

INTERNATIONAL CENTER FOR THE STUDY OF  
THE DEVELOPMENT OF THE PUBLIC ADMINISTRATION  
IN THE TROPICAL AREAS

THE DEVELOPMENT STUDY  
ON  
MANAGEMENT OF LOCAL GOVERNMENTS

REPORT NUMBER  
MASTER PLAN STUDY

JANUARY 1981

INTERNATIONAL CENTER FOR THE STUDY OF  
THE DEVELOPMENT OF THE PUBLIC ADMINISTRATION  
IN THE TROPICAL AREAS

1981



JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)  
MINISTRY OF PUBLIC WORKS  
THE GOVERNMENT OF THE REPUBLIC OF INDONESIA

THE DEVELOPMENT STUDY  
ON  
WASTEWATER DISPOSAL FOR DENPASAR

SUPPORTING REPORT I  
MASTER PLAN STUDY

JICA LIBRARY



1102662121

24607

JANUARY 1993

PACIFIC CONSULTANTS INTERNATIONAL

国際協力事業団

24607

## TABLE OF CONTENTS

	Page
Table of Contents .....	i
List of Tables .....	vii
List of Figures .....	xii
<b>APPENDIX A      STUDY AREA</b>	
1.      Administrative Area .....	A - 1
2.      Population .....	A - 1
2.1 Existing Population .....	A - 1
2.2 Future Population .....	A - 2
3.      Land Use .....	A - 5
3.1 Existing Land Use .....	A - 5
3.2 Future Land Use .....	A - 7
4.      Economy .....	A - 10
4.1 GRDP .....	A - 10
4.2 People's Income Level .....	A - 12
5.      Tourism .....	A - 14
5.1 Existing Tourism (1990) .....	A - 14
5.2 Future Tourism (2010) .....	A - 16
6.      Climate, Topography and Geology .....	A - 17
6.1 Climate .....	A - 17
6.2 Topography .....	A - 19
6.3 Geology .....	A - 20

## APPENDIX B WATER ENVIRONMENTS

1.	River Networks .....	B - 1
2.	River Water Quality and Use .....	B - 2
2.1	River Discharge .....	B - 2
2.2	River Water Quality .....	B - 4
2.3	Existing Water Quality by Section .....	B - 5
2.4	Existing Water Use by Section .....	B - 13
3.	Sea Water Quality and Use .....	B - 18
3.1	Observed Water Quality .....	B - 18
3.2	Existing Water Quality by Area .....	B - 19
3.3	Existing Water Use by Area .....	B - 23
3.4	Existing Coral Life .....	B - 25
4.	Sea Current .....	B - 26
4.1	General Characteristics of Oceanography .....	B - 26
4.2	Sea Bed Topography .....	B - 27
4.3	Observed Sea Currents .....	B - 27
5.	Groundwater Quality and Use .....	B - 29
5.1	Groundwater Table .....	B - 29
5.2	Groundwater Quality .....	B - 29
5.3	Groundwater Use .....	B - 31
6.	Soil Permeability .....	B - 31
6.1	Observed Permeability .....	B - 31
7.	Water-Borne Disease .....	B - 33
7.1	Results of Sampling Questionnaire Survey .....	B - 33
7.2	Statistical Data .....	B - 35
8.	Water Quality Standards .....	B - 36
8.1	General .....	B - 36
8.2	River Water Quality Standards .....	B - 37
8.3	Sea Water Quality Standards .....	B - 38
8.4	Effluent Standards of Wastewater .....	B - 39

## APPENDIX C POLLUTION LOAD GENERATION

1.	Water Consumption .....	C - 1
1.1	PDAM and BTDC Water Supply .....	C - 1
1.2	Domestic Water Consumption.....	C - 2
1.3	Commercial and Institutional Water Consumption .....	C - 3
1.4	Tourism Water Consumption .....	C - 4
1.5	Industrial Water Consumption .....	C - 7
2.	Unit Pollution Load .....	C - 8
2.1	Domestic Wastewater .....	C - 8
2.2	Commercial and Institutional Waste .....	C - 12
2.3	Tourism Wastes .....	C - 12
2.4	Industrial Wastes .....	C - 13
3.	Generated Pollution Load .....	C - 14
3.1	Domestic Pollution Load .....	C - 14
3.2	Commercial and Institutional Pollution Load .....	C - 15
3.3	Tourism Pollution Load .....	C - 15
3.4	Industrial Pollution Load .....	C - 16
3.5	Total Pollution Load .....	C - 17

## APPENDIX D EXISTING SANITATION AND SEWERAGE PROJECTS AND FACILITIES

1.	Existing On-site Sanitation Facilities .....	D - 1
1.1	Domestic On-site Sanitation Facilities .....	D - 1
1.2	On-site Sanitation Facilities of Commerce and Institution .....	D - 3
1.3	Desludging and Treatment .....	D - 4
2.	Related Existing Drainage Network .....	D - 12
2.1	Condition of Existing Road Side Ditch .....	D - 12
2.2	Flood in the Study Area .....	D - 13
3.	Existing Sewerage Facilities .....	D - 14
3.1	Sewer System .....	D - 15
3.2	Treatment Plant .....	D - 15

3.3	Operation and Maintenance .....	D - 16
4.	On-going Sanitation and Sewerage Project .....	D - 18
4.1	East Java and Bali Urban Development Project .....	D - 18
4.2	Human Waste Disposal of Kabupaten Badung .....	D - 21
4.3	Kuta Sewerage Project .....	D - 22
5.	Related On-going Projects .....	D - 24
5.1	Water Supply Project of PDAM .....	D - 24
5.2	Estuary Reservoir Project .....	D - 25
5.3	Taman Hutan Raya (Great Forest Park) Project .....	D - 27

## **APPENDIX E WASTEWATER DISPOSAL DEVELOPMENT**

1.	Simulation of River and Sea Water Quality .....	E - 1
1.1	Simulation of River Water Quality .....	E - 1
1.2	Simulation of Sea Water Quality .....	E - 7
2.	Zoning of Wastewater Disposal System .....	E - 17
2.1	Target of Wastewater Disposal Development .....	E - 17
2.2	General Zoning Principle of Wastewater Disposal System .....	E - 20
2.3	Wastewater Disposal System for Central and Southern Denpasar .....	E - 21
2.4	Wastewater Disposal System of Resort Area .....	E - 29
2.5	Wastewater Disposal in Other Areas .....	E - 34
2.6	Total Wastewater Disposal System .....	E - 36
3.	Potential Sites for Sewage Treatment Plant .....	E - 37
4.	Alternative Studies of Sewerage Development System.....	E - 38
4.1	General .....	E - 38
4.2	Design Wastewater Discharge .....	E - 39
4.3	Sewage Collection System .....	E - 39
4.4	Force Main .....	E - 40
4.5	Sewage Treatment Plant .....	E - 40
4.6	Estimated Cost .....	E - 41
4.7	Comparative Evaluation .....	E - 45



5.	Proposed Sewerage Development Plan .....	E - 46
5.1	Wastewater Collection System .....	E - 46
5.2	Denpasar Sewerage Development .....	E - 50
5.3	Kuta Sewerage Development .....	E - 56
5.4	Sanur Sewerage Development .....	E - 59
5.5	Tanjung Benoa Sewerage Development .....	E - 62
5.6	Treatment Plant .....	E - 65
6.	Proposed On-site Sanitation Development Plan .....	E - 78
6.1	Septic Tank with Up-flow Filter .....	E - 78
6.2	Septic Tank with Leaching Pit .....	E - 84
6.3	Desludging and Treatment .....	E - 85
7.	Estimated Cost .....	E - 86
7.1	Project Cost .....	E - 86
7.2	Operation and Maintenance Cost .....	E - 87

## APPENDIX F PROJECT EVALUATION

1.	Economic and Social Evaluation .....	F - 1
1.1	Reduction of Water-Borne Disease .....	F - 1
1.2	Increase of Tourism Income .....	F - 2
1.3	Others .....	F - 6
2.	Financial Evaluation .....	F - 7
2.1	People's Willingness to Pay .....	F - 7
2.2	Estimated Allocable Budget of Government .....	F - 10

## APPENDIX G SUPPLEMENTARY STUDY

1.	Introduction .....	G - 1
1.1	Background .....	G - 1
1.2	Purpose of the Guidelines .....	G - 2
1.3	Users of the Guidelines .....	G - 2
2.	Environmental Protection .....	G - 4
2.1	Water Quality Standards .....	G - 4
2.2	Water Quality Requirements .....	G - 5
3.	Water Consumption .....	G - 8
3.1	Residential Water Consumption .....	G - 8
3.2	Tourism Water Consumption .....	G - 9
4.	Pollution Generation .....	G - 11
4.1	Residential Unit Pollution Load .....	G - 11
4.2	Tourism Unit Pollution Load .....	G - 14
5.	Wastewater Disposal .....	G - 18
5.1	Wastewater Treatment .....	G - 18
5.2	On-site Treatment System .....	G - 19
5.3	Tourism Resort Area (TRA) .....	G - 19
5.4	Tourism Facility Monitoring .....	G - 21
5.5	Sea Water Monitoring .....	G - 22

## LIST OF TABLES

		Page
<b>APPENDIX A</b>	<b>STUDY AREA</b>	
Table A.1.1	Existing Population and Population Density by Kelurahan/Desa in 1990 .....	A - 22
Table A.2.2	Future Population and Population Density by Kelurahan/Desa in 2010 .....	A - 24
Table A.3.1	Existing Land Use Condition by Kelurahan/Desa in 1989 .....	A - 26
Table A.3.2	Future Land Use Condition by Kelurahan/Desa in 2010 .....	A - 28
Table A.3.3	Existing and Future Land Use Pattern by Kecamatan .....	A - 30
Table A.4.1	Gross Regional Domestic Product (GRDP) by Sector and Per Capita GRDP of the Study Area in 1990 and 2010 .....	A - 31
Table A.4.2	Definition of Income Classes by Type of Houses .....	A - 32
Table A.4.3	Composition of Population by Income Class in 1991 .....	A - 33
Table A.4.4	Per Capita Per Month Income by Kelurahan/Desa in 1991 .....	A - 35
Table A.4.5	Composition of Population by Income Class in 2010 .....	A - 36
Table A.4.6	Per Capita Per Month Income by Kelurahan/Desa in 2010 .....	A - 38
Table A.5.1	Projection of Tourist Arrivals in Bali .....	A - 39
Table A.5.2	Projection of No. of International and Domestic Tourists Coming to Bali .....	A - 40
Table A.5.3	Projection of No. of Tourists to Stay in the Study Area by Class of Accommodations .....	A - 41
Table A.5.4	Projection of No. of Rooms to be Occupied by Tourists in the Study Area by Class of Accommodations .....	A - 42
Table A.5.5	Projection of Room Nights to be Realized by Tourists in the Study Area by Class of Accommodations .....	A - 43
Table A.5.6	Projection of Room Occupancy Rate in the Study Area by Class of Accommodations .....	A - 44
Table A.5.7	Projection of Bed Nights to be Realized by Tourists in the Study Area by Class of Accommodations .....	A - 45
Table A.5.8	Projection of Tourists' Expenditures in the Study Area by Class of Accommodations .....	A - 46
Table A.6.1	Temperature, Humidity and Rainfall of the Study Area .....	A - 47

## APPENDIX B WATER ENVIRONMENTS

Table B.1.1	Catchment Area and Length of River .....	B - 42
Table B.2.1	Monthly River Discharge and Intake Volume .....	B - 43
Table B.2.2	Average Monthly River Discharge .....	B - 49
Table B.2.3	Observed River Discharge by JICA .....	B - 50
Table B.2.4	River Water Quality in August, 1987 .....	B - 51
Table B.2.5	River Water Quality in December, 1987 .....	B - 52
Table B.2.6	Observed River Water Quality by JICA in Dry Season .....	B - 54
Table B.2.7	Observed River Water Quality by JICA in Rainy Season .....	B - 55
Table B.2.8	Color and Smell of River Water by Kelurahan/Desa .....	B - 56
Table B.2.9	Color and Smell of River Water by River .....	B - 58
Table B.2.10	Uses of Rivers by Kelurahan/Desa .....	B - 60
Table B.2.11	Uses of Rivers by River .....	B - 63
Table B.2.12	Average Monthly Intake Volume by Season by Intake Site .....	B - 66
Table B.3.1	Sea Water Quality in December, 1987 .....	B - 67
Table B.3.2	Sea Water Quality by JICA in June, 1988 .....	B - 67
Table B.3.3	Observed Sea Water Quality by JICA in 1991 .....	B - 68
Table B.3.4	Observed Sea Water Quality by JICA in 1992 .....	B - 70
Table B.3.5	Observed Sea Water Quality by JICA in 1991 .....	B - 72
Table B.3.6	Production of Fish in Badung 1985 to 1989 .....	B - 73
Table B.3.7	Values of Fish Produced in Badung 1985 to 1989 .....	B - 74
Table B.3.8	Number of Households Engaged in Fisheries in Badung 1985 to 1989 .....	B - 75
Table B.3.9	Production and Values of Salt Produced by Salt Farming in Badung 1985 - 1991 .....	B - 76
Table B.4.1	Principal Tidal Constituents .....	B - 77
Table B.5.1	Observed Groundwater Table and Quality by JICA in November, 1991 .....	B - 78
Table B.5.2	Groundwater Quality in December, 1987 .....	B - 81
Table B.5.3	Integrated Pollution Index of Groundwater .....	B - 82
Table B.5.4	Existing Condition of Groundwater Use .....	B - 84
Table B.6.1	Observed Permeability by JICA in January, 1992 .....	B - 86
Table B.7.1	Contraction Rate of Water-Borne Diseases per Year .....	B - 87
Table B.7.2	Cases of Water-Borne Diseases Recorded in Public Health Centers in Badung 1988 to 1990 .....	B - 90
Table B.8.1	Laws, Regulations and Others Concerning Environmental Management .....	B - 91

Table B.8.2	River Water Quality Standards in DKI Jakarta (Governor's Decree No.1608, 1988) .....	B - 93
Table B.8.3	Water Quality Standards for Sea .....	B - 96
Table B.8.4	Coastal Sea Water Quality Standards of International Beach Resorts .....	B - 99
Table B.8.5	Effluent Standard for Wastewater .....	B - 100
Table B.8.6	Effluent Quality Standards for Leather Industry .....	B - 102

## APPENDIX C POLLUTION LOAD GENERATION

Table C.1.1	Unit Water Consumption by Household Income Level .....	C - 18
Table C.1.2	Water Consumption by Water Use in PDAM Badung Served Area .....	C - 19
Table C.1.3	Land Use Area Ratio by Water Service District .....	C - 20
Table C.1.4	Unit Water Consumption per Hotel Guest .....	C - 21
Table C.1.5	Unit Water Consumption per Seat of Restaurant .....	C - 22
Table C.1.6	Unit Water Consumption of Factory .....	C - 23
Table C.1.7	Projection of Industrial Production in the Study Area by Type and Size of Industries .....	C - 24
Table C.2.1	Observed Toilet Waste (Without Treatment) .....	C - 25
Table C.2.2	Observed Toilet Waste (With Septic Tank) .....	C - 26
Table C.2.3	Observed Gray Water .....	C - 27
Table C.2.4	Estimated Unit Pollution Load Generation of Domestic Waste .....	C - 28
Table C.2.5	Observed Quality of Commercial and Institutional Wastewater .....	C - 29
Table C.2.6	Observed Wastewater Quality of Hotels .....	C - 30
Table C.2.7	Estimated Unit Pollution Load Generation of Hotel Waste .....	C - 31
Table C.2.8	Observed Wastewater Quality of Restaurants .....	C - 32
Table C.2.9	Estimated Unit Pollution Load Generation of Industrial Waste .....	C - 33
Table C.2.10	Observed Industrial Wastewater .....	C - 34
Table C.3.1	Existing Wastewater Generation by Kelurahan/Desa in 1990 .....	C - 35
Table C.3.2	Existing Pollution Load Generation by Kelurahan/Desa in 1990 .....	C - 37
Table C.3.3	Future Wastewater Generation by Kelurahan/Desa in 2010 .....	C - 39
Table C.3.4	Future Pollution Load Generation by Kelurahan/Desa in 2010 .....	C - 41

**APPENDIX D      EXISTING SANITATION AND SEWERAGE PROJECTS AND FACILITIES**

Table D.1.1	Kelurahan-wise Domestic Sanitation Service Level in the Study Area - 1991.....	D - 29
Table D.1.2	Kelurahan-wise Domestic Sanitation Service Level in the Study Area - 1988 .....	D - 31
Table D.1.3	Existing Service Ratio of Commerce and Institution by Type Sanitation Facility .....	D - 33
Table D.2.1	Survey Results of Flood Area .....	D - 34
Table D.3.1	Operation Results of STP in Nusa Dua .....	D - 35
Table D.4.1	Population and Wastewater in Kel. Kuta .....	D - 36
Table D.4.2	Water Use and Wastewater Disposal in Service Area .....	D - 37
Table D.4.3	Diameter Calculation of Pipes .....	D - 38
Table D.4.4	Depth Calculation of Burried Pipes .....	D - 39
Table D.4.5	Estimated Cost of Kuta Sewerage Project .....	D - 40

**APPENDIX E      WASTEWATER DISPOSAL DEVELOPMENT**

Table E.1.1	Catchment Area and Population of Divided Sub-basin .....	E - 88
Table E.1.2	Existing Wastewater Generation by Sub-Basin .....	E - 89
Table E.1.3	Existing Pollution Load Generation (BOD <sub>5</sub> ) by Sub-Basin .....	E - 91
Table E.1.4	Existing and Future River Water Quality in Dry Season .....	E - 93
Table E.2.1	Estimated Construction and Annual O&M Costs for Two (2) Alternatives .....	E - 95
Table E.2.2	Estimated Construction and O&M Costs for Sewerage and On-site Systems .....	E - 96
Table E.4.1	Break-down of Construction Cost of Each Alternative .....	E - 97
Table E.4.2	Break-down of O/M Cost of Each Alternative Plan .....	E - 99
Table E.5.1	Future Wastewater Generation by Kelurahan/Desa in Denpasar (2010) .....	E - 101
Table E.7.1	Break-down of Construction Cost for Sewerage Development .....	E - 102
Table E.7.2	Unit Basic Construction Cost .....	E - 104
Table E.7.3	Break-down of Project Cost and O&M Cost by Sewerage Development Area .....	E - 105
Table E.7.4	Break-down of Operation and Maintenance Cost .....	E - 106

## APPENDIX F PROJECT EVALUATION

Table F.1.1	Formulas for Estimation of Average Economic Costs per Water-Borne Disease Case .....	F - 14
Table F.1.2	Medical Cost per Patient .....	F - 15
Table F.1.3	Results of Questionnaire for Tourists .....	F - 16
Table F.1.4	Estimation of Benefits .....	F - 18
Table F.2.1	Results of Regression Analysis of Relationships between Household Income/Corporate Sales and Willingness to Pay .....	F - 19
Table F.2.2	Willingness to Pay per Month of Households and Establishments in 1991 .....	F - 20
Total F.2.3	Total Willingness to Pay per Year in 1990 .....	F - 21
Total F.2.4	Total Willingness to Pay per Year in 2010 .....	F - 22
Table F.2.5	Development Budget for Badung 1991/1992 .....	F - 23
Table F.2.6	Development Budget for Badung in Repelita V .....	F - 28
Table F.2.7	Estimation of Budget Allocable for Development of Infrastructure and Related Fields for Study Area .....	F - 31

## APPENDIX G SUPPLEMENTARY STUDY

Table G.2.1	Water Quality Standards for Sea .....	G - 23
Table G.2.2	Coastal Sea Water Quality Standards of International Beach Resorts .....	G - 26
Table G.5.1	Tourism Resort Areas (TRA) in Bali Island .....	G - 27





## LIST OF FIGURES

	Page
<b>APPENDIX A      STUDY AREA</b>	
Fig. A.1.1	Administrative Boundary ..... A - 48
Fig. A.2.1	Existing Population Density by Kelurahan/Desa (1990) ..... A - 49
Fig. A.2.2	Classification of Kelurahan/Desa by Location and Population Density ..... A - 50
Fig. A.2.3	Future Population Density by Kelurahan/Desa (2010) ..... A - 51
Fig. A.3.1	Share of Existing Residential Use by Kelurahan/Desa ..... A - 52
Fig. A.3.2	Share of Existing Commercial & Institutional Use by Kelurahan/Desa ..... A - 53
Fig. A.4.1	Per Capita Per Month Household Income by Kelurahan/Desa in 1991 ..... A - 54
Fig. A.5.1	Projection of Tourist Arrivals in Bali ..... A - 55
Fig. A.6.1	Average Monthly Rainfall Depth and Rainy Days ..... A - 56
Fig. A.6.2	Topographic Map of Study Area ..... A - 57
Fig. A.6.3	Geological Map ..... A - 58
 <b>APPENDIX B      WATER ENVIRONMENTS</b>	
Fig. B.1.1	River Networks in the Study Area ..... B - 105
Fig. B.2.1	Irrigation Intake Site and Commanding Area ..... B - 106
Fig. B.2.2	Average Monthly River Discharge ..... B - 107
Fig. B.2.3	Discharge Measurement Sites by JICA ..... B - 109
Fig. B.2.4	River Water Quality Observation Point ..... B - 110
Fig. B.2.5	River Water Quality Observation Point by JICA (1991~1992).. B - 111
Fig. B.2.6	Observed River Water Quality by JICA ..... B - 112
Fig. B.2.7	Classification of River Stretches by Water Quality (Dry Season) ..... B - 125
Fig. B.2.8	Classification of River Stretches by Water Quality (Rainy Season) ..... B - 126
Fig. B.2.9	Colour of River Water by Kelurahan/Desa ..... B - 127
Fig. B.2.10	Smell of River Water by Kelurahan/Desa ..... B - 128
Fig. B.2.11	Color and Smell of River Water ..... B - 129
Fig. B.2.12	Distribution of Kelurahan/Desa Where Rivers are Used for Washing/Bathing ..... B - 130

Fig. B.2.13	Distribution of Kelurahan/Desa Where River Water is Used for Agriculture .....	B - 131
Fig. B.2.14	Distribution of Kelurahan/Desa Where Rivers are Used for Wastewater/Refuse Disposal .....	B - 132
Fig. B.2.15	Uses of Rivers .....	B - 133
Fig. B.2.16	Existing Major Water Use by River Section .....	B - 134
Fig. B.3.1	Sea Water Quality Observation Point .....	B - 135
Fig. B.3.2	Sea Water Quality Observation Point by JICA (1991~1992) .....	B - 136
Fig. B.3.3	Observed Sea Water Quality by JICA .....	B - 137
Fig. B.3.4	COD Pollution Distribution in dry season by JICA .....	B - 147
Fig. B.3.5	Distribution of Coral Life .....	B - 149
Fig. B.4.1	Distribution of Off-Shore Currents .....	B - 150
Fig. B.4.2	Tidal Levels in Benoa Harbor .....	B - 151
Fig. B.4.3	Deep Water Waves .....	B - 152
Fig. B.4.4	Distribution of Wave Height and Period at Nusa Dua .....	B - 153
Fig. B.4.5	Sea Bottom Topography in Study Sea Area .....	B - 154
Fig. B.4.6	Sea Bottom Topography and Location of Instrument in Sanur .....	B - 155
Fig. B.4.7	Sea Bottom Topography and Location of Instruments in Nusa Dua .....	B - 156
Fig. B.4.8	Past Record on Waves and Currents at Sanur .....	B - 157
Fig. B.4.9	Past Record on Waves and Currents at Nusa Dua .....	B - 158
Fig. B.4.10	Location of Current Meters .....	B - 159
Fig. B.4.11	Tidal Ellipses at ST.A.....	B - 160
Fig. B.5.1	Location of Observed Wells in the Past .....	B - 165
Fig. B.5.2	Location of Observed Groundwater Table and Water Quality by JICA in 1991 .....	B - 166
Fig. B.5.3	Contour of Groundwater Table Depth .....	B - 167
Fig. B.5.4	Location of Observed Groundwater Quality in December, 1987 .....	B - 168
Fig. B.5.5	Observed Groundwater Quality by JICA in 1991 (NH <sub>4</sub> -N) .....	B - 169
Fig. B.5.6	Observed Groundwater Quality by JICA in 1991 (Fecal Coliform) .....	B - 170
Fig. B.5.7	Existing Situation of Groundwater Contamination (Integrated Pollution Index) .....	B - 171
Fig. B.6.1	Soil Infiltration Capacity by Kelurahan/Desa in Previous Study .....	B - 172
Fig. B.6.2	Location of Permeability Test .....	B - 173
Fig. B.6.3	Soil Infiltration Capacity by Kelurahan/Desa .....	B - 174

## APPENDIX C POLLUTION LOAD GENERATION

Fig. C.1.1	Water Service Area of PDAM .....	C - 43
Fig. C.1.2	Relation between Water Consumption and Land Use Ratios .....	C - 44
Fig. C.2.1	Sampling Location of Unit Pollution Load Generation .....	C - 45
Fig. C.3.1	Existing Specific Wastewater Generation .....	C - 46
Fig. C.3.2	Future Specific Wastewater Generation.....	C - 47
Fig. C.3.3	Existing Specific Pollution Load Generation .....	C - 48
Fig. C.3.4	Future Specific Pollution Load Generation .....	C - 49

## APPENDIX D EXISTING SANITATION AND SEWERAGE PROJECTS AND FACILITIES

Fig. D.1.1	Ratio of Population Having Toilet with Treatment .....	D - 41
Fig. D.1.2	Location of Desludging Organization and Sludge Disposal .....	D - 42
Fig. D.2.1	Existing Drainage Condition Observed Area by JICA .....	D - 43
Fig. D.2.2	Classification of Existing Road Side Ditch .....	D - 44
Fig. D.2.3	Wastewater Observed Ditch .....	D - 47
Fig. D.2.4	Observed Wastewater Flow Direction in Ditches .....	D - 50
Fig. D.2.5	Distribution Flood Area .....	D - 52
Fig. D.3.1	Nusa Dua Tourist Resort .....	D - 53
Fig. D.3.2	Sewerage System of BTDC in Nusa Dua .....	D - 54
Fig. D.3.3	Bali Airport Sewerage System .....	D - 55
Fig. D.3.4	BTDC Sewage Treatment Plant (Lagoon) .....	D - 56
Fig. D.3.5	Facultative Aerated Lagoon (Bali Airport) .....	D - 57
Fig. D.4.1	Location of Human Waste Disposal Site .....	D - 58
Fig. D.4.2	Human Waste Disposal Plant .....	D - 59
Fig. D.4.3	Location of Kuta Sewerage Project .....	D - 60
Fig. D.4.4	Plan of Trunk Sewers in Kuta .....	D - 61
Fig. D.5.1	Location of Estuary Reservoir .....	D - 62
Fig. D.5.2	Layout of Proposed Estuary Reservoir Project .....	D - 63
Fig. D.5.3	Mangrove Forest Park Project (Tahura) .....	D - 64

APPENDIX E

WASTEWATER DISPOSAL DEVELOPMENT

Fig. E.1.1	Division of Objective River Basin .....	E - 107
Fig. E.1.2	Model of River System .....	E - 108
Fig. E.1.3	Simulated Future River Water Quality .....	E - 109
Fig. E.1.4	Comparison between Finite Element Method and Finite Difference Method .....	E - 111
Fig. E.1.5	Flow Chart of Simulation of Sea Water Quality .....	E - 112
Fig. E.1.6	Coordinate System and Boundary Conditions of Diffusion Model .....	E - 113
Fig. E.1.7	Simulation Area for Sea Water Quality .....	E - 114
Fig. E.1.8	Distribution of Finite Elements .....	E - 115
Fig. E.1.9	Contour Map of Depth .....	E - 116
Fig. E.1.10	Tidal Velocity in Flood Tide .....	E - 117
Fig. E.1.11	Tidal Velocity in EBB Tide .....	E - 118
Fig. E.1.12	Tidal Ellipses in Study Area .....	E - 119
Fig. E.1.13	Tidal Elevation Changes .....	E - 120
Fig. E.1.14	COD Pollution Loads (Existing).....	E - 121
Fig. E.1.15	COD Distribution in Dry Season (Existing) .....	E - 122
Fig. E.1.16	COD Distribution in Rainy Season (Existing) .....	E - 123
Fig. E.1.17	COD Pollution Loads (Future) - without Project.....	E - 124
Fig. E.1.18	COD Distribution in Dry Season (Future) - without Project.....	E - 125
Fig. E.1.19	COD Distribution in Rainy Season (Future) - without Project.....	E - 126
Fig. E.2.1	Existing Status of Graywater Management .....	E - 127
Fig. E.2.2	Sewerage Development Area .....	E - 128
Fig. E.2.3	Simulated River Water Quality by Sewerage System Only of Case-I .....	E - 129
Fig. E.2.4	Simulated River Water Quality by Sewerage System Only of Case-II .....	E - 131
Fig. E.2.5	Simulated River Water Quality by Sewerage System Only of Case-III .....	E - 133
Fig. E.2.6	Septic Tank with Up-flow Filter .....	E - 135
Fig. E.2.7	Combination of Sewerage and On-site System .....	E - 136
Fig. E.2.8	Simulated River Water Quality by Combination of Sewerage and On-site System .....	E - 137
Fig. E.2.9	COD Pollution Loads (Future) - with Project.....	E - 139
Fig. E.2.10	COD Distribution in Dry Season (Future) - with Project.....	E - 140
Fig. E.2.11	COD Distribution in Rainy Season (Future) - with Project.....	E - 141

Fig. E.2.12	Household Package Treatment Plant .....	E - 142
Fig. E.2.13	Sewerage System Development Area (Resort Area) .....	E - 143
Fig. E.2.14	Zoning of Wastewater Disposal System Development .....	E - 144
Fig. E.3.1	Existing Land Use of Benoa Bay .....	E - 145
Fig. E.3.2	Proposed Zoning of Benoa Bay by Ministry of Forestry .....	E - 146
Fig. E.3.3	Potential Area of Treatment Plant .....	E - 147
Fig. E.4.1	Individual Treatment System .....	E - 148
Fig. E.4.2	Partially Integrated Treatment System .....	E - 149
Fig. E.4.3	Integrated Treatment System .....	E - 150
Fig. E.5.1	Proposed Sewerage Development Plan .....	E - 151
Fig. E.5.2	Sewerage Development Plan in Denpasar .....	E - 152
Fig. E.5.3	Sewerage Development Plan in Kuta .....	E - 153
Fig. E.5.4	Sewerage Development Plan in Sanur .....	E - 154
Fig. E.5.5	Sewerage Development Plan in Tanjung Benoa .....	E - 155
Fig. E.5.6	Location of Alternative Treatment Plants .....	E - 156
Fig. E.5.7	Layout of Alternative Treatment Plant (Aerated Lagoon).....	E - 157
Fig. E.5.8	Layout of Alternative Treatment Plant (Conventional Activated Sludge).....	E - 158
Fig. E.5.9	Layout of Alternative Treatment Plant (Oxidation Ditch).....	E - 159
Fig. E.6.1	Proposed On-site Development Area .....	E - 160
Fig. E.6.2	Septic Tank with Up-flow Filter .....	E - 161

## APPENDIX G SUPPLEMENTARY STUDY

Fig. G.1.1	Tourism Development Zone in Bali .....	G - 28
------------	--	--------



*APPENDIX A*

*STUDY AREA*





## APPENDIX A STUDY AREA

### 1. Administrative Area

The Study Area of approximately 237 km<sup>2</sup> consists of three (3) districts (Kecamatan) of West Denpasar (Denpasar Barat), East Denpasar (Denpasar Timur) and South Denpasar (Denpasar Selatan), and a part of Kuta district. The Study Area is further divided into 50 sub-districts (Kelurahan/Desa).

The Number of Kelurahan/Desa and land area covered by the respective Kecamatan of the Study Area are shown below.

Kecamatan	Nos. of Kelurahan/Desa	Area(ha)
Denpasar Barat	18	5,006
Denpasar Timur	15	2,773
Denpasar Selatan	10	4,619
Kuta	7	11,255
Total	50	23,653

The administrative boundaries of the Kecamatan and Kelurahan/Desa of the Study Area are shown in Fig. A.1.1.

### 2. Population

#### 2.1 Existing Population

Denpasar and Kuta have been undergoing a rapid population increase in the recent years. According to the national population census and mid-term census, the population of Denpasar and Kuta have increased from 256,363 in 1975 to 330,325 in 1980, 356,264 in 1985 and 477,437 in 1990 with an average annual growth rate of 4.2%.

While the registered population of the Study Area in 1990 is 394,600 and is 82,837 different from the census population.

The existing population of the Study Area is determined to be 477,437 based on the discussion with CIPTA KARYA and BAPPEDA Badung.

The average population density of the Study Area in 1990 is 20.2 person/ha. The population density by Kelurahan/Desa ranges from 3.9 person/ha in Jimbaran to 269.7 person/ha in Tegal Kerta. The number of Kelurahan/Desa by population density distribution is shown below.

Population Density (person/ha)	Nos. of Kelurahan/Desa
More than 201	2
151 ~ 200	1
101 ~ 150	5
51 ~ 100	10
11 ~ 50	24
Less than 10	8
Total	50

The existing population and population density by Kelurahan/Desa are shown in Table A.2.1. The regional distribution of the existing population density by Kelurahan/Desa is shown in Fig. A.2.1. The population density of residential area ( hereinafter referred to as "net population density" ) in 1990 by Kelurahan/Desa is also shown in Table A.2.1 accompanied with the existing residential area.

## 2.2 Future Population

The future population of four (4) Kecamatan of Denpasar Barat, Denpasar Timur, Denpasar Selatan and Kuta was estimated by the several previous studies. The highest future population projection of 980,567 in the year 2010 with the annual growth rate of 3.9% was made by the Denpasar Water Supply Master Plan. While the lowest of 630,355 with the annual growth rate of 2.0% was proposed by Integrated Urban Infrastructure

Development Projects (IUIDP). And the annual growth rate of 2.0% was recently accepted by the local government of Bali for the projection of future population in Denpasar and Kuta.

The JICA Study Team estimates the future population of the Study Area in 2010 by assuming the annual growth rate of 2.0% and the total population of the Study Area becomes 709,300.

The above total future population of the Study Area is allocated to each Kelurahan/Desa based on the future land use plan of Denpasar in the year 2009 covering three (3) Kecamatans of Denpasar Barat, Denpasar Timur and Denpasar Selatan. This land use plan was prepared by BAPPEDA of Badung and CIPTA KARYA in 1989. In this land use plan, Kelurahan/Desa of Denpasar are classified into the following three (3) groups.

Group A : Kelurahan/Desa located in the central part of Denpasar are classified in this group. The future net population density in the residential area of Kelurahan/Desa in this group is planned to be about 300 person/ha.

Group B : Kelurahan/Desa located at the fringe of Group A are classified in this group. The future net population density in the residential area is planned between 150 person/ha and 300 person/ha.

Group C : Kelurahan/Desa located in the out skirt area of the Study Area are classified in this Group C. The future net population density is proposed at less than 150 person/ha.

Moreover, it is assumed that land of each Kelurahan/Desa in all the groups will be developed for residential use up to 60% of the total area in this land use plan.

However, 60% is considered too large for the Kelurahan/Desa of Group B and Group C in view of their existing land use condition. The JICA Study Team proposes 30% for Group B and 15% for Group C.

In this JICA Study, Kelurahan/Desa of Kec. Kuta are incorporated into Group C, considering their location, existing population density and land use patterns.

Grouping of Kelurahan/Desa in the Study Area is shown below.

Group A : Dauh Puri, Dauh Puri Kaja, Dauh Puri Kauh, Dauh Puri Kangin, Dauh Puri Kelod, Pemecutan, Tegal Kerta, Tegal Harum, Dangin Puri, Dangin Puri Kauh, Dangin Puri Kaja, Dangin Puri Kangin, Dangin Puri Kelod, Sumerta Kauh, Sumerta Kaja.

Group B : Pemecutan Kaja, Pemecutan Kelod, Padang Sambian, Sumerta Kelod, Kesiman, Kesiman petilan, Kesiman Kertalangu, Tonja, Sanur Kaja, Sanur, Renon, Panjer, Sesetan, Serangan.

Group C : Peguyangan, Peguyangan Kaja, Peguyangan Kangin, Padang Sambian Kaja, Padang Sambian Kelod, Ubung, Ubung Kaja, Tonja, Penatih, Penatih Dangin Puri, Sanur Kauh, Sidakarya, Pedungan, Pemogan, Dalung, Cangu, Kerobokan, Kuta, Tuban, Jimbaran, Benoa.

Their location are shown in Fig. A.2.2.

Hence, the population of each Kelurahan/Desa in 2010 is firstly projected at the annual growth rate of 2.0% and then, adjusted based on the following conditions.

- (1) If the existing residential area is wider than the estimated one, the existing residential area is considered to remain unaltered and hence the future one.
- (2) The surplus population in excess of the proposed population density are transferred to other Kelurahan/Desa in the same Kecamatan.
- (3) The population do not decrease in any Kelurahan/Desa in future.

The population, population density and net population density in 2010 by Kelurahan/Desa conforming the above conditions are determined as shown in Table A.2.2.

The average population density of the Study Area in 2010 is 30.0 person/ha. The population density by Kelurahan/Desa ranges from 5.8 person/ha to 283.5 person/ha in 2010. The number of Kelurahan/Desa by population density distribution is shown below.

Gross Population Density (person/ha)	Nos. of Kelurahan/Desa
More than 201	2
151 ~ 200	6
101 ~ 150	8
51 ~ 100	6
11 ~ 50	24
Less than 10	4
Total	50

The regional distribution of the future population density by Kelurahan/Desa is shown in Fig. A.2.3.

### 3. Land Use

#### 3.1 Existing Land Use

The Study Area was divided into three (3) development zones in the previous studies. One consists of three (3) Kecamatan of Denpasar Barat, Denpasar Timur and Denpasar Selatan, and the second is the tourism area of Kec. Kuta and the third is the other areas.

The existing land use map and data for three (3) Kecamatans of Denpasar and the tourism area of Kec. Kuta were prepared by BAPPEDA of Badung and CIPTA KARYA in 1989. The existing land use data for the other areas was prepared by BAPPEDA of Badung in 1989.

In these maps and statistical data, land use of the Study Area is classified into five (5) patterns : (1) residential use (2) commercial and institutional use (3) tourism use (4) industrial use (5) other uses

The area and share of existing land use patterns in 1989 by Kecamatan are shown below.

Land Use	Denpasar Barat		Denpasar Timur		Denpasar Selatan		Kuta	
	Area(ha)	Ratio(%)	Area(ha)	Ratio(%)	Area(ha)	Ratio(%)	Area(ha)	Ratio(%)
Residential	854.3	17.1	579.6	20.9	484.7	10.5	963.2	8.6
Commercial & Institutional	134.2	3.0	122.4	4.4	74.3	1.6	615.1	5.5
Tourism	8.6	0.2	6.3	0.3	86.5	1.9	328.5	2.9
Industry	17.6	0.4	7.6	0.3	18.2	0.4	27.3	0.2
Others	3,991.3	79.3	2,057.1	74.1	3,955.3	85.6	9,320.9	82.8
Total	5,006.0	100.0	2,773.0	100.0	4,619.0	100.0	11,255.0	100.0

The existing land use patterns in 1989 by Kelurahan/Desa are shown in Table A.3.1.

The main features of the existing land use in the Study Area are summarized below.

- (1) Residential area is concentrated in the central part of Denpasar. The share of residential use in Kel. Tegal Kerta and Tegal Harum is higher than 80% as shown in Fig. A.3.1.
- (2) Commercial and institutional areas are concentrated in the central part of Denpasar and Kel. Kuta and Tuban as shown in Fig. A.3.2. The commercial and institutional areas of Kel. Kuta and Tuban include the airport area of 69.4 ha and 222.6 ha respectively.
- (3) Tourism areas of 429.9 ha are located at the three (3) international beaches of Sanur, Kuta and Nusa Dua.
- (4) Total industrial area of 70.7 ha is spreader over the whole Study Area. Most factories in the Study Area are small and domestic ones.

- (5) Other areas covering rice field, dry field and swamp are mainly located at the fringes of the Study Area.

### 3.2 Future Land Use

The following future land use plans are available for the Study Area.

- (1) Future land use plan in the year 2009 for the three (3) Kecamatan of Denpasar Barat, Denpasar Timur and Denpasar Selatan prepared by BAPPEDA of Badung and CIPTA KARYA in 1989
- (2) Future land use plan in the year 2009 for the four (4) Kelurahan of Dalung, Canggu, Kerobokan and Kuta in Kecamatan Kuta prepared by BAPPEDA of Badung and CIPTA KARYA in 1989
- (3) Future land use plan in the year 2010 for the tourism areas of Kelurahan Tuban and Jimbaran in Kecamatan Kuta prepared by BAPPEDA of Badung and CIPTA KARYA in 1987
- (4) Future land use plan in the year 2000 for Kelurahan Benoa in Kecamatan Kuta prepared by CIPTA KARYA in 1980/1981

In this JICA Study, future land use patterns of the Study Area in the year 2010 are estimated by Kelurahan/Desa based on the above future land use plans as described below.

#### (1) Residential Land Use

As discussed in the previous Section 2.2, Kelurahan/Desa of the Study Area are classified into the following three (3) groups in terms of the land development level for residential use.

Group A : Dauh Puri, Dauh Puri Kaja, Dauh Puri Kauh, Dauh Puri Kangin, Dauh Puri Kelod, Pemecutan, Tegal Kerta, Tegal Harum, Dangin Puri, Dangin Puri Kauh, Dangin Puri Kaja, Dangin Puri Kangin, Dangin Puri Kelod, Sumerta, Sumerta Kauh, Sumerta Kaja.

Group B : Pemecutan Kaja, Pemecutan Kelod, Padang Sambian, Sumerta Kelod, Kesiman, Kesiman Petilan, Kesiman Kertalangu, Tonja, Sanur Kaja, Sanur, Renon, Panjer, Sesetan, Serangan.

Group C : Peguyangan, Peguyangan Kaja, Peguyangan Kangin, Padang Sambian Kaja, Padang Sambian Kelod, Ubung, Ubung Kaja, Tonja, Penatih, Penatih Dangin Puri, Sanur Kauh, Sidakarya, Pedungan, Pemogan, Dalung, Cangu, Kerobokan, Kuta, Tuban, Jimbaran, Benoa.

For their location, see Fig. A.2.2.

In Group A, residential area of each Kelurahan/Desa will be developed upto 60% of the total land in 2010. While, the existing land development for residential use exceeds over the proposed limit of 60% in Kel. Pemecutan, Tegal Kerta and Tegal Harum as shown below.

Kel./Desa	Total Area (ha)	Existing Residential Area (ha)	Share (%)
Pemecutan	194.0	118.8	61
Tegal Kerta	24.0	22.4	93
Tegal Harum	26.0	20.8	80

In the above three (3) Kelurahans, it is assumed that residential land use will remain as it is until 2010.

In Group B, 30% of the total land in each Kelurahan/Desa will be used for residential purpose in 2010.

In Group C, 15% of the total land in each Kelurahan/Desa will be allocated to residential use in 2010. While, the existing residential area shares 39% and 19% of the total land in Kel. Ubung and Kel. Kuta respectively, exceeding the proposed future target of 15%. The



existing residential land uses in the above Kelurahan are assumed to last until 2010.

(2) Commercial & Institutional, Tourism and Industrial Land Uses

Commercial & Institutional, tourism and industrial land uses of each Kelurahan/Desa in the year 2010 are assumed to be those proposed in the above four (4) future land use plans.

(3) Other Land Uses

Other land uses cover farm land, fish pond, swamp forestry and other open spaces.

Future land use pattern of each Kelurahan/Desa in 2010 is estimated as shown in Table A.3.2.

The land use patterns in 1989 and 2010 by Kecamatan are summarized in Table A.3.3.

The overall land use patterns of the Study Area in 1989 and 2010 are compared as shown below.

Land Use	1989		2010	
	Area(ha)	Ratio(%)	Area(ha)	Ratio(%)
Residential	2,881.8	(12.2)	5,059.7	(21.4)
Commercial and Institutional	946.0	(4.0)	1,306.7	(5.5)
Tourism	429.9	(1.8)	1,658.8	(7.0)
Industrial	70.7	(0.3)	72.6	(0.3)
Others	19,324.6	(81.7)	15,555.2	(65.8)
<b>Total</b>	<b>23,653.0</b>	<b>(100.0)</b>	<b>23,653.0</b>	<b>(100.0)</b>

Salient features of the future land use in the Study Area are summarized as follows.

- (1) Increase of residential, commercial & institutional and tourism uses in future will be large. While, industrial use will remain as it is. A large area of farm lands, swamps, fish ponds and open spaces will be converted into urban lands. However, rural land use will still be predominant in the fringes of the Study Area. Ratio of urban land use (residential, commercial & institutional, tourism and industrial uses) of the Study Area in 2010 is estimated at approximately 35%.
- (2) Large residential land developments are expected in Kec. Denpasar Selatan and Kec. Kuta. The residential areas of those Kecamatan will both double during 21 years from 1989 to 2010 (See Table A.3.3).
- (3) Future land developments for tourism use will also concentrate in Kec. Kuta. Approximately 90% of the total additional land development for tourism use in the Study Area will appear in this Kecamatan in 2010.
- (4) The most developed areas of the Study Area are located in the central part of Denpasar. Those are the following 10 Kelurahan/Desa.

Central Denpasar : Kel. Dauh Puri, Dauh Puri Kaja, Dauh Puri Kangin, Dauh Puri Kelod, Pemecutan, Tegal Kerta, Tegal Harum, Dangin Puri Kangin, Dangin Puri Kelod

The ratio of urban land use of the above Kelurahan/Desa in 2010 is estimated to be more than 75%.

#### 4. Economy

##### 4.1 GRDP

##### 4.1.1 Existing (1990) GRDP by Sector and per Capita

The gross regional domestic product (GRDP) of the Study Area in 1990 is estimated at Rp. 815,484 million at 1990 prices.

Sector-wise, the Sector of Trade, Hotels and Restaurants has the biggest share of 25.5%. It is followed by the Sector of Transport and

Communications with 20.7% and the Sector of Agriculture with 18.7% (for more details refer to Table A.4.1).

The per Capita GRDP of the Study Area in the same year is calculated at Rp. 1708,045. At the exchange rate of Rp. 1864 per one US dollar it corresponds to US\$ 916.

#### 4.1.2 Future (2010) GRDP by Sector and per Capita

The GRDP of Badung grew at the average annual rate of 11.1% from 1983 to 1989. The government of Badung projected the average annual economic growth rate of 8.99% for Badung during the Repelita V period of 1989/1990 to 1993/1994. However, the GRDP of the regency is growing at the average annual rate of 11.5% from 1989 to 1991.

The per capita GRDP of Badung grew at the average annual rate of 8.1% from 1983 to 1989.

There are no statistical data on GRDP of Badung before 1983 because calculation of the GRDP only started in 1983. However, the GRDP of the Province of Bali is statistically available for decades. During the last 20 years from 1969 to 1989 the GRDP of Bali grew at the average annual rate of 9.7%. During the same period the per capita GRDP of Bali grew at the average annual rate of 8.2%.

Based on the past and current performance of the economic growth of the regions concerned it is projected that the GRDP of the Study Area will grow from 1990 to 2000 at the average annual rate of 8% and from 2000 to 2010 at the average annual rate of 7%, the average annual growth rate from 1990 to 2010 being calculated at 7.5%.

Thus, the GRDP of the Study Area is projected to reach Rp. 3,463,310 million in 2010. Sector-wise, the Sector of Transport and Communications will have the top share of 27.7%, followed by the Sector of Trade, Hotels and Restaurants with 26.9% and the Sector of Banking and Other Financial Institutions with 10.5% (for more details refer to Table A.4.1).

The per capita GRDP of the Study Area is estimated to come to Rp. 4,882,715 at 1990 prices in 2010 growing at the average annual rate of 5.4% from 1990 to 2010. It corresponds to US\$ 2,619.

## 4.2 People's Income Level

### 4.2.1 Existing (1991) Income Level by Kelurahan

The JICA Study Team conducted the sampling questionnaire survey in October, 1991 to know the existing level of household income in the Study Area. 15 households were sampled on random basis for each of the 50 Kelurahan/Desa. The number of samples thus totaled 750.

Households were classified into 3 income classes, i.e. High, Middle and Low Income Classes based on the appearance of houses (refer to Table A.4.2).

As a result of the survey it was found that the average monthly household income of the High, Middle and Low Income Classes across the Study Area was Rp. 1,043,000, Rp. 320,000 and Rp. 210,000, respectively. At the same time, it was found that the average number of household members of the above classes was 6.3, 5.8 and 5.3, respectively. Thus, the per capita monthly household income of the respective classes works out at Rp. 165,600, Rp. 55,200 and Rp. 39,600.

The composition of population by Income Class was estimated for each Kelurahan/Desa based on the sampling questionnaire survey (refer to Table A.4.3). It was revealed that across the Study Area the composition of population for High, Middle and Low Income Classes was 3.2%, 51.0% and 45.8%, respectively. In terms of the number of households the above three classes account for 2.8%, 49.0% and 48.2%, respectively.

The monthly household income, the number of household members and the per capita monthly household income on the total average basis are calculated at Rp. 287,000, 5.6 and Rp. 51,500, respectively.

The existing status of the per capita monthly household income by Kelurahan/Desa is shown in Table A.4.4 and Fig. A.4.1. According to them Dangin Puri Kelod and Dangin Puri Kaja in Denpasar Timur have the topmost per capita monthly household income of Rp. 61,000 and Rp. 60,600,

respectively. Dangin Puri Kauh, Dangin Puri Kangin, Dangin Puri and Sumerta Kauh in Denpasar Timur and Tegal Harum, Dauh Puri Kaja, Dauh Puri kelod and Dauh Puri in Denpasar Barat have the comparatively high income level of Rp. 55,000 to 59,900. Serangan in Denpasar Selatan has the lowest per capita monthly household income of Rp. 41,300. Also, Ubung and Peguyangan Kangin in Denpasar Barat and Penatih Dangin Puri in Denpasar Timur belong to the lowest income bracket of less than Rp. 45,000.

#### 4.2.2 Future (2010) Income Level by Kelurahan

The composition of population by income class by Kelurahan/Desa and the per capita monthly household income by income class in the target year of 2010 were estimated based on the existing composition of population by income class by Kelurahan/Desa, the existing per capita monthly household income by income class, projected population in 2010 and projected GRDP in 2010.

As shown in Table A.4.5, the composition of population for High, Middle and Low Income Classes across the Study Area in 2010 is projected to be 18.8%, 53.7% and 27.5%, respectively. In terms of the number of households the three classes account for 17.1%, 53.1% and 29.8%, respectively.

The per capita monthly household income in 2010 is projected to reach Rp. 335,600 for the High Income Class, Rp. 104,100 for the Middle Income Class and Rp. 74,900 for the Low Income Class. The per capita monthly household income on the total average basis works out at Rp. 139,800 (refer to Table A.4.6). The monthly household income for the three classes and the total average in the same year is calculated at Rp. 2,144,000, Rp. 604,000, Rp. 397,000 and Rp. 801,000, respectively.

## 5. Tourism

### 5.1 Existing Tourism (1990)

#### 5.1.1 Number and Expenditures of Tourists

Tourists come to Bali by air, sea or boat. Airline passengers arrive at Ngurah Rai Airport either by international flight or domestic flight. Some tourists arrive at the shores of this island by liner. Also, tourists come ashore "overland" from other parts of Indonesia.

In-coming airline passengers counted 1,176,395 in 1990, of which 542,960 or 46.2% were by international flight and the balance of 633,435 or 53.8% were by domestic flight.

98.7% of international flight passengers were foreigners coming directly from their own countries and the remaining 1.3% were Indonesians. On the other hand, 53.3% of domestic flight passengers were Indonesians and the remainder or 46.7% were foreigners. Summing up, 70.7% of airline arrivals were made up of foreigners and 29.3%, of Indonesians.

Those arriving in Bali over oceans by liner directly from foreign countries numbered 8,503 in 1990.

"Overland" tourists reached 1,367,837, of which 98% are estimated to have been Indonesians and remaining 2% foreigners.

Summing up, 2,552,735 tourists came to Bali in 1990, of which 53.6% were by boat, 46.1% by air and 0.3% by sea.

Nationality-wise, 1,685,159 or 66.0% were Indonesians and the balance of 867,576 or 34.0% were foreigners (refer to Table A.5.1, Fig. A.5.1 and Table A.5.2).

It is estimated that out of 867,576 foreign (=international) tourists 735,392 or 84.8% stayed at commercial accommodations in the Study Area, of which 637,881 or 86.7% stayed at classified hotels and 97,511 or 13.3% at non-classified hotels or other accommodations. Likewise, out of 1,685,159 Indonesian (=domestic) tourists 1,182,490 or 70.2% stayed at commercial

accommodations in the Study Area, of which 180,052 or 15.2% stayed at classified hotels and 1,002,438 or 84.8% at non-classified hotels or other accommodations.

Summing up, 1,917,882 tourists are estimated to have stayed at commercial accommodations in the Study Area in 1990, of which domestic tourists accounted for 61.7% and international tourists 38.3%. Also, out of 1,917,882 tourists 817,933 or 42.6% stayed at classified hotels and 1,099,949 or 57.4% at non-classified or other accommodations (refer to Table A.5.3).

It was found that 2.02 persons on average stayed in one room in classified hotels as well as in non-classified hotels & other accommodations. Therefore, the number of rooms occupied by tourists in the Study Area in 1990 works out at 949,447. It was found also that the average length of stay in classified hotels was 4.3 days for international tourists and 3.1 days for domestic tourists, while the average length of stay in non-classified hotels & other accommodations was 3.8 days for international tourists and 2.3 days for domestic tourists. Based on these data total room nights realized by tourists in the Study Area in 1990 are calculated at 2,959,008 (refer to Table A.5.4 and Table A.5.5).

Based on the above information and the available number of rooms in hotels & other accommodations, the average room occupancy rate in classified hotels and non-classified hotels & other accommodations in the Study Area in 1990 is calculated at 71.3% and 45.6%, respectively. The room occupancy rate on the total average basis works out at 57.1% (refer to Table A.5.6).

Multiplaying room nights by 2.02, which is the average number of occupants in one room one gets bed nights, which totaled 5,977,198 in the Study Area in 1990 (refer to Table A.5.7).

It is estimated that international and domestic tourists who stayed at classified hotels in 1990 on average per day spent Rp. 150,000 and Rp. 100,000, respectively. Likewise, international and domestic tourists who stayed at non-classified hotels & other accommodations in 1990 on average per day spent Rp. 75,000 and Rp. 50,000, respectively. Based on the above estimation the total expenditures by tourists in the Study Area in 1990 are calculated at Rp. 610,321 million at 1990 prices (refer to Table A.4.8).

## 5.2 Future Tourism (2010)

### 5.2.1 Number and Expenditures of Tourists

The number of tourists coming to Bali by air grew at the average annual rate of 10.8% from 1980 to 1990. The number of tourists who came by way of international flights grew at a higher rate than the number of tourists via domestic flights. The yearly number of tourists arriving by sea fluctuates irregularly. The number of tourists reaching the shores by boat increased at the average annual rate of 5.5% from 1980 to 1990.

Based on the past accomplishments it is projected that the number of air travellers to the island will grow at the average annual rate of 7.3% between 1990 and 2010 to 4,775,327 in 2010. Liner passengers from beyond the oceans will not change so much in number, being estimated at 10,713 in 2010. Overland in-tourists will reach 3,231,929 in 2010 growing at the average annual rate of 4.4%.

Summing up, the total number of tourists to Bali will come to 8,017,969 in 2010 growing at the average annual rate of 5.9%, of which those by air will account for 59.6%, those by boat 40.3% and those by sea 0.1% (refer to Table A.5.1).

The projected 8,017,969 in-tourists will comprise of 3,795,332 foreigners accounting for 47.3% and 4,222,637 Indonesians accounting for 52.7%. Out of 3,795,332 international tourists 3,719,980 or 98.0% will come by air, 10,713 or 0.3% by sea and 64,639 or 1.7% by boat. Out of 4,222,638 domestic tourists 1,055,347 or 25.0% will be by air and 3,167,291 or 75.0% by boat (refer to Table A.5.2).

Out of 8,017,969 in-tourists 6,214,930 or 77.5% are projected to stay at commercial accommodations in the Study Area. Out of those 6,214,930 travellers 3,383,573 or 54.4% will stay at classified hotels and the balance of 2,831,357 or 45.6% will stay at non-classified hotels or other accommodations.

Those 3,383,573 tourists who will stay at classified hotels will be composed of 2,832,286 foreigners accounting for 83.7% and 551,287 Indonesians accounting for 16.3%. Those 2,831,357 tourists who will stay at non-



classified hotels or other accommodations will be made up of 395,121 foreigners accounting for 14.0% and 2,436,236 Indonesians accounting for 86.0%.

Foreign (=international) tourists will total 3,227,407, of which 87.8% will stay at classified hotels and 12.2% at non-classified hotels or other accommodations. Indonesian (=domestic) tourists will total 2,987,523, of which 18.5% will stay at classified hotels and 81.5% at non-classified hotels or other accommodations (refer to Table A.5.3).

The total number of rooms to be occupied by tourists and the total room nights to be realized by them in the Study Area in 2010 will reach 3,076,697 and 10,392,386, respectively (refer to Table A.5.4 and Table A.5.5).

Based on the projected room nights to be realized and the projected available room nights the average room occupancy rate in classified hotels and non-classified hotels & other accommodations in the Study Area in 2010 is calculated at 62.6% and 67.6%, respectively. The room occupancy rate on the total average basis works out at 64.2% (refer to Table A.5.6).

The total bed nights to be realized and the total expenditures to be disbursed by tourists in the Study Area in 2010 are estimated at 20,992,621 and Rp. 2,390,500 million at 1990 prices, respectively (refer to Table A.5.7 and Table A.5.8).

## 6. Climate, Topography and Geology

### 6.1 Climate

The climate of the Bali island is a tropical one and characterized by two distinct monsoon seasons :

Rainy season : November - April

Dry season : May - October

The island is away from the tracks of cyclone and typhoon. The climatic features between the northern and southern slopes are very different due to the mountain ranges crossing the island in an east-west direction.

The southern slope, to which the Study Area belongs, is characterized by a more accentuated and longer rainy season with a much higher rainfall than in the north.

Specific conditions of the climate in the Study Area are summarized as below.

#### Air Temperature

Monthly average air temperature of the Study Area ranges from 26°C in July and August to 28.0°C in November and December with a yearly average of 27.2°C (See Table A.6.1).

#### Relative Humidity

Relative Humidity of the Study area averages 79.6%. The highest monthly average humidity of 81.1% occurs in March and April in the end of rainy season. While, the lowest one of 77.5% appears in October in the end of dry season (See Table A.6.1).

#### Wind

Wind from the west and the northwest is predominant during the rainy season, and reversely during the dry season the east and the east southeast wind from the Australian continent is predominant. The wind during the transitional periods (Apr, May, Oct, Nov) is unstable in its direction.

#### Rainfall

Average Annual rainfall of the Study Area is estimated to be 1,890 mm of which more than 50% concentrates in the three (3) rainy months of December to February. While in the driest months of August, September and October, the Study Area is blessed with a rainfall of less than even 50 mm.

Monthly rainfall depth of the Study Area during the recent 10 years (1981-1990) are shown in Table A.6.1.

Distribution of the average monthly rainy days is also shown in Fig. A.6.1. In this figure, number of monthly rainy days with more than 20 mm/day is shown in terms of percentage.

## 6.2 Topography

The Topography of the Bali island is divided into four (4) units as follows ;

- (a) Volcanic range crossing the Island in an east-west direction.
- (b) Southern slopes of the volcanic range.
- (c) Low land area between the southern slopes and Bukit Badung in the southern peninsula.
- (d) Bukit Badung flat hills crossing the peninsula in east-west.

The Study area is characterized by the three (3) units [(b), (c), (d)].

### Southern slopes

The southern slopes are fertile and have many rivers. The major streams are called He, Empass, Penet, Ayung, Wos, Petanu, Sangsang and Unda. These rivers run in parallel with each other through the alluvial fan. Sea cliffs are found on the south-western coast at the southern slopes, as at Tanah Lot. However, there are no cliffs on the southern coast.

### Low Land Area

The low land area consists of alluvial plain, sand beach, sand dune, tombolos, lagoon and spit. The topography in this area is variable due to beach erosion and sedimentation. Many portions of the Study Area are included in this type of area.

### Bukit Badung

Bukit Badung in the southern peninsula, is a land-tied island and is composed of flat hills of coral limestone. Coral limestone forms the karst landform, having dolines and caves. Steep sea cliffs are found in the south-western coast of Bukit Badung. On the north-eastern side, the flat hill shows gentle sloping.