l, while the water temperatures ranged from 24.3°C to 29.0°C.

(2) $COD_{cr}$

The regional variation of $COD_{cr}$ in the coastal sea of the Study Area ranged from 0.4 mg/l to 25.3 mg/l. The maximum value was observed along the approach route of navigation to Benoa Port between the Serangan Island and the Cape Benoa, while the minimum was observed at the off shore of Nusa Dua.

High $COD_{cr}$ of more than 5 mg/l was observed along the coastal line of the Sanur, Nusa Dua and a part of Kuta beaches, around the Serangan Island and inside of Benoa Bay.

Generally speaking, the sea water pollution is reduced with the increasing distance from the beach. For details, see Fig. B.3.4(1).

Distribution of the sea water pollution in $COD_{cr}$ is shown in Fig. B.3.4.

(3) SS

SS ranges from 0 to 9.8 mg/l of the Study Area. The regional variation of SS is rather difficult to identify, because the wave movements or others create SS. The highest figures were found in the channel near the Benoa Port, due to port activities. The general trends indicate that the longer the distance from the sea shore is, the less SS is found.

(4) pH

The pH figures changed in a small range between 7.9 to 8.1, which seems to be normal. No regional variation was found in pH values.

(5) Total-N

The figures of total-N ranged from 0.30 to 71.00 mg/l, showing almost no regional variation. The maximum of 71.00 mg/l was found near Sanur, but seemed to be extreme.

At 19 stations no $NO_2$-N was found. The maximum of 24.0 mg/l was observed at one (1) station along the Nusa Dua Beach. Also higher concentrations of 12.0 to 16.0 mg/l were found along the Kuta, Sanur and Nusa Dua Beaches.

The were only two (2) stations, where $NO_3$-N was found, while other station found no $NO_3$-N. Even two (2) stations observed a low level of 0.1 mg $NO_3$-N/l.

(6) Total-P

The figures of total-P ranged from 0.030 mg/l to 0.130 mg/l, showing almost no regional variation.

(7) n-Hexan Extracts

At more than half of the stations (33 stations of the total) n-Hexan extracts were not observed. The maximum of 7.54 mg/l was found at station No.R6 in Benoa Bay, which seemed to be due to oil discharge by port activities.

(8) Fecal Coliform

It was found that most of the sea water were not bacteriologically polluted. The maximum figures of 240/100 ml were found at two (2) stations at off-shore of Sanur and Benoa Bay. At 33 stations no bacteriological pollution was found.

Rainy Season

(1) DO

No significant regional variation of DO was found. DO ranged from 6.9 mg/l as the lowest to 7.8 mg/l as the highest which an average of 7.3 mg/l. DO varies depending upon the water temperature. The water temperatures ranged from 27.5°C to 31.0°C.

(2) $COD_{cr}$

The regional variation of $COD_{cr}$ ranged from 2.3 mg/l to 11.7 mg/l. The highest figure was found in the channel near the Benoa Port, while the lowest one was found off-shore from Tanjung Sanur. Generally speaking, such trends were observed that as the distance increases from the sea shore, $COD_{cr}$ decreases. For details, see Fig. B.3.4(2).

(3) SS

SS ranges from 0.1 to 7.7 mg/l. The regional variation of SS is rather difficult to identify, but generally higher concentrations were found near the sea-shores.

(4) pH

The pH figures ranged from 7.9 to 8.4. They are slightly higher than in the dry season, but still seem to be in a normal range.

(5) Total-N

The figures of total-N ranged from 0.00 mg/l to 0.88 mg/l, showing almost no regional variation. The maximum of 0.88 mg/l was found between Tanjung Sanur and Serangan Island. At ten (10) stations there was no total-N found.

At only ten (10) stations there were NO2-N observed, of which the levels were so lower as 0.1 to 0.2 mg/l. There was no regional variation.

At 13 stations no $NO_3$-N was observed. At the remaining stations the concentrations of $NO_3$-N ranged from 0.1 to 0.4 mg/l. No clear regional variations were found.

(6) Total-P

The figures the total-P ranged from 0.01 mg/l to 0.35 mg/l, showing almost no regional variation.

(7) n-Hexan Extracts

At more than 80% of stations, or 42 of a total 52 stations, n-hexan extracts were not observed. The maximum of 8.4 mg/l was found off-shore from Jimbaran, which seemed to be due to fishery activities, though no extract was found near by the sea shore there.

(8) Fecal Coliform

At most of stations the fecal coliforms were not observed. However the maximum figure of 240/100 ml was found two (2) stations, Sanur and Nusa Dua. This means that, generally no bacteriological pollution was found.

## 3.3 Existing Water Use by Area

### 3.3.1 Water Recreations

As is widely known, there are three tourism centers in Bali, namely, Sanur, Kuta and Nusa Dua. They are all situated within the boundaries of the Study Area. All of them have beautiful and attractive beaches and many hotels, restaurants, shops and other tourism facilities concentrate there. Along these beaches tourists enjoy swimming, sun-bathing, fishing, surfing, boating, parasailing and so forth.

Suppose the quality of sea water deteriorates more in the future, the negative impacts on these tourism centers will be serious.

### 3.3.2 Fish Production

The importance of fish production in the Study Area cannot be overlooked. Many types of fisheries are practised there. Fisheries are broadly classified into sea and inland fisheries. Sea fiseries are divided into catching in the outer seas and seaweed breeding. Inland fisheries are conducted in public waters, static water ponds, moving water ponds, irrigation channels and rice fields.

Seaweed breeding is practised in the Benoa Bay. Inland fisheries in brackish water are conducted in the Suwung Area between Sanur and Benoa Bay areas. Inland fisheries in public waters means fisheries in the rivers. They are observed in such rivers as Badung, Loloan, Mati, Punggawa, Teba and Yeh Ayung. Fisheries in static water ponds are witnessed in such Kelurahans as Sesetan, Peguyangan, Ubung, Kerobokan, Dalung and Canggu. Fisheries in irrigation channels and rice fields are practised all over the Study Area excluding the city and tourism centers.

Total production of fish in Badung in 1989 was 17,670.8 tons, of which catching in the outer seas accounted for 68.1%, seaweed breeding 20.7%, brackish water fisheries 9.9% and fisheries in rice fields 0.6%. Excluding catching in the outer seas, fish production in Badung in 1989 works out at 5,642.9 tons, of which seaweed breeding accounts for 65.0%, brackish water fisheries 31.0%, fisheries in rice fields 2.0%, fisheries in static water ponds 1.0%, catching in public waters 1.0%. Fish production by fisheries in irrigation channels and moving water ponds is negligible (refer to Table B.3.6).

The total values of fish produced in Badung in 1989 came to Rp. 27,821.2 million, of which brackish water fisheries accounted for 53.8%, catching in the outer seas 44.0%, seaweed breeding 0.8%, fisheries in rice fields 0.8% and fisheries in static water ponds 0.4%. Excluding catching in the outer seas the values of fish production in Badung in 1989 work out at Rp. 15,570.3 million, of which brackish water fisheries account for 96.2%, fisheries in rice fields 1.4%, fisheries in static water ponds 0.7% and catching in public waters 0.3%. The production values by fisheries in irrigation channels and moving water ponds are negligible (refer to Table B.3.7).

The total number of households engaged in fisheries fully or part time was 3,812 in Badung in 1989. Excluding catching in the outer seas the number works out at 2,972, of which the number of those engaged in brackish water fisheries was 109 or 3.7% (refer to Table B.3.8).

If water quality in the near-by seas and rivers/canals deteriorates more in the future, fisheries in Badung excluding catching in the outer seas will be much affected.

### 3.3.3 Salt Farming

In 1985 100 families were engaged in salt making utilizing sea water full time or part time at several locations in Denpasar Selatan and Kuta. Production and values of salt reached 633 tons and Rp. 126.6 million, respectively. Now, production efficiency has greatly gone up and in 1991 5 families were engaged in salt farming in Pedungan, Denpasar Selatan producing 575 tons of salt valued at Rp. 116 million (refer to Table B.3.9).

If the quality of sea water deteriorates more in the future, this traditional way of salt making will be completely phased out.

## 3.4 Existing Coral Life

### (1) Observation of Coral Damage

The JICA Study Team conducted the coral damage survey at 70 locations of coastal waters along the Sanur and Nusa Dua beaches in the rainy season of 1991 (November 13 ~ 20, 1991). Of the selected observation points 41 were the same as those of sea water quality sampling points. The remaining 29 points were selected to supplement the above 41 locations. The survey locations common to both sea water quality and coral sampling are shown in Fig. B.3.5. The other locations of coral sampling only, fall within these areas of both sea water and coral sampling. The observation points are concentrated in the Sanur and Nusa Dua beach areas because no coral life are recognized both in Benoa Bay and Kuta beach areas. The exact location of sampling points was identified by the same way used in sea water quality sampling : global positioning system (GPS).

The condition of coral life/damage was observed by taking under-water photographs from both above and side at each location. The existing condition of coral life is classified into four (4) classes as follows.

Class A : Most corals are healthy

Class B : A few corals are healthy

Class C : Some corals are dead

Class D : No coral or no healthy coral life

### (2) Classification of Sea Area by Coral Condition

The classification of coastal sea area along the Sanur, Benoa and Nusa Dua beaches, made based on the coral damage survey is shown in Fig. B.3.5.

As evident from Fig. B.3.5 ;

- With increasing distance from the beach, in general, the coral life becomes healthy.
- Coral is not observed in the Benoa Bay and around the Serangan Island because the sea bed is covered by mud.
- Coral is damaged along the approach sea route to Benoa Port between the Serangan Island and the Cape Benoa.
- Coral is damaged at the northern portion of the Sanur beach where many small hotels are located.
- Between the Cape Benoa and Nusa Dua, corals are healthy at the sea 300 m more distant from the beach.
- At immediate north of Nusa Dua resort area, healthy coral is decreased in quantity.

## 4. Sea Current

### 4.1 General Characteristics of Oceanography

#### (1) Offshore Currents

The offshore currents around the Indonesian Archipelago including Bali Island are shown in Fig. B.4.1. The directions of currents in Jawa Sea correspond with those of seasonal winds.

In Badung Strait near the east side of Bali Island, no detailed data of currents are available. However, in the Lombok Strait, which is connected with the Badung Strait, the northern currents are dominant during the rainy season, when the north-west seasonal winds blow. The southern currents are dominant during the dry season, when the south-east seasonal winds blow. Thus, in the Badung Strait, the same patterns of currents as in the Lombok Strait are supposed to be dominant.

#### (2) Tides

The tide data in Benoa Harbor are shown in Table B.4.1 and Fig. B.4.2. According to those data, the principal lunar $M_2$ is dominant, and an amplitude of the semi-diurnal tides $M_2$ and $S_2$ amounts about 1 meter. This concludes that there are high tides and low tides twice a day respectively.

(3) Waves

As for the offshore wave climate in the Indian Ocean to the south of Bali, the US. Navy Marine Climatic Atlas of the World Vol. 3 Indian Ocean (1976) provides the statistics on the height, period and direction of the waves over 120 years (Fig. B.4.3). The predominant direction of the waves is south-east to south-west. The field observations of wave climates were carried out in Sanur and Nusa Dua beaches in 1988, as the Feasibility Study on the Urgent Bali Beach Conservation Project (1989). The distributions of wave height and period in Nusa Dua are shown in Fig. B.4.4.

4.2 Sea Bed Topography

The chart in study sea area is shown in Fig. B.4.5. This chart is a result of a Netherlands Government survey in 1949, which was corrected by the Indonesian Government in 1982. In Pantai Timur Bay where Benoa Harbor is located, the depth is very sallow, so during low tides, most of the sea bottoms appear above the water surface. Along the coast in the Study Area, the coral reef is developed. The topographies near the shore in Sanur and Nusa Dua are shown in Fig. B.4.6 and Fig. B.4.7 respectively. These data were sounded in 1988, as the Feasibility Study on the Urgent Bali Beach Conservation Project (1989). The depth of the coral reef is about 1 ~ 2 meter deep under the mean sea level.

4.3 Observed Sea Currents

(1) Past Records

The current observations were carried out in Sanur and Nusa Dua beaches in 1988 as the Feasibility Study on the Urgent Bali Beach Conservation Project (1989). The current meters were set in the near shore area as shown in Fig. B.4.6 and B.4.7. The purpose of those observations was to find out the causes of the beach erosion. Fig. B.4.8 and B.4.9 show the time series of the current directions and velocity at each station. Furthermore in this observation, the incident wave data were observed at the same time.

(2) Field Survey

The JICA Study Team carried out a field survey of currents at 5 stations in fall 1991.

The locations of 5 current meters are shown in Fig. B.4.10.

The current observations at St. A, B, C and D started from 25 October 1991, and one at St. E started from 10 November 1991. Each observation was conducted for 15 days.

At St. A, B and C, where the depth are very shallow, about 1 ~ 3 meters deep, the electromagnetic current meters were set on the bottom. The sensors were placed about 0.7 meter above the bottom. At St. D and E, where the depths are about 20 meters, the rotor type current meters supported by buoys and anchors were installed. The sensors were set about 5 meters under the water surface.

Results of JICA Survey

Fig. B.4.11(1) to (5) indicates the tidal ellipses at each station, obtained by the harmonic analysis. As for the components of the tidal currents, $M_2$ components were dominant in all stations. The amplitude of $M_2$ component at St. D and E are larger than St. A, B and C. They reached about 0.2 m/sec and 0.4 m/sec respectively. Since the tidal currents are influenced by the sea bottom and the coastal topography, the directions of currents at St. A, B and C agree with those of the channels, and those at St. D and E are almost parallel to the coastal lines. Thus, the shapes of ellipses are relatively flat. The constant currents derived from the harmonic analysis are very important, because the movable materials in the sea, such as pollutants and sediments, are moved in the direction of the constant currents. At St. D and E outside of coral reef, the constant currents whose velocity are stronger than those at the other stations. They recorded 0.19 m/sec and 0.2 m/sec respectively. However, the directions of both currents are different ; the current at St. D flows toward the south, and that at St. E flows to the north-east.

## 5. Groundwater Quality and Use

### 5.1 Groundwater Table

The existing available data of groundwater table in the Study Area are those which "Bali Water Resources Study" of IUIDP compiled in 1989, based on the observation results of Perusahaan Daerah Air Minum (PDAM) and Geological Survey of Indonesia Tata Lingkungan (GTL). Location of the 18 observed wells along with observed depth of groundwater table are shown in Fig. B.5.1.

The JICA Study Team conducted an observation of groundwater table and water quality for 75 existing wells of the Study Area during November to December in 1991. Location of the observed wells are shown in Fig. B.5.2. The observed groundwater table depths are shown in Table B.5.1(1) - B.5.1(3)

Contourline of the groundwater table depth in the Study Area are drawn based on the above data of 93 wells as shown in Fig. B.5.3

Groundwater table is deeper than 3.0 m in most part of the Study Area. However, Kec. Denpasar Selatan, southern part of Kec. Denpasar Barat and Denpasar Timur, and eastern half of Kel. Kuta are prone to shallow groundwater table. Groundwater table of Sanur, Kuta and Nusa Dua beach resort areas is not shallow, approximately 3.0 m.

### 5.2 Groundwater Quality

#### (1) Available Data

The previous study on wastewater disposal for Denpasar<1 conducted groundwater quality observation at nine (9) points of the Study Area in December, 1987. Location of the observed wells are shown in Fig. B.5.4.

The observed water quality parameters are as follows.

<1: Pengembangan Sistem Perencanaan Pembuangan Air Limbah and Kotoran Manusia Di Kota Denpasar by Cipta Karya, 1988

- pH, $BOD_5$, $COD_{cr}$, DO, Conductivity, SS, Ammonia, Nitrate, Nitrite, Phosphate, Chloride and Coliform

The results are shown in Table B.5.2.

The JICA Study Team conducted groundwater quality observation at 75 points of the Study Area as dealt with in the foregone section (ref. Fig. B.5.1). The observed water quality parameters are as follows :

- pH, DO, $COD_{cr}$, SS, $NH_4$-N, $NO_2$-N, $NO_3$-N, T-N, T-P, FC(Fecal Coliform), Temperature, Water Temperature and Transparency.

The results are shown in Table B.5.1(1) - B.5.1(3).

(2) Organic Pollution

The JICA survey observed organic pollution in shallow wells. $NH_4$-N was detected in the 25 wells with a groundwater table depth of shallower than 5.0 m and of which 22 wells are shallower than 3.0 m. Fecal Coliform was found out in the 54 wells of which 41 wells are shallower than 5.0 m and 29 wells are shallower than 3.0 m.

The maximum $NH_4$-N of 7.3 mg/l was observed in a well with the groundwater table depth of 1.25 m. The maximum Fecal Coliform of 2,400 MPN/100 ml was detected in two wells of which depths are 2.22 m and 1.93 m respectively.

The regional distribution of $NH_4$-N and Fecal Coliform observed by the Study Team are shown in Figs. B.5.5 and B.5.6 along with the contour of groundwater table depths.

Moreover, the Study Team evaluated organic pollution of the wells by giving the evaluation index from 0 to 4 with respect to water quality parameters of $COD_{cr}$, $NH_4$-N and Fecal Coliform as shown in Table B.5.3. The regional distribution of the integrated pollution indexes are shown in Fig. B.5.7.

As seen from Fig. B.5.7, highly polluted wells with an integrated pollution index of more than 7 are limited in the area where groundwater table depth is shallower than 3.0 m.

### 5.3 Groundwater Use

The JICA Study Team conducted a questionnaire survey on the existing groundwater use along with water quality sampling test. The results are summarized in Table B.5.4(1) - B.5.4(2).

Among the 75 JICA observation wells, 55 wells are located in the PDAM services area and the remaining 20 wells are in the outside of the service area. Even in the PDAM service area, well water is still a major source of domestic water. Among the above 55 wells, 50 wells are used to supply domestic water independently from the PDAM water supply system. Supplementary wells to the PDAM water service are only five (5).

Most of the wells are used for all domestic purposes : drinking, cooking, washing and bathing. Water use is limited to washing/bathing in only five (5) wells among the surveyed 75 wells.

## 6. Soil Permeability

### 6.1 Observed Permeability

#### (1) Past Data

A percolation test was conducted at 36 locations in the area covering the three (3) Kecamatans of Denpasar and a portion of Kecamatan Kuta during 1987-1990 by local consultants for CIPTA KARYA. Based on the test the soil infiltration of the Study Area was categorized into three (3) groups ; high infiltration, medium infiltration and low infiltration. The criteria adopted for this classification is as follows :

- High infiltration : Percolation is in the range of 0.2 ~ 1.0 cm/min.
- Medium infiltration : Percolation is in the range of 0.03 ~ 0.2 cm/min.
- Low infiltration : Percolation is less than 0.03 cm/min.

Zoning of the soil infiltration capacity was made according to the above criteria as shown in Fig. B.6.1. The zoning area covers most part of the JICA Study Area excluding the north western and souther fringe areas.

(2) JICA Observation

The Study Team conducted permeability test for 20 soil samples taken from 10 sites of the Study Area. Two (2) undisturbed samples were collected from the underground of 2 m and 5 m deep by core boring at each sampling location for laboratory test. Location of the sampling points is shown in Fig. B.6.2.

Among the 10 sampling locations, five (5) location of No.1, No.2, No.4, No.9 and No.10 were selected from the outside area of the foresaid previous study. The remaining five (5) locations of No.3, No.5, No.6, No.7, and No.8 were selected from the covered area of the previous study to confirm the results of the previous study.

The results are summarized in Table B.6.1.

The data of No.1, No.2 and No.4 represent the soil infiltration capacity in the north western part of the Study Area. The soil consists of sandy clay/silty clay/rock in the upper layer and rock/medium clay in the lower layer with a poor permeability. The soil permeability is in the order of $10^{-6}$ cm/s to $10^{-8}$ cm/s or impermeable.

No.3 and No.5 cover the central part of Denpasar. The upper layers consisting of sandy silt have a poor soil permeability of $10^{-6}$ cm/s. While, the lower layers composed of coarse sand/silty sand show a moderate soil permeability of $10^{-4}$ cm/s.

No.6, No.8 and No.10 are located in the beach resort areas of Sanur, Kuta and Nusa Dua. Both upper and lower lays consisting of beach sand show a good soil permeability of $10^{-2}$ cm/s to $10^{-3}$ cm/s.

The data of No.7 shows a representative soil infiltration of the southern low-lying areas of Denpasar. The both layers consisting of sandy clay have a poor permeability of $10^{-6}$ cm/s.

No.9 present a typical soil infiltration of the norther part of Bukit Badung area. The soil permeability is $10^{-5}$ cm/s in the upper layer of stiff silt and impermeable in the lower layer of lime stone.

(3) Soil Infiltration of the Study Area

Based on the above two (2) surveys, the soil condition in the Study Area is classified into three (3) groups in terms of its infiltration capacity as follows :

- High infiltration : Permeability is greater than $10^{-3}$ cm/sec
- Medium infiltration : Permeability is in the range of $10^{-4} \sim 10^{-3}$ cm/sec
- Low infiltration : Permeability is less than $10^{-4}$ cm/sec

The classification of soil infiltration by Kelurahan/Desa is shown in Fig. B.6.3.

Kel. Sanur, Sanur Kaja and Serangan of Kec. Denpasar Selatan, and Kel. Kuta of Kec. Kuta covered by beach sand fall in the high infiltration group.

The whole area of Kec. Denpasar Timur and Denpasar Barat excluding Kel. Pemecutan, Pemecutan Kaja, Pemecutan Kelod, Tegal Kerta and Tegal Harum are classified into the medium infiltration group.

The other areas of the Study Area are in the low infiltration group.

## 7. Water-Borne Disease

### 7.1 Results of Sampling Questionnaire Survey

The JICA Study Team conducted the sampling questionnaire survey to know the incidence of water-borne diseases in the Study Area. 15 households were selected on random basis per Kelurahan/Desa, the total number of samples coming to 750.

Sampled households were asked about the number of actual cases for each of major water-borne diseases among household members during the last three years.

Major water-borne diseases are as listed below :

Malaria, Diarrhea, Cholera, Tuberculosis, D.H.F, Typhoid, Dysentery, Diphtheria, Measles, Hepatitis A and Hepatitis B.

The results of the survey are shown in Table B.7.1.

Table B.7.1 shows contraction rate expressed as the number of cases per 1000 population per year for each of the above water-borne diseases by Kelurahan/Desa, by Kecamatan and for the Study Area.

In Denpasar Barat the contraction rate of diarrhea is the highest with 60.2 cases, followed by dysentery with 5.2 cases, malaria with 4.7 cases, tuberculosis with 2.5 cases, diphtheria with 1.3% and so forth. The total contraction rate works out at 76.0 cases.

In Denpasar Timur the contraction rate of diarrhea is the highest with 18.7 cases, followed by malaria with 4.0%, dysentery with 3.5%, measles with 2.4%, typhoid with 1.9%, D.H.F with 1.6%, diphtheria with 1.3%, etc. The total contraction rate works out at 34.0%.

In Denpasar Selatan diarrhea has the highest contraction rate with 60.0 cases, followed by dysentery with 6.0 cases, malaria with 3.6 cases, measles with 2.8 cases, cholera and diphtheria with 2.0 cases, hepatitis B with 1.6 cases and so on. The total contraction rate adds up to 79.2 cases.

In Kuta also diarrhea has the highest contraction rate with 15.7 cases, followed by typhoid with 4.6 cases, malaria with 2.9 cases, tuberculosis with 2.3 cases and dysentery with 1.7 cases. The total contraction rate adds up to 27.2 cases.

It follows from the above that Denpasar Selatan has the highest contraction rate with Denpasar Barat placed second highest and also that Kuta has the lowest contraction rate with Denpasar Timur placed second lowest.

It is to be noted that this order in the existing status of things among the four Kecamatan holds true also with regard to the colors and smells of river water as well as with regard to the uses of rivers.

Across the entire Study Area the contraction rate of diarrhea is the highest with 41.5 cases per 1,000 population, followed by dysentery with 4.4 cases, malaria with 4.0 cases, tuberculosis with 1.4 cases, typhoid, diphtheria and measles with 1.3 cases, etc. The total contraction rate of water-borne diseases adds up to 57.1 cases per 1,000 population.

Translated into actual number of cases, it is calculated that in the Study Area in 1990 there were 19,814 cases of diarrhea, 2,101 cases of dysentery, 1,910 cases of malaria, 668 cases of tuberculosis, 621 cases of typhoid, diphtheria and measles, 430 cases of D.H.F, 286 cases of cholera, 143 cases of hepatitis B and 48 cases of hepatitis A, adding up to 27,263 cases in total.

## 7.2 Statistical Data

According to Badung dalam Angka 1988 to 1990, the incidence of water-borne diseases is as shown in Table B.7.2.

According to the table, the number of diarrhea and the entire water-borne disease cases was 22,642 and 33,062 respectively in Badung in 1990. As the population of the study area was 72.0% of that of Badung in 1990, the number of diarrhea and the entire water-borne disease cases in the study area in the same year works out at 16,302 and 23,805 respectively.

When one compares the results of the questionnaire survey and the statistical figures regarding the incidence of diarrhea in the study area, one finds that the latter are less than the former. It may be because the latter are based on the reported cases in health centers only and it is probable that there are substantial unreported cases. Also, regarding the incidence of the entire water-borne diseases the statistical figures are less than the survey results. It is because the incidence of diarrhea is less and at the same time the number of types of water-borne diseases is less in the latter than in the former.

## 8. Water Quality Standards

### 8.1 General

The ministry which is primarily responsible for water quality standards is MENKLH (Menteri Negara Kependudukan dan Lingkungan Hidup, or State Minister of Population and Environment).

The major laws and regulations concerning environment are summarized in Table B.8.1. In Indonesia the main frame concerning environmental management was formulated in 1982. This law is called as "Law for Main Decision on Environmental Management (No. 4/1982)", whose aim is to frame the basic idea concerning economic development and environmental management.

Since 1982 the Government of Indonesia (GOI) had studied various aspects in the field, and MENKLH stipulated a law concerning the water quality standards in 1988. This is called as the Law for Decision Guideline of Environmental Quality Standard (KEP-02/MENKLH/1988). It is a national law of environmental quality standards, in which the water quality standards are also described. The Regional Governments of Level I are allowed to upgrade their environmental quality standards based on the law, reflecting their regional requirements.

The Provincial Government of Bali stipulated in 1988 the Law for Control and Protection of Environmental Pollution (No. 16/1988). This law is basically the same as the national law, which consists of two areas of water and air.

Concerning the water quality standards the law decides the environmental standards of water in rivers and sea, as well as effluent standards of wastewater.

In 1990 the President of Indonesia enclosed the relevant environmental laws by issuing the Law of Water Pollution Control (No. 20/1990), which is the basic low pf water pollution control. In 1991 MENKLH stipulated the Law of Standard Wastewater Quality for Operating Activities (KEP-03/MENKLH/II/1991) to clarify the relationship between environmental water quality standards and wastewater effluent standards.

## 8.2 River Water Quality Standards

The provincial Government of Bali determined the environmental standards of river water quality by the following four (4) groups :

Group A : Water which can be used as drinking water without treatment.

Group B : Water which can be used as standard water for drinking after proper treatment.

Group C : Water which can be used for fishery and livestock.

Group D : Water which can be used for agriculture, urban activities, industries and hydropower stations.

The four (4) groups are classified by the following five (5) sets of parameters :

- Physical parameters (7 items)
- Chemical parameters (38 items)
- Bacteriological parameters (3 items)
- Radioactivity parameters (3 items)
- Pesticides parameters (15 items)

The parameters themselves are quite wide and comprehensive for river grouping. According to the Law of Water Pollution Control (No.20/1990) all the rivers are supposed to be grouped by the relevant Governor's of Level based on a total of 66 parameters. However, it is still not clear how these parameters are to be used to determine which river should be categorized to which group.

The provincial Government of Bali has not yet decided the existing grouping of the rivers there more the future river use.

The Law of Water Pollution Control (No. 20/1990) is based on the almost same idea for river grouping.

These laws are significant for river grouping, but can not be used directly for sewerage planning. Hence the JICA Study Team suggested to use the Governor's Decree (No.1608, 1988) of DKI Jakarta, which are shown in Table B.8.2(1) to (3).

The Decree determines the following four (4) groups :

- Group A for drinking water source
- Group B for fishery
- Group C for agriculture
- Group D for aquatic biota

It should be noted that all the groups have two (2) limits : Desirable Limit (DL) and Permissible Limit (PL). The DL is the limit recommended by the Government, but is still difficult to be realized considering the existing situation. The PL is the minimum requirement that needs to be kept. There are still many cases where presently applying the DL is difficult because the DLs are in a sense highly idealistic. In such cases the PL is applied for a time being and will be upgraded to the DL.

Based on the existing conditions of the Study Area the JICA Team suggested to maintain the water quality standard of irrigation :

BOD : 20 mg/l

## 8.3 Sea Water Quality Standards

Seas around the Study Area are used for various purposes like tourism, recreation, fishery or industry. The Bali Government is now investigating actual situations of sea use in the areas to establish appropriate sea water quality standards. But its own law for sea water quality standards has not yet been stipulated. For a time being the Decree of MENKLH (KEP-02/MENKLH/1988) is being referred to as the basis of sea water quality standards, shown in Table B.8.3(1) to (3).

There are six (6) groups of sea water uses as follows :

- Group I for Swimming
- Group II for Mining and Industry

- Group III for Fishery
- Group IV for Sea Park
- Group V for Public and Aesthetic
- Group VI for Cooling

The Group I for swimming requires the most stringent water quality standards. Because Bali is the center of tourism in Indonesia, it is very important to keep the cleanest environment as possible. However the JICA Study Team judges that the water quality standards of KEP-02/MENKLH/I/1988 are not sufficient to ensure a clean environment, because the desirable limits for swimming are not stringent like :

| | | |
|---|---|---|
| $BOD_5$ | : | 10 mg/l |
| COD | : | 20 mg/l |
| SS | : | 20 mg/l |

But the desirable limits for biological standards are stringent enough requiring zero.

The JICA Study Team collected sea water quality standards from four (4) countries (Table B.8.4) and suggested the sea water quality standards, and based on it, as follows :

| | | |
|---|---|---|
| pH | : | 7.8 ~ 8.3 |
| $COD_{cr}$ | : | 5 mg/l |
| DO | : | 7.5 mg/l |
| n-Hexan extracts | : | not detectable |
| E. Coliform | : | 1,000 MPN/100 ml |

## 8.4 Effluent Standards of Wastewater

The Effluent Standards of Wastewater Quality is shown in Table B.8.5(1) and (2). This standard is subject to any effluents, not only to industrial effluents. The main purpose of the table is to control and monitor the effluents from industries and others.

The table contains physical, chemical and biological items, as well as radioactivity and pesticides. The standard is divided into four categories

from I to IV. The most stringent category of I has for example $BOD_5$ of 20 mg/l, while the values of II, III and IV are 50, 150 and 300, respectively.

The effluent standard for wastewater is related to the river water quality. If the river water quality should be maintained within Group B of the Law No. 16/1988 stipulated by the provincial Government of Bali, the category I is applied to discharging wastewater, regardless whether it is treated or not. If the river water quality should be maintained within Group C and D, the categories II and III are applied to them, respectively. In the other cases beside the above-mentioned ones, the category IV is applied to wastewater discharges, though this seems to be a very rare case.

MENKLH (State Ministry of Population and Environment) developed the industrial wastewater standards for 14 types of industrial in the Law of Standard Wastewater Quality for Operating Activities (KEP-03/MENKLH/II/1991) as follows :

a. Caustic soda
b. Metal coating
c. Leather
d. Oil palm
e. Pulp and paper
f. Rubber
g. Sugar
h. Tapioca
i. Textile
j. Urea fertilizer
k. Ethanol
l. Mono sodium glutamate
m. Wood

The law describes the maximum limits of major parameters and maximum pollution loads of those parameters proportional to the production amount for the industry.

For those industries beside the 14 industries described by the law the Effluent Standards of Wastewater Quality (No.16/1988 Governor of Bali Province) will be applied.

Among those listed above, the industries existing in the Study Area are basically c, f, h, i and n. The effluent standards for those industries are shown in Table B.8.6(1) to (5). These standards are considered to be achievable by using Best Practicable Technology (BPT), and are minimum requirements for existing industries.

According to the law, covered industries must be samples and analyze them periodically but at least once a month and report the results to the authority periodically but at least once in six (6) months.

Table B.1.1 Catchment Area and Length of River

| River | Catchement Area within Study Area (km2) | River Length within Study Area (km) |
|---|---|---|
| Yeh Ayung | 13.6 | 9.3 |
| Main | 8.7 | 5.9 |
| Pengegeh | 4.9 | 3.4 |
| Badung | 44.9 | 12.4 |
| Main | 37.4 | 10.0 |
| Oongan | 7.5 | 2.4 |
| Abian Base | 3.1 | 3.2 |
| Loloan | 12.3 | 5.0 |
| Punggawa | 9.8 | 5.4 |
| Rangda | 13.3 | 4.5 |
| Mati | 43.2 | 19.2 |
| Main | 32.6 | 11.5 |
| Teba | 10.6 | 7.7 |
| Sama | 21.7 | 4.0 |
| Total | 161.9 | 63.0 |

Table B.2.1 (1) Monthly River Discharge and Intake Volume

River : Ayung

Intake Site : Mambal ( No. 1 )

River Discharge (Before Intake) Unit : m3/s

| | 1986 | 1987 | 1988 | 1989 | 1990 | Average |
|---|---|---|---|---|---|---|
| Jan. | 9.050 | 7.941 | 5.151 | 4.520 | 9.223 | 7.177 |
| Feb. | 10.121 | 6.332 | 6.264 | 5.259 | 7.275 | 7.050 |
| Mar. | 11.187 | 5.144 | 5.846 | 6.636 | 6.285 | 7.020 |
| Apr. | 10.565 | 4.816 | 4.732 | 5.683 | 5.587 | 6.277 |
| May | 6.969 | 5.540 | 5.401 | 3.714 | 5.548 | 5.434 |
| Jun. | 7.841 | 5.808 | 4.379 | 4.792 | 5.168 | 5.598 |
| Jul. | 7.048 | 5.673 | 4.534 | 5.305 | 5.191 | 5.550 |
| Aug. | 5.481 | 4.972 | 4.380 | 5.004 | 5.231 | 5.014 |
| Sep. | 4.523 | 4.165 | 5.113 | 3.855 | 4.561 | 4.443 |
| Oct. | 5.265 | 4.673 | 3.899 | 4.994 | 4.933 | 4.753 |
| Nov. | 6.794 | 4.891 | 4.128 | 4.608 | 4.609 | 5.006 |
| Dec. | 6.955 | 6.600 | 4.613 | 7.276 | 5.893 | 6.267 |
| Average | 7.650 | 5.546 | 4.870 | 5.137 | 5.792 | 5.799 |

Intake Volume Unit : m3/s

| | 1986 | 1987 | 1988 | 1989 | 1990 | Average |
|---|---|---|---|---|---|---|
| Jan. | 4.749 | 5.249 | 4.215 | 3.274 | 4.605 | 4.418 |
| Feb. | 4.820 | 4.225 | 4.237 | 3.463 | 4.387 | 4.226 |
| Mar. | 5.428 | 3.908 | 4.013 | 4.070 | 4.141 | 4.312 |
| Apr. | 5.157 | 3.684 | 3.694 | 4.665 | 4.106 | 4.261 |
| May | 4.475 | 3.840 | 3.654 | 2.933 | 4.074 | 3.795 |
| Jun. | 3.723 | 3.905 | 3.463 | 3.462 | 3.881 | 3.687 |
| Jul. | 3.312 | 3.596 | 3.511 | 3.724 | 3.859 | 3.600 |
| Aug. | 4.032 | 3.585 | 3.236 | 3.167 | 3.825 | 3.569 |
| Sep. | 3.215 | 3.005 | 3.224 | 2.777 | 3.527 | 3.150 |
| Oct. | 3.606 | 3.381 | 2.875 | 2.918 | 3.558 | 3.268 |
| Nov. | 3.123 | 3.234 | 2.852 | 3.158 | 3.324 | 3.138 |
| Dec. | 4.528 | 4.280 | 3.024 | 4.227 | 3.856 | 3.983 |
| Average | 4.181 | 3.824 | 3.500 | 3.487 | 3.929 | 3.784 |

Table B.2.1 (2) Monthly River Discharge and Intake Volume

River : Ayung

Intake Site : Peraupan ( No.2 )

River Discharge (Before Intake) Unit : m3/s

| | 1986 | 1987 | 1988 | 1989 | 1990 | Average |
|---|---|---|---|---|---|---|
| Jan. | 5.485 | 5.702 | 3.078 | 4.106 | 6.227 | 4.920 |
| Feb. | 7.254 | 2.920 | 3.017 | 5.355 | 6.009 | 4.911 |
| Mar. | 5.836 | 2.354 | 2.891 | 7.454 | 10.001 | 5.707 |
| Apr. | 6.422 | 1.672 | 2.136 | 3.252 | 4.500 | 3.596 |
| May | 2.301 | 1.676 | 3.451 | 2.275 | 4.208 | 2.782 |
| Jun. | 3.228 | 1.557 | 1.772 | 3.518 | 2.994 | 2.614 |
| Jul. | 3.941 | 1.657 | 2.364 | 2.076 | 3.113 | 2.630 |
| Aug. | 1.466 | 1.329 | 2.951 | 3.352 | 2.370 | 2.294 |
| Sep. | 1.464 | 1.060 | 1.724 | 1.978 | 1.748 | 1.595 |
| Oct. | 1.754 | 1.155 | 1.540 | 3.354 | 1.528 | 1.866 |
| Nov. | 3.317 | 2.737 | 3.156 | 2.664 | 1.700 | 2.715 |
| Dec. | 1.892 | 4.281 | 3.844 | 6.138 | 3.453 | 3.922 |
| Average | 3.697 | 2.342 | 2.660 | 3.794 | 3.988 | 3.296 |

Intake Volume Unit : m3/s

| | 1986 | 1987 | 1988 | 1989 | 1990 | Average |
|---|---|---|---|---|---|---|
| Jan. | 0.474 | 0.313 | 0.380 | 0.390 | 0.649 | 0.441 |
| Feb. | 0.649 | 0.426 | 0.408 | 0.440 | 0.801 | 0.545 |
| Mar. | 0.530 | 0.353 | 0.395 | 0.726 | 0.814 | 0.564 |
| Apr. | 0.505 | 0.380 | 0.401 | 0.819 | 0.853 | 0.592 |
| May | 0.479 | 0.398 | 0.409 | 0.808 | 0.841 | 0.587 |
| Jun. | 0.448 | 0.401 | 0.398 | 0.826 | 0.816 | 0.578 |
| Jul. | 0.516 | 0.395 | 0.154 | 0.793 | 0.826 | 0.537 |
| Aug. | 0.380 | 0.393 | 0.393 | 0.806 | 0.800 | 0.554 |
| Sep. | 0.272 | - | 0.398 | 0.790 | 0.803 | 0.566 |
| Oct. | 0.377 | - | 0.399 | 0.787 | 0.645 | 0.552 |
| Nov. | 0.346 | - | 0.398 | 0.775 | 0.607 | 0.532 |
| Dec. | 0.357 | 0.415 | 0.390 | 0.773 | 0.804 | 0.548 |
| Average | 0.444 | 0.386 | 0.377 | 0.728 | 0.772 | 0.550 |

Table B.2.1 (3) Monthly River Discharge and Intake Volume

River : Ayung

Intake Site : Oongan ( No.3 )

River Discharge (Before Intake) Unit : m3/s

| | 1986 | 1987 | 1988 | 1989 | 1990 | Average |
|---|---|---|---|---|---|---|
| Jan. | 7.861 | 4.709 | 4.320 | 4.074 | 4.663 | 5.125 |
| Feb. | 8.914 | 2.970 | 3.000 | 7.443 | 5.050 | 5.475 |
| Mar. | 7.748 | 1.882 | 3.186 | 9.144 | 7.333 | 5.859 |
| Apr. | 8.219 | 1.271 | 1.600 | 4.277 | 4.411 | 3.956 |
| May | 3.297 | 1.677 | 4.166 | 2.962 | 4.393 | 3.299 |
| Jun. | 4.888 | 2.230 | 1.819 | 2.831 | 2.563 | 2.866 |
| Jul. | 5.071 | 2.081 | 2.313 | 1.860 | 2.532 | 2.771 |
| Aug. | 1.637 | 1.329 | 2.614 | 3.515 | 2.029 | 2.225 |
| Sep. | 1.763 | 1.482 | 1.620 | 1.897 | 1.518 | 1.656 |
| Oct. | 2.011 | 1.547 | 1.399 | 2.593 | 0.831 | 1.676 |
| Nov. | 3.659 | 2.170 | 3.022 | 2.111 | 3.121 | 2.817 |
| Dec. | 2.486 | 5.054 | 3.251 | 5.485 | 3.623 | 3.980 |
| Average | 4.796 | 2.367 | 2.692 | 4.016 | 3.506 | 3.475 |

Intake Volume Unit : m3/s

| | 1986 | 1987 | 1988 | 1989 | 1990 | Average |
|---|---|---|---|---|---|---|
| Jan. | 5.107 | 2.488 | 2.183 | 3.412 | 3.367 | 3.311 |
| Feb. | 4.727 | 2.359 | 2.345 | 5.101 | 3.491 | 3.605 |
| Mar. | 5.886 | 1.829 | 2.787 | 3.773 | 3.836 | 3.622 |
| Apr. | 4.992 | 1.271 | 1.487 | 3.278 | 3.665 | 2.939 |
| May | 2.791 | 1.565 | 3.345 | 2.627 | 2.675 | 2.601 |
| Jun. | 2.883 | 1.939 | 1.773 | 3.472 | 2.056 | 2.425 |
| Jul. | 3.060 | 1.880 | 2.199 | 1.765 | 2.026 | 2.186 |
| Aug. | 1.581 | 1.329 | 1.648 | 1.472 | 1.823 | 1.571 |
| Sep. | 1.674 | 2.901 | 1.601 | 1.604 | 1.498 | 1.856 |
| Oct. | 1.836 | 1.380 | 1.399 | 1.641 | 1.723 | 1.596 |
| Nov. | 2.192 | 0.850 | 2.439 | 1.408 | 1.817 | 1.741 |
| Dec. | 2.051 | 1.988 | 2.750 | 3.536 | 2.772 | 2.619 |
| Average | 3.232 | 1.815 | 2.163 | 2.757 | 2.562 | 2.506 |