Appendices

Appendix-1
Reference Crop Evapotranspiration

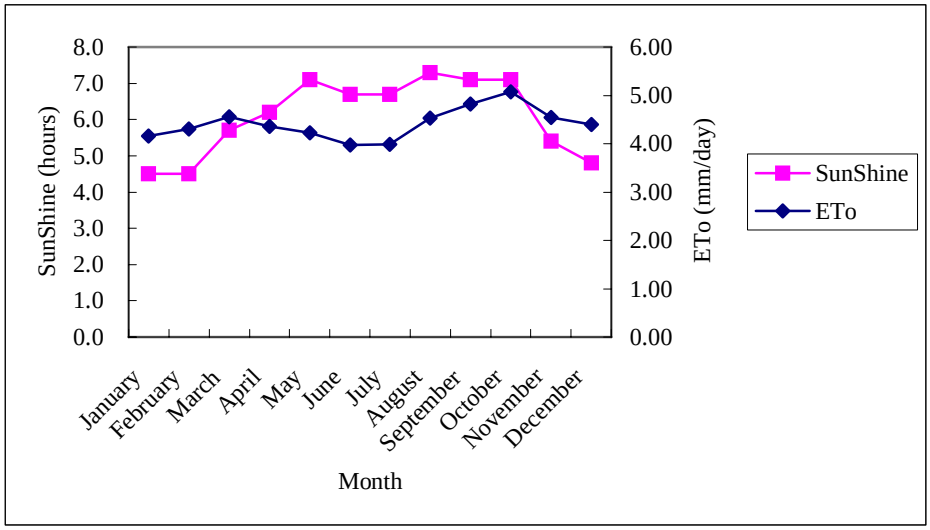
2005/1/12 CropWat 4 Windows Ver 4.2

Climate and ETo (grass) Data

Country : Indonesia Station : Denpasar (BMG)
Altitude: 15 meter(s) above M.S.L.
Latitude: -8.68 Deg. (South) Longitude: 115.20 Deg. (East)

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	31.8	24.6	80.9	179.3	4.5	16.9	4.16
February	32.1	24.7	81.5	229.1	4.5	17.0	4.31
March	33.5	24.5	80.3	169.3	5.7	18.4	4.55
April	32.6	24.5	79.6	182.6	6.2	17.9	4.36
May	32.0	23.9	78.8	205.9	7.1	17.5	4.23
June	31.0	23.7	78.1	232.4	6.7	16.1	3.98
July	30.3	23.8	78.4	245.7	6.7	16.4	3.99
August	30.3	22.7	76.7	262.3	7.3	18.7	4.53
September	30.9	23.4	77.1	249.0	7.1	19.9	4.82
October	32.0	24.4	77.8	235.8	7.1	20.8	5.07
November	32.2	24.8	79.7	205.9	5.4	18.2	4.54
December	31.6	24.8	79.2	229.1	4.8	17.2	4.40
Average	31.7	24.1	79.0	218.9	6.1	17.9	4.41

Penman-Montheith equation was used in ETo calculations with the following values.
for Angstrom's Coefficients:
a = 0.25 b = 0.5



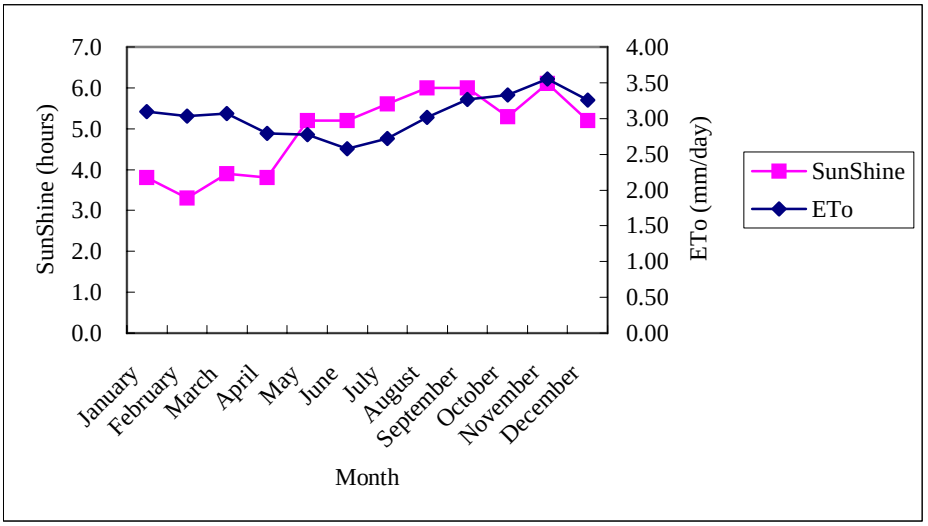
2005/1/12 CropWat 4 Windows Ver 4.2

Climate and ETo (grass) Data

Country : Indonesia Station : Bedugul (PU)
Altitude: 1,200 meter(s) above M.S.L.
Latitude: -8.28 Deg. (South) Longitude: 115.18 Deg. (East)

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	26.4	16.6	95.3	42.4	3.8	15.7	3.10
February	26.6	17.7	91.3	38.8	3.3	15.0	3.03
March	26.5	17.1	94.1	41.8	3.9	15.6	3.07
April	26.2	17.2	94.1	47.9	3.8	14.4	2.79
May	26.2	17.2	94.0	45.3	5.2	15.0	2.77
June	26.1	17.0	92.8	33.2	5.2	14.2	2.58
July	25.9	17.1	94.9	120.5	5.6	15.0	2.72
August	25.1	16.5	95.4	68.7	6.0	16.9	3.02
September	24.8	16.4	95.0	119.8	6.0	18.3	3.27
October	24.8	16.6	93.2	78.0	5.3	18.0	3.33
November	24.5	16.8	93.6	45.9	6.1	19.3	3.55
December	24.3	16.9	95.4	79.1	5.2	17.8	3.26
Average	25.6	16.9	94.1	63.5	5.0	16.3	3.04

Penman-Montheith equation was used in ETo calculations with the following values.
for Angstrom's Coefficients:
a = 0.25 b = 0.5



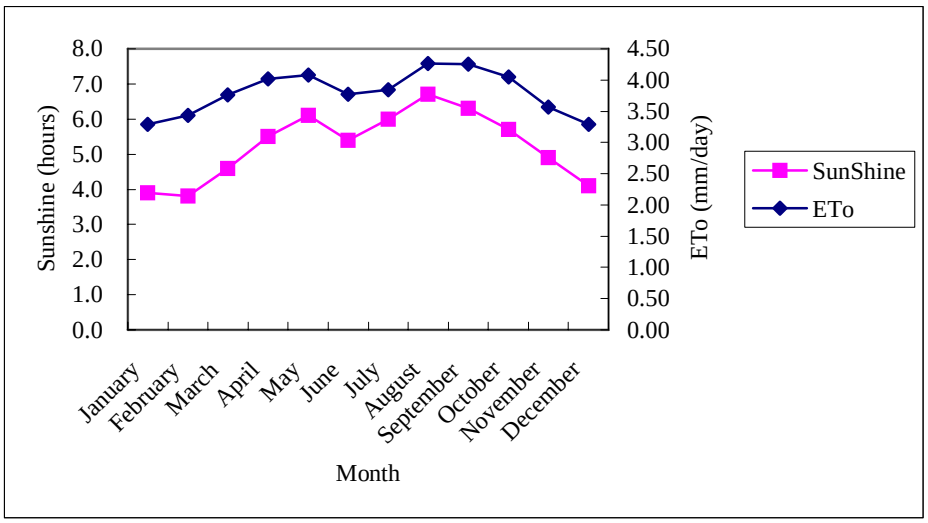
2005/1/12 CropWat 4 Windows Ver 4.2

Climate and ETo (grass) Data

Country : Indonesia Station : Negara (BMG)
Altitude: 23.65 meter(s) above M.S.L.
Latitude: 8.33 Deg. (North) Longitude: 114.60 Deg. (East)

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	30.7	23.9	84.5	182.6	3.9	13.7	3.29
February	30.9	23.9	85.4	182.6	3.8	14.4	3.43
March	31.0	23.5	85.8	169.3	4.6	16.4	3.76
April	30.7	23.6	85.9	189.3	5.5	18.0	4.02
May	30.0	22.6	84.2	202.5	6.1	18.4	4.08
June	29.0	21.9	84.7	229.1	5.4	17.0	3.77
July	28.3	20.8	84.2	219.2	6.0	18.0	3.84
August	28.5	20.9	81.4	245.7	6.7	19.5	4.26
September	29.3	22.6	81.9	242.4	6.3	19.0	4.25
October	30.3	23.5	81.8	212.5	5.7	17.4	4.05
November	30.6	24.1	83.5	189.3	4.9	15.3	3.57
December	30.6	24.3	83.1	179.3	4.1	13.6	3.29
Average	30.0	23.0	83.9	203.7	5.3	16.7	3.80

Penman-Montheith equation was used in ETo calculations with the following values.
for Angstrom's Coefficients:
a = 0.25 b = 0.5



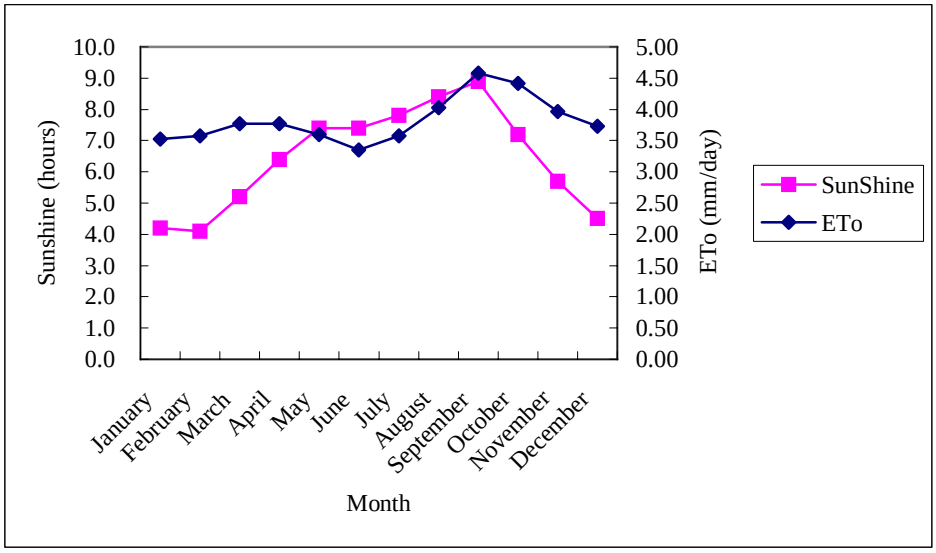
2005/1/12 CropWat 4 Windows Ver 4.2

Climate and ETo (grass) Data

Country : Indonesia Station : Singaraja (PU)
Altitude: 5 meter(s) above M.S.L.
Latitude: −8.25 Deg. (South) Longitude : 115.25 Deg. (East)

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	30.5	24.1	75.8	32.3	4.2	16.3	3.52
February	31.4	24.6	77.4	34.4	4.1	16.3	3.58
March	31.6	24.3	76.3	30.3	5.2	17.7	3.77
April	32.0	24.4	74.4	26.7	6.4	18.2	3.77
May	32.1	24.2	70.9	29.2	7.4	18.0	3.60
June	32.1	23.5	72.1	29.7	7.4	17.1	3.35
July	32.0	23.2	74.3	41.9	7.8	17.9	3.58
August	31.8	22.7	71.1	39.4	8.4	20.3	4.03
September	31.9	23.5	71.2	37.9	8.9	22.7	4.58
October	32.4	23.6	72.6	40.9	7.2	20.9	4.42
November	32.9	23.4	68.1	27.5	5.7	18.6	3.97
December	32.7	25.8	77.9	32.9	4.5	16.7	3.73
Average	31.9	23.9	73.5	33.6	6.4	18.4	3.83

Penman−Montheith equation was used in ETo calculations with the following values.
for Angstrom's Coefficients:
a = 0.25 b = 0.5



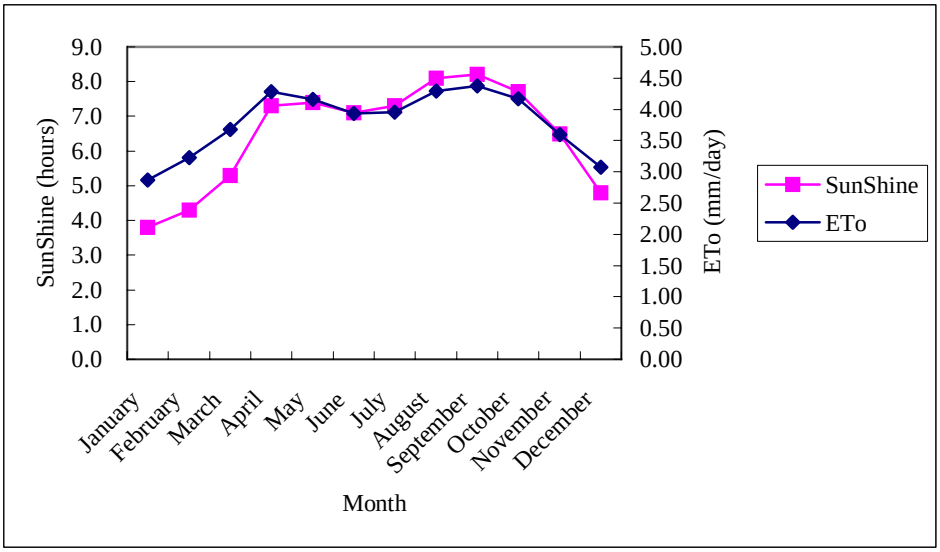
2005/1/12 CropWat 4 Windows Ver 4.2

Climate and ETo (grass) Data

Country : Indonesia Station : Susuan (PU)
Altitude: 150 meter(s) above M.S.L.
Latitude: 8.43 Deg. (North) Longitude : 115.60 Deg. (East)

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	30.5	22.5	89.6	63.2	3.8	13.5	2.87
February	30.4	22.6	88.7	78.0	4.3	15.1	3.23
March	30.8	22.6	89.0	68.0	5.3	17.5	3.68
April	31.1	22.8	88.3	52.5	7.3	20.8	4.28
May	30.9	22.6	89.1	40.9	7.4	20.4	4.16
June	30.4	22.2	89.0	42.1	7.1	19.5	3.93
July	30.0	21.8	89.0	35.6	7.3	19.9	3.96
August	30.3	21.3	87.2	40.6	8.1	21.6	4.29
September	30.6	22.0	89.5	47.6	8.2	21.9	4.38
October	31.3	22.9	88.2	55.4	7.7	20.4	4.17
November	31.3	23.0	89.2	56.7	6.5	17.5	3.60
December	30.8	22.6	88.2	77.1	4.8	14.6	3.07
Average	30.7	22.4	88.8	54.8	6.5	18.6	3.80

Penman-Montheith equation was used in ETo calculations with the following values.
for Angstrom's Coefficients:
a = 0.25 b = 0.5



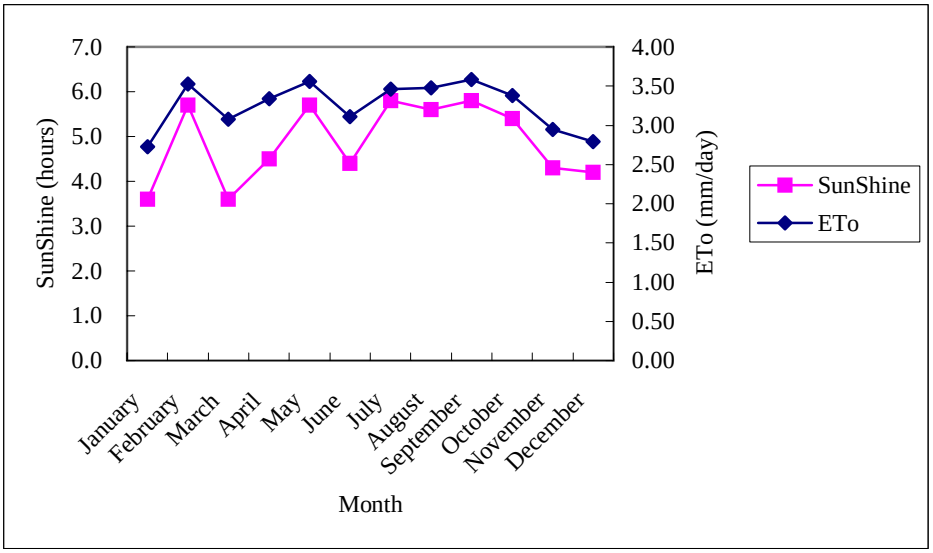
2005/1/12 CropWat 4 Windows Ver 4.2

Climate and ETo (grass) Data

Country : Indonesia Station : Tampaksiring (PU)
Altitude: 485 meter(s) above M.S.L.
Latitude: 8.48 Deg. (North) Longitude : 115.25 Deg. (East)

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	27.6	25.3	95.0	36.9	3.6	13.2	2.73
February	28.0	25.8	91.2	42.6	5.7	17.2	3.53
March	27.2	24.9	96.0	35.9	3.6	14.9	3.08
April	27.0	24.9	96.0	54.4	4.5	16.4	3.34
May	26.7	24.4	96.0	45.5	5.7	17.8	3.56
June	26.1	23.9	96.8	36.9	4.4	15.5	3.11
July	25.9	23.5	95.5	38.1	5.8	17.7	3.46
August	26.0	23.2	94.7	48.2	5.6	17.8	3.48
September	26.2	23.8	93.2	50.2	5.8	18.2	3.58
October	27.0	24.3	95.2	43.0	5.4	17.0	3.38
November	27.8	25.1	96.3	31.1	4.3	14.4	2.95
December	27.7	25.1	93.2	41.9	4.2	13.7	2.79
Average	26.9	24.5	94.9	42.1	4.9	16.2	3.25

Penman-Montheith equation was used in ETo calculations with the following values.
for Angstrom's Coefficients:
a = 0.25 b = 0.5



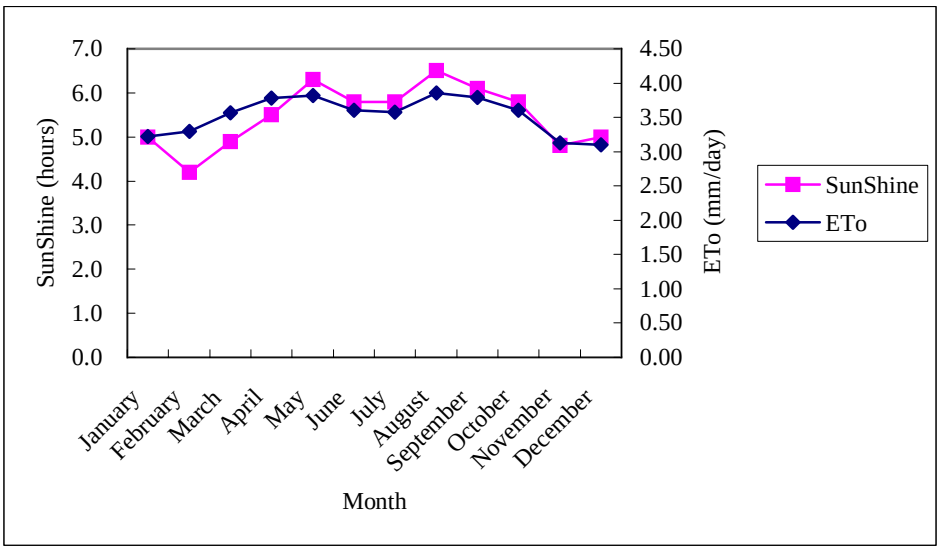
2005/1/12 CropWat 4 Windows Ver 4.2

Climate and ETo (grass) Data

Country : Indonesia Station : Tiyinggading (PU)
Altitude: 300 meter(s) above M.S.L.
Latitude: 8.21 Deg. (North) Longitude : 115.25 Deg. (East)

Month	MaxTemp (deg.C)	MiniTemp (deg.C)	Humidity (%)	Wind Spd. (Km/d)	SunShine (Hours)	Solar Rad. (MJ/m2/d)	ETo (mm/d)
January	29.9	23.7	88.4	99.9	5.0	15.3	3.22
February	29.8	24.2	86.6	113.0	4.2	15.0	3.30
March	29.6	23.5	87.6	81.5	4.9	16.9	3.57
April	29.9	23.5	87.2	71.7	5.5	18.0	3.78
May	29.4	22.9	87.5	60.6	6.3	18.7	3.82
June	28.9	23.3	88.1	72.6	5.8	17.5	3.60
July	28.3	22.7	86.6	68.0	5.8	17.7	3.58
August	28.3	22.4	84.8	76.4	6.5	19.2	3.86
September	28.5	22.9	86.4	76.0	6.1	18.7	3.79
October	29.1	23.5	88.5	71.8	5.8	17.6	3.60
November	29.5	23.3	88.1	63.3	4.8	15.1	3.13
December	29.4	22.9	86.4	89.3	5.0	14.9	3.10
Average	29.2	23.2	87.2	78.7	5.5	17.0	3.53

Penman-Montheith equation was used in ETo calculations with the following values.
for Angstrom's Coefficients:
a = 0.25 b = 0.5



Appendix-2
Irrigation Water Requirement

Jembrana Regency

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1. Crop Coefficient																								
1) Paddy x 3	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		
2) Paddy x 2 + Palawija x 1	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		0.00	0.00	0.00	0.00	0.00	0.00	0.00		
3) Paddy x 1 + Palawija x 2	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P	P
	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P
Average	1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00			
4) Paddy x 2	P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95									
		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95								
Average			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95								
5) Paddy x 1 + Palawija x 1	P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95										
		P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95									
Average			1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00									
6) Palawija x 2	0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95										
		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95									
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00									
7) Paddy x 1	P	P	1.10	1.10	1.05	1.05	0.95																	
		P	P	1.10	1.10	1.05	1.05	0.95																
Average			1.10	1.10	1.08	1.05	1.00	0.95																
2. Cropped Area Ratio																								
1) Paddy x 3	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		
2) Paddy x 2 + Palawija x 1	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5		
3) Paddy x 1 + Palawija x 2	0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5			
4) Paddy x 2			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5								
5) Paddy x 1 + Palawija x 1			0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5									
6) Palawija x 2	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5									
7) Paddy x 1			0.5	1	1	1	1	0.5																
3. ETo (mm/day) BMG-3	3.29	3.29	3.29	3.29	3.43	3.43	3.76	3.76	4.02	4.02	4.08	4.08	3.77	3.77	3.84	3.84	4.26	4.26	4.25	4.25	4.05	4.05	3.57	3.57
4. Crop Water Requirement (mm/day)																								
1) Paddy x 3	1.81	3.62	3.55	3.45	3.43	1.63	0.00	0.00	2.21	4.42	4.41	4.28	3.77	1.79	0.00	0.00	2.34	4.69	4.59	4.46	4.05	1.92	0.00	0.00
2) Paddy x 2 + Palawija x 1	1.81	3.62	3.55	3.45	3.43	1.63	0.00	0.00	2.21	4.42	4.41	4.28	3.77	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	1.81	3.62	3.55	3.45	3.43	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) Paddy x 2	0.00	0.00	1.81	3.62	3.70	3.60	3.76	1.79	0.00	0.00	2.24	4.49	4.07	3.96	3.84	1.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.00	0.00	1.81	3.62	3.70	3.60	3.76	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.00	0.00	1.81	3.62	3.70	3.60	3.76	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5. Effective Rainfall (mm/day)	3.32	3.32	4.20	4.20	3.58	3.58	2.53	2.53	1.28	1.28	0.63	0.63	0.07	0.07	0.14	0.14	0.14	0.14	0.42	0.42	0.78	0.78	3.03	3.03
No. 437 1) Paddy x 3	3.32	3.32	4.20	4.20	3.58	3.58	2.53	2.53	1.28	1.28	0.63	0.63	0.07	0.07	0.14	0.14	0.14	0.14	0.42	0.42	0.78	0.78	3.03	3.03
2) Paddy x 2 + Palawija x 1	3.32	3.32	4.20	4.20	3.58	3.58	2.53	2.53	1.28	1.28	0.63	0.63	0.07	0.07	0.14	0.14	0.14	0.14	0.42	0.42	0.78	0.78	3.03	3.03
3) Paddy x 1 + Palawija x 2	3.32	3.32	4.20	4.20	3.58	3.58	2.53	2.53	1.28	1.28	0.63	0.63	0.07	0.07	0.14	0.14	0.14	0.14	0.42	0.42	0.78	0.78	3.03	3.03
4) Paddy x 2	3.32	3.32	4.20	4.20	3.58	3.58	2.53	2.53	1.28	1.28	0.63	0.63	0.07	0.07	0.14	0.14	0.14	0.14	0.42	0.42	0.78	0.78	3.03	3.03
5) Paddy x 1 + Palawija x 1	3.32	3.32	4.20	4.20	3.58	3.58	2.53	2.53	1.28	1.28	0.63	0.63	0.07	0.07	0.14	0.14	0.14	0.14	0.42	0.42	0.78	0.78	3.03	3.03
6) Palawija x 2	3.32	3.32	4.20	4.20	3.58	3.58	2.53	2.53	1.28	1.28	0.63	0.63	0.07	0.07	0.14	0.14	0.14	0.14	0.42	0.42	0.78	0.78	3.03	3.03
7) Paddy x 1	3.32	3.32	4.20	4.20	3.58	3.58	2.53	2.53	1.28	1.28	0.63	0.63	0.07	0.07	0.14	0.14	0.14	0.14	0.42	0.42	0.78	0.78	3.03	3.03
6. Land Preparation (mm/day)																								
1) Paddy x 3	3.33						3.33	6.67	3.33						3.33	6.67	3.33						3.33	6.67
2) Paddy x 2 + Palawija x 1	3.33						3.33	6.67	3.33														3.33	6.67
3) Paddy x 1 + Palawija x 2	3.33																						3.33	6.67
4) Paddy x 2	3.33	6.67	3.33						3.33	6.67	3.33													
5) Paddy x 1 + Palawija x 1	3.33	6.67	3.33																					
6) Palawija x 2																								
7) Paddy x 1	3.33	6.67	3.33																					
7. Water Layer Replacement (mm/day)																								
1) Paddy x 3		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67			
2) Paddy x 2 + Palawija x 1		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67											
3) Paddy x 1 + Palawija x 2		1.67	1.67	1.67	1.67																			
4) Paddy x 2				1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67									
5) Paddy x 1 + Palawija x 1				1.67	1.67	1.67	1.67																	
6) Palawija x 2																								
7) Paddy x 1				1.67	1.67	1.67	1.67																	
8. Infiltration Loss (2mm/day)																								
1) Paddy x 3	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2
2) Paddy x 2 + Palawija x 1	2	2	2	2	2	1	1	2	2	2	2	2	2	1									1	2
3) Paddy x 1 + Palawija x 2	2	2	2	2	2	1																	1	2
4) Paddy x 2	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1								
5) Paddy x 1 + Palawija x 1	1	2	2	2	2	2	2	1																
6) Palawija x 2																								
7) Paddy x 1	1	2	2	2	2	2	2	1																
9. Field Water Requirement by Cropping Pattern(mm/day)																								
1) Paddy x 3	3.82	3.97	3.02	2.92	3.52	0.00	1.80	6.14	6.26	6.81	7.45	7.32	7.37	2.72	4.19	8.53	7.53	8.22	7.84	7.71	6.94	2.14	1.30	5.64
2) Paddy x 2 + Palawija x 1	3.82	3.97	3.02	2.92	3.52	0.00	1.80	6.14	6.26	6.81	7.45	7.32	7.37	2.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	5.64
3) Paddy x 1 + Palawija x 2	3.82	3.97	3.02	2.92	3.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	5.64
4) Paddy x 2	1.01	5.35	2.94	3.09	3.79	3.69	4.90	0.26	3.05	7.39	6.94	7.53	7.67	7.56	7.37	2.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	1.01	5.35	2.94	3.09	3.79	3.69	4.90	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	1.01	5.35	2.94	3.09	3.79	3.69	4.90	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
10. Unit Irrigation Water Requirement by Cropping Pattern (mm/day) Overall Efficiency =50%																									
	1) Paddy x 3	7.64	7.94	6.04	5.84	7.04	0.00	3.60	12.28	12.52	13.62	14.90	14.64	14.74	5.44	8.38	17.06	15.06	16.44	15.68	15.42	13.88	4.28	2.60	11.28
	2) Paddy x 2 + Palawija x 1	7.64	7.94	6.04	5.84	7.04	0.00	3.60	12.28	12.52	13.62	14.90	14.64	14.74	5.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.60	11.28
	3) Paddy x 1 + Palawija x 2	7.64	7.94	6.04	5.84	7.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.60	11.28
	4) Paddy x 2	2.02	10.70	5.88	6.18	7.58	7.38	9.80	0.52	6.10	14.78	13.88	15.06	15.34	15.12	14.74	5.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5) Paddy x 1 + Palawija x 1	2.02	10.70	5.88	6.18	7.58	7.38	9.80	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7) Paddy x 1	2.02	10.70	5.88	6.18	7.58	7.38	9.80	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11. Unit Irrigation Water Requirement by Regency (50% Efficiency) = Ratio of Cropping Pattern x Unit Irrigation Water Requirement (mm/day)																									
0.017	1) Paddy x 3	0.13	0.13	0.10	0.10	0.12	0.00	0.06	0.21	0.21	0.23	0.25	0.25	0.25	0.09	0.14	0.29	0.26	0.28	0.27	0.26	0.24	0.07	0.04	0.19
0.112	2) Paddy x 2 + Palawija x 1	0.86	0.89	0.68	0.65	0.79	0.00	0.40	1.38	1.40	1.53	1.67	1.64	1.65	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	1.26
0.088	3) Paddy x 1 + Palawija x 2	0.67	0.70	0.53	0.51	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.99
0.173	4) Paddy x 2	0.35	1.85	1.02	1.07	1.31	1.28	1.70	0.09	1.06	2.56	2.40	2.61	2.65	2.62	2.55	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.357	5) Paddy x 1 + Palawija x 1	0.72	3.82	2.10	2.21	2.71	2.63	3.50	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.051	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.202	7) Paddy x 1	0.41	2.16	1.19	1.25	1.53	1.49	1.98	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.000																									
	Total (mm/day)	3.14	9.55	5.62	5.79	7.08	5.40	7.64	1.98	2.67	4.32	4.32	4.50	4.55	3.32	2.69	1.22	0.26	0.28	0.27	0.26	0.24	0.07	0.56	2.44
	Total (liter/sec/ha)	0.363	1.105	0.650	0.670	0.819	0.625	0.884	0.229	0.309	0.500	0.500	0.521	0.527	0.384	0.311	0.141	0.030	0.032	0.031	0.030	0.028	0.008	0.065	0.282

12. Unit Irrigation Water Requirement by Regency (liter/sec/ha) : 50% Efficiency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average (liter/sec/ha)	0.660	0.722	0.557	0.405	0.511	0.456	0.226	0.031	0.031	0.018	0.174	0.734

2 paddy
0.302

Note
P : Land Preparation
ETo : Reference Crop Evapotranspiration
Irrigation is applied to only paddy culture.

Tabanan Regency

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1. Crop Coefficient																								
1) Paddy x 3	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		
2) Paddy x 2 + Palawija x 1	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		0.00	0.00	0.00	0.00	0.00	0.00	0.00		
3) Paddy x 1 + Palawija x 2	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P	P
	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P
Average	1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00			
4) Paddy x 2	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95										P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95										P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95										
5) Paddy x 1 + Palawija x 1	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95											P	P
	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95											P
Average	1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00											
6) Palawija x 2	0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95										
		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95									
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00									
7) Paddy x 1	P	P	1.10	1.10	1.05	1.05	0.95																P	P
		P	P	1.10	1.10	1.05	1.05	0.95																P
Average			1.10	1.10	1.08	1.05	1.00	0.95																
2. Cropped Area Ratio																								
1) Paddy x 3	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		
2) Paddy x 2 + Palawija x 1	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5		
3) Paddy x 1 + Palawija x 2	0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5			
4) Paddy x 2	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5										
5) Paddy x 1 + Palawija x 1	0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5											
6) Palawija x 2	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5									
7) Paddy x 1	0.5	1	1	1	1	0.5																		
3. ETo (mm/day) 511004	3.10	3.10	3.22	3.22	3.30	3.30	3.57	3.57	3.78	3.78	3.82	3.82	3.60	3.60	3.58	3.58	3.86	3.86	3.79	3.79	3.60	3.60	3.13	3.13
4. Crop Water Requirement (mm/day)																								
1) Paddy x 3	1.71	3.41	3.48	3.38	3.30	1.57	0.00	0.00	2.08	4.16	4.13	4.01	3.60	1.71	0.00	0.00	2.12	4.25	4.09	3.98	3.60	1.71	0.00	0.00
2) Paddy x 2 + Palawija x 1	1.71	3.41	3.48	3.38	3.30	1.57	0.00	0.00	2.08	4.16	4.13	4.01	3.60	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	1.71	3.41	3.48	3.38	3.30	1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) Paddy x 2	1.71	3.41	3.48	3.38	3.30	1.57	0.00	0.00	2.08	4.16	4.13	4.01	3.60	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	1.71	3.41	3.48	3.38	3.30	1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.00	0.00	3.54	3.54	3.56	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5. Effective Rainfall (mm/day)	3.61	3.61	5.58	5.58	5.70	5.70	4.56	4.56	1.45	1.45	0.25	0.25	0.28	0.28	0.70	0.70	0.05	0.05	0.16	0.16	0.99	0.99	2.46	2.46
No.440h 1) Paddy x 3	3.61	3.61	5.58	5.58	5.70	5.70	4.56	4.56	1.45	1.45	0.25	0.25	0.28	0.28	0.70	0.70	0.05	0.05	0.16	0.16	0.99	0.99	2.46	2.46
2) Paddy x 2 + Palawija x 1	3.61	3.61	5.58	5.58	5.70	5.70	4.56	4.56	1.45	1.45	0.25	0.25	0.28	0.28	0.70	0.70	0.05	0.05	0.16	0.16	0.99	0.99	2.46	2.46
3) Paddy x 1 + Palawija x 2	3.61	3.61	5.58	5.58	5.70	5.70	4.56	4.56	1.45	1.45	0.25	0.25	0.28	0.28	0.70	0.70	0.05	0.05	0.16	0.16	0.99	0.99	2.46	2.46
4) Paddy x 2	3.61	3.61	5.58	5.58	5.70	5.70	4.56	4.56	1.45	1.45	0.25	0.25	0.28	0.28	0.70	0.70	0.05	0.05	0.16	0.16	0.99	0.99	2.46	2.46
5) Paddy x 1 + Palawija x 1	3.61	3.61	5.58	5.58	5.70	5.70	4.56	4.56	1.45	1.45	0.25	0.25	0.28	0.28	0.70	0.70	0.05	0.05	0.16	0.16	0.99	0.99	2.46	2.46
6) Palawija x 2	3.61	3.61	5.58	5.58	5.70	5.70	4.56	4.56	1.45	1.45	0.25	0.25	0.28	0.28	0.70	0.70	0.05	0.05	0.16	0.16	0.99	0.99	2.46	2.46
7) Paddy x 1	3.61	3.61	5.58	5.58	5.70	5.70	4.56	4.56	1.45	1.45	0.25	0.25	0.28	0.28	0.70	0.70	0.05	0.05	0.16	0.16	0.99	0.99	2.46	2.46
6. Land Preparation (mm/day)																								
1) Paddy x 3	3.33						3.33	6.67	3.33						3.33	6.67	3.33						3.33	6.67
2) Paddy x 2 + Palawija x 1	3.33						3.33	6.67	3.33														3.33	6.67
3) Paddy x 1 + Palawija x 2	3.33																						3.33	6.67
4) Paddy x 2	3.33						3.33	6.67	3.33														3.33	6.67
5) Paddy x 1 + Palawija x 1	3.33																						3.33	6.67
6) Palawija x 2																								
7) Paddy x 1	3.33																						3.33	6.67
7. Water Layer Replacement (mm/day)																								
1) Paddy x 3		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67			
2) Paddy x 2 + Palawija x 1		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67											
3) Paddy x 1 + Palawija x 2		1.67	1.67	1.67	1.67																			
4) Paddy x 2		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67											
5) Paddy x 1 + Palawija x 1		1.67	1.67	1.67	1.67																			
6) Palawija x 2																								
7) Paddy x 1		1.67	1.67	1.67	1.67																			
8. Infiltration Loss (2mm/day)																								
1) Paddy x 3	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2
2) Paddy x 2 + Palawija x 1	2	2	2	2	2	1	1	2	2	2	2	2	2	1									1	2
3) Paddy x 1 + Palawija x 2	2	2	2	2	2	1																	1	2
4) Paddy x 2	2	2	2	2	2	1	1	2	2	2	2	2	2	1									1	2
5) Paddy x 1 + Palawija x 1	2	2	2	2	2	1																	1	2
6) Palawija x 2																								
7) Paddy x 1	2	2	2	2	2	1																	1	2
9. Field Water Requirement by Cropping Pattern(mm/day)																								
1) Paddy x 3	3.43	3.47	1.57	1.47	1.27	0.00	0.00	4.11	5.96	6.38	7.55	7.43	6.99	2.43	3.63	7.97	7.40	7.87	7.60	7.49	6.28	1.72	1.87	6.21
2) Paddy x 2 + Palawija x 1	3.43	3.47	1.57	1.47	1.27	0.00	0.00	4.11	5.96	6.38	7.55	7.43	6.99	2.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.87	6.21
3) Paddy x 1 + Palawija x 2	3.43	3.47	1.57	1.47	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.87	6.21
4) Paddy x 2	3.43	3.47	1.57	1.47	1.27	0.00	0.00	4.11	5.96	6.38	7.55	7.43	6.99	2.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.87	6.21
5) Paddy x 1 + Palawija x 1	3.43	3.47	1.57	1.47	1.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.87	6.21
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	1.72	0.06	1.63	1.63	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.87	6.21

		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
10. Unit Irrigation Water Requirement by Cropping Pattern (mm/day) Overall Efficiency =50%																									
	1) Paddy x 3	6.86	6.94	3.14	2.94	2.54	0.00	0.00	8.22	11.92	12.76	15.10	14.86	13.98	4.86	7.26	15.94	14.80	15.74	15.20	14.98	12.56	3.44	3.74	12.42
	2) Paddy x 2 + Palawija x 1	6.86	6.94	3.14	2.94	2.54	0.00	0.00	8.22	11.92	12.76	15.10	14.86	13.98	4.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74	12.42
	3) Paddy x 1 + Palawija x 2	6.86	6.94	3.14	2.94	2.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74	12.42
	4) Paddy x 2	6.86	6.94	3.14	2.94	2.54	0.00	0.00	8.22	11.92	12.76	15.10	14.86	13.98	4.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74	12.42
	5) Paddy x 1 + Palawija x 1	6.86	6.94	3.14	2.94	2.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74	12.42
	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7) Paddy x 1	3.44	0.12	3.26	3.26	3.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74	12.42
11. Unit Irrigation Water Requirement by Regency (50% Efficiency) = Ratio of Cropping Pattern x Unit Irrigation Water Requirement (mm/day)																									
0.277	1) Paddy x 3	1.90	1.92	0.87	0.81	0.70	0.00	0.00	2.28	3.30	3.53	4.18	4.12	3.87	1.35	2.01	4.42	4.10	4.36	4.21	4.15	3.48	0.95	1.04	3.44
0.073	2) Paddy x 2 + Palawija x 1	0.50	0.51	0.23	0.21	0.19	0.00	0.00	0.60	0.87	0.93	1.10	1.08	1.02	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.91
0.009	3) Paddy x 1 + Palawija x 2	0.06	0.06	0.03	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.11
0.545	4) Paddy x 2	3.74	3.78	1.71	1.60	1.38	0.00	0.00	4.48	6.50	6.95	8.23	8.10	7.62	2.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.04	6.77
0.026	5) Paddy x 1 + Palawija x 1	0.18	0.18	0.08	0.08	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.32
0.020	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.050	7) Paddy x 1	0.17	0.01	0.16	0.16	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.62
1.000																									
	Total (mm/day)	6.55	6.46	3.08	2.89	2.51	0.00	0.00	7.36	10.67	11.41	13.51	13.30	12.51	4.35	2.01	4.42	4.10	4.36	4.21	4.15	3.48	0.95	3.67	12.17
	Total (liter/sec/ha)	0.758	0.748	0.356	0.334	0.291	0.000	0.000	0.852	1.235	1.321	1.564	1.539	1.448	0.503	0.233	0.512	0.475	0.505	0.487	0.480	0.403	0.110	0.425	1.409

12. Unit Irrigation Water Requirement by Regency (liter/sec/ha) : 50% Efficiency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average (liter/sec/ha)	0.345	0.146	0.426	1.278	1.552	0.976	0.373	0.490	0.484	0.257	0.917	0.753

Note

P : Land Preparation

ETo : Reference Crop Evapotranspiration

Irrigation is applied to only paddy culture.

Badung Regency

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1. Crop Coefficient																								
1) Paddy x 3	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		
2) Paddy x 2 + Palawija x 1	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		0.00	0.00	0.00	0.00	0.00	0.00	0.00		
3) Paddy x 1 + Palawija x 2	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P	P
	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P
Average	1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00			
4) Paddy x 2	P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95									
		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95								
Average			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95								
5) Paddy x 1 + Palawija x 1	P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95										
		P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95									
Average			1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00									
6) Palawija x 2	0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95										
		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95									
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00									
7) Paddy x 1	P	P	1.10	1.10	1.05	1.05	0.95																	
		P	P	1.10	1.10	1.05	1.05	0.95																
Average			1.10	1.10	1.08	1.05	1.00	0.95																
2. Cropped Area Ratio																								
1) Paddy x 3	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		
2) Paddy x 2 + Palawija x 1	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5		
3) Paddy x 1 + Palawija x 2	0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5			
4) Paddy x 2			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5								
5) Paddy x 1 + Palawija x 1			0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5									
6) Palawija x 2	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5									
7) Paddy x 1			0.5	1	1	1	1	0.5																
3. ETo (mm/day) BMG1	4.40	4.40	4.16	4.16	4.31	4.31	4.55	4.55	4.36	4.36	4.23	4.23	3.98	3.98	3.99	3.99	4.53	4.53	4.82	4.82	5.07	5.07	4.54	4.54
4. Crop Water Requirement (mm/day)																								
1) Paddy x 3	2.42	4.84	4.49	4.37	4.31	2.05	0.00	0.00	2.40	4.80	4.57	4.44	3.98	1.89	0.00	0.00	2.49	4.98	5.21	5.06	5.07	2.41	0.00	0.00
2) Paddy x 2 + Palawija x 1	2.42	4.84	4.49	4.37	4.31	2.05	0.00	0.00	2.40	4.80	4.57	4.44	3.98	1.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	2.42	4.84	4.49	4.37	4.31	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) Paddy x 2	0.00	0.00	2.29	4.58	4.65	4.53	4.55	2.16	0.00	0.00	2.33	4.65	4.30	4.18	3.99	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.00	0.00	2.29	4.58	4.65	4.53	4.55	2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.00	0.00	2.29	4.58	4.65	4.53	4.55	2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5. Effective Rainfall (mm/day)	3.91	3.91	5.24	5.24	4.78	4.78	3.43	3.43	1.56	1.56	0.75	0.75	0.44	0.44	0.59	0.59	0.29	0.29	0.26	0.26	0.43	0.43	2.46	2.46
No.440a 1) Paddy x 3	3.91	3.91	5.24	5.24	4.78	4.78	3.43	3.43	1.56	1.56	0.75	0.75	0.44	0.44	0.59	0.59	0.29	0.29	0.26	0.26	0.43	0.43	2.46	2.46
2) Paddy x 2 + Palawija x 1	3.91	3.91	5.24	5.24	4.78	4.78	3.43	3.43	1.56	1.56	0.75	0.75	0.44	0.44	0.59	0.59	0.29	0.29	0.26	0.26	0.43	0.43	2.46	2.46
3) Paddy x 1 + Palawija x 2	3.91	3.91	5.24	5.24	4.78	4.78	3.43	3.43	1.56	1.56	0.75	0.75	0.44	0.44	0.59	0.59	0.29	0.29	0.26	0.26	0.43	0.43	2.46	2.46
4) Paddy x 2	3.91	3.91	5.24	5.24	4.78	4.78	3.43	3.43	1.56	1.56	0.75	0.75	0.44	0.44	0.59	0.59	0.29	0.29	0.26	0.26	0.43	0.43	2.46	2.46
5) Paddy x 1 + Palawija x 1	3.91	3.91	5.24	5.24	4.78	4.78	3.43	3.43	1.56	1.56	0.75	0.75	0.44	0.44	0.59	0.59	0.29	0.29	0.26	0.26	0.43	0.43	2.46	2.46
6) Palawija x 2	3.91	3.91	5.24	5.24	4.78	4.78	3.43	3.43	1.56	1.56	0.75	0.75	0.44	0.44	0.59	0.59	0.29	0.29	0.26	0.26	0.43	0.43	2.46	2.46
7) Paddy x 1	3.91	3.91	5.24	5.24	4.78	4.78	3.43	3.43	1.56	1.56	0.75	0.75	0.44	0.44	0.59	0.59	0.29	0.29	0.26	0.26	0.43	0.43	2.46	2.46
6. Land Preparation (mm/day)																								
1) Paddy x 3	3.33						3.33	6.67	3.33						3.33	6.67	3.33						3.33	6.67
2) Paddy x 2 + Palawija x 1	3.33						3.33	6.67	3.33														3.33	6.67
3) Paddy x 1 + Palawija x 2	3.33																						3.33	6.67
4) Paddy x 2	3.33	6.67	3.33						3.33	6.67	3.33													
5) Paddy x 1 + Palawija x 1	3.33	6.67	3.33																					
6) Palawija x 2																								
7) Paddy x 1	3.33	6.67	3.33																					
7. Water Layer Replacement (mm/day)																								
1) Paddy x 3		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67			
2) Paddy x 2 + Palawija x 1		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67											
3) Paddy x 1 + Palawija x 2		1.67	1.67	1.67	1.67																			
4) Paddy x 2				1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67									
5) Paddy x 1 + Palawija x 1				1.67	1.67	1.67	1.67																	
6) Palawija x 2																								
7) Paddy x 1				1.67	1.67	1.67	1.67																	
8. Infiltration Loss (2mm/day)																								
1) Paddy x 3	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2
2) Paddy x 2 + Palawija x 1	2	2	2	2	2	1	1	2	2	2	2	2	2	1									1	2
3) Paddy x 1 + Palawija x 2	2	2	2	2	2	1																	1	2
4) Paddy x 2	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1								
5) Paddy x 1 + Palawija x 1	1	2	2	2	2	2	2	1																
6) Palawija x 2																								
7) Paddy x 1	1	2	2	2	2	2	2	1																
9. Field Water Requirement by Cropping Pattern(mm/day)																								
1) Paddy x 3	3.84	4.60	2.92	2.80	3.20	0.00	0.90	5.24	6.17	6.91	7.49	7.36	7.21	2.45	3.74	8.08	7.53	8.36	8.62	8.47	8.31	2.98	1.87	6.21
2) Paddy x 2 + Palawija x 1	3.84	4.60	2.92	2.80	3.20	0.00	0.90	5.24	6.17	6.91	7.49	7.36	7.21	2.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.87	6.21
3) Paddy x 1 + Palawija x 2	3.84	4.60	2.92	2.80	3.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.87	6.21
4) Paddy x 2	0.42	4.76	2.38	3.01	3.54	3.42	4.79	0.00	2.77	7.11	6.91	7.57	7.53	7.41	7.07	2.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.42	4.76	2.38	3.01	3.54	3.42	4.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.42	4.76	2.38	3.01	3.54	3.42	4.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
10. Unit Irrigation Water Requirement by Cropping Pattern (mm/day) Overall Efficiency =50%																									
	1) Paddy x 3	7.68	9.20	5.84	5.60	6.40	0.00	1.80	10.48	12.34	13.82	14.98	14.72	14.42	4.90	7.48	16.16	15.06	16.72	17.24	16.94	16.62	5.96	3.74	12.42
	2) Paddy x 2 + Palawija x 1	7.68	9.20	5.84	5.60	6.40	0.00	1.80	10.48	12.34	13.82	14.98	14.72	14.42	4.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74	12.42
	3) Paddy x 1 + Palawija x 2	7.68	9.20	5.84	5.60	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.74	12.42
	4) Paddy x 2	0.84	9.52	4.76	6.02	7.08	6.84	9.58	0.00	5.54	14.22	13.82	15.14	15.06	14.82	14.14	4.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5) Paddy x 1 + Palawija x 1	0.84	9.52	4.76	6.02	7.08	6.84	9.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7) Paddy x 1	0.84	9.52	4.76	6.02	7.08	6.84	9.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11. Unit Irrigation Water Requirement by Regency (50% Efficiency) = Ratio of Cropping Pattern x Unit Irrigation Water Requirement (mm/day)																									
0.465	1) Paddy x 3	3.57	4.28	2.72	2.60	2.98	0.00	0.84	4.87	5.74	6.43	6.97	6.84	6.71	2.28	3.48	7.51	7.00	7.77	8.02	7.88	7.73	2.77	1.74	5.78
0.389	2) Paddy x 2 + Palawija x 1	2.99	3.58	2.27	2.18	2.49	0.00	0.70	4.08	4.80	5.38	5.83	5.73	5.61	1.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.45	4.83
0.004	3) Paddy x 1 + Palawija x 2	0.03	0.04	0.02	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05
0.098	4) Paddy x 2	0.08	0.93	0.47	0.59	0.69	0.67	0.94	0.00	0.54	1.39	1.35	1.48	1.48	1.45	1.39	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.009	5) Paddy x 1 + Palawija x 1	0.01	0.09	0.04	0.05	0.06	0.06	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.015	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.020	7) Paddy x 1	0.02	0.19	0.10	0.12	0.14	0.14	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.000																									
	Total (mm/day)	6.70	9.11	5.62	5.56	6.39	0.87	2.76	8.95	11.08	13.20	14.15	14.05	13.80	5.64	4.87	7.96	7.00	7.77	8.02	7.88	7.73	2.77	3.20	10.66
	Total (liter/sec/ha)	0.775	1.054	0.650	0.644	0.740	0.101	0.319	1.036	1.282	1.528	1.638	1.626	1.597	0.653	0.564	0.921	0.810	0.899	0.928	0.912	0.895	0.321	0.370	1.234

12. Unit Irrigation Water Requirement by Regency (liter/sec/ha) : 50% Efficiency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average (liter/sec/ha)	0.647	0.421	0.678	1.405	1.632	1.125	0.743	0.855	0.920	0.608	0.802	0.915

Note
P : Land Preparation
ETo : Reference Crop Evapotranspiration
Irrigation is applied to only paddy culture.

Gianyar Regency

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1. Crop Coefficient																								
1) Paddy x 3	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		
2) Paddy x 2 + Palawija x 1	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		0.00	0.00	0.00	0.00	0.00	0.00	0.00		
3) Paddy x 1 + Palawija x 2	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P	P
	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P
Average	1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00			
4) Paddy x 2	P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95									
		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95								
Average			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95								
5) Paddy x 1 + Palawija x 1	P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95										
		P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95									
Average			1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00									
6) Palawija x 2	0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95										
		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95									
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00									
7) Paddy x 1	P	P	1.10	1.10	1.05	1.05	0.95																	
		P	P	1.10	1.10	1.05	1.05	0.95																
Average			1.10	1.10	1.08	1.05	1.00	0.95																
2. Cropped Area Ratio																								
1) Paddy x 3	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		
2) Paddy x 2 + Palawija x 1	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5		
3) Paddy x 1 + Palawija x 2	0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5			
4) Paddy x 2			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5								
5) Paddy x 1 + Palawija x 1			0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5									
6) Palawija x 2	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5									
7) Paddy x 1			0.5	1	1	1	1	0.5																
3. ETo (mm/day) 511003	2.79	2.79	2.73	2.73	3.53	3.53	3.08	3.08	3.34	3.34	3.56	3.56	3.11	3.11	3.46	3.46	3.48	3.48	3.58	3.58	3.38	3.38	2.95	2.95
4. Crop Water Requirement (mm/day)																								
1) Paddy x 3	1.53	3.07	2.95	2.87	3.53	1.68	0.00	0.00	1.84	3.67	3.84	3.74	3.11	1.48	0.00	0.00	1.91	3.83	3.87	3.76	3.38	1.61	0.00	0.00
2) Paddy x 2 + Palawija x 1	1.53	3.07	2.95	2.87	3.53	1.68	0.00	0.00	1.84	3.67	3.84	3.74	3.11	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	1.53	3.07	2.95	2.87	3.53	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) Paddy x 2	0.00	0.00	1.50	3.00	3.81	3.71	3.08	1.46	0.00	0.00	1.96	3.92	3.36	3.27	3.46	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.00	0.00	1.50	3.00	3.81	3.71	3.08	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.00	0.00	1.50	3.00	3.81	3.71	3.08	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5. Effective Rainfall (mm/day)	4.00	4.00	7.50	7.50	6.38	6.38	3.92	3.92	1.33	1.33	0.86	0.86	0.84	0.84	1.20	1.20	0.27	0.27	0.61	0.61	1.11	1.11	3.90	3.90
No.440a 1) Paddy x3	4.00	4.00	7.50	7.50	6.38	6.38	3.92	3.92	1.33	1.33	0.86	0.86	0.84	0.84	1.20	1.20	0.27	0.27	0.61	0.61	1.11	1.11	3.90	3.90
2) Paddy x 2 + Palawija x 1	4.00	4.00	7.50	7.50	6.38	6.38	3.92	3.92	1.33	1.33	0.86	0.86	0.84	0.84	1.20	1.20	0.27	0.27	0.61	0.61	1.11	1.11	3.90	3.90
3) Paddy x 1 + Palawija x 2	4.00	4.00	7.50	7.50	6.38	6.38	3.92	3.92	1.33	1.33	0.86	0.86	0.84	0.84	1.20	1.20	0.27	0.27	0.61	0.61	1.11	1.11	3.90	3.90
4) Paddy x 2	4.00	4.00	7.50	7.50	6.38	6.38	3.92	3.92	1.33	1.33	0.86	0.86	0.84	0.84	1.20	1.20	0.27	0.27	0.61	0.61	1.11	1.11	3.90	3.90
5) Paddy x 1 + Palawija x 1	4.00	4.00	7.50	7.50	6.38	6.38	3.92	3.92	1.33	1.33	0.86	0.86	0.84	0.84	1.20	1.20	0.27	0.27	0.61	0.61	1.11	1.11	3.90	3.90
6) Palawija x 2	4.00	4.00	7.50	7.50	6.38	6.38	3.92	3.92	1.33	1.33	0.86	0.86	0.84	0.84	1.20	1.20	0.27	0.27	0.61	0.61	1.11	1.11	3.90	3.90
7) Paddy x 1	4.00	4.00	7.50	7.50	6.38	6.38	3.92	3.92	1.33	1.33	0.86	0.86	0.84	0.84	1.20	1.20	0.27	0.27	0.61	0.61	1.11	1.11	3.90	3.90
6. Land Preparation (mm/day)																								
1) Paddy x3	3.33						3.33	6.67	3.33						3.33	6.67	3.33						3.33	6.67
2) Paddy x 2 + Palawija x 1	3.33						3.33	6.67	3.33														3.33	6.67
3) Paddy x 1 + Palawija x 2	3.33																						3.33	6.67
4) Paddy x 2	3.33	6.67	3.33						3.33	6.67	3.33													
5) Paddy x 1 + Palawija x 1	3.33	6.67	3.33																					
6) Palawija x 2																								
7) Paddy x 1	3.33	6.67	3.33																					
7. Water Layer Replacement (mm/day)																								
1) Paddy x3		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67			
2) Paddy x 2 + Palawija x 1		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67											
3) Paddy x 1 + Palawija x 2		1.67	1.67	1.67	1.67																			
4) Paddy x 2				1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67									
5) Paddy x 1 + Palawija x 1				1.67	1.67	1.67	1.67																	
6) Palawija x 2																								
7) Paddy x 1				1.67	1.67	1.67	1.67																	
8. Infiltration Loss (2mm/day)																								
1) Paddy x 3	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2
2) Paddy x 2 + Palawija x 1	2	2	2	2	2	1	1	2	2	2	2	2	2	1									1	2
3) Paddy x 1 + Palawija x 2	2	2	2	2	2	1																	1	2
4) Paddy x 2	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1								
5) Paddy x 1 + Palawija x 1	1	2	2	2	2	2	2	1																
6) Palawija x 2																								
7) Paddy x 1	1	2	2	2	2	2	2	1																
9. Field Water Requirement by Cropping Pattern (mm/day)																								
1) Paddy x 3	2.86	2.74	0.00	0.00	0.82	0.00	0.41	4.75	5.84	6.01	6.65	6.55	5.94	1.64	3.13	7.47	6.97	7.23	6.93	6.82	5.94	1.50	0.43	4.77
2) Paddy x 2 + Palawija x 1	2.86	2.74	0.00	0.00	0.82	0.00	0.41	4.75	5.84	6.01	6.65	6.55	5.94	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	4.77
3) Paddy x 1 + Palawija x 2	2.86	2.74	0.00	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	4.77
4) Paddy x 2	0.33	4.67	0.00	0.00	1.10	1.00	2.83	0.00	3.00	7.34	6.43	6.73	6.19	6.10	5.93	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.33	4.67	0.00	0.00	1.10	1.00	2.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.33	4.67	0.00	0.00	1.10	1.00	2.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
10. Unit Irrigation Water Requirement by Cropping Pattern (mm/day) Overall Efficiency =50%																									
	1) Paddy x 3	5.72	5.48	0.00	0.00	1.64	0.00	0.82	9.50	11.68	12.02	13.30	13.10	11.88	3.28	6.26	14.94	13.94	14.46	13.86	13.64	11.88	3.00	0.86	9.54
	2) Paddy x 2 + Palawija x 1	5.72	5.48	0.00	0.00	1.64	0.00	0.82	9.50	11.68	12.02	13.30	13.10	11.88	3.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	9.54
	3) Paddy x 1 + Palawija x 2	5.72	5.48	0.00	0.00	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	9.54
	4) Paddy x 2	0.66	9.34	0.00	0.00	2.20	2.00	5.66	0.00	6.00	14.68	12.86	13.46	12.38	12.20	11.86	2.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5) Paddy x 1 + Palawija x 1	0.66	9.34	0.00	0.00	2.20	2.00	5.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7) Paddy x 1	0.66	9.34	0.00	0.00	2.20	2.00	5.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11. Unit Irrigation Water Requirement by Regency (50% Efficiency) = Ratio of Cropping Pattern x Unit Irrigation Water Requirement (mm/day)																									
0.304	1) Paddy x 3	1.74	1.67	0.00	0.00	0.50	0.00	0.25	2.89	3.55	3.65	4.04	3.98	3.61	1.00	1.90	4.54	4.24	4.40	4.21	4.15	3.61	0.91	0.26	2.90
0.074	2) Paddy x 2 + Palawija x 1	0.42	0.41	0.00	0.00	0.12	0.00	0.06	0.70	0.86	0.89	0.98	0.97	0.88	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.71
0.021	3) Paddy x 1 + Palawija x 2	0.12	0.12	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.20
0.471	4) Paddy x 2	0.31	4.40	0.00	0.00	1.04	0.94	2.67	0.00	2.83	6.91	6.06	6.34	5.83	5.75	5.59	1.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.024	5) Paddy x 1 + Palawija x 1	0.02	0.22	0.00	0.00	0.05	0.05	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.038	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.068	7) Paddy x 1	0.04	0.64	0.00	0.00	0.15	0.14	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.000																									
	Total (mm/day)	2.65	7.46	0.00	0.00	1.89	1.13	3.50	3.59	7.24	11.45	11.08	11.29	10.32	6.99	7.49	5.90	4.24	4.40	4.21	4.15	3.61	0.91	0.34	3.81
	Total (liter/sec/ha)	0.307	0.863	0.000	0.000	0.219	0.131	0.405	0.416	0.838	1.325	1.282	1.307	1.194	0.809	0.867	0.683	0.491	0.509	0.487	0.480	0.418	0.105	0.039	0.441

12. Unit Irrigation Water Requirement by Regency (liter/sec/ha) : 50% Efficiency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average (liter/sec/ha)	0.000	0.175	0.411	1.082	1.295	1.002	0.775	0.500	0.484	0.262	0.240	0.585

Note
P : Land Preparation
ETo : Reference Crop Evapotranspiration
Irrigation is applied to only paddy culture.

Klungkung Regency

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1. Crop Coefficient																								
1) Paddy x 3	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		
2) Paddy x 2 + Palawija x 1	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		0.00	0.00	0.00	0.00	0.00	0.00	0.00		
3) Paddy x 1 + Palawija x 2	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P	P
	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P
Average	1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00			
4) Paddy x 2	P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95									
		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95								
Average			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95								
5) Paddy x 1 + Palawija x 1	P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95										
		P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95									
Average			1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00									
6) Palawija x 2	0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95										
		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95									
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00									
7) Paddy x 1	P	P	1.10	1.10	1.05	1.05	0.95																	
		P	P	1.10	1.10	1.05	1.05	0.95																
Average			1.10	1.10	1.08	1.05	1.00	0.95																
2. Cropped Area Ratio																								
1) Paddy x 3	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		
2) Paddy x 2 + Palawija x 1	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5		
3) Paddy x 1 + Palawija x 2	0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5			
4) Paddy x 2			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5								
5) Paddy x 1 + Palawija x 1			0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5									
6) Palawija x 2	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5									
7) Paddy x 1			0.5	1	1	1	1	0.5																
3. ETo (mm/day) 511003	2.79	2.79	2.73	2.73	3.53	3.53	3.08	3.08	3.34	3.34	3.56	3.56	3.11	3.11	3.46	3.46	3.48	3.48	3.58	3.58	3.38	3.38	2.95	2.95
4. Crop Water Requirement (mm/day)																								
1) Paddy x 3	1.53	3.07	2.95	2.87	3.53	1.68	0.00	0.00	1.84	3.67	3.84	3.74	3.11	1.48	0.00	0.00	1.91	3.83	3.87	3.76	3.38	1.61	0.00	0.00
2) Paddy x 2 + Palawija x 1	1.53	3.07	2.95	2.87	3.53	1.68	0.00	0.00	1.84	3.67	3.84	3.74	3.11	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	1.53	3.07	2.95	2.87	3.53	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) Paddy x 2	0.00	0.00	1.50	3.00	3.81	3.71	3.08	1.46	0.00	0.00	1.96	3.92	3.36	3.27	3.46	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.00	0.00	1.50	3.00	3.81	3.71	3.08	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.00	0.00	1.50	3.00	3.81	3.71	3.08	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5. Effective Rainfall (mm/day)	3.03	3.03	5.01	5.01	4.05	4.05	3.09	3.09	0.96	0.96	0.81	0.81	0.30	0.30	0.45	0.45	0.34	0.34	0.05	0.05	0.52	0.52	2.78	2.78
No.444f 1) Paddy x 3	3.03	3.03	5.01	5.01	4.05	4.05	3.09	3.09	0.96	0.96	0.81	0.81	0.30	0.30	0.45	0.45	0.34	0.34	0.05	0.05	0.52	0.52	2.78	2.78
2) Paddy x 2 + Palawija x 1	3.03	3.03	5.01	5.01	4.05	4.05	3.09	3.09	0.96	0.96	0.81	0.81	0.30	0.30	0.45	0.45	0.34	0.34	0.05	0.05	0.52	0.52	2.78	2.78
3) Paddy x 1 + Palawija x 2	3.03	3.03	5.01	5.01	4.05	4.05	3.09	3.09	0.96	0.96	0.81	0.81	0.30	0.30	0.45	0.45	0.34	0.34	0.05	0.05	0.52	0.52	2.78	2.78
4) Paddy x 2	3.03	3.03	5.01	5.01	4.05	4.05	3.09	3.09	0.96	0.96	0.81	0.81	0.30	0.30	0.45	0.45	0.34	0.34	0.05	0.05	0.52	0.52	2.78	2.78
5) Paddy x 1 + Palawija x 1	3.03	3.03	5.01	5.01	4.05	4.05	3.09	3.09	0.96	0.96	0.81	0.81	0.30	0.30	0.45	0.45	0.34	0.34	0.05	0.05	0.52	0.52	2.78	2.78
6) Palawija x 2	3.03	3.03	5.01	5.01	4.05	4.05	3.09	3.09	0.96	0.96	0.81	0.81	0.30	0.30	0.45	0.45	0.34	0.34	0.05	0.05	0.52	0.52	2.78	2.78
7) Paddy x 1	3.03	3.03	5.01	5.01	4.05	4.05	3.09	3.09	0.96	0.96	0.81	0.81	0.30	0.30	0.45	0.45	0.34	0.34	0.05	0.05	0.52	0.52	2.78	2.78
6. Land Preparation (mm/day)																								
1) Paddy x 3	3.33						3.33	6.67	3.33						3.33	6.67	3.33						3.33	6.67
2) Paddy x 2 + Palawija x 1	3.33						3.33	6.67	3.33														3.33	6.67
3) Paddy x 1 + Palawija x 2	3.33																						3.33	6.67
4) Paddy x 2	3.33	6.67	3.33						3.33	6.67	3.33													
5) Paddy x 1 + Palawija x 1	3.33	6.67	3.33																					
6) Palawija x 2																								
7) Paddy x 1	3.33	6.67	3.33																					
7. Water Layer Replacement (mm/day)																								
1) Paddy x 3		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67			
2) Paddy x 2 + Palawija x 1		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67											
3) Paddy x 1 + Palawija x 2		1.67	1.67	1.67	1.67																			
4) Paddy x 2				1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67									
5) Paddy x 1 + Palawija x 1				1.67	1.67	1.67	1.67																	
6) Palawija x 2																								
7) Paddy x 1				1.67	1.67	1.67	1.67																	
8. Infiltration Loss (2mm/day)																								
1) Paddy x 3	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2
2) Paddy x 2 + Palawija x 1	2	2	2	2	2	1	1	2	2	2	2	2	2	1									1	2
3) Paddy x 1 + Palawija x 2	2	2	2	2	2	1																	1	2
4) Paddy x 2	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1								
5) Paddy x 1 + Palawija x 1	1	2	2	2	2	2	2	1																
6) Palawija x 2																								
7) Paddy x 1	1	2	2	2	2	2	2	1																
9. Field Water Requirement by Cropping Pattern (mm/day)																								
1) Paddy x 3	3.83	3.71	1.61	1.53	3.15	0.00	1.24	5.58	6.21	6.38	6.70	6.60	6.48	2.18	3.88	8.22	6.90	7.16	7.49	7.38	6.53	2.09	1.55	5.89
2) Paddy x 2 + Palawija x 1	3.83	3.71	1.61	1.53	3.15	0.00	1.24	5.58	6.21	6.38	6.70	6.60	6.48	2.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.55	5.89
3) Paddy x 1 + Palawija x 2	3.83	3.71	1.61	1.53	3.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.55	5.89
4) Paddy x 2	1.30	5.64	1.82	1.66	3.43	3.33	3.66	0.00	3.37	7.71	6.48	6.78	6.73	6.64	6.68	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	1.30	5.64	1.82	1.66	3.43	3.33	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	1.30	5.64	1.82	1.66	3.43	3.33	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
10. Unit Irrigation Water Requirement by Cropping Pattern (mm/day) Overall Efficiency =50%																									
	1) Paddy x 3	7.66	7.42	3.22	3.06	6.30	0.00	2.48	11.16	12.42	12.76	13.40	13.20	12.96	4.36	7.76	16.44	13.80	14.32	14.98	14.76	13.06	4.18	3.10	11.78
	2) Paddy x 2 + Palawija x 1	7.66	7.42	3.22	3.06	6.30	0.00	2.48	11.16	12.42	12.76	13.40	13.20	12.96	4.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.10	11.78
	3) Paddy x 1 + Palawija x 2	7.66	7.42	3.22	3.06	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.10	11.78
	4) Paddy x 2	2.60	11.28	3.64	3.32	6.86	6.66	7.32	0.00	6.74	15.42	12.96	13.56	13.46	13.28	13.36	4.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5) Paddy x 1 + Palawija x 1	2.60	11.28	3.64	3.32	6.86	6.66	7.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7) Paddy x 1	2.60	11.28	3.64	3.32	6.86	6.66	7.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11. Unit Irrigation Water Requirement by Regency (50% Efficiency) = Ratio of Cropping Pattern x Unit Irrigation Water Requirement (mm/day)																									
0.084	1) Paddy x 3	0.64	0.62	0.27	0.26	0.53	0.00	0.21	0.94	1.04	1.07	1.13	1.11	1.09	0.37	0.65	1.38	1.16	1.20	1.26	1.24	1.10	0.35	0.26	0.99
0.432	2) Paddy x 2 + Palawija x 1	3.31	3.21	1.39	1.32	2.72	0.00	1.07	4.82	5.37	5.51	5.79	5.70	5.60	1.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34	5.09
0.330	3) Paddy x 1 + Palawija x 2	2.53	2.45	1.06	1.01	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02	3.89
0.022	4) Paddy x 2	0.06	0.25	0.08	0.07	0.15	0.15	0.16	0.00	0.15	0.34	0.29	0.30	0.30	0.29	0.29	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.068	5) Paddy x 1 + Palawija x 1	0.18	0.77	0.25	0.23	0.47	0.45	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.000	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.064	7) Paddy x 1	0.17	0.72	0.23	0.21	0.44	0.43	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.000																									
	Total (mm/day)	6.89	8.02	3.28	3.10	6.39	1.03	2.41	5.76	6.56	6.92	7.21	7.11	6.99	2.54	0.94	1.48	1.16	1.20	1.26	1.24	1.10	0.35	2.62	9.97
	Total (liter/sec/ha)	0.797	0.928	0.380	0.359	0.740	0.119	0.279	0.667	0.759	0.801	0.834	0.823	0.809	0.294	0.109	0.171	0.134	0.139	0.146	0.144	0.127	0.041	0.303	1.154

12. Unit Irrigation Water Requirement by Regency (liter/sec/ha) : 50% Efficiency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average (liter/sec/ha)	0.370	0.430	0.473	0.780	0.829	0.552	0.140	0.137	0.145	0.084	0.729	0.863

Note
P : Land Preparation
ETo : Reference Crop Evapotranspiration
Irrigation is applied to only paddy culture.

Bangli Regency

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1. Crop Coefficient																								
1) Paddy x 3	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		
2) Paddy x 2 + Palawija x 1	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		0.00	0.00	0.00	0.00	0.00	0.00	0.00		
3) Paddy x 1 + Palawija x 2	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P	P
	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P
Average	1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00			
4) Paddy x 2	P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95									
		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95								
Average			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95								
5) Paddy x 1 + Palawija x 1	P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95										
		P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95									
Average			1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00									
6) Palawija x 2	0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95										
		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95									
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00									
7) Paddy x 1	P	P	1.10	1.10	1.05	1.05	0.95																	
		P	P	1.10	1.10	1.05	1.05	0.95																
Average			1.10	1.10	1.08	1.05	1.00	0.95																
2. Cropped Area Ratio																								
1) Paddy x 3	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		
2) Paddy x 2 + Palawija x 1	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5		
3) Paddy x 1 + Palawija x 2	0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5			
4) Paddy x 2			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5								
5) Paddy x 1 + Palawija x 1			0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5									
6) Palawija x 2	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5									
7) Paddy x 1			0.5	1	1	1	1	0.5																
3. ETo (mm/day) 511003	2.79	2.79	2.73	2.73	3.53	3.53	3.08	3.08	3.34	3.34	3.56	3.56	3.11	3.11	3.46	3.46	3.48	3.48	3.58	3.58	3.38	3.38	2.95	2.95
4. Crop Water Requirement (mm/day)																								
1) Paddy x 3	1.53	3.07	2.95	2.87	3.53	1.68	0.00	0.00	1.84	3.67	3.84	3.74	3.11	1.48	0.00	0.00	1.91	3.83	3.87	3.76	3.38	1.61	0.00	0.00
2) Paddy x 2 + Palawija x 1	1.53	3.07	2.95	2.87	3.53	1.68	0.00	0.00	1.84	3.67	3.84	3.74	3.11	1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	1.53	3.07	2.95	2.87	3.53	1.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) Paddy x 2	0.00	0.00	1.50	3.00	3.81	3.71	3.08	1.46	0.00	0.00	1.96	3.92	3.36	3.27	3.46	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.00	0.00	1.50	3.00	3.81	3.71	3.08	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.00	0.00	1.50	3.00	3.81	3.71	3.08	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5. Effective Rainfall (mm/day)	4.13	4.13	7.29	7.29	5.20	5.20	5.49	5.49	1.63	1.63	1.29	1.29	0.26	0.26	0.75	0.75	0.29	0.29	0.61	0.61	1.47	1.47	3.92	3.92
No.441d 1) Paddy x 3	4.13	4.13	7.29	7.29	5.20	5.20	5.49	5.49	1.63	1.63	1.29	1.29	0.26	0.26	0.75	0.75	0.29	0.29	0.61	0.61	1.47	1.47	3.92	3.92
2) Paddy x 2 + Palawija x 1	4.13	4.13	7.29	7.29	5.20	5.20	5.49	5.49	1.63	1.63	1.29	1.29	0.26	0.26	0.75	0.75	0.29	0.29	0.61	0.61	1.47	1.47	3.92	3.92
3) Paddy x 1 + Palawija x 2	4.13	4.13	7.29	7.29	5.20	5.20	5.49	5.49	1.63	1.63	1.29	1.29	0.26	0.26	0.75	0.75	0.29	0.29	0.61	0.61	1.47	1.47	3.92	3.92
4) Paddy x 2	4.13	4.13	7.29	7.29	5.20	5.20	5.49	5.49	1.63	1.63	1.29	1.29	0.26	0.26	0.75	0.75	0.29	0.29	0.61	0.61	1.47	1.47	3.92	3.92
5) Paddy x 1 + Palawija x 1	4.13	4.13	7.29	7.29	5.20	5.20	5.49	5.49	1.63	1.63	1.29	1.29	0.26	0.26	0.75	0.75	0.29	0.29	0.61	0.61	1.47	1.47	3.92	3.92
6) Palawija x 2	4.13	4.13	7.29	7.29	5.20	5.20	5.49	5.49	1.63	1.63	1.29	1.29	0.26	0.26	0.75	0.75	0.29	0.29	0.61	0.61	1.47	1.47	3.92	3.92
7) Paddy x 1	4.13	4.13	7.29	7.29	5.20	5.20	5.49	5.49	1.63	1.63	1.29	1.29	0.26	0.26	0.75	0.75	0.29	0.29	0.61	0.61	1.47	1.47	3.92	3.92
6. Land Preparation (mm/day)																								
1) Paddy x 3	3.33						3.33	6.67	3.33						3.33	6.67	3.33						3.33	6.67
2) Paddy x 2 + Palawija x 1	3.33						3.33	6.67	3.33														3.33	6.67
3) Paddy x 1 + Palawija x 2	3.33																						3.33	6.67
4) Paddy x 2	3.33	6.67	3.33						3.33	6.67	3.33													
5) Paddy x 1 + Palawija x 1	3.33	6.67	3.33																					
6) Palawija x 2																								
7) Paddy x 1	3.33	6.67	3.33																					
7. Water Layer Replacement (mm/day)																								
1) Paddy x 3		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67			
2) Paddy x 2 + Palawija x 1		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67											
3) Paddy x 1 + Palawija x 2		1.67	1.67	1.67	1.67																			
4) Paddy x 2				1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67									
5) Paddy x 1 + Palawija x 1				1.67	1.67	1.67	1.67																	
6) Palawija x 2																								
7) Paddy x 1				1.67	1.67	1.67	1.67																	
8. Infiltration Loss (2mm/day)																								
1) Paddy x 3	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2
2) Paddy x 2 + Palawija x 1	2	2	2	2	2	1	1	2	2	2	2	2	2	1									1	2
3) Paddy x 1 + Palawija x 2	2	2	2	2	2	1																	1	2
4) Paddy x 2	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1								
5) Paddy x 1 + Palawija x 1	1	2	2	2	2	2	2	1																
6) Palawija x 2																								
7) Paddy x 1	1	2	2	2	2	2	2	1																
9. Field Water Requirement by Cropping Pattern (mm/day)																								
1) Paddy x 3	2.73	2.61	0.00	0.00	2.00	0.00	0.00	3.18	5.54	5.71	6.22	6.12	6.52	2.22	3.58	7.92	6.95	7.21	6.93	6.82	5.58	1.14	0.41	4.75
2) Paddy x 2 + Palawija x 1	2.73	2.61	0.00	0.00	2.00	0.00	0.00	3.18	5.54	5.71	6.22	6.12	6.52	2.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	4.75
3) Paddy x 1 + Palawija x 2	2.73	2.61	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	4.75
4) Paddy x 2	0.20	4.54	0.00	0.00	2.28	2.18	1.26	0.00	2.70	7.04	6.00	6.30	6.77	6.68	6.38	1.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.20	4.54	0.00	0.00	2.28	2.18	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.20	4.54	0.00	0.00	2.28	2.18	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
10. Unit Irrigation Water Requirement by Cropping Pattern (mm/day) Overall Efficiency =50%																									
	1) Paddy x 3	5.46	5.22	0.00	0.00	4.00	0.00	0.00	6.36	11.08	11.42	12.44	12.24	13.04	4.44	7.16	15.84	13.90	14.42	13.86	13.64	11.16	2.28	0.82	9.50
	2) Paddy x 2 + Palawija x 1	5.46	5.22	0.00	0.00	4.00	0.00	0.00	6.36	11.08	11.42	12.44	12.24	13.04	4.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	9.50
	3) Paddy x 1 + Palawija x 2	5.46	5.22	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	9.50
	4) Paddy x 2	0.40	9.08	0.00	0.00	4.56	4.36	2.52	0.00	5.40	14.08	12.00	12.60	13.54	13.36	12.76	3.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5) Paddy x 1 + Palawija x 1	0.40	9.08	0.00	0.00	4.56	4.36	2.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7) Paddy x 1	0.40	9.08	0.00	0.00	4.56	4.36	2.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11. Unit Irrigation Water Requirement by Regency (50% Efficiency) = Ratio of Cropping Pattern x Unit Irrigation Water Requirement (mm/day)																									
0.396	1) Paddy x 3	2.16	2.07	0.00	0.00	1.58	0.00	0.00	2.52	4.39	4.52	4.93	4.85	5.16	1.76	2.84	6.27	5.50	5.71	5.49	5.40	4.42	0.90	0.32	3.76
0.367	2) Paddy x 2 + Palawija x 1	2.00	1.92	0.00	0.00	1.47	0.00	0.00	2.33	4.07	4.19	4.57	4.49	4.79	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	3.49
0.071	3) Paddy x 1 + Palawija x 2	0.39	0.37	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.67
0.126	4) Paddy x 2	0.05	1.14	0.00	0.00	0.57	0.55	0.32	0.00	0.68	1.77	1.51	1.59	1.71	1.68	1.61	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.040	5) Paddy x 1 + Palawija x 1	0.02	0.36	0.00	0.00	0.18	0.17	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.000	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.000	7) Paddy x 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.000																									
	Total (mm/day)	4.62	5.86	0.00	0.00	4.08	0.72	0.42	4.85	9.14	10.48	11.01	10.93	11.66	5.07	4.45	6.75	5.50	5.71	5.49	5.40	4.42	0.90	0.68	7.92
	Total (liter/sec/ha)	0.535	0.678	0.000	0.000	0.472	0.083	0.049	0.561	1.058	1.213	1.274	1.265	1.350	0.587	0.515	0.781	0.637	0.661	0.635	0.625	0.512	0.104	0.079	0.917

12. Unit Irrigation Water Requirement by Regency (liter/sec/ha) : 50% Efficiency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average (liter/sec/ha)	0.000	0.278	0.305	1.136	1.270	0.969	0.648	0.649	0.630	0.308	0.498	0.607

Note
P : Land Preparation
ETo : Reference Crop Evapotranspiration
Irrigation is applied to only paddy culture.

Karangasem Regency

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1. Crop Coefficient																								
1) Paddy x 3	P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95	
		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95
Average			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95
2) Paddy x 2 + Palawija x 1	P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95	
		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95
Average			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		
		P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95	
Average			1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	
4) Paddy x 2			P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95							
				P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95						
Average					1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95						
5) Paddy x 1 + Palawija x 1			P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95								
				P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95							
Average					1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
6) Palawija x 2			0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95								
				0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95							
Average			0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00							
7) Paddy x 1			P	P	1.10	1.10	1.05	1.05	0.95															
				P	P	1.10	1.10	1.05	1.05	0.95														
Average					1.10	1.10	1.08	1.05	1.00	0.95														
2. Cropped Area Ratio																								
1) Paddy x 3			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5
2) Paddy x 2 + Palawija x 1			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5
3) Paddy x 1 + Palawija x 2			0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5	
4) Paddy x 2					0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5						
5) Paddy x 1 + Palawija x 1					0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5							
6) Palawija x 2			0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5							
7) Paddy x 1					0.5	1	1	1	1	0.5														
3. ETo (mm/day) 511005	3.07	3.07	2.87	2.87	3.23	3.23	3.68	3.68	4.28	4.28	4.16	4.16	3.93	3.93	3.96	3.96	4.29	4.29	4.38	4.38	4.17	4.17	3.60	3.60
4. Crop Water Requirement (mm/day)																								
1) Paddy x 3	0.00	0.00	1.58	3.16	3.49	3.39	3.68	1.75	0.00	0.00	2.29	4.58	4.24	4.13	3.96	1.88	0.00	0.00	2.41	4.82	4.50	4.38	3.60	1.71
2) Paddy x 2 + Palawija x 1	0.00	0.00	1.58	3.16	3.49	3.39	3.68	1.75	0.00	0.00	2.29	4.58	4.24	4.13	3.96	1.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	0.00	0.00	1.58	3.16	3.49	3.39	3.68	1.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) Paddy x 2	0.00	0.00	0.00	0.00	1.78	3.55	3.97	3.86	4.28	2.03	0.00	0.00	2.16	4.32	4.28	4.16	4.29	2.04	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.00	0.00	0.00	0.00	1.78	3.55	3.97	3.86	4.28	2.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.00	0.00	0.00	0.00	1.78	3.55	3.97	3.86	4.28	2.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5. Effective Rainfall (mm/day)	3.25	3.25	6.03	6.03	5.40	5.40	3.27	3.27	1.42	1.42	0.50	0.50	0.28	0.28	0.72	0.72	0.38	0.38	0.40	0.40	0.43	0.43	1.68	1.68
No.442d 1) Paddy x 3	3.25	3.25	6.03	6.03	5.40	5.40	3.27	3.27	1.42	1.42	0.50	0.50	0.28	0.28	0.72	0.72	0.38	0.38	0.40	0.40	0.43	0.43	1.68	1.68
2) Paddy x 2 + Palawija x 1	3.25	3.25	6.03	6.03	5.40	5.40	3.27	3.27	1.42	1.42	0.50	0.50	0.28	0.28	0.72	0.72	0.38	0.38	0.40	0.40	0.43	0.43	1.68	1.68
3) Paddy x 1 + Palawija x 2	3.25	3.25	6.03	6.03	5.40	5.40	3.27	3.27	1.42	1.42	0.50	0.50	0.28	0.28	0.72	0.72	0.38	0.38	0.40	0.40	0.43	0.43	1.68	1.68
4) Paddy x 2	3.25	3.25	6.03	6.03	5.40	5.40	3.27	3.27	1.42	1.42	0.50	0.50	0.28	0.28	0.72	0.72	0.38	0.38	0.40	0.40	0.43	0.43	1.68	1.68
5) Paddy x 1 + Palawija x 1	3.25	3.25	6.03	6.03	5.40	5.40	3.27	3.27	1.42	1.42	0.50	0.50	0.28	0.28	0.72	0.72	0.38	0.38	0.40	0.40	0.43	0.43	1.68	1.68
6) Palawija x 2	3.25	3.25	6.03	6.03	5.40	5.40	3.27	3.27	1.42	1.42	0.50	0.50	0.28	0.28	0.72	0.72	0.38	0.38	0.40	0.40	0.43	0.43	1.68	1.68
7) Paddy x 1	3.25	3.25	6.03	6.03	5.40	5.40	3.27	3.27	1.42	1.42	0.50	0.50	0.28	0.28	0.72	0.72	0.38	0.38	0.40	0.40	0.43	0.43	1.68	1.68
6. Land Preparation (mm/day)																								
1) Paddy x 3	3.33	6.67	3.33						3.33	6.67	3.33						3.33	6.67	3.33					
2) Paddy x 2 + Palawija x 1	3.33	6.67	3.33						3.33	6.67	3.33													
3) Paddy x 1 + Palawija x 2	3.33	6.67	3.33																					
4) Paddy x 2			3.33	6.67	3.33						3.33	6.67	3.33											
5) Paddy x 1 + Palawija x 1			3.33	6.67	3.33																			
6) Palawija x 2																								
7) Paddy x 1			3.33	6.67	3.33																			
7. Water Layer Replacement (mm/day)																								
1) Paddy x 3				1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67	
2) Paddy x 2 + Palawija x 1				1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67									
3) Paddy x 1 + Palawija x 2				1.67	1.67	1.67	1.67																	
4) Paddy x 2						1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67							
5) Paddy x 1 + Palawija x 1						1.67	1.67	1.67	1.67															
6) Palawija x 2																								
7) Paddy x 1						1.67	1.67	1.67	1.67															
8. Infiltration Loss (2mm/day)																								
1) Paddy x 3	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1
2) Paddy x 2 + Palawija x 1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1				2	2	2	2	
3) Paddy x 1 + Palawija x 2	1	2	2	2	2	2	2	1																
4) Paddy x 2			1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1						
5) Paddy x 1 + Palawija x 1			1	2	2	2	2	2	2	1														
6) Palawija x 2																								
7) Paddy x 1			1	2	2	2	2	2	2	1														
9. Field Water Requirement by Cropping Pattern (mm/day)																								
1) Paddy x 3	1.08	5.42	0.88	0.80	1.76	1.66	4.08	0.00	2.91	7.25	7.12	7.75	7.63	7.52	6.91	2.16	3.95	8.29	7.34	8.09	7.74	7.62	5.59	1.03
2) Paddy x 2 + Palawija x 1	1.08	5.42	0.88	0.80	1.76	1.66	4.08	0.00	2.91	7.25	7.12	7.75	7.63	7.52	6.91	2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	1.08	5.42	0.88	0.80	1.76	1.66	4.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) Paddy x 2	0.00	0.00	0.00	2.64	1.71	1.82	4.37	4.26	6.53	1.61	3.83	8.17	7.21	7.71	7.23	7.11	7.58	2.66	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.00	0.00	0.00	2.64	1.71	1.82	4.37	4.26	6.53	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.00	0.00	0.00	2.64	1.71	1.82	4.37	4.26	6.53	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
10. Unit Irrigation Water Requirement by Cropping Pattern (mm/day) Overall Efficiency =50%																									
	1) Paddy x 3	2.16	10.84	1.76	1.60	3.52	3.32	8.16	0.00	5.82	14.50	14.24	15.50	15.26	15.04	13.82	4.32	7.90	16.58	14.68	16.18	15.48	15.24	11.18	2.06
	2) Paddy x 2 + Palawija x 1	2.16	10.84	1.76	1.60	3.52	3.32	8.16	0.00	5.82	14.50	14.24	15.50	15.26	15.04	13.82	4.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3) Paddy x 1 + Palawija x 2	2.16	10.84	1.76	1.60	3.52	3.32	8.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4) Paddy x 2	0.00	0.00	0.00	5.28	3.42	3.64	8.74	8.52	13.06	3.22	7.66	16.34	14.42	15.42	14.46	14.22	15.16	5.32	0.00	0.00	0.00	0.00	0.00	0.00
	5) Paddy x 1 + Palawija x 1	0.00	0.00	0.00	5.28	3.42	3.64	8.74	8.52	13.06	3.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7) Paddy x 1	0.00	0.00	0.00	5.28	3.42	3.64	8.74	8.52	13.06	3.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11. Unit Irrigation Water Requirement by Regency (50% Efficiency) = Ratio of Cropping Pattern x Unit Irrigation Water Requirement (mm/day)																									
0.043	1) Paddy x 3	0.09	0.47	0.08	0.07	0.15	0.14	0.35	0.00	0.25	0.62	0.61	0.67	0.66	0.65	0.59	0.19	0.34	0.71	0.63	0.70	0.67	0.66	0.48	0.09
0.333	2) Paddy x 2 + Palawija x 1	0.72	3.61	0.59	0.53	1.17	1.11	2.72	0.00	1.94	4.83	4.74	5.16	5.08	5.01	4.60	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.462	3) Paddy x 1 + Palawija x 2	1.00	5.01	0.81	0.74	1.63	1.53	3.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.043	4) Paddy x 2	0.00	0.00	0.00	0.23	0.15	0.16	0.38	0.37	0.56	0.14	0.33	0.70	0.62	0.66	0.62	0.61	0.65	0.23	0.00	0.00	0.00	0.00	0.00	0.00
0.056	5) Paddy x 1 + Palawija x 1	0.00	0.00	0.00	0.30	0.19	0.20	0.49	0.48	0.73	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.031	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.032	7) Paddy x 1	0.00	0.00	0.00	0.17	0.11	0.12	0.28	0.27	0.42	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.000																									
	Total (mm/day)	1.81	9.09	1.48	2.04	3.40	3.26	7.99	1.12	3.90	5.87	5.68	6.53	6.36	6.32	5.81	2.24	0.99	0.94	0.63	0.70	0.67	0.66	0.48	0.09
	Total (liter/sec/ha)	0.209	1.052	0.171	0.236	0.394	0.377	0.925	0.130	0.451	0.679	0.657	0.756	0.736	0.731	0.672	0.259	0.115	0.109	0.073	0.081	0.078	0.076	0.056	0.010

12. Unit Irrigation Water Requirement by Regency (liter/sec/ha) : 50% Efficiency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average (liter/sec/ha)	0.204	0.386	0.528	0.565	0.707	0.734	0.466	0.112	0.077	0.077	0.033	0.631

Note
P : Land Preparation
ETo : Reference Crop Evapotranspiration
Irrigation is applied to only paddy culture.

Buleleng Regency

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1. Crop Coefficient																								
1) Paddy x 3	P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95	
		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95
Average			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95
2) Paddy x 2 + Palawija x 1	P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95	
		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95
Average			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		
		P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95	
Average			1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	
4) Paddy x 2			P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95								
				P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95						
Average					1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95						
5) Paddy x 1 + Palawija x 1			P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95								
				P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95							
Average					1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
6) Palawija x 2			0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95								
				0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95							
Average			0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00							
7) Paddy x 1			P	P	1.10	1.10	1.05	1.05	0.95															
				P	P	1.10	1.10	1.05	1.05	0.95														
Average					1.10	1.10	1.08	1.05	1.00	0.95														
2. Cropped Area Ratio																								
1) Paddy x 3			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5
2) Paddy x 2 + Palawija x 1			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5
3) Paddy x 1 + Palawija x 2			0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5	
4) Paddy x 2					0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5						
5) Paddy x 1 + Palawija x 1					0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5							
6) Palawija x 2			0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5							
7) Paddy x 1					0.5	1	1	1	1	0.5														
3. ETo (mm/day) 511001	3.73	3.73	3.52	3.52	3.58	3.58	3.77	3.77	3.77	3.77	3.60	3.60	3.35	3.35	3.58	3.58	4.03	4.03	4.58	4.58	4.42	4.42	3.97	3.97
4. Crop Water Requirement (mm/day)																								
1) Paddy x 3	0.00	0.00	1.94	3.87	3.87	3.76	3.77	1.79	0.00	0.00	1.98	3.96	3.62	3.52	3.58	1.70	0.00	0.00	2.52	5.04	4.77	4.64	3.97	1.89
2) Paddy x 2 + Palawija x 1	0.00	0.00	1.94	3.87	3.87	3.76	3.77	1.79	0.00	0.00	1.98	3.96	3.62	3.52	3.58	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	0.00	0.00	1.94	3.87	3.87	3.76	3.77	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) Paddy x 2	0.00	0.00	0.00	0.00	1.97	3.94	4.07	3.96	3.77	1.79	0.00	0.00	1.84	3.69	3.87	3.76	4.03	1.91	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.00	0.00	0.00	0.00	1.97	3.94	4.07	3.96	3.77	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.00	0.00	0.00	0.00	1.97	3.94	4.07	3.96	3.77	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5. Effective Rainfall (mm/day)	2.42	2.42	4.81	4.81	5.55	5.55	2.91	2.91	1.00	1.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.37
No.438e 1) Paddy x 3	2.42	2.42	4.81	4.81	5.55	5.55	2.91	2.91	1.00	1.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.37
2) Paddy x 2 + Palawija x 1	2.42	2.42	4.81	4.81	5.55	5.55	2.91	2.91	1.00	1.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.37
3) Paddy x 1 + Palawija x 2	2.42	2.42	4.81	4.81	5.55	5.55	2.91	2.91	1.00	1.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.37
4) Paddy x 2	2.42	2.42	4.81	4.81	5.55	5.55	2.91	2.91	1.00	1.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.37
5) Paddy x 1 + Palawija x 1	2.42	2.42	4.81	4.81	5.55	5.55	2.91	2.91	1.00	1.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.37
6) Palawija x 2	2.42	2.42	4.81	4.81	5.55	5.55	2.91	2.91	1.00	1.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.37
7) Paddy x 1	2.42	2.42	4.81	4.81	5.55	5.55	2.91	2.91	1.00	1.00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.37
6. Land Preparation (mm/day)																								
1) Paddy x 3	3.33	6.67	3.33						3.33	6.67	3.33						3.33	6.67	3.33					
2) Paddy x 2 + Palawija x 1	3.33	6.67	3.33						3.33	6.67	3.33													
3) Paddy x 1 + Palawija x 2	3.33	6.67	3.33																					
4) Paddy x 2			3.33	6.67	3.33						3.33	6.67	3.33											
5) Paddy x 1 + Palawija x 1			3.33	6.67	3.33																			
6) Palawija x 2																								
7) Paddy x 1			3.33	6.67	3.33																			
7. Water Layer Replacement (mm/day)																								
1) Paddy x 3				1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67	
2) Paddy x 2 + Palawija x 1				1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67									
3) Paddy x 1 + Palawija x 2				1.67	1.67	1.67	1.67																	
4) Paddy x 2						1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67							
5) Paddy x 1 + Palawija x 1						1.67	1.67	1.67	1.67															
6) Palawija x 2																								
7) Paddy x 1						1.67	1.67	1.67	1.67															
8. Infiltration Loss (2mm/day)																								
1) Paddy x 3	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1
2) Paddy x 2 + Palawija x 1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1								
3) Paddy x 1 + Palawija x 2	1	2	2	2	2	2	2	1																
4) Paddy x 2			1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1						
5) Paddy x 1 + Palawija x 1			1	2	2	2	2	2	2	1														
6) Palawija x 2																								
7) Paddy x 1			1	2	2	2	2	2	2	1														
9. Field Water Requirement by Cropping Pattern (mm/day)																								
1) Paddy x 3	1.91	6.25	2.46	2.73	1.99	1.88	4.53	0.00	3.33	7.67	7.26	7.58	7.29	7.19	7.25	2.70	4.33	8.67	7.85	8.71	8.44	8.31	7.27	2.52
2) Paddy x 2 + Palawija x 1	1.91	6.25	2.46	2.73	1.99	1.88	4.53	0.00	3.33	7.67	7.26	7.58	7.29	7.19	7.25	2.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	1.91	6.25	2.46	2.73	1.99	1.88	4.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) Paddy x 2	0.00	0.00	0.00	3.86	1.75	2.06	4.83	4.72	6.44	1.79	4.28	8.62	7.17	7.36	7.54	7.43	7.70	2.91	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.00	0.00	0.00	3.86	1.75	2.06	4.83	4.72	6.44	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.00	0.00	0.00	3.86	1.75	2.06	4.83	4.72	6.44	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
10. Unit Irrigation Water Requirement by Cropping Pattern (mm/day) Overall Efficiency =50%																									
	1) Paddy x 3	3.82	12.50	4.92	5.46	3.98	3.76	9.06	0.00	6.66	15.34	14.52	15.16	14.58	14.38	14.50	5.40	8.66	17.34	15.70	17.42	16.88	16.62	14.54	5.04
	2) Paddy x 2 + Palawija x 1	3.82	12.50	4.92	5.46	3.98	3.76	9.06	0.00	6.66	15.34	14.52	15.16	14.58	14.38	14.50	5.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3) Paddy x 1 + Palawija x 2	3.82	12.50	4.92	5.46	3.98	3.76	9.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4) Paddy x 2	0.00	0.00	0.00	7.72	3.50	4.12	9.66	9.44	12.88	3.58	8.56	17.24	14.34	14.72	15.08	14.86	15.40	5.82	0.00	0.00	0.00	0.00	0.00	0.00
	5) Paddy x 1 + Palawija x 1	0.00	0.00	0.00	7.72	3.50	4.12	9.66	9.44	12.88	3.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7) Paddy x 1	0.00	0.00	0.00	7.72	3.50	4.12	9.66	9.44	12.88	3.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11. Unit Irrigation Water Requirement by Regency (50% Efficiency) = Ratio of Cropping Pattern x Unit Irrigation Water Requirement (mm/day)																									
0.290	1) Paddy x 3	1.11	3.63	1.43	1.58	1.15	1.09	2.63	0.00	1.93	4.45	4.21	4.40	4.23	4.17	4.21	1.57	2.51	5.03	4.55	5.05	4.90	4.82	4.22	1.46
0.386	2) Paddy x 2 + Palawija x 1	1.47	4.83	1.90	2.11	1.54	1.45	3.50	0.00	2.57	5.92	5.60	5.85	5.63	5.55	5.60	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.094	3) Paddy x 1 + Palawija x 2	0.36	1.18	0.46	0.51	0.37	0.35	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.089	4) Paddy x 2	0.00	0.00	0.00	0.69	0.31	0.37	0.86	0.84	1.15	0.32	0.76	1.53	1.28	1.31	1.34	1.32	1.37	0.52	0.00	0.00	0.00	0.00	0.00	0.00
0.136	5) Paddy x 1 + Palawija x 1	0.00	0.00	0.00	1.05	0.48	0.56	1.31	1.28	1.75	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.003	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.002	7) Paddy x 1	0.00	0.00	0.00	0.02	0.01	0.01	0.02	0.02	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.000																									
	Total (mm/day)	2.94	9.64	3.79	5.96	3.86	3.83	9.17	2.14	7.43	11.19	10.57	11.78	11.14	11.03	11.15	4.97	3.88	5.55	4.55	5.05	4.90	4.82	4.22	1.46
	Total (liter/sec/ha)	0.340	1.116	0.439	0.690	0.447	0.443	1.061	0.248	0.860	1.295	1.223	1.363	1.289	1.277	1.291	0.575	0.449	0.642	0.527	0.584	0.567	0.558	0.488	0.169

12. Unit Irrigation Water Requirement by Regency (liter/sec/ha) : 50% Efficiency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average (liter/sec/ha)	0.565	0.445	0.655	1.078	1.293	1.283	0.933	0.546	0.556	0.563	0.329	0.728

Note

P : Land Preparation

ETo : Reference Crop Evapotranspiration

Irrigation is applied to only paddy culture.

Denpasar

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
1. Crop Coefficient																								
1) Paddy x 3	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		
2) Paddy x 2 + Palawija x 1	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P	P
	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95		P
Average	1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95		0.00	0.00	0.00	0.00	0.00	0.00	0.00		
3) Paddy x 1 + Palawija x 2	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P	P
	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95			P
Average	1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00			
4) Paddy x 2	P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95									
		P	P	1.10	1.10	1.05	1.05	0.95		P	P	1.10	1.10	1.05	1.05	0.95								
Average			1.10	1.10	1.08	1.05	1.00	0.95			1.10	1.10	1.08	1.05	1.00	0.95								
5) Paddy x 1 + Palawija x 1	P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95										
		P	P	1.10	1.10	1.05	1.05	0.95		0.50	0.68	0.86	1.05	1.05	0.95									
Average			1.10	1.10	1.08	1.05	1.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00									
6) Palawija x 2	0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95										
		0.50	0.68	0.86	1.05	1.05	0.95			0.50	0.68	0.86	1.05	1.05	0.95									
Average	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00									
7) Paddy x 1	P	P	1.10	1.10	1.05	1.05	0.95																	
		P	P	1.10	1.10	1.05	1.05	0.95																
Average			1.10	1.10	1.08	1.05	1.00	0.95																
2. Cropped Area Ratio																								
1) Paddy x 3	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		
2) Paddy x 2 + Palawija x 1	0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5		
3) Paddy x 1 + Palawija x 2	0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5			
4) Paddy x 2			0.5	1	1	1	1	0.5			0.5	1	1	1	1	0.5								
5) Paddy x 1 + Palawija x 1			0.5	1	1	1	1	0.5	0.5	1	1	1	1	1	0.5									
6) Palawija x 2	0.5	1	1	1	1	1	0.5		0.5	1	1	1	1	1	0.5									
7) Paddy x 1			0.5	1	1	1	1	0.5																
3. ETo (mm/day) BMG-1	4.40	4.40	4.16	4.16	4.31	4.31	4.55	4.55	4.36	4.36	4.23	4.23	3.98	3.98	3.99	3.99	4.53	4.53	4.82	4.82	5.07	5.07	4.54	4.54
4. Crop Water Requirement (mm/day)																								
1) Paddy x 3	2.42	4.84	4.49	4.37	4.31	2.05	0.00	0.00	2.40	4.80	4.57	4.44	3.98	1.89	0.00	0.00	2.49	4.98	5.21	5.06	5.07	2.41	0.00	0.00
2) Paddy x 2 + Palawija x 1	2.42	4.84	4.49	4.37	4.31	2.05	0.00	0.00	2.40	4.80	4.57	4.44	3.98	1.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3) Paddy x 1 + Palawija x 2	2.42	4.84	4.49	4.37	4.31	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4) Paddy x 2	0.00	0.00	2.29	4.58	4.65	4.53	4.55	2.16	0.00	0.00	2.33	4.65	4.30	4.18	3.99	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	0.00	0.00	2.29	4.58	4.65	4.53	4.55	2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	0.00	0.00	2.29	4.58	4.65	4.53	4.55	2.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
5. Effective Rainfall (mm/day)	1.81	1.81	7.34	7.34	6.05	6.05	1.29	1.29	0.79	0.79	0.07	0.07	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.09	0.09	0.72	0.72
No.445 1) Paddy x 3	1.81	1.81	7.34	7.34	6.05	6.05	1.29	1.29	0.79	0.79	0.07	0.07	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.09	0.09	0.72	0.72
2) Paddy x 2 + Palawija x 1	1.81	1.81	7.34	7.34	6.05	6.05	1.29	1.29	0.79	0.79	0.07	0.07	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.09	0.09	0.72	0.72
3) Paddy x 1 + Palawija x 2	1.81	1.81	7.34	7.34	6.05	6.05	1.29	1.29	0.79	0.79	0.07	0.07	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.09	0.09	0.72	0.72
4) Paddy x 2	1.81	1.81	7.34	7.34	6.05	6.05	1.29	1.29	0.79	0.79	0.07	0.07	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.09	0.09	0.72	0.72
5) Paddy x 1 + Palawija x 1	1.81	1.81	7.34	7.34	6.05	6.05	1.29	1.29	0.79	0.79	0.07	0.07	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.09	0.09	0.72	0.72
6) Palawija x 2	1.81	1.81	7.34	7.34	6.05	6.05	1.29	1.29	0.79	0.79	0.07	0.07	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.09	0.09	0.72	0.72
7) Paddy x 1	1.81	1.81	7.34	7.34	6.05	6.05	1.29	1.29	0.79	0.79	0.07	0.07	0.00	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.09	0.09	0.72	0.72
6. Land Preparation (mm/day)																								
1) Paddy x 3	3.33						3.33	6.67	3.33						3.33	6.67	3.33						3.33	6.67
2) Paddy x 2 + Palawija x 1	3.33						3.33	6.67	3.33														3.33	6.67
3) Paddy x 1 + Palawija x 2	3.33																						3.33	6.67
4) Paddy x 2	3.33	6.67	3.33						3.33	6.67	3.33													
5) Paddy x 1 + Palawija x 1	3.33	6.67	3.33																					
6) Palawija x 2																								
7) Paddy x 1	3.33	6.67	3.33																					
7. Water Layer Replacement (mm/day)																								
1) Paddy x 3		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67			
2) Paddy x 2 + Palawija x 1		1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67											
3) Paddy x 1 + Palawija x 2		1.67	1.67	1.67	1.67																			
4) Paddy x 2				1.67	1.67	1.67	1.67					1.67	1.67	1.67	1.67									
5) Paddy x 1 + Palawija x 1				1.67	1.67	1.67	1.67																	
6) Palawija x 2																								
7) Paddy x 1				1.67	1.67	1.67	1.67																	
8. Infiltration Loss (2mm/day)																								
1) Paddy x 3	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1	1	2
2) Paddy x 2 + Palawija x 1	2	2	2	2	2	1	1	2	2	2	2	2	2	1									1	2
3) Paddy x 1 + Palawija x 2	2	2	2	2	2	1																	1	2
4) Paddy x 2	1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	1								
5) Paddy x 1 + Palawija x 1	1	2	2	2	2	2	2	1																
6) Palawija x 2																								
7) Paddy x 1	1	2	2	2	2	2	2	1																
9. Field Water Requirement by Cropping Pattern (mm/day)																								
1) Paddy x 3	5.94	6.70	0.82	0.70	1.93	0.00	3.04	7.38	6.94	7.68	8.17	8.04	7.65	2.89	4.08	8.42	7.82	8.65	8.88	8.73	8.65	3.32	3.61	7.95
2) Paddy x 2 + Palawija x 1	5.94	6.70	0.82	0.70	1.93	0.00	3.04	7.38	6.94	7.68	8.17	8.04	7.65	2.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.61	7.95
3) Paddy x 1 + Palawija x 2	5.94	6.70	0.82	0.70	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.61	7.95
4) Paddy x 2	2.52	6.86	0.28	0.91	2.27	2.15	6.93	1.87	3.54	7.88	7.59	8.25	7.97	7.85	7.41	2.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5) Paddy x 1 + Palawija x 1	2.52	6.86	0.28	0.91	2.27	2.15	6.93	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7) Paddy x 1	2.52	6.86	0.28	0.91	2.27	2.15	6.93	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
10. Unit Irrigation Water Requirement by Cropping Pattern (mm/day) Overall Efficiency =50%																									
	1) Paddy x 3	11.88	13.40	1.64	1.40	3.86	0.00	6.08	14.76	13.88	15.36	16.34	16.08	15.30	5.78	8.16	16.84	15.64	17.30	17.76	17.46	17.30	6.64	7.22	15.90
	2) Paddy x 2 + Palawija x 1	11.88	13.40	1.64	1.40	3.86	0.00	6.08	14.76	13.88	15.36	16.34	16.08	15.30	5.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.22	15.90
	3) Paddy x 1 + Palawija x 2	11.88	13.40	1.64	1.40	3.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.22	15.90
	4) Paddy x 2	5.04	13.72	0.56	1.82	4.54	4.30	13.86	3.74	7.08	15.76	15.18	16.50	15.94	15.70	14.82	5.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5) Paddy x 1 + Palawija x 1	5.04	13.72	0.56	1.82	4.54	4.30	13.86	3.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7) Paddy x 1	5.04	13.72	0.56	1.82	4.54	4.30	13.86	3.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11. Unit Irrigation Water Requirement by Regency (50% Efficiency) = Ratio of Cropping Pattern x Unit Irrigation Water Requirement (mm/day)																									
0.086	1) Paddy x 3	1.02	1.15	0.14	0.12	0.33	0.00	0.52	1.27	1.19	1.32	1.41	1.38	1.32	0.50	0.70	1.45	1.35	1.49	1.53	1.50	1.49	0.57	0.62	1.37
0.274	2) Paddy x 2 + Palawija x 1	3.26	3.67	0.45	0.38	1.06	0.00	1.67	4.04	3.80	4.21	4.48	4.41	4.19	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.98	4.36
0.178	3) Paddy x 1 + Palawija x 2	2.11	2.39	0.29	0.25	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.29	2.83
0.153	4) Paddy x 2	0.77	2.10	0.09	0.28	0.69	0.66	2.12	0.57	1.08	2.41	2.32	2.52	2.44	2.40	2.27	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.165	5) Paddy x 1 + Palawija x 1	0.83	2.26	0.09	0.30	0.75	0.71	2.29	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.102	6) Palawija x 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.042	7) Paddy x 1	0.21	0.58	0.02	0.08	0.19	0.18	0.58	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.000																									
	Total (mm/day)	8.20	12.15	1.08	1.41	3.71	1.55	7.18	6.66	6.07	7.94	8.21	8.31	7.95	4.48	2.97	2.26	1.35	1.49	1.53	1.50	1.49	0.57	3.89	8.56
	Total (liter/sec/ha)	0.949	1.406	0.125	0.163	0.429	0.179	0.831	0.771	0.703	0.919	0.950	0.962	0.920	0.519	0.344	0.262	0.156	0.172	0.177	0.174	0.172	0.066	0.450	0.991

12. Unit Irrigation Water Requirement by Regency (liter/sec/ha) : 50% Efficiency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average (liter/sec/ha)	0.144	0.304	0.801	0.811	0.956	0.720	0.303	0.164	0.176	0.119	0.721	1.178

Note
P : Land Preparation
ETo : Reference Crop Evapotranspiration
Irrigation is applied to only paddy culture.

Appendix-3
Area Increase in Second Paddy with Residual Water

Area Improved for 2 Paddy Cropping

Jembrana Regency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1) Unit Irrigation Water Requirement with 50% Efficiency (liter/sec/ha)	0.660	0.722	0.557	0.405	0.511	0.456	0.226	0.031	0.031	0.018	0.174	0.734	
2) Unit Irrigation Water Requirement with 60% Efficiency (liter/sec/ha)	0.551	0.603	0.463	0.337	0.426	0.381	0.189	0.026	0.025	0.015	0.145	0.611	
3) Difference in Unit Irrigation Water Requirement (liter/sec/ha) =1) - 2)	0.110	0.120	0.094	0.068	0.085	0.075	0.038	0.006	0.006	0.003	0.029	0.123	
4) Difference in Irrigation Water Requirement (liter/sec) =3) x 9)	614.4	670.5	524.6	378.7	476.9	420.8	210.4	30.9	30.9	16.8	159.9	690.2	
5) Unit Irrigation Water Requirement for second paddy with 60% efficiency (liter/sec/ha)			0.766	1.261	1.425	0.973							
6) Area Increase without Storage Facilities (ha)=Min[4)/5)]			685	300	335	432							Total
7) Difference in Irrigation Water Requirement (million m^3)	1.65	1.62	1.41	0.98	1.28	1.09	0.56	0.08	0.08	0.05	0.41	1.85	11.06
8) Irrigation Water Requirement for Second Paddy with 60% Efficiency (million m^3/ha)			0.002	0.003	0.004	0.003							0.012
9) Irrigation Area in 2025 (ha)	5,611												
10) Area Increase with Storage Facilities (ha) = Total of 7)/Total of 8)	922												
11) Target Area to be improved (ha)	4,537												

Tabanan Regency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1) Unit Irrigation Water Requirement with 50% Efficiency (liter/sec/ha)	0.345	0.146	0.426	1.278	1.552	0.976	0.373	0.490	0.484	0.257	0.917	0.753	
2) Unit Irrigation Water Requirement with 60% Efficiency (liter/sec/ha)	0.289	0.122	0.355	1.066	1.293	0.814	0.310	0.408	0.403	0.214	0.765	0.628	
3) Difference in Unit Irrigation Water Requirement (liter/sec/ha) =1) - 2)	0.057	0.024	0.072	0.212	0.259	0.162	0.063	0.082	0.081	0.043	0.153	0.126	
4) Difference in Irrigation Water Requirement (liter/sec) =3) x 9)	1182.8	502.4	1496.9	4438.2	5411.7	3391.5	1308.4	1716.7	1685.3	900.2	3192.6	2627.3	
5) Unit Irrigation Water Requirement for second paddy with 60% efficiency (liter/sec/ha)			0.396	1.190	1.445	0.909							
6) Area Increase without Storage Facilities (ha)=Min[4)/5)]			3776	3729	3746	3733							Total
7) Difference in Irrigation Water Requirement (million m^3)	3.17	1.22	4.01	11.5	14.49	8.79	3.5	4.6	4.37	2.41	8.28	7.04	73.38
8) Irrigation Water Requirement for Second Paddy with 60% Efficiency (million m^3/ha)			0.001	0.003	0.004	0.002							0.010
9) Irrigation Area in 2025 (ha)	20,935												
10) Area Increase with Storage Facilities (ha) = Total of 7)/Total of 8)	7,338												
11) Target Area to be improved (ha)	1,924												

Badung Regency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1) Unit Irrigation Water Requirement with 50% Efficiency (liter/sec/ha)	0.647	0.421	0.678	1.405	1.632	1.125	0.743	0.855	0.920	0.608	0.802	0.915	
2) Unit Irrigation Water Requirement with 60% Efficiency (liter/sec/ha)	0.540	0.350	0.564	1.171	1.360	0.937	0.619	0.713	0.766	0.506	0.669	0.763	
3) Difference in Unit Irrigation Water Requirement (liter/sec/ha) =1) - 2)	0.107	0.071	0.114	0.235	0.272	0.188	0.124	0.142	0.154	0.102	0.134	0.152	
4) Difference in Irrigation Water Requirement (liter/sec) =3) x 9)	931.3	618.0	987.9	2041.1	2367.5	1636.4	1074.9	1231.6	1340.4	887.8	1162.0	1323.0	
5) Unit Irrigation Water Requirement for second paddy with 60% efficiency (liter/sec/ha)			0.592	1.262	1.432	0.932							
6) Area Increase without Storage Facilities (ha)=Min[4)/5)]			1668	1618	1653	1756							Total
7) Difference in Irrigation Water Requirement (million m^3)	2.49	1.50	2.65	5.29	6.34	4.24	2.88	3.30	3.47	2.38	3.01	3.54	41.09
8) Irrigation Water Requirement for Second Paddy with 60% Efficiency (million m^3/ha)			0.002	0.003	0.004	0.002							0.011
9) Irrigation Area in 2025 (ha)	8,704												
10) Area Increase with Storage Facilities (ha) = Total of 7)/Total of 8)	3,735												
11) Target Area to be improved (ha)	341												

Gianyar Regency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1) Unit Irrigation Water Requirement with 50% Efficiency (liter/sec/ha)	0.000	0.175	0.411	1.082	1.295	1.002	0.775	0.500	0.484	0.262	0.240	0.585	
2) Unit Irrigation Water Requirement with 60% Efficiency (liter/sec/ha)	0.000	0.146	0.342	0.902	1.079	0.835	0.646	0.417	0.403	0.218	0.201	0.488	
3) Difference in Unit Irrigation Water Requirement (liter/sec/ha) =1) - 2)	0.000	0.030	0.069	0.180	0.216	0.167	0.130	0.084	0.081	0.044	0.039	0.097	
4) Difference in Irrigation Water Requirement (liter/sec) =3) x 9)	0.0	424.1	984.8	2580.7	3098.2	2401	1861.8	1200.5	1157.3	625.4	560.7	1394.6	
5) Unit Irrigation Water Requirement for second paddy with 60% efficiency (liter/sec/ha)			0.498	1.143	1.273	0.731							
6) Area Increase without Storage Facilities (ha)=Min[4)/5)]			1979	2258	2434	3284							Total
7) Difference in Irrigation Water Requirement (million m^3)	0.00	1.03	2.64	6.69	8.30	6.22	4.99	3.22	3.00	1.68	1.45	3.74	42.96
8) Irrigation Water Requirement for Second Paddy with 60% Efficiency (million m^3/ha)			0.001	0.003	0.003	0.002							0.009
9) Irrigation Area in 2025 (ha)	14,377												
10) Area Increase with Storage Facilities (ha) = Total of 7)/Total of 8)	4,773												
11) Target Area to be improved (ha)	1,688												

Klungkung Regency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1) Unit Irrigation Water Requirement with 50% Efficiency (liter/sec/ha)	0.370	0.430	0.473	0.780	0.829	0.552	0.140	0.137	0.145	0.084	0.729	0.863	
2) Unit Irrigation Water Requirement with 60% Efficiency (liter/sec/ha)	0.309	0.359	0.393	0.650	0.690	0.460	0.116	0.114	0.121	0.070	0.607	0.720	
3) Difference in Unit Irrigation Water Requirement (liter/sec/ha) =1) - 2)	0.061	0.071	0.080	0.131	0.139	0.092	0.024	0.023	0.025	0.015	0.122	0.143	
4) Difference in Irrigation Water Requirement (liter/sec) =3) x 9)	229.5	267.1	301.0	490.9	522.9	344.2	90.3	84.6	92.2	54.5	457.1	538.0	
5) Unit Irrigation Water Requirement for second paddy with 60% efficiency (liter/sec/ha)			0.658	1.214	1.283	0.835							
6) Area Increase without Storage Facilities (ha)=Min[4)/5)]			458	404	408	412							Total
7) Difference in Irrigation Water Requirement (million m^3)	0.61	0.65	0.81	1.27	1.40	0.89	0.24	0.23	0.24	0.15	1.18	1.44	9.11
8) Irrigation Water Requirement for Second Paddy with 60% Efficiency (million m^3/ha)			0.002	0.003	0.003	0.002							0.010
9) Irrigation Area in 2025 (ha)	3,762												
10) Area Increase with Storage Facilities (ha) = Total of 7)/Total of 8)	911												
11) Target Area to be improved (ha)	1,817												

Bangli Regency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1) Unit Irrigation Water Requirement with 50% Efficiency (liter/sec/ha)	0.000	0.278	0.305	1.136	1.270	0.969	0.648	0.649	0.630	0.308	0.498	0.607	
2) Unit Irrigation Water Requirement with 60% Efficiency (liter/sec/ha)	0.000	0.233	0.254	0.947	1.057	0.807	0.540	0.541	0.525	0.257	0.416	0.505	
3) Difference in Unit Irrigation Water Requirement (liter/sec/ha) =1) - 2)	0.000	0.045	0.051	0.189	0.213	0.162	0.108	0.108	0.105	0.052	0.083	0.102	
4) Difference in Irrigation Water Requirement (liter/sec) =3) x 9)	0.0	128.5	147.3	544.4	613.7	466.4	311.9	311.9	303.2	148.7	238.3	294.6	
5) Unit Irrigation Water Requirement for second paddy with 60% efficiency (liter/sec/ha)			0.307	1.085	1.190	0.843							
6) Area Increase without Storage Facilities (ha)=Min[4)/5)]			480	502	516	553							Total
7) Difference in Irrigation Water Requirement (million m^3)	0.00	0.31	0.39	1.41	1.64	1.21	0.84	0.84	0.79	0.40	0.62	0.79	9.24
8) Irrigation Water Requirement for Second Paddy with 60% Efficiency (million m^3/ha)			0.001	0.003	0.003	0.002							0.009
9) Irrigation Area in 2025 (ha)	2,888												
10) Area Increase with Storage Facilities (ha) = Total of 7)/Total of 8)	1,027												
11) Target Area to be improved (ha)	321												

Karangasem Regency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1) Unit Irrigation Water Requirement with 50% Efficiency (liter/sec/ha)	0.204	0.386	0.528	0.565	0.707	0.734	0.466	0.112	0.077	0.077	0.033	0.631	
2) Unit Irrigation Water Requirement with 60% Efficiency (liter/sec/ha)	0.170	0.322	0.439	0.472	0.589	0.611	0.389	0.093	0.064	0.064	0.027	0.526	
3) Difference in Unit Irrigation Water Requirement (liter/sec/ha) =1) - 2)	0.034	0.064	0.089	0.093	0.118	0.123	0.077	0.020	0.013	0.013	0.006	0.105	
4) Difference in Irrigation Water Requirement (liter/sec) =3) x 9)	225.8	421.8	587.8	617.7	780.4	813.6	508.1	129.5	86.3	86.3	39.9	697.4	
5) Unit Irrigation Water Requirement for second paddy with 60% efficiency (liter/sec/ha)				0.980	1.434	1.461	0.875						
6) Area Increase without Storage Facilities (ha)=Min[4)/5)]				630	544	557	581						Total
7) Difference in Irrigation Water Requirement (million m^3)	0.60	1.02	1.57	1.60	2.09	2.11	1.36	0.35	0.22	0.23	0.10	1.87	13.12
8) Irrigation Water Requirement for Second Paddy with 60% Efficiency (million m^3/ha)				0.003	0.004	0.004	0.002						0.013
9) Irrigation Area in 2025 (ha)	6,642												
10) Area Increase with Storage Facilities (ha) = Total of 7)/Total of 8)	1,009												
11) Target Area to be improved (ha)	3,869												

Buleleng Regency

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1) Unit Irrigation Water Requirement with 50% Efficiency (liter/sec/ha)	0.565	0.445	0.655	1.078	1.293	1.283	0.933	0.546	0.556	0.563	0.329	0.728	
2) Unit Irrigation Water Requirement with 60% Efficiency (liter/sec/ha)	0.470	0.372	0.546	0.898	1.079	1.069	0.777	0.455	0.463	0.469	0.274	0.606	
3) Difference in Unit Irrigation Water Requirement (liter/sec/ha) =1) - 2)	0.095	0.074	0.109	0.180	0.215	0.214	0.156	0.091	0.093	0.094	0.055	0.122	
4) Difference in Irrigation Water Requirement (liter/sec) =3) x 9)	984.4	765.6	1135.5	1869.9	2234.4	2229.2	1625.1	947.9	963.6	979.2	572.9	1270.9	
5) Unit Irrigation Water Requirement for second paddy with 60% efficiency (liter/sec/ha)				1.061	1.431	1.397	0.960						
6) Area Increase without Storage Facilities (ha)=Min[4)/5)]				1762	1561	1596	1693						Total
7) Difference in Irrigation Water Requirement (million m^3)	2.64	1.85	3.04	4.85	5.98	5.78	4.35	2.54	2.50	2.62	1.49	3.40	41.04
8) Irrigation Water Requirement for Second Paddy with 60% Efficiency (million m^3/ha)				0.003	0.004	0.004	0.003						0.014
9) Irrigation Area in 2025 (ha)	10,417												
10) Area Increase with Storage Facilities (ha) = Total of 7)/Total of 8)	2,931												
11) Target Area to be improved (ha)	2,555												

Denpasar

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1) Unit Irrigation Water Requirement with 50% Efficiency (liter/sec/ha)	0.144	0.304	0.801	0.811	0.956	0.720	0.303	0.164	0.176	0.119	0.721	1.178	
2) Unit Irrigation Water Requirement with 60% Efficiency (liter/sec/ha)	0.120	0.254	0.668	0.676	0.797	0.599	0.253	0.137	0.146	0.100	0.600	0.982	
3) Difference in Unit Irrigation Water Requirement (liter/sec/ha) =1) - 2)	0.025	0.051	0.133	0.135	0.160	0.121	0.051	0.027	0.030	0.019	0.121	0.196	
4) Difference in Irrigation Water Requirement (liter/sec) =3) x 9)	55.9	115.3	303.6	308.2	364.1	275.1	115.3	61.6	67.3	43.4	275.1	447.5	
5) Unit Irrigation Water Requirement for second paddy with 60% efficiency (liter/sec/ha)			1.005	1.410	1.563	1.017							
6) Area Increase without Storage Facilities (ha)=Min[4)/5)]			302	219	233	271							Total
7) Difference in Irrigation Water Requirement (million m^3)	0.15	0.28	0.81	0.80	0.98	0.71	0.31	0.17	0.17	0.12	0.71	1.20	6.41
8) Irrigation Water Requirement for Second Paddy with 60% Efficiency (million m^3/ha)			0.003	0.004	0.004	0.003							0.014
9) Irrigation Area in 2025 (ha)	2,283												
10) Area Increase with Storage Facilities (ha) = Total of 7)/Total of 8)	458												
11) Target Area to be improved (ha)	1,100												

DIRECTORATE GENERAL OF WATER RESOURCES,
MINISTRY OF PUBLIC WORKS
PUBLIC WORKS SERVICE, BALI PROVINCE

THE COMPREHESIVE STUDY
ON
WATER RESOURCES DEVELOPMENT
AND MANAGEMENT IN BALI PROVINCE
IN
THE REPUBLIC OF INDONESIA

FINAL REPORT
SUPPORTING REPORT

[G] DEMAND PROJECTION FOR WATER SUPPLY

AUGUST 2006

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.

THE COMPREHENSIVE STUDY
ON WATER RESOURCES DEVELOPMENT AND MANAGEMENT
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SUPPORTING REPORT (G)
DEMAND PROJECTION FOR WATER SUPPLY

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G-1 DEMAND PROJECTION FOR WATER SUPPLY

G-1.1 Water Supply System of Bali Province

G-1.1.1 Water Supply Enterprises

In Bali Province, ten (10) enterprises, which are 9 PDAMs (Persahaan Daerah Air Minum) and PT.TB (PT. Tirtaartha Buanamula), supply domestic and non-domestic water. PDAM is an exclusive water supply enterprise that is wholly owned by the regency/city government. Each regency/city has one PDAM to serve water in its own jurisdiction.

PT.TB is a joint-enterprise, whose 45 % of shares are owned by PDAM Badung and 55 % by two local firms and covers southern area of Badung regency. PT.TB has been awarded with 20-years' concession by Badung Regency Government since 1993.

Covering areas of 9 PDAMs and PT.TB as well as their headquarters are shown in Figure-G.1.

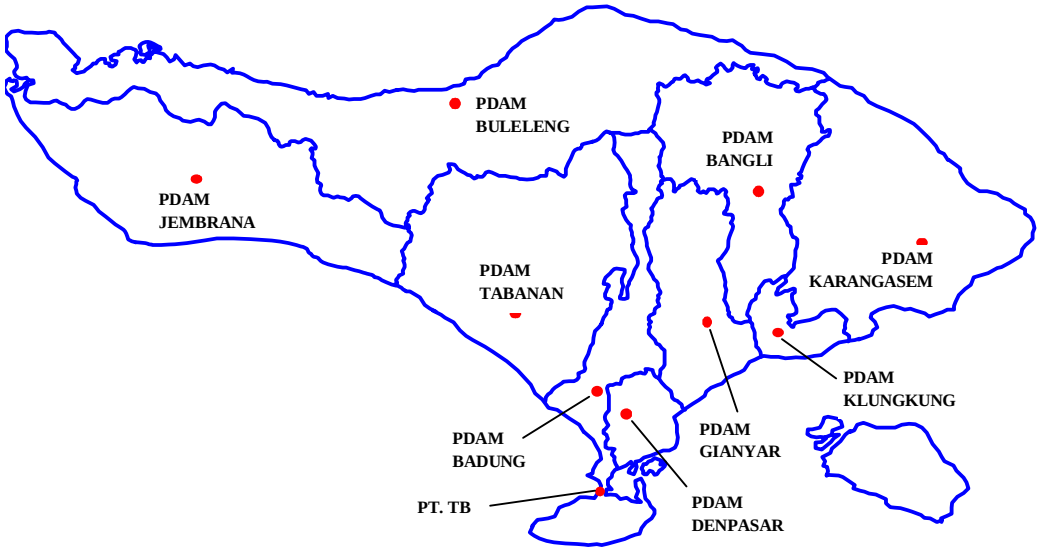

Figure-G.1 Covering Areas and Location Map of 9 PDAMs and PT.TB

G-1.2 Water Sources

Table-G.1 shows the features of water sources of Bali Province, which are deep well water, spring water and river water, accounting respectively for 28 %, 32 % and 40 %.

Wells are only water source for PDAM Jembrana. Springs are main water source for PDAM Tabanan, Klungkung, Bangli and Buleleng. PDAM Gianyar uses both deep wells and springs for their water sources. Meanwhile, PDAM Badung, Denpasar and PT.TB, which have own large-scale water treatment plants in their districts, take water mainly from river.

G-1.3 Water Supply

9 PDAMs and PT.TB supplied 6.6million m^3/month in 2004 according to Table-G.1. However, it should be noted that the sum of PDAM Denpasar, Badung and PT.TB amounted to more than half of whole supply amount in Bali Province.

G-1.4 Customer's Connections

Number of customer's connections was 250,000 in Bali Province as shown in Table-G.1, from which served population was estimated at 1.1 million persons, and service ratio at 34 % on average. Unaccounted water was characterized by low level of 23 % on average in Bali Province.

Table-G.1 Actual Data of Water Sources, Supply Amount and Customers in 2004

PDAM	JEM[1)]	TAB[1)]	BAD	GIA	KLU[4)]		BAN[1)]	KAR	BUL[1)]	DEN	PT.TB	Total /Average
Water Sources (Upper row: No. of Water Intake, Lower row: Amount of Water Intake (liter/second))												
Wells	20	1	18	34	1	1	0	13	14	14	2	1,204 lit/s
	139	5	236	348	5	5	0	69	82	315	0	(28%)
Springs	0	22	8	29	4	1	15	8	14	0	0	1,360 lit/s
	0	458	79	214	75	20	120	82	312	0	0	(32%)
Rivers	0	4	0	0	1	0	0	9	0	3	2	1,734 lit/s
	0	81	0	0	130	0	0	73	0	800	650	(40%)
Total	20	27	26	63	6	2	15	30	28	17	4	4,298lit/s
	139	544	315	562	210	25	120	224	394	1,115	650	(100%)
Amount of Supplied Water on average ($1000m^3$/month)												
Domestic	n/a	456	407	640	244		109	n/a	n/a	1,709	438	-
Commercial /Institution	n/a	87	38	69	12		8	n/a	n/a	371	130	-
Industry/hotel	n/a	6	4	15	11		-	n/a	n/a	42	355	-
Harbor & Others	n/a	-	-	-	-		-	n/a	n/a	-	18	-
Total	290	549	449	724	267		117	379	827	2,122	941	6,665
Total (lit/s)	112	212	173	279	103		45	146	319	819	363	2,571 lit/s
Related Information												
No. of Connection	14,181	33,050	19,943	39,855	16,382		8,528	15,377	25,767	61,887	16,788	252,658
House Connection	14,000[3)]	29,558	18,705	36,854	15,560		8,171	14,546	22,802	53,324	14,480	228,000
Served Population[2)]	70,000	147,790	93,525	184,270	77,800		40,855	72,730	114,010	266,620	72,400	1,140,000
Served Ratio	28%	38%	35%	44%	52%		20%	20%	19%	44%	65%	34%
Unaccounted water	18%	28%	24%	23%	19%		25%	28%	22%	21%	20%	23%
No. of Employee	99	238	165	193	87		103	155	201	238	110	1,589

Note: 1) data of year 2003, 2) The served population was estimated by assuming the family size to be 5 persons. 3) House connections are estimated at 14,000. 4) Water sources of Klungkun are divided into 2 areas, "Klungkun-Bali" (left) and Nusa Penida (right).

Source: Study Team based on data and information from PDAMs and PT.TB

G-1.5 Water Price

Based on the data and information collected, actual water price, including bulk water price, of PDAM Denpasar, Badung, Gianyar and PT.TB is estimated as shown in Table-G.2.

PDAM Badung and PT.TB raised water tariff from January 2005 and have a plan to raise it again in 2006. PDAM Gianyar also raised it from September 2005. However, PDAM Denpasar has been keeping the same tariff since 1999.

Actual water price of PT.TB amounted to Rp.4,090/m^3, which was the highest because of greater number of big industrial users running in the PT.TB area.

Table-G.2 Actual Water Price

Unit: Rp/m^3

Customer	PDAM			PT.TB
	Denpasar	Badung	Gianyar	
	Average of Year 2005	Average of Year 2005	Av. of Sept/Dec 2005	Average of Year 2005
Domestic	790	1,210	2,260	1,630
Industrial (including hotels)	3,200	6,840	6,430	7,620
Commercial/Public/Institutional	1,940	2,930	3,210	3,700
Average	1,040	1,460	2,470	4,090
Bulk Water Supply	-	1,310	1,150	1,250

Note: PDAM Badung and PT.TB raised water tariff from Jan. 2005, and PDAM Gianyar from Sept. 2005.

Source: Study Team based on the data and information of respective PDAMs and PT.TB

G-1.6 Financial Conditions of respective PDAMs

Table-G.3 shows financial conditions of 9 PDAMs, which are obviously not sound. Net income of 9 PDAMs in total resulted in negative of Rp.19.8billion. Only PDAM Buleleng resulted in surplus due to continuous low operation cost. PDAM Badung and Gianyar are expected to turn into surplus in 2005 due to tariff increase. The rest of PDAMs may continue to be in heavily loss. Furthermore, shareholders' equity account of 5 PDAMs has been continuously negative, which means accumulated losses have exceeded the capital account.

Every PDAM have owed long-term debt mostly to Central Government. According to the interview, Buleleng is the only PDAM that has continued repaying it; however, the rest PDAMs could not repay it caused by their bad financial conditions. Debt to revenue ratio of 5 PDAMs exceeded 100%; that is, these PDAMs owe such big size of debt larger than annual revenue.

Financial data of PT.TB was not available. However, revenue of water sales of PT.TB could be estimated, by analyzing data of PT.TB, to reach Rp.40billion in 2005, of which more than 60% might be generated from water sales to industry category including hotels.

Table-G.3 Financial Conditions of 9 PDAMs

Unit: million Rp.

Items	JEM	TAB	BAD	GIA	KLU	BAN	KAR	BLE	DEN	Total
1. Revenue	4,201	6,235	17,196	15,362	4,745	1,695	4,512	10,922	30,406	95,274
2. Net Income	-1,171	-3,367	-4,868	-1,101	-1,078	-1,172	-1,209	1,161	-7,080	-19,885
(Ratio=2/1)	-28%	-54%	-28%	-7%	-23%	-69%	-27%	11%	-23%	-21%
3. Equity	-5,312	-7,387	17,300	4,897	-3,627	-1,947	1,555	6,407	-14,145	-2,259
4. Debt	5,025	7,719	28,138	13,234	3,639	4,067	1,115	3,653	50,439	117,029
(Ratio=4/1)	120%	124%	164%	86%	77%	240%	25%	33%	166%	123%

Note: 1) Year 2004 financial data for PDAM Denpasar, Badung and Gianyar, and Year 2003 financial data for the rest of PDAMs 2) Debt is sum of short-term debt and long-term debt including accumulated interest payable.
Source: Study Team based on financial data of 9 PDAMs

G-2 PRESENT WATER CONSUMPTION

G-2.1 Customer Classification of and Consumption

Customers of PDAMs are classified generally into 15 categories as shown in Table-G.4. Water tariff rate is set also separately in line with the categories. According to the billing records of PDAMs, the consumption features of customers are summarized as follows:

- Category D (household customers: from D1 to D5) is the biggest customers in terms of connection number and consumption volume (more than 80 % in 9 PDAMs).
- Category E (commercial customers) consumes 10% of total public water supplied by PDAMs and PT.TB.
- Category F (industry customers including hotel) consumes 8% of total public water. However, PT.TB serves 40% of the production to Category F because PT.TB supplies water mainly to Nusa-Dua area where is world-widely known as resort area with many luxurious hotels. Accordingly, hotels categorized as F are the biggest customers for PT.TB
- Categories A, B, D6, H, and J (public, institution, and harbor customers) consume less than 2 % of public water in total.

Table-G.4 Customer Classification of PDAMs

Category			Description
A		Public A & G	Public hydrant, public toilet
B		Public B	Schools and hospitals
D	D1	Household A1	Houses where 0-3.99 meters' width road exist in front
	D2	Household A2	Houses where 4-6.99 meters' width road exist in front
	D3	Household A3	Houses where 7-10 meters' width road exist in front
	D4	Household A4	Houses where more than 10 meters' width road exist in front
	D5	Household B	Houses where small industry exists together
	D6	Institution	Medium government office and other government agency.
E	E1	Small commercial	Kiosk, booth, shop, company office that there is a road which width is 4-6.99 meters in front of it.
	E2	Medium commercial	Kiosk, booth, shop, company office where 7-10 meters' road exist in front
	E3	Big commercial	Shopping complex, kiosk, booth, company office, supermarkets and public/private swimming pool that there is a road where more than 10 meters' width road exist in front
F	F1	Small industry	Handicraft, household craft and other small industry
	F2	Big industry	Star hotel, canning plant, ice plant, cold storage, beverage factory, big ranch, etc
H		Harbor/airport	
J		Special	

Source: Data and information from PDAMs

G-2.2 Unit Consumption

(1) Domestic Water

Unit consumption rate is very important for the future water demand projection. The rate of domestic water (liter/person/day) of 6 PDAMs and PT.TB is calculated based on the collected data presented in Table-G.5.

The rate of PDAM Denpasar and PT.TB is more than 200 liter/person/day, which is the highest among others. PDAM Bangli is the lowest rate of 89 liter/person/day. Incidentally, though the data of PDAM Jembrana, Karangasem and Buleleng could not be obtained, the unit rate of these PDAMs is considered to be the same level as the rate of PDAM Tabanan and Klungkung, which are around 100 liter/person/day.

Table-G.5 Unit Consumption Rate of Domestic Water of 6 PDAMs in Year 2004

Item	Denpasar	Badung	PT.TB	Gianyar	Bangli	Tabanan	Klungkung
Litter/person/day	213	146	202	116	89	103	105

Source: Study Team based on the data and information from PDAMs and PT.TB

(2) Commercial/public/Institutional Water

Commercial/public/institutional customers are categorized in A, B, D6, E1, E2, E3 and G. According to the data collected, the unit consumption rate of these categories in total is calculated as shown in Table-G.6. The rate of PDAM Denpasar was ranked the highest due to a lot of Government facilities existing in the area.

Incidentally, the ratio to domestic consumption varies from 30% of PT.TB, 20% of Denpasr and Tabanan, and 10% of the rest. This ratio indicates concentration magnitude of these categories in the respective area.

Table-G.6 Present Commercial/Social/Institutional Water Use

Items	Unit	Denpasar	Badung	PT.TB	Gianyar	Bangli	Tabanan	Gianyar	Klungkung
Connection	Number	8,275	1,210	-	2,659	-	-	2,659	-
Consumption	m^3/month	371	38	143	69	8	87	69	12
Unit Consumption Rate	Liter/day	1,494	1,047	-	865	-	-	865	-
Ratio to Domestic Consumption		21.7%	9.3%	29.3%	10.7%	7.3%	19.1%	10.7%	4.9%

Source: Study Team based on the data and information from PDAMs and PT.TB

(3) Industrial Water

Industry customers are categorized in F including hotels. According to the data collected, the unit

consumption rate of the category is calculated as shown in Table-G.7. PDAM Denpasar was ranked the highest rate of 4,878 liter/industry/day. The ratio to domestic consumption indicates concentration magnitude of this category in the respective area. It is obvious that the industry sector, mostly hotel industries, is the important customer for PT.TB.

Table-G.7 Present Industrial Water Use

Items	Unit	Denpasar	Badung	PT.TB	Gianyar	Bangli	Tabanan	Gianyar	Klungkung
Connection	Number	287	29	-	322	-	-	-	287
Consumption	m^3/month	42	4	355	15	0	6	11	42
Unit Consumption	Liter/day	4,878	4,597	-	1,553	-	-	-	4,878
Ratio to Domestic Consumption		2.5%	1.0%	81.0%	2.3%	0%	1.3%	2.3%	4.5%

Source: Study Team based on the data and information from PDAMs and PT.TB

G-3 SOCIO-ECONOMIC FRAMEWORK

G-3.1 Development Plan in Indonesia and Bali

(1) National Development Program

"*Program Pembangunan Nasional (PROPENAS)*" is the five-year development plan of the Central Government that was formed in August 2000 based on the Guidelines of the Government Policy named "*Garis-Garis Besar Haluan Negara* (GBHN)". PROPENAS sets out five national objectives as follows:

1) Develop the democracy in political system, and ensure national cohesion and social stability;
2) Achieve good governance and rule of law;
3) Accelerate economic recovery and strengthen the foundations for sustainable growth;
4) Develop the social sectors and human welfare; and
5) Strengthen regional autonomy, rural and urban development, and structural poverty programs.

The Central Government considers regional autonomy as a key measure to improve nation-wide governance, expecting local government autonomy to make more participatory decision-making and create greater accountability. Decentralization of government functions is also expected to enhance the quality of public services and strengthen program implementation.

From the economic point of view, PROPENAS aims to achieve broad-based economic growth oriented by market on the basis of Indonesia's comparative advantages by focusing on globalization and decentralization. To achieve the economic objectives, the Central Government strategy aims macroeconomic stability, a strong banking sector, faster progress on corporate debt restructuring, and generating market confidence. For infrastructure, PROPENAS put the priority on rehabilitation and betterment of existing infrastructure to fulfill the economic and urgent social needs that support production and export activities and expanding employment and business opportunities.

(2) Development Program of Bali Province

"*Program Pembangunan Daerah (PROPEDA) 2001-2005*" is drawn up as the provincial five-year development plan to support national development policy of PROPENAS. The strategy of Bali Provincial Government (the Government) aims economic recovery in short term and economic stability in medium term by fulfilling the socio-economic targets of population, GRDP, GRDP per capita, economic structures and job opportunity. To achieve those aims, the Government sets out the policy and development programs especially on the leading sectors of Bali Province such as tourism, small & medium industry, and agriculture.

The Government made up "Spatial Plan of Bali Province" in 1996, which was revised as "Revised Spatial Plan of Bali Province 2003 – 2010" for super-ordinate plan of PROPEDA.

There is another program named "*Rencana Strategic (Renstra) 2003-2008*". *Renstra* was drawn up in 2003 as a regulation about Bali Provincial strategic plans aiming to give a guideline to the government agencies for carrying out the implementation and accountability.

(3) New National and Provincial Planning System

The Law No.25, 2004 provides establishment of new National and Provincial Planning System; therefore above PROPENAS and PROPEDA end the role and the following planning system described in Table-G.8 will supersede them.

Table-G.8 New National and Provincial Planning System

Government	Name of the Plan	Duration
Central	Rencana Pembangunam Jangka Panjang (RPJP)	National Long-term Development Plan: 20 years
	Rencana Pembangunam Jangka Menengah (RPJM)	National Medium-term Development Plan: 5 years
	Rencana Kerja Pemerintah (RKP)	National Annual Development Plan: 1 year
Regional	Satuan Kerja Perangkat Daerah (RENSTRA-SKPD)	Regional Medium-term Development Plan: 5 years
	Rencana Kerja Pemerintah Daerah (RKPD)	Regional Annual Development Plan: 1 year

Source: National System of Development Planning, Law No.25, 2004

G-3.2 Spatial Plan of Bali Province

"Spatial Plan of Bali Province 1996-2010" was originally made out according to the Law No. 24 of Year 1992 and specified to the Law of Bali Province No. 4 of Year 1996. The original spatial plan is revised as "Revised Spatial Plan of Bali Province 2003 – 2010" (the Revised Spatial Plan), and its draft was issued on August 2003. The Revised Spatial Plan, by fulfilling the socio-economic targets, aims the broad revision of transportation network, irrigation system, river water system, and economic sectors such as agriculture, manufacturing industry and tourism. The socio-economic targets of the Revised Spatial Plan are summarized bellow.

(1) Population

The Revised Spatial Plan envisages the future population in Bali Province on the basis of three scenarios as shown in Table-G.9. The scenario 1 is a highest growth scenario that adopts the actual growth rate during the period of 1990 – 2000, by assuming the rate of natural growth 1.01% and social growth 0.25%. The social growth is envisaged to drop by likely limitation of low-class migration to Bali Province.

Table-G.9 Projected Population in 2010

Scenario	Population Growth	Projected Population of Year 2010
1. High Growth Scenario	1.26% (actual rate during 1990 - 2000)	3,567,000
2. Medium Growth Scenario	1.18%	3,539,000
3. Low Growth Scenario	1.05%	3,493,000

Source: Revised Spatial Plan of Bali Province 2003 – 2010

(2) Economic Growth

The Revised Spatial Plan envisages the economic growth as shown in Table-G.10. The manufacturing sector of Bali Province consists mostly of food processing, garments, and wood related industries. The Revised Spatial Plan, taking into consideration the growing demand of domestic consumption and export, views that the growth rate of the manufacturing sector could be achieved.

Table-G.10 Projected Economic Growth

Sector	2003-2005	2006-2010
All Sector	3.73 %	6.63 %
Manufacturing	5.49 %	8.44 %
Transportation & Communications	5.82 %	8.03 %

Source: Revised Spatial Plan of Bali Province 2003 – 2010

(3) Manufacturing Industry

In order to strengthen manufacturing industries in Bali Province, the Revised Spatial Plan focuses the development of middle/large processing industries related to agriculture products that are regarded as the most important sector in Bali Province. To achieve this, the Revised Spatial Plan also proposes the necessity for development of industrial zone especially at the area of Celukan Bawang in Buleleng and Pengambengan in Jembrana.

(4) Tourism

There are six tourism areas already developed in Bali Province that are: 1) Sanur, 2) Kuta, 3) Nusa Dua, 4) Tuban, 5) Ubud and 6) Lebih (Gianyar). The Revised Spatial Plan proposes the following nine areas to be developed more intensively in order to attract and increase number of tourists.

1) Kailibukbuk in Buleleng
2) Batuampar in Buleleng
3) Candikesuma in Jembrana
4) Nusa Penida in Klungkung
5) Candidasa in Karangasem
6) Ujung in Karangasem
7) Tulamben in Karangasem
8) Soka in Tabanan
9) Perancak in Jembrana

G-3.3 Socio-economic Framework

In formulating the socio-economic framework, the basic data and information of the Revised Spatial Plan were mostly referred to with careful study and discussion with Bali Provincial Government.

(1) Population

The population projection is principally based on the Revised Spatial Plan, and framed by applying two steps that are: 1) Trend Projection and 2) Development Projection. The result of two population projections is presented in Table-G.11.

Trend Projection

According to the discussion with Bali Provincial Government, the population of the target year of 2025 was projected as follows:

1) Growth rate during 1990-2000 was 1.26%: natural growth was 1.01% and social growth 0.25%;
2) Natural growth is estimated to decrease continuously in future.
3) The restriction policy on social migrations to Bali Province is likely suggested.
4) Consequently, future growth rate could be lower than 1990-2000 level of 1.26%.
5) Until 2010, the middle scenario 1.18% of the Revised Spatial Plan is considered to be more realistic according to the information from Bali Provincial Government.
6) From 2011, the low scenario 1.05% of the Spatial Revised Plan is applied.

Development Projection

According to the suggestion of the Revised Spatial Plan for the industrial development at Celukan Bawang in Buleleng, the inter-regency migration of workers is taken into consideration by assuming as follows:

- A half of food/beverage and textile industries in Badung and Denpasar are assumed to be shifted to Celukan Bawang in Buleleng during the period of years 2010-2025.
- Accordingly, employees of the industries and their families are assumed to move to Buleleng. A half of employees are assumed singles, and household size is set at 4 persons.

As a result, the population of Buleleng of the year 2025 increases to 613,000 compared with 591,000 of the tend projection. Meanwhile, the population of Badung and Denpasar decreases for that. Thus, the population of the development projection is applied as shown in Table-G.11. The population by district is presented in Appendix-1.1.

Table-G.11 Population Projection

Unit: 1000 persons

Regency/City	Census	Trend Projection			Development Projection
	2000	2004	2010	2025	2025
Jembrana	232	237	244	263	263
Tabanan	376	386	400	436	436
Badung	346	378	425	547	540
Gianyar	393	416	451	541	541
Klungkung	155	157	159	164	164
Bangli	194	200	210	235	235
Karangasem	361	366	375	396	396
Buleleng	558	563	571	591	613
Denpasar	532	601	704	966	951
Total	3,147	3,304	3,539	4,139	4,139

Note: The actual growth rate of 1990 – 2000 was reflected in projection of the respective Kabupaten.
Source: Study Team

(2) Economic Growth of Manufacturing Industry Sector

The economic growth estimate of the manufacturing industry sector is essential for industrial water demand projection. The Revised Spatial Plan envisages the industry sector economic growth as follows: 1) 5.49% for years 2003 – 2005, and 2) 8.44% for years 2006 – 2010. However, the growth rate is reviewed and projected by Study Team as shown in Table-5.5 because of the following reasons:

Year 2004 - 2005

Economic growth of the manufacturing industry sector of the year 2003 dropped to 2.7% compared with 4.5% of the previous years 1999 – 2002 average. Main reason was a sharp decline of wood related industry performance (-6.9%) due to terrorism in 2002. Wood related sector, especially art-craft industry, relies heavily on tourists to Bali Province. In order to eliminate this exceptional factor of 2002, growth rate of wood related industry is adjusted to the previous 3-years level of 5.0%. After adjustment, year 2003 growth rate of manufacturing industry resulted in 6.0%.

Thus, the potential economic growth of manufacturing industry sector can be confirmed as above, so that growth rate of 5.5% of the Revised Spatial Plan is applied for the period of 2004 – 2005.

Year 2006 -2025

Celukan Bawang in Buleleng is proposed as industrial promotion area by the Revised Spatial Plan. However, development potentiality of the area might be small when considering the size of the area and current condition of the infrastructure.

In addition, although food/beverage, textile and wood related industries are major industries in Bali Province, the growth of these industries would be limited because: 1) consumption of the industrial products in Bali could not be highly expected due to declining population growth rate, and 2) export to foreign countries and shipment to domestic market also could not grow at high level due to keen competition with other Asian countries and other provinces of Indonesia.

As a result, economic growth rate of manufacturing industry sector is set at 7%, which is the average rate between 5.5% and 8.4% of the Revised Spatial Plan.

Table-G.12 Projected Growth Rate of Manufacturing Industry Sector

Actual	Projected	
2002/2003	2004-2005	2006-2025
2.6 %	5.5 %	7 %

Source: Study Team

(3) Output of Manufacturing Industry

Industrial output is used for industrial water demand projection. Based on the output by industrial sector of the year 2003, which is previously described in Chapter A, the industrial output until the target year 2025 is projected as presented in Table-G.13 by applying the above economic growth rate to manufacturing industry sector. The projection of output by district is presented in Appendix-2.1.

Table-G.13 Projection of Industrial Output

Unit: billion Rp.

Kabupaten	Actual	Trend Projection			Development Projection
	2003	2004	2010	2025	2025
Jembrana	297	313	463	1,270	1,270
Tabanan	137	144	213	585	585
Badung	293	309	458	1,256	715
Gianyar	155	164	242	664	664
Klungkung	22	23	34	93	93
Bangli	5	5	7	20	20
Karangasem	62	66	97	267	267
Buleleng	10	10	15	42	1,559
Denpasar	538	568	838	2,302	1,326
Total	1,519	1,602	2,367	6,499	6,499

Source: Study Team

(4) Necessary Number of Hotel Rooms

Water demand for tourism is to be projected based on *necessary number of hotel rooms* that is estimated by assuming the number of tourist, number of guest at hotel, number of guest at room, and length of stay at hotel. Taking into consideration of these assumptions, necessary number of hotel rooms is estimated as shown in Table-G.14.

It reveals that necessary number of hotel rooms in year 2025 rises as large as 2.5 times of year 2004. Necessary number of hotel rooms by regency/city and district is presented in Appendix-3.1.

Table-G.14 Projected Necessary Hotel Rooms

Classification of Hotel	2004	2010	2025
Classified hotel	9,300	12,200	24,100
Non-classified hotel and other accommodations	5,400	7,100	14,000
Total	14,700	19,300	38,100

Source: Study Team

Number of Foreign Tourists

Number of foreign tourist visiting direct to Bali Province has been completely recovered in 2004 in spite of sharp drop in year 2003 caused by terrorism in late 2002. Foreign tourists direct to Bali Province increased by 4.5 % per year during the period of years 1999 - 2004 but year 2003. The number of foreign tourists is assumed to continuously increase, so that the same rate of 4.5% is applied for the Mater Plan. Accordingly, the number of foreign tourists direct to Bali Province is projected as follows:

	Year 2004	Year 2010	Year 2025
Estimated Number of Foreign Tourist:	1,458,000	1,900,000	3,690,000

Number of Hotel Guest

1) Foreigners: Number of hotel guests is estimated on the basis of number of foreign direct visitors to Bali and the statistic data of BPS of Bali Province during the years of 1999 – 2002 as follows:

   At classified hotel: 87% of foreign direct visitors
   At non-classified hotel and other accommodations: 49% of foreign direct visitors

2) Indonesian: Number of hotel guests is estimated on the basis of the statistic data of BPS of Bali

Province during the years of 2000-2003 by applying average growth rate of GDP/capita (3%) of the years 2000-2003.

Number of Guests at Room

Average number of 2.1 persons at one room is applied according to the statistic data of BPS of Bali Province over the period of the years 1999 – 2002.

Length of Stay

The following average length of stay at hotel is applied according to the statistic data of BPS of Bali Province over the period of the years 1999 – 2002.

	Foreigners	Indonesian
At classified hotel:	4.3 days	3.7 days
At non-classified hotel and other accommodations:	4.2 days	2.0 days

G-4 WATER DEMAND PROJECTION

G-4.1 Domestic and Non-domestic Water

Water demand of domestic water and non-domestic water (commercial/public/institutional water, manufacturing industry water and tourism water) was projected in this chapter.

(1) Domestic Water Demand

Domestic water is obtained from public supply system and non-public supply such as individual well, spring, rainwater, etc. Domestic water demand of both public supply and non-public supply was projected by applying the following factors.

<Unit Water Consumption>

Unit water consumption rate of public supply was set up as shown in Table-G.15 through discussion with respective PDAM and PT.TB based on the data of present unit consumption rate.

Unit water consumption rate of non-public supply was set up at 60 liter/person /day for every area based on the data of survey conducted by Study Team as shown in Table-G.15.

<Service Coverage Ratio>

Service coverage ratio was set up as shown in Table-G.15 through discussion with respective PDAM and PT.TB based on the data of present coverage ratio.

<Unaccounted Water Rate>

Current rate of 25 % in 2004 is set up at by referring the average unaccounted water rate of Bali Province. Until 2010, the rate is assumed to improve to 20% and then continue the same as shown in Table-G.15.

<Population>

Population of Bali Province was previously projected by District and presented in Appendix-1.1.

Table-G.15 Base Data for Domestic Water Demand Projection

<table>
<tr><td rowspan="3">Water Supply Enterprises</td><td colspan="9">Public Supply</td><td rowspan="2">Non-Public Supply</td></tr>
<tr><td colspan="3">Unit Consumption (liter/person/day)</td><td colspan="3">Service Coverage Ratio (%)</td><td colspan="3">Unaccounted Water Rate (%)</td></tr>
<tr><td>2004</td><td>2010</td><td>2025</td><td>2004</td><td>2010</td><td>2025</td><td>2004</td><td>2010</td><td>2025</td><td>Consump. (ltr/prs/day) 2004</td></tr>
<tr><td>Denpasar</td><td>210</td><td>220</td><td>220</td><td>45</td><td>55</td><td>70</td><td rowspan="2">25*</td><td rowspan="2">20*</td><td rowspan="2">20*</td><td rowspan="2">60*</td></tr>
<tr><td>Badung</td><td>170</td><td>180</td><td>210</td><td>35</td><td>45</td><td>70</td></tr>
<tr><td>PT.TB</td><td>200</td><td>210</td><td>210</td><td>65</td><td>70</td><td>80</td><td rowspan="8">25*</td><td rowspan="8">20*</td><td rowspan="8">20*</td><td rowspan="8">60*</td></tr>
<tr><td>Gianyar</td><td>130</td><td>140</td><td>160</td><td>45</td><td>55</td><td>70</td></tr>
<tr><td>Jembrana</td><td rowspan="6">110*</td><td rowspan="6">120*</td><td rowspan="6">150*</td><td>30</td><td>35</td><td>50</td></tr>
<tr><td>Tabanan</td><td>40</td><td>50</td><td>70</td></tr>
<tr><td>Klungkung</td><td>50</td><td>55</td><td>70</td></tr>
<tr><td>Bangli</td><td rowspan="3">20*</td><td rowspan="3">30*</td><td rowspan="3">50*</td></tr>
<tr><td>Karangasem</td></tr>
<tr><td>Buleleng</td></tr>
</table>

Note: * - figures to be applied for each PDAM
Source: Study Team

(2) Non-domestic Water Demand

<Commercial/Public/Institutional Water>

Bali Water Supply Master Plan conducted by SMEC International PTY LTD in 2000 estimated commercial/public/institutional water consumption by applying the ratio of 20% to domestic water consumption. Similarly, the same ratio was set up in this study as shown in Table-G.16 referring to the present consumption of this category of each water supply enterprise.

Service coverage ratio is assumed to be 100 % considering the place where this category actually locates and difficulty in obtaining non-public supply water there.

<Manufacturing Industry Water>

The survey on major industry of Bali Province such as food/beverage, textile and wood industries was conducted by Study Team. According to the data collected, the unit water consumption of manufacturing industry was estimated at $10m^3$/day/annual output of 1billion Ruphia as shown in Table-G.16. Manufacturing industry output is previously projected and presented in Appendix-2.1.

Actually, there are many manufacturing industries that take water from wells, river water, etc. Accordingly, service coverage ratio for this category is supposed to be low. In this study, the service coverage ratio is estimated currently at 20 % and 40 % in 2025.

<Tourism Water>

The survey on hotels of Bali Province was conducted by Study Team. According to the data collected, the unit water consumption of star hotel and non-star hotels was estimated respectively at $3.3m^3$/room/day and $1.5m^3$/room/day as shown in Table-G.16. Number of hotel rooms is previously projected and presented in Appendix-3.1.

In fact, there are many hotels that utilize well water. So, current service coverage ratio of this category is not high, which is estimated at around 20 %. It is expected that number of tourists to Bali Island will continuously increase. However, most luxurious hotels that utilize well water are located near the sea. The well near the sea is limited to use because it may bring about contamination of sea water into the well. In order to cope with incidental increasing tourism water demand, most of hotels supposedly use more public water in future. Thus, service coverage ratio was assumed 70 % in 2025.

Table-G.16 Base Data for Non-domestic Water Demand Projection

Category	Water Consumption		Service Coverage Ratio (%)		
	Entity	Unit Rate	2004	2010	2025
Commercial/ Public/ Institutional	PT.TB	30% of Domestic Water	100	100	100
	PDAM Denpasar and Tabanan	20% of Domestic Water			
	Other 7 PDAMs	10% of Domestic Water			
Industrial	Manufacturing	10 m^3/output in billion Rp.	20	25	40
Tourism	Star hotel	3.3 m^3/room/day	20	40	70
	Non-star hotel	1.5 m^3/room/day	100	100	100
Unaccounted Water	Same as rate of domestic water (%)		25	20	20

Source: Study Team

(3) Water Supply Requirement of Bali Province

By applying all factors mentioned above (1) and (2), overall water supply requirement of Bali Province is projected and summarized in

Table-G.17 (1/2) and Table-G.17 (2/2).

Table-G.17 (1/2) Water Supply Requirement by Regency of Bali Province

Unit: liter per second

Year	2005	2010	2015	2020	2025	2005	2010	2015	2020	2025
Regency:	Jembrana					Tabanan				
1. Public Supply	152	184	254	324	395	345	436	577	718	858
1) Domestic Water	125	148	194	240	285	276	347	452	558	663
2) Non-domestic Water	26	35	60	85	109	69	89	124	160	195
2. Non-public Supply	144	149	159	169	179	174	160	152	144	135
1) Domestic Water	113	109	103	97	91	156	138	122	106	90
2) Non-domestic Water	31	40	56	72	88	19	23	30	38	45
3. Supply Requirement	296	333	413	493	573	519	597	729	861	993
1) Domestic Water	239	258	297	337	376	432	485	574	664	753
2) Non-domestic Water	57	75	116	157	197	88	112	155	197	240
Regency:	Badung Total = 1+2					1. (Badung - PDAM)				
1. Public Supply	718	1,003	1,398	1,793	2,189	273	398	549	700	851
1) Domestic Water	470	625	813	1,001	1,189	237	343	469	595	721
2) Non-domestic Water	248	378	585	792	1,000	37	55	80	105	130
2. Non-public Supply	396	396	385	374	363	147	146	134	123	111
1) Domestic Water	145	138	125	112	99	118	111	98	86	74
2) Non-domestic Water	251	257	260	262	264	29	35	36	37	38
3. Supply Requirement	1,114	1,398	1,783	2,167	2,552	421	544	683	822	962
1) Domestic Water	615	763	938	1,113	1,288	355	454	567	681	794
2) Non-domestic Water	499	635	845	1,054	1,264	66	90	116	142	167

Note: Badung is the sum of Badung–PDAM and PT.TB.
Source: Study Team

Table-G.17 (2/2) Water Supply Requirement by Regency of Bali Province

Unit: liter per second

Year	2005	2010	2015	2020	2025	2005	2010	2015	2020	2025
Regency:	2. (PT.TB)					Gianyar				
1. Public Supply	444	604	849	1,094	1,338	461	586	744	901	1,058
1) Domestic Water	233	281	344	406	468	397	503	627	752	876
2) Non-domestic Water	211	323	505	687	870	64	83	116	149	182
2. Non-public Supply	249	250	251	251	252	178	168	167	165	164
1) Domestic Water	27	27	27	26	25	155	140	131	121	112
2) Non-domestic Water	222	223	224	225	226	23	28	36	44	53
3. Supply Requirement	693	854	1,099	1,345	1,590	639	754	910	1,066	1,223
1) Domestic Water	260	309	370	432	494	552	643	758	873	988
2) Non-domestic Water	433	545	729	913	1,096	87	111	152	194	235
Regency:	Klungkung Total = 3+4					3. (Klungkung - Bali)				
1. Public Supply	151	169	207	244	282	108	121	149	178	206
1) Domestic Water	136	151	184	216	249	97	109	133	158	182
2) Non-domestic Water	15	18	23	28	33	11	12	16	20	24
2. Non-public Supply	56	53	49	45	41	40	38	36	34	31
1) Domestic Water	53	49	44	39	34	38	35	32	28	25
2) Non-domestic Water	3	4	5	6	7	2	3	4	5	6
3. Supply Requirement	207	222	255	289	323	148	159	185	211	237
1) Domestic Water	189	201	228	255	282	135	144	165	186	207
2) Non-domestic Water	18	21	27	34	40	13	15	20	25	30
Regency:	4. (Klungkung - Nusapenida)					Bangli				
1. Public Supply	43	48	57	67	76	83	123	180	232	287
1) Domestic Water	39	42	50	58	66	74	109	160	207	255
2) Non-domestic Water	5	5	7	8	10	10	14	20	25	31
2. Non-public Supply	16	14	13	11	10	110	102	96	89	82
1) Domestic Water	15	14	12	11	9	110	101	96	88	81
2) Non-domestic Water	1	1	1	1	1	0	1	1	1	1
3. Supply Requirement	59	62	70	78	86	193	225	276	321	369
1) Domestic Water	54	56	63	69	75	183	211	255	294	336
2) Non-domestic Water	5	6	7	9	10	10	14	21	27	33

Regency:	Karangasem					Buleleng				
1. Public Supply	166	236	333	430	526	245	344	515	687	859
1) Domestic Water	136	195	273	351	430	211	297	420	543	665
2) Non-domestic Water	30	41	59	78	97	34	46	95	145	194
2. Non-public Supply	208	192	181	169	158	309	281	295	310	324
1) Domestic Water	198	181	166	151	136	304	275	254	232	211
2) Non-domestic Water	10	11	15	18	21	6	6	41	77	113
3. Supply Requirement	374	428	513	599	684	554	625	811	997	1,182
1) Domestic Water	334	376	439	503	566	515	573	674	775	876
2) Non-domestic Water	39	52	74	96	118	39	52	137	222	306
Regency:	Denpasar					Total of Bali				
1. Public Supply	1,180	1,577	1,986	2,396	2,805	3,501	4,657	6,191	7,725	9,259
1) Domestic Water	929	1,232	1,528	1,823	2,119	2,754	3,608	4,649	5,690	6,731
2) Non-domestic Water	251	345	459	572	686	747	1,048	1,541	2,034	2,527
2. Non-public Supply	326	333	332	331	330	1,901	1,834	1,815	1,795	1,776
1) Domestic Water	227	218	211	204	197	1,460	1,350	1,250	1,150	1,050
2) Non-domestic Water	99	115	121	127	134	441	485	565	646	726
3. Supply Requirement	1,507	1,910	2,318	2,727	3,136	5,402	6,491	8,005	9,520	11,035
1) Domestic Water	1,157	1,450	1,739	2,027	2,316	4,215	4,958	5,899	6,840	7,782
2) Non-domestic Water	350	460	580	700	820	1,188	1,533	2,106	2,680	3,253

Note: Klungkung is the sum of “Klungkung–Bali” and Nusapenida.
Source: Study Team

(4) Sensitivity Analysis on Water Supply Requirement

Sensitivity analysis on water supply requirement previously projected is conducted herein. As material variation factors, population growth, manufacturing industry growth, foreign tourist increase, and domestic water coverage ratio are selected. Scenarios for respective factors are set from both viewpoints of higher and lower scenarios than the projection as shown in Table-G.18.

Table-G.18 Scenarios for Sensitivity Analysis

Demand Variation Factors	Scenarios		Remarks
1. Population Growth	High 1	1.26%	Spatial Plan of Bali Province
	High 2	1.18%	Spatial Plan of Bali Province
	Low	1.05%	Spatial Plan of Bali Province
2. Manufacturing Ind. Growth	High	8.4%	Spatial Plan of Bali Province from 2006
	Low	5%	30% lower than the projection from 2006
3. Foreign Tourist Increase	High	5%	10% higher than the projection
	Low	4%	10% lower than the projection
4. Coverage Ratio of Domestic Water	90% in 2025		Coverage ratio of WB study

Source: Study Team

The result of water supply requirement based on the above scenarios is presented in Table-G.19. It is obvious that the water supply requirement does not change significantly compared with the projection as for variation factors of population, manufacturing and foreign tourist; however, it should be noted that the requirement will soar by 22% in year 2025 if domestic water coverage ratio increases from 70% and 80% of the projection to 90%.

Table-G.19 Variation in Water Supply Requirement

Unit: liter per second

Demand V. Factor	Scenario	Badung			Gianyar	Denpasar	Total	Projection =100
		PDAM	PTTB	Total				
Projection		851	1,338	2,189	1,058	2,805	6,052	100
1. Population	High 1	899	1,375	2,274	1,102	2,995	6,371	105
	High 2	874	1,356	2,230	1,080	2,898	6,208	103
	Low	835	1,326	2,161	1,044	2,744	5,949	98
2. Manufacturing	High	857	1,344	2,201	1,070	2,829	6,100	101
	Low	844	1,332	2,176	1,046	2,782	6,004	99
3. Foreign Tourist	High	853	1,395	2,248	1,063	2,820	6,131	101
	Low	848	1,282	2,130	1,054	2,791	5,975	99
4. Coverage Ratio	90%	1,077	1,418	2,495	1,334	3,532	7,361	122

Source: Study Team

Appendices

Appendix-1
Population Projection

Appendix-1.1 Population Projection

Regency/City		District		Census	Trend Projection			Development Projection
Code	Name	Code	Name	2000	2004	2010	2025	**2025**
01	Jembrana	010	MELAYA	44,762	45,056	45,497	46,623	**46,623**
		020	NEGARA	111,089	115,046	120,982	136,142	**136,142**
		030	MENDOYO	52,325	52,940	53,864	56,221	**56,221**
		040	PEKUTATAN	23,630	23,695	23,791	24,039	**24,039**
			Total	231,806	236,737	244,134	263,025	**263,025**
02	Tabanan	010	SELEMADEG	56,378	18,909	19,084	19,530	**19,530**
		011	SELEMADEG BARAT	0	18,909	19,084	19,530	**19,530**
		012	SELEMADEG TIMUR	0	18,909	19,084	19,530	**19,530**
		020	KERAMBITAN	34,843	35,727	37,053	40,439	**40,439**
		030	TABANAN	61,580	62,869	64,802	69,740	**69,740**
		040	KEDIRI	64,411	67,586	72,349	84,514	**84,514**
		050	MARGA	37,004	38,355	40,381	45,557	**45,557**
		060	BATURITI	42,029	43,414	45,491	50,796	**50,796**
		070	PENEBEL	42,955	43,435	44,156	45,996	**45,996**
		080	PUPUAN	36,830	37,456	38,395	40,794	**40,794**
			Total	376,030	385,570	399,880	436,427	**436,427**
03	Badung	010	KUTA SELATAN	48,573	55,579	66,088	92,926	**90,785**
		020	KUTA	48,701	55,725	66,262	93,171	**93,171**
		030	KUTA UTARA	53,042	60,692	72,168	101,476	**101,141**
		040	MENGWI	96,396	101,639	109,504	129,590	**128,051**
		050	ABIANSEMAL	73,839	77,733	83,573	98,489	**95,813**
		060	PETANG	25,312	26,185	27,493	30,836	**30,836**
			Total	345,863	377,553	425,088	546,488	**539,797**
04	Gianyar	010	SUKAWATI	84,199	90,748	100,571	125,658	**125,658**
		020	BLAHBATUH	54,520	57,494	61,955	73,347	**73,347**
		030	GIANYAR	72,656	75,624	80,077	91,449	**91,449**
		040	TAMPAK SIRING	40,370	42,522	45,751	53,997	**53,997**
		050	UBUD	60,064	64,494	71,139	88,111	**88,111**
		060	TEGALLALANG	43,990	46,575	50,454	60,358	**60,358**
		070	PAYANGAN	37,356	39,005	41,479	47,797	**47,797**
			Total	393,155	416,463	451,426	540,718	**540,718**
05	Klungkung	010	NUSAPENIDA	44,886	44,700	44,420	43,707	**43,707**
		020	BANJARANGKAN	32,307	32,659	33,187	34,535	**34,535**
		030	KLUNGKUNG	48,017	48,926	50,290	53,773	**53,773**
		040	DAWAN	30,052	30,297	30,664	31,601	**31,601**
			Total	155,262	156,582	158,561	163,616	**163,616**
06	Bangli	010	SUSUT	40,164	41,654	43,889	49,598	**49,598**
		020	BANGLI	41,505	42,328	43,562	46,713	**46,713**
		030	TEMBUKU	31,612	31,739	31,930	32,417	**32,417**
		040	KINTAMANI	80,495	84,610	90,783	106,548	**106,548**
			Total	193,776	200,331	210,164	235,276	**235,276**
07	Karangasem	010	RENDANG	30,809	30,784	30,747	30,651	**30,651**
		020	SIDEMEN	28,523	28,892	29,445	30,858	**30,858**
		030	MANGGIS	40,756	41,063	41,525	42,702	**42,702**
		040	KARANG ASEM	71,387	71,818	72,465	74,118	**74,118**
		050	ABANG	57,776	59,010	60,861	65,588	**65,588**
		060	BEBANDEM	43,292	44,620	46,611	51,697	**51,697**
		070	SELAT	34,995	35,602	36,511	38,835	**38,835**
		080	KUBU	52,948	54,310	56,354	61,573	**61,573**
			Total	360,486	366,099	374,519	396,022	**396,022**
08	Buleleng	010	GEROKGAK	67,159	68,973	71,694	78,643	**100,482**
		020	SERIRIT	62,874	63,086	63,403	64,214	**64,214**
		030	BUSUNGBIU	37,372	37,296	37,182	36,890	**36,890**
		040	BANJAR	61,443	61,896	62,574	64,308	**64,308**
		050	SUKASADA	60,489	61,173	62,198	64,818	**64,818**
		060	BULELENG	110,772	111,194	111,827	113,444	**113,444**
		070	SAWAN	54,483	54,339	54,123	53,572	**53,572**
		080	KUBUTAMBAHAN	49,892	51,113	52,945	57,624	**57,624**
		090	TEJAKULA	53,697	54,304	55,215	57,540	**57,540**
			Total	558,181	563,373	571,162	591,053	**612,892**
09	Denpasar (1)	010	DENPASAR SELATAN	152,687	179,748	220,340	324,007	**320,372**
		020	DENPASAR TIMUR	141,250	151,895	167,863	208,645	**206,675**
		030	DENPASAR BARAT	238,503	269,330	315,571	433,666	**424,123**
			Total	532,440	600,974	703,774	966,318	**951,170**
Total of Bari				3,146,999	3,303,683	3,538,708	4,138,943	**4,138,943**

Source: Study Team

Appendix-2
Projection of Manufacturing Industry Output

Appendix-2.1 Projection of Manufacturing Industry Output (1/2)

(Million Rp.)

Regency/City		District	Ind. Sector	Actual	Trend Estimate			Development Projection
				2003	2004	2010	2025	**2025**
01	Jembrana	010	3	2,259	2,384	3,521	9,667	**9,667**
		020	1	283,785	299,393	442,286	1,214,306	**1,214,306**
		020	2	1,092	1,152	1,702	4,672	**4,672**
		020	3	990	1,045	1,544	4,238	**4,238**
		020	6	1,238	1,306	1,929	5,297	**5,297**
		020	7	1,191	1,256	1,856	5,096	**5,096**
		030	2	890	939	1,387	3,807	**3,807**
		040	1	5,375	5,670	8,377	22,998	**22,998**
Total				296,820	313,145	462,601	1,270,082	**1,270,082**
02	Tabanan	010	3	774	816	1,206	3,311	**3,311**
		010	8	838	884	1,306	3,585	**3,585**
		020	1	21,857	23,059	34,065	93,526	**93,526**
		020	2	10,839	11,435	16,892	46,378	**46,378**
		020	3	9,068	9,567	14,133	38,802	**38,802**
		030	1	4,121	4,347	6,422	17,632	**17,632**
		030	2	16,056	16,939	25,023	68,701	**68,701**
		030	3	14,020	14,791	21,850	59,991	**59,991**
		030	8	8,001	8,441	12,470	34,237	**34,237**
		040	1	39,235	41,393	61,149	167,887	**167,887**
		040	2	809	853	1,261	3,461	**3,461**
		040	3	836	882	1,302	3,576	**3,576**
		040	7	3,109	3,280	4,845	13,301	**13,301**
		040	8	3,214	3,391	5,009	13,753	**13,753**
		050	3	805	849	1,254	3,443	**3,443**
		070	2	3,195	3,371	4,979	13,671	**13,671**
Total				136,775	144,297	213,167	585,255	**585,255**
03	Badung	010	2	81,087	85,547	126,376	346,968	**173,484**
		010	3	30,206	31,867	47,077	129,251	**129,251**
		010	4	1,970	2,078	3,070	8,430	**8,430**
		010	7	3,124	3,296	4,869	13,368	**13,368**
		030	2	12,052	12,715	18,783	51,569	**25,785**
		040	1	59,122	62,374	92,143	252,980	**126,490**
		040	3	5,354	5,649	8,345	22,910	**22,910**
		050	1	100,507	106,035	156,643	430,067	**215,033**
Total				293,422	309,560	457,305	1,255,543	**714,751**
04	Gianyar	010	1	45,864	48,387	71,480	196,251	**196,251**
		010	2	3,276	3,456	5,105	14,017	**14,017**
		010	3	28,194	29,745	43,942	120,643	**120,643**
		020	1	6,091	6,426	9,494	26,065	**26,065**
		020	2	3,235	3,413	5,042	13,844	**13,844**
		020	3	3,838	4,049	5,981	16,421	**16,421**
		030	2	12,011	12,672	18,720	51,396	**51,396**
		030	3	2,847	3,004	4,438	12,184	**12,184**
		030	7	541	571	844	2,316	**2,316**
		040	3	15,598	16,456	24,310	66,744	**66,744**
		040	8	1,026	1,082	1,599	4,389	**4,389**
		050	2	2,912	3,072	4,538	12,460	**12,460**
		050	3	25,595	27,002	39,890	109,519	**109,519**
		060	3	3,961	4,179	6,174	16,951	**16,951**
Total				154,991	163,516	241,557	663,201	**663,201**

Note: Ind. Sector; 1. food & beverage, 2. Textile, 3. wood related, 4. printing, 5. rubber, 6. chemical, 7 other non-metal, 8. fabricated metal

Source: Study Team

Appendix-2.1 Projection of Manufacturing Industry Output (2/2)

(Million Rp.)

Regency/City		District	Ind. Sector	Actual	Trend Estimate			Development Projection
05	Klungkung	030	1	11,108	11,719	17,312	47,530	**47,530**
		030	2	4,894	5,163	7,627	20,939	**20,939**
		040	2	5,298	5,589	8,257	22,670	**22,670**
		040	7	418	441	651	1,787	**1,787**
Total				21,717	22,911	33,846	92,925	**92,925**
06	Bangli	020	3	898	947	1,399	3,840	**3,840**
		030	3	3,869	4,081	6,029	16,554	**16,554**
Total				4,766	5,028	7,428	20,394	**20,394**
07	Karangasem	010	1	13,974	14,743	21,779	59,795	**59,795**
		010	2	849	896	1,324	3,634	**3,634**
		020	2	3,680	3,883	5,736	15,748	**15,748**
		040	1	11,824	12,475	18,429	50,596	**50,596**
		050	1	4,300	4,536	6,701	18,399	**18,399**
		050	3	2,383	2,514	3,714	10,197	**10,197**
		060	1	9,674	10,207	15,078	41,397	**41,397**
		060	7	371	392	578	1,588	**1,588**
		070	3	619	653	965	2,649	**2,649**
		070	7	13,826	14,587	21,548	59,162	**59,162**
		080	3	619	653	965	2,649	**2,649**
		080	7	356	375	554	1,522	**1,522**
Total				62,477	65,913	97,371	267,335	**267,335**
08	Buleleng	010	7	495	522	771	2,118	**2,118**
		010	1	0	0	0	0	**839,818**
		010	2	0	0	0	0	**676,631**
		040	1	7,525	7,938	11,727	32,198	**32,198**
		060	4	1,182	1,247	1,842	5,058	**5,058**
		070	7	665	702	1,036	2,846	**2,846**
Total				9,867	10,409	15,377	42,219	**1,558,668**
09	Denpasar	010	1	82,412	86,945	128,442	352,639	**176,320**
		010	2	27,258	28,757	42,482	116,637	**58,318**
		010	3	14,484	15,281	22,574	61,977	**61,977**
		010	7	356	375	554	1,522	**1,522**
		010	8	684	721	1,066	2,926	**2,926**
		020	2	58,601	61,824	91,331	250,751	**125,376**
		020	3	3,064	3,232	4,775	13,111	**13,111**
		020	4	37,937	40,024	59,126	162,333	**162,333**
		030	1	150,492	158,769	234,545	643,950	**321,975**
		030	2	137,261	144,811	213,925	587,336	**293,668**
		030	3	15,134	15,966	23,587	64,758	**64,758**
		030	4	9,907	10,451	15,440	42,390	**42,390**
		030	8	376	397	586	1,609	**1,609**
Total				537,966	567,554	838,433	2,301,939	**1,326,283**
Total				1,518,800	1,602,334	2,367,086	6,498,893	**6,498,893**

Note: Ind. Sector; 1. food & beverage, 2. Textile, 3. wood related, 4. printing, 5. rubber, 6. chemical, 7 other non-metal, 8. fabricated metal

Source: Study Team

Appendix-3
Necessary Number of Hotel Rooms

Appendix-3.1 Necessary Number of Hotel Rooms

Regency/City		District		Classified Hotel			Non-classified Hotel & Others		
				2004	2010	**2025**	2004	2010	**2025**
01	Jembrana	010	Melaya				37	48	**95**
		020	Negara				62	82	**161**
		030	Mendoyo				2	2	**4**
		040	Pekutatan				27	35	**68**
02	Tabanan	010	Selemadeg				27	35	**69**
		011	Selemadeg Barat						
		012	Selemadeg Timur						
		020	Kerambitan				4	5	**10**
		030	Tabanan				61	80	**158**
		040	Kediri	13	17	**33**	33	43	**85**
		050	Marga				2	2	**4**
		060	Baturiti	131	172	**338**	141	185	**364**
		070	Penebel				12	16	**31**
		080	Pupuan				14	19	**37**
03	Badung	010	Kuta Selatan	3,412	4,473	**8,807**	114	150	**294**
		020	Kuta	3,520	4,614	**9,086**	1,957	2,565	**5,041**
		030	Kuta Utara	358	470	**925**	79	103	**202**
		040	mengwi						
		050	Abiansemal						
		060	Petang						
04	Gianyar	010	Sukawati				2	2	**4**
		020	Blahbatuh	15	20	**39**	5	7	**14**
		030	Gianyar				16	21	**41**
		040	Tampak Siring				3	4	**9**
		050	Ubud	176	231	**455**	617	809	**1,590**
		060	Tegalalang				12	16	**32**
		070	Payangan	34	45	**88**	2	2	**4**
05	Klungkung	010	Nusa Penida	20	26	**51**	17	22	**43**
		020	Banjarangkan						
		030	Klungkung				7	9	**17**
		040	Dawan						
06	Bangli	010	Susut						
		020	Bangli				2	2	**4**
		030	Tembuku						
		040	Kintamani				81	106	**208**
07	Karangasem	010	Rendang				2	3	**5**
		020	Sidemen				10	13	**26**
		030	Manggis				58	76	**150**
		040	Karangasem	74	97	**191**	373	489	**961**
		050	Abang	25	33	**66**	54	71	**140**
		060	Bebandem						
		070	Selat				3	4	**8**
		080	Kubu				31	40	**79**
08	Buleleng	010	Gerokgak	28	37	**73**	14	19	**37**
		020	Seririt	49	64	**125**	12	16	**32**
		030	Busungbiu						
		040	Banjar				54	71	**140**
		050	Sukasada				4	6	**11**
		060	Buleleng	8	11	**21**	327	429	**843**
		070	Sawan	66	86	**169**			
		080	Kubutambahan				13	17	**32**
		090	Tejakula				5	6	**12**
09	Denpasar	010	Denpasar Selatan				468	613	**1,205**
		020	Denpasar Timur	1,379	1,808	**3,560**	289	379	**744**
		030	Denpasar Barat	33	44	**86**	394	516	**1,014**
Total				9,341	12,246	**24,114**	5,447	7,136	**14,028**

Source: Study Team

DIRECTORATE GENERAL OF WATER RESOURCES,
MINISTRY OF PUBLIC WORKS
PUBLIC WORKS SERVICE, BALI PROVINCE

THE COMPREHESIVE STUDY
ON
WATER RESOURCES DEVELOPMENT
AND MANAGEMENT IN BALI PROVINCE
IN
THE REPUBLIC OF INDONESIA

FINAL REPORT
SUPPORTING REPORT

[H] WATER SUPPLY

AUGUST 2006

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.

THE COMPREHENSIVE STUDY
ON WATER RESOURCES DEVELOPMENT AND MANAGEMENT
IN BALI PROVINCE IN THE REPUBLIC OF INDONESIA

SUPPORTING REPORT (H)
WATER SUPPLY

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H-1 WATER SUPPLY

H-1.1 Alternative Water Supply Plans for SARBAGI Areas

Alternative water supply plans for metropolitan areas (SARBAGI Areas) are shown in Table-H.1 and Figure-H.1.

Table-H.1 Alternative Water Supply Plans for SARBAGI

System and Alternatives	Intake Point	Water Treatment Plant	Water Conveyance	Remarks
Western System	➢ Capacity: 300lit/s ➢ Service Area: Mainly middle parts of Badung regency ➢ Water Source: Penet River located on the boundary between Badung and Tabanan regencies ➢ Terminal Point of Main Water Conveyance Line: KEROBOKAN			
W1	Middle reach of Penet river	Kapal	Pump intake and gravity conveyance	◆ Some existing intakes for irrigation and water supply in downstream.
W2	Mouth of Penet river	Mungu	Pump intake and gravity conveyance	◆ No intake in downstream
Central System	➢ Capacity: 1,800lit/s ➢ Service Area: Denpasar and southern parts of Badung regency ➢ Water Source (1): With dam in Ayung river ➢ Water Source (2): Without Dam, a) Surface water, b) Groundwater, c) Surface water + Groundwater ➢ Terminal Point of Main Water Conveyance Line: Existing IPA-Ayung			
C1 (With Dam)	Downstream near dam site	Downstream near dam site	Gravity intake and gravity conveyance	◆ Some existing intakes for irrigation and water supply in downstream
C2 (With Dam)	Middle reach of Ayung river	Near existing IPA-Ayung	Pump intake and no conveyance	◆ Some existing intakes for irrigation and water supply in downstream
C3 (Without Dam)	Surface Water	Near existing IPA-Ayung	Pump intake and pump conveyance	◆ Intake points: River mouths of 6 rivers
C4 (Without Dam)	Groundwater	Near existing IPA-Ayung	Well production and pump conveyance	◆ Well: 180 deep wells
C5 (Without Dam)	Surface Water + Groundwater	Near existing IPA-Ayung	Pump intake / well production and pump conveyance	◆ Intake points: River mouths of 5 rivers ◆ Well: 90 deep wells
C6 (With Small Dam)	Middle reach of Ayung river	Near existing IPA-Ayung	Well production and pump conveyance	◆ Small size of dam ◆ Well: 90 deep wells
Eastern System	➢ Capacity: 800lit/s ➢ Service Area: Southern parts of Badung regency and southern parts of Gianyar regency ➢ Water Source: Petanu river and Unda river ➢ Terminal Point of Main Water Conveyance Line: Existing IPA/Badung Estuary			
E1	Middle reach of Unda river (Telagawaja)	Middle reach of Unda river (Telagawaja)	Gravity intake and gravity conveyance	◆ Some existing intakes for irrigation and water supply in downstream ◆ Water Conveyance: Via Ubud
E2	Middle reach of Unda river (Telagawaja)	Middle reach of Unda river (Telagawaja)	Gravity intake and gravity conveyance	◆ Some existing intakes for irrigation and water supply in downstream ◆ Water Conveyance: Via Sunrise Road
E3	Mouth of Unda river	Mouth of Unda river	Pump intake and pump conveyance	◆ Water Conveyance: Via Sunrise Road
E4	Mouth of Petanu river + Mouth of Unda river	Mouth of Petanu river + Mouth of Unda river	Pump intake and pump conveyance	◆ Water Conveyance: Via Sunrise Road ◆ Stage installation of intake point
E5	River mouth of Petanu river + Middle reach of Unda river	Mouth of Petanu river + Middle reach of Unda river	Combination of (1) Pump intake and pump conveyance + (2) Gravity intake and gravity conveyance	◆ Water Conveyance: Via Sunrise Road ◆ Stage installation of intake point

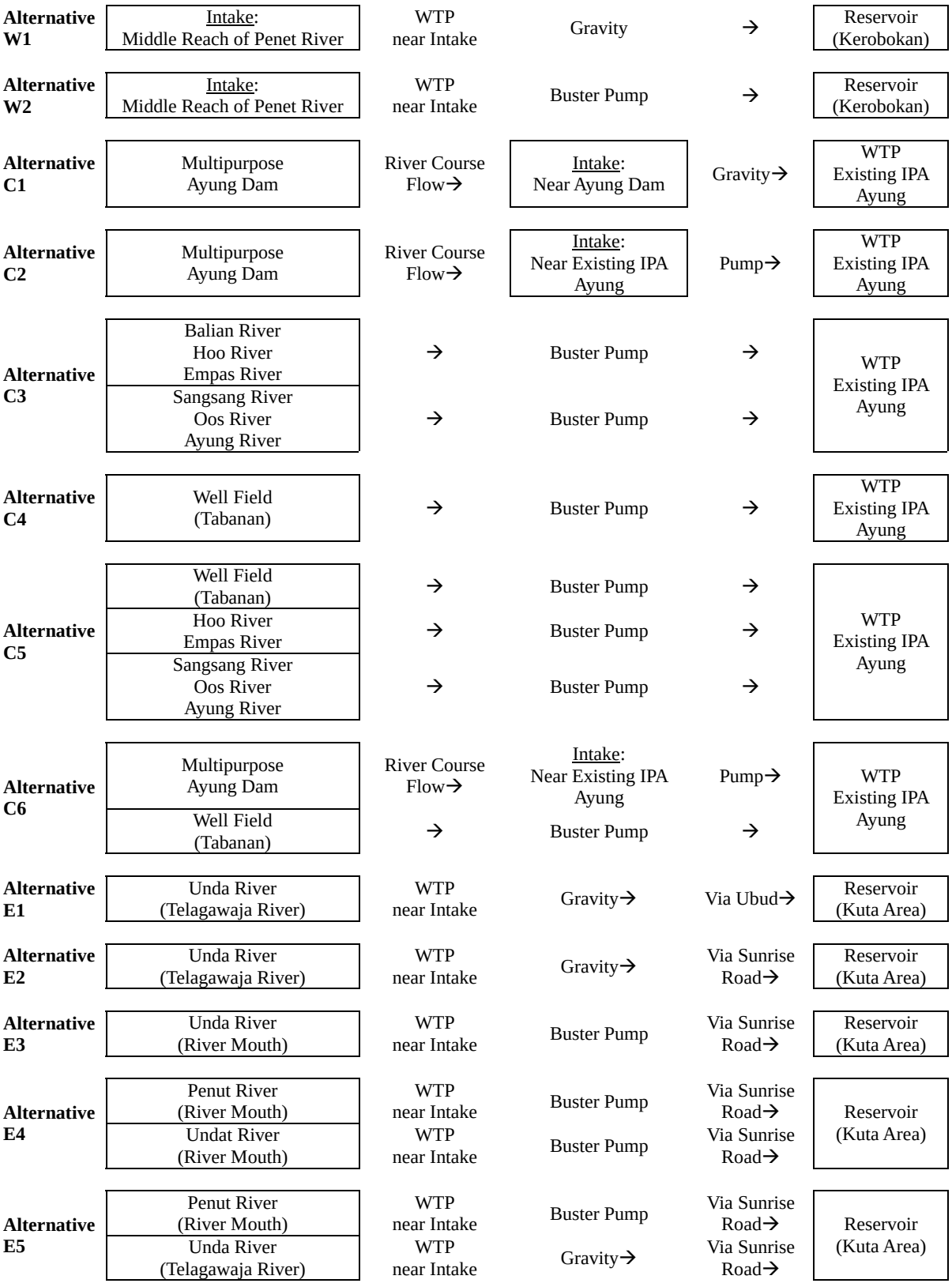

Figure-H.1 Schematic Diagram for Alternative Plans

H-1.1.1 Design for Booster Pump Station and Transmission Pipeline

(1) Calculation

Water Supply Capacity

Water supply capacity for each system is as follows

- Western Public Water Supply System; 300 lit/sec (Penet River)
- Central Public Water Supply System; 1800 lit/sec (Ayung River)
- Eastern Water Supply System; 800lit/sec (500 lit/sec from Unda River 300 lit/sec from Petanu River)

Pipe Loss Computation (H1)

$H_1=10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$

Where H_1; Pipe loss (m)
C ; Coefficient of friction of pipe (110)
D; Size of pipe (m)
Q; Flow rate (m^3/sec)
L; Pipe length (m)

Total Head Loss (H)

Total head loss (H) is gotten by use of the following formula,

$H=H_1 + H_2 + H_3$

Where H_1; Pipe loss (m)
H_2; Actual head (m)

Number of Pump

Minimum number of pump is 3, which is included one (1) stand by pump, taking into consideration of water supply capacity.

Material of Transmission Pipeline

Material of transmission pipeline is adopted a steel pipe with mortar lining to resist against the high pipeline pressure and the corrosion, therefore thrust block is not determined.

Earth Covering Depth

Earth covering depth is adopted one (1) m to minimize the pipe installation cost and ten (10) cm thickness of sand is determined for the foundation.

(2) Calculation Results

The result of the pipe loss computation for alternatives is shown in the Table-H.2. Longitudinal section and hydraulic gradient line for each water supply system is shown in the figures from Figure-H.2 to Figure-H.13.

Table-H.2 Result of Pipe Loss Computation for Thirteen (13) Alternatives

Water source	Alternative	C	D (m)	Q (m3/s)	L (m)	V (m/s)	H1 (m)	H2 (Actual Head; m)	H3 (m)	H4 (Total Head; m)	Remarks
Middle Reach of Penet	W1	110	0.5	0.3	15000	1.53	84.37	-100	0	-15.63	Gravity
River Mouth of Penet	W2	110	0.5	0.3	2000	1.53	11.25	25	3	39.25	Pump
		110	0.6	0.3	7500	1.06	17.36	5	3	25.36	Pump
Ayung	C1	110	1.1	1.8	8000	1.89	26.62	-34.50	0	-7.88	Gravity
Balian(1)	C3	110	1	0.9	7000	1.15	10.28	50	3	63.28	Pump
Balian(2)		110	1	0.9	2500	1.15	3.67	50	3	56.67	Pump
Balian(3)		110	1	0.9	11500	1.15	16.88	50	3	69.88	Pump
Ballian+Ho		110	1	1.2	7500	1.53	18.75	-65	0	-46.25	Gravity
Ballian+Ho +Empas		110	1	1.4	12500	1.78	41.56	-44	0	-2.44	Gravity
Sangsang	C3&C5	110	0.4	0.1	8500	0.80	18.57	20.00	3	41.57	Pump
Oos		110	0.5	0.2	7000	1.02	18.60	20.00	3	41.60	Pump
Ayung		110	0.7	0.4	8000	1.04	14.88	30.00	3	47.88	Pump
Well	C4	110	0.4	0.2	4500	1.59	35.44	0	3	38.44	Pump
		110	0.5	0.4	4500	2.04	43.10	0	3	46.10	Pump
		110	0.6	0.6	4500	2.12	37.55	0	3	40.55	Pump
		110	0.8	0.8	4500	1.59	15.75	50	3	68.75	Pump
		110	1	1	2500	1.27	4.46	50	3	57.46	Pump
		110	1	1.2	4500	1.53	11.25	50	3	64.25	Pump
		110	1	1.4	4500	1.78	14.96	-10	3	7.96	Pump
		110	1	1.6	4500	2.04	19.15	-10	3	12.15	Pump
		110	1.1	1.8	17000	1.89	56.56	-35	3	24.56	Pump
Well	C5	110	0.3	0.1	2500	1.41	22.17	0	3	25.17	Pump
		110	0.4	0.2	2000	1.59	15.75	0	3	18.75	Pump
		110	0.5	0.3	3000	1.53	16.87	-10	3	9.87	Pump
		110	0.5	0.4	2500	2.04	23.94	0	3	26.94	Pump
		110	0.5	0.5	2500	2.55	36.18	-25	3	14.18	Pump
		110	0.6	0.6	2500	2.12	20.86	-5	3	18.86	Pump
		110	0.6	0.7	2500	2.48	27.75	0	3	30.75	Pump
		110	0.7	0.8	2500	2.08	16.77	10	3	29.77	Pump
		110	0.8	0.9	7000	1.79	30.47	-5	3	28.47	Pump
Unda	E1	110	1	0.8	5000	1.02	5.90	0	0	5.90	Gravity
		110	0.6	0.8	15800	2.83	224.49	0	0	224.49	Gravity
		110	0.7	0.8	15000	2.08	100.60	0	0	100.60	Gravity
		110	0.8	0.8	38200	1.59	133.71	0	0	133.71	Gravity
Unda	E2	110	1	0.8	5000	1.02	5.90	0	0	5.90	Gravity
		110	0.6	0.8	23000	2.83	326.79	0	0	326.79	Gravity
		110	0.7	0.8	28600	2.08	191.81	0	0	191.81	Gravity
Unda	E3	110	0.9	0.8	11800	1.26	23.27	6.5	3	32.77	Pump
		110	0.9	0.8	11600	1.26	22.88	12.5	3	38.38	Pump
		110	1	0.8	13500	1.02	15.94	-20	0	-4.06	Gravity
Unda+Petanu	E4	110	0.9	0.8	5600	1.26	11.05	19	3	33.05	Pump
		110	0.7	0.5	11800	1.30	33.17	6.5	3	42.67	Pump
		110	0.7	0.5	6000	1.30	16.87	27		43.87	Gravity
		110	1	0.8	13500	1.02	15.94	-20	0	-4.06	Gravity
Unda+Petanu	E5	110	1	0.5	5000	0.64	2.47	0		2.47	Gravity
		110	0.5	0.5	32800	2.55	474.69			474.69	Gravity
		110	0.9	0.8	18800	1.26	37.08			37.08	Gravity

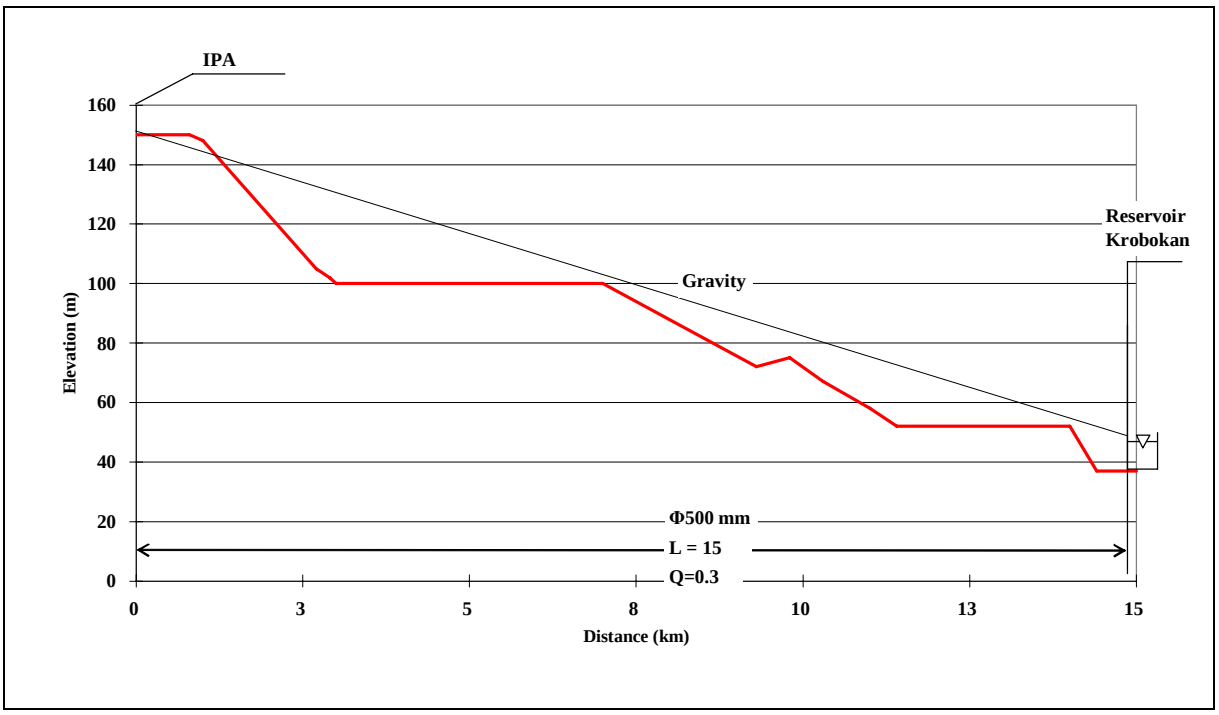

Figure-H.2 Longitudinal Section and hydraulic Gradient Line of Alternative W1

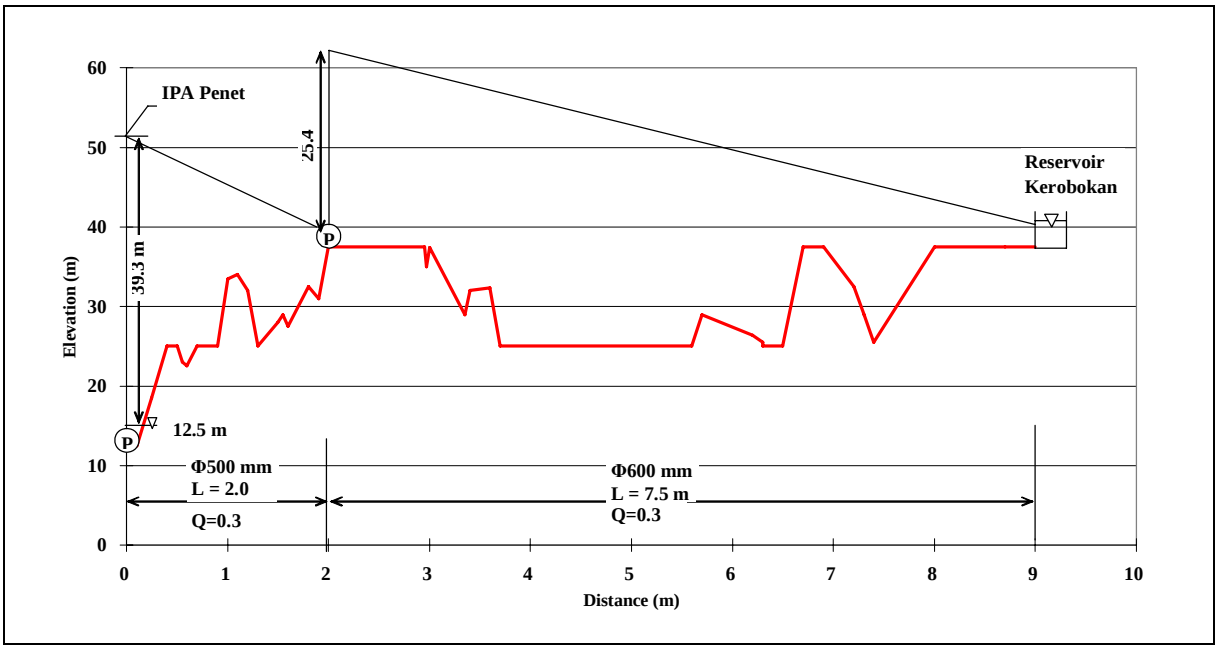

Figure-H.3 Longitudinal Section and hydraulic Gradient Line of Alternative W2

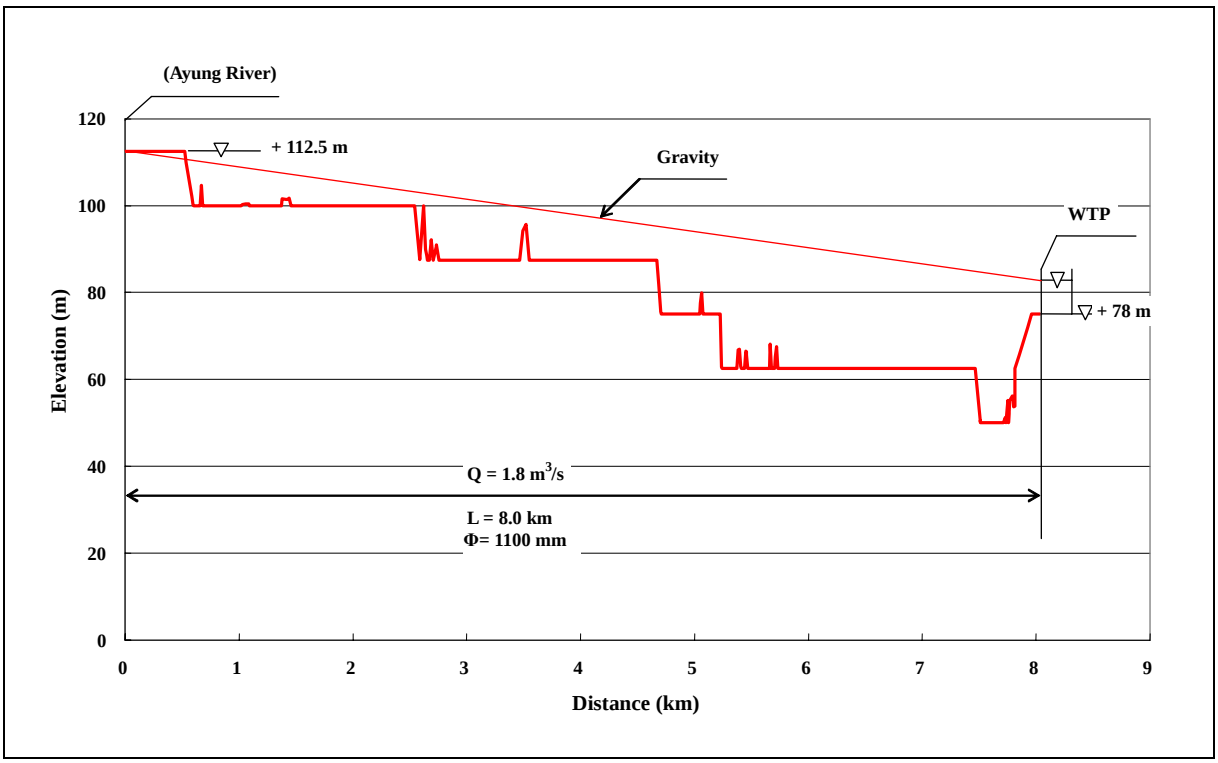

Figure-H.4 Longitudinal Section and hydraulic Gradient Line of Alternative C1

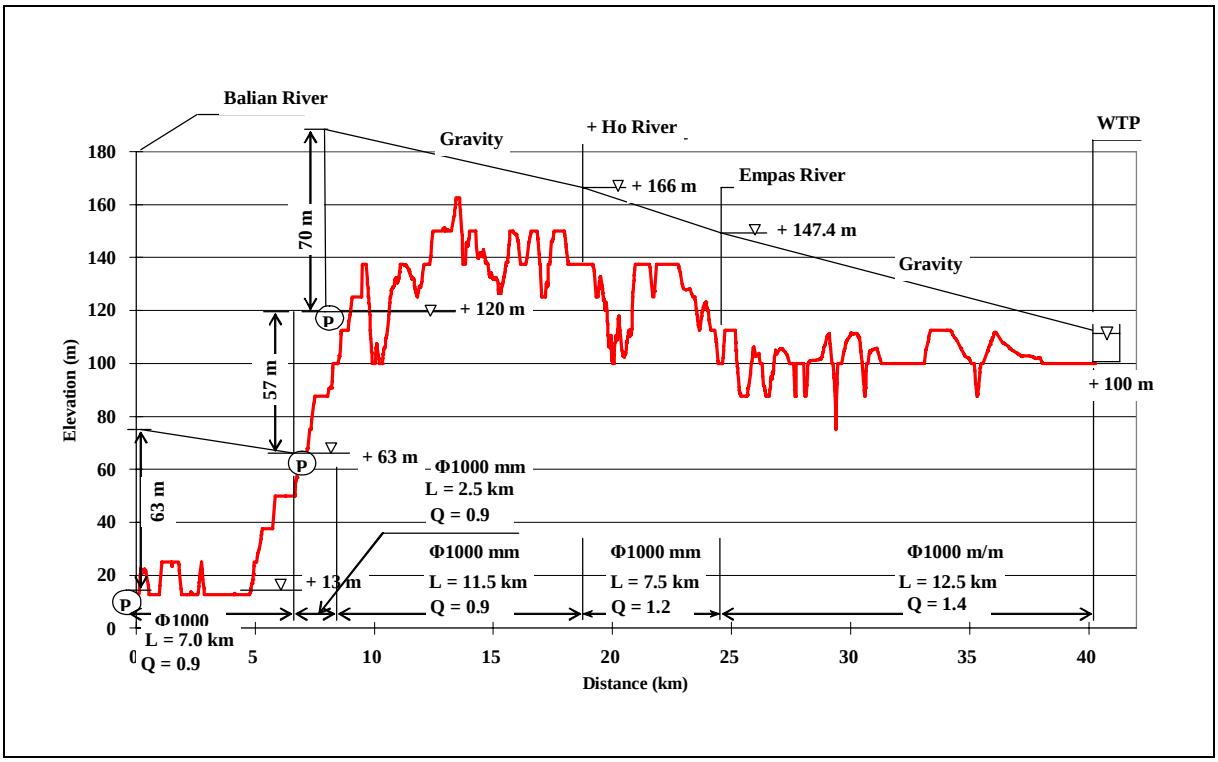

Figure-H.5 Longitudinal Section and hydraulic Gradient Line of Alternative C3

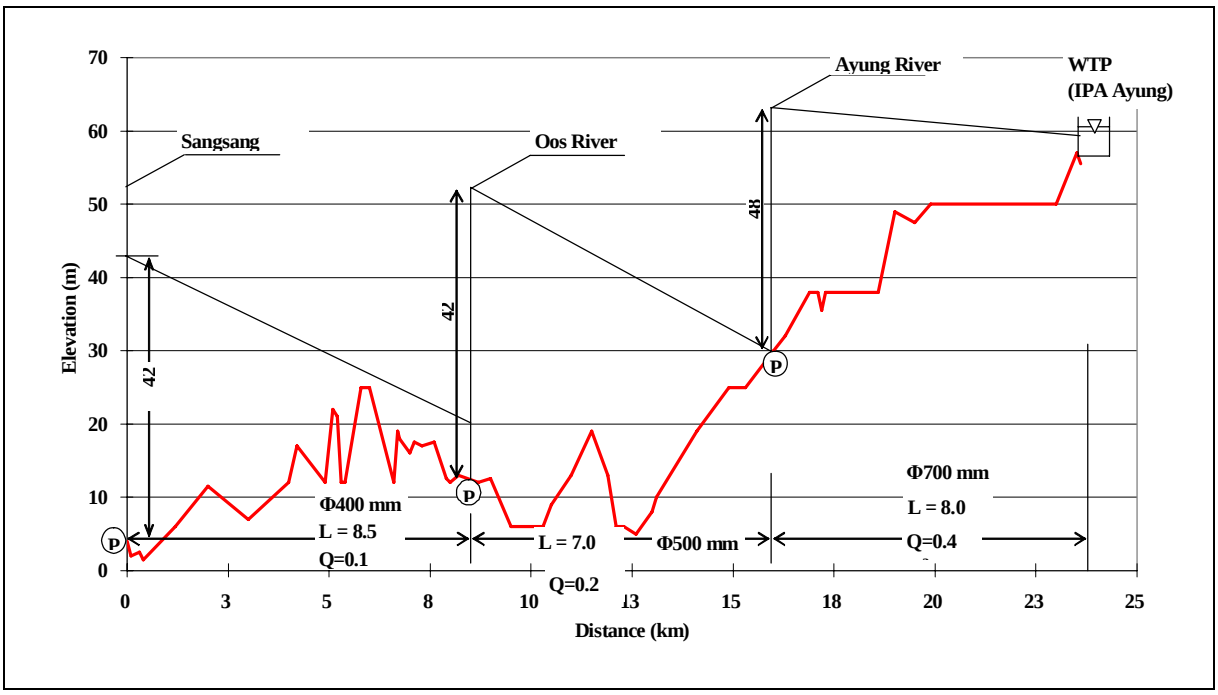

Figure-H.6 Longitudinal Section and hydraulic Gradient Line of Alternative C3&C5

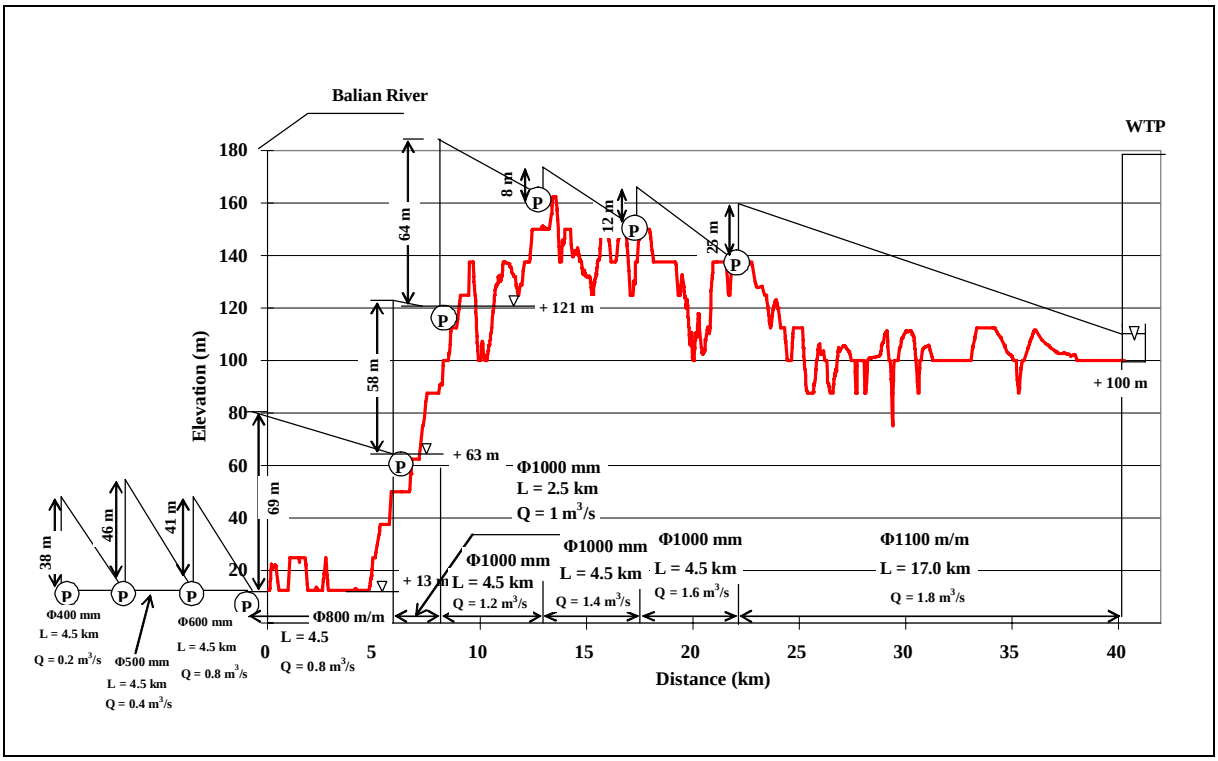

Figure-H.7 Longitudinal Section and hydraulic Gradient Line of Alternative C4

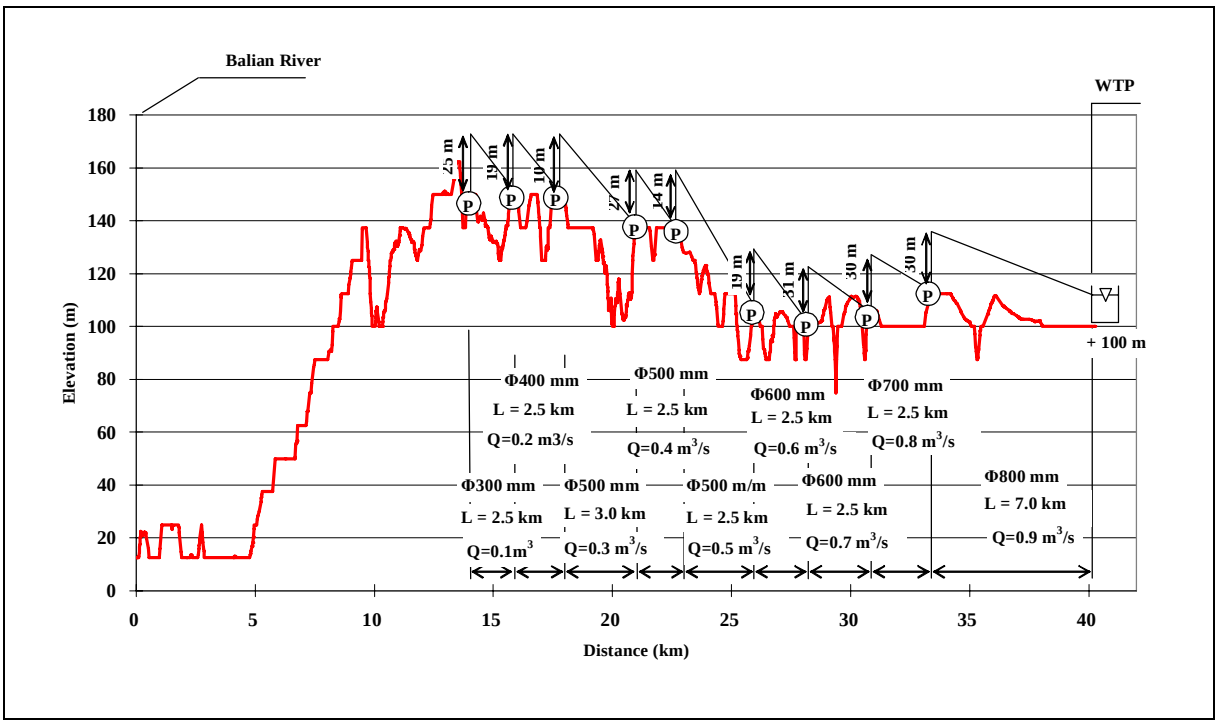

Figure-H.8 Longitudinal Section and hydraulic Gradient Line of Alternative C5

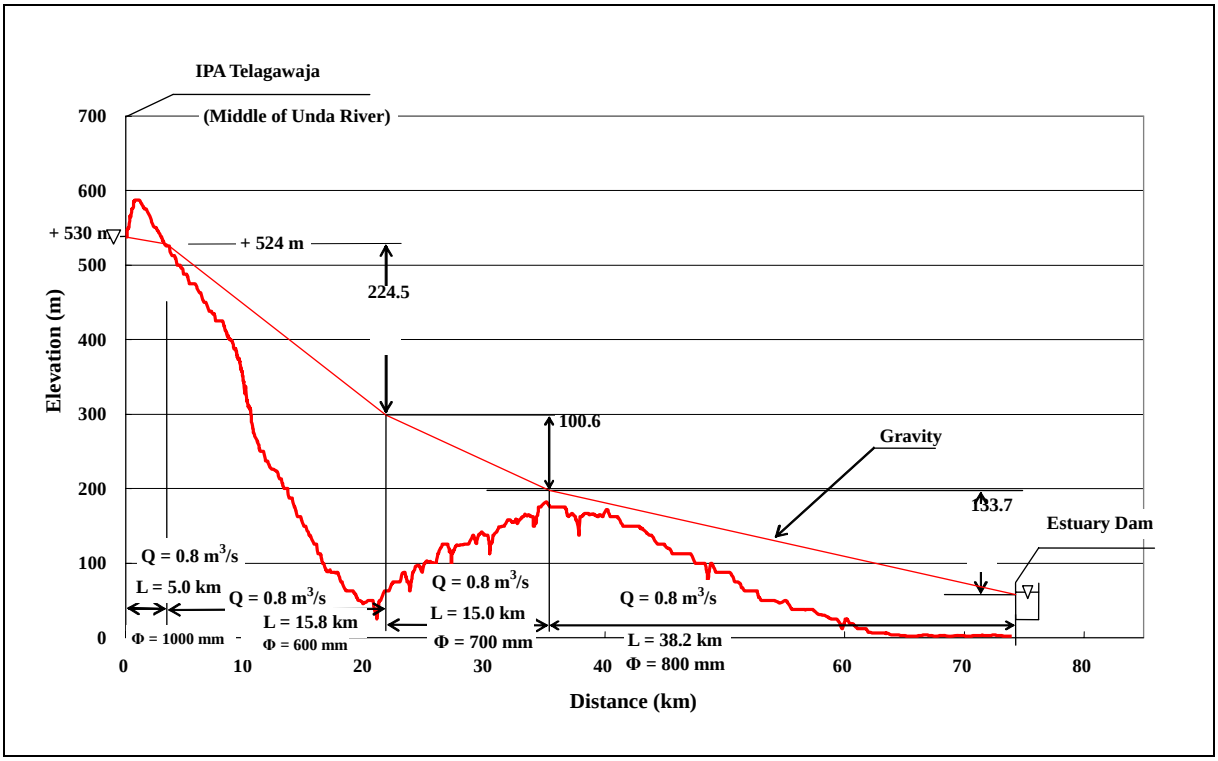

Figure-H.9 Longitudinal Section and hydraulic Gradient Line of Alternative E1

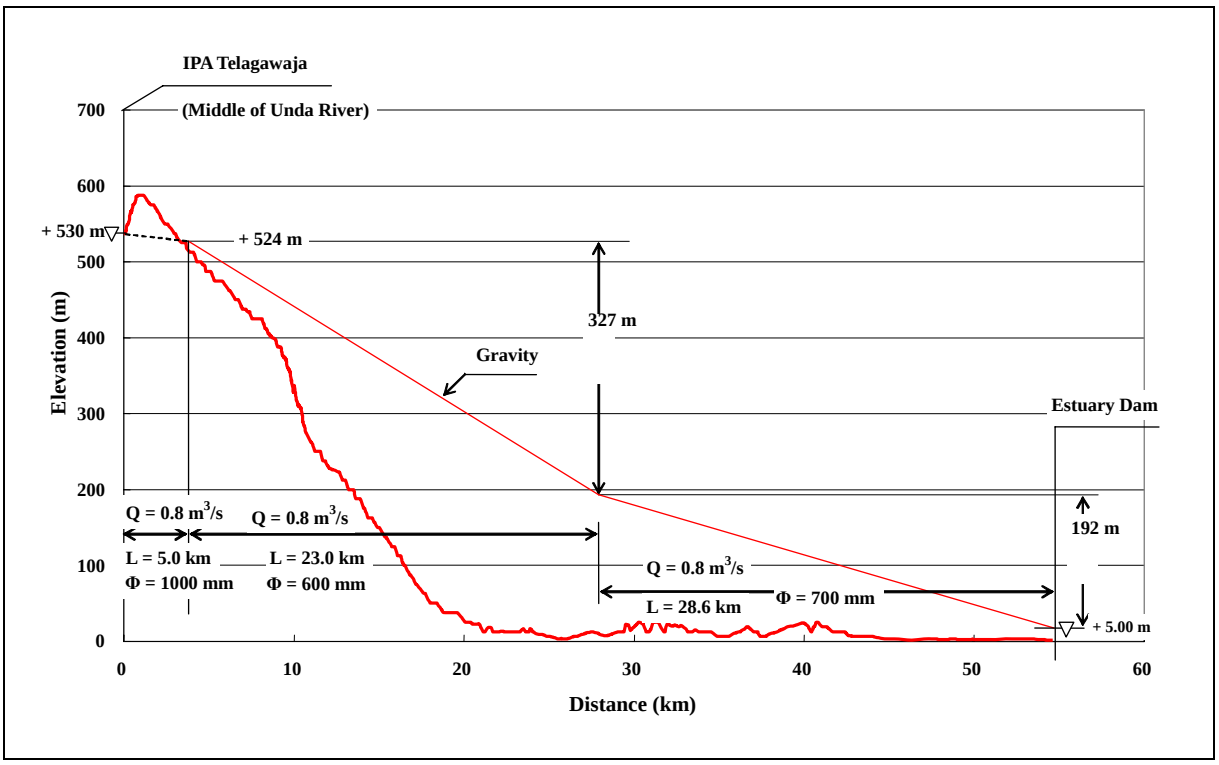

Figure-H.10 Longitudinal Section and hydraulic Gradient Line of Alternative E2

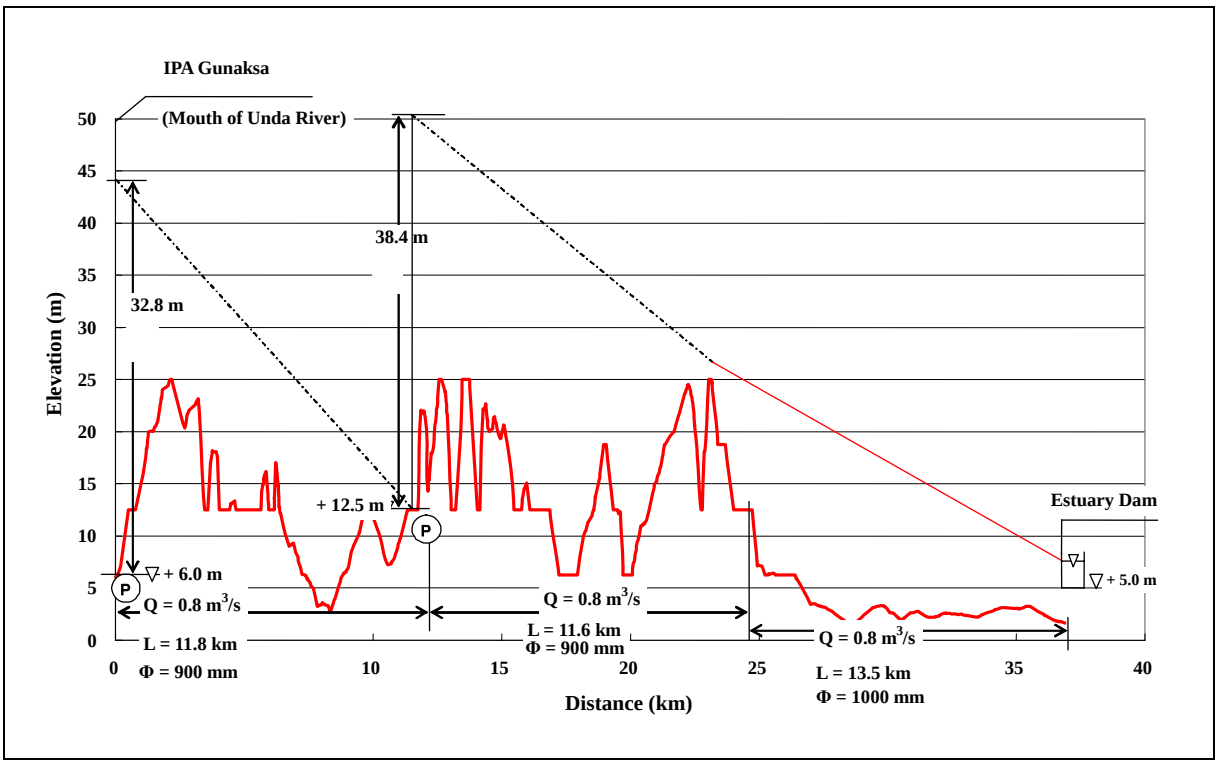

Figure-H.11 Longitudinal Section and hydraulic Gradient Line of Alternative E3

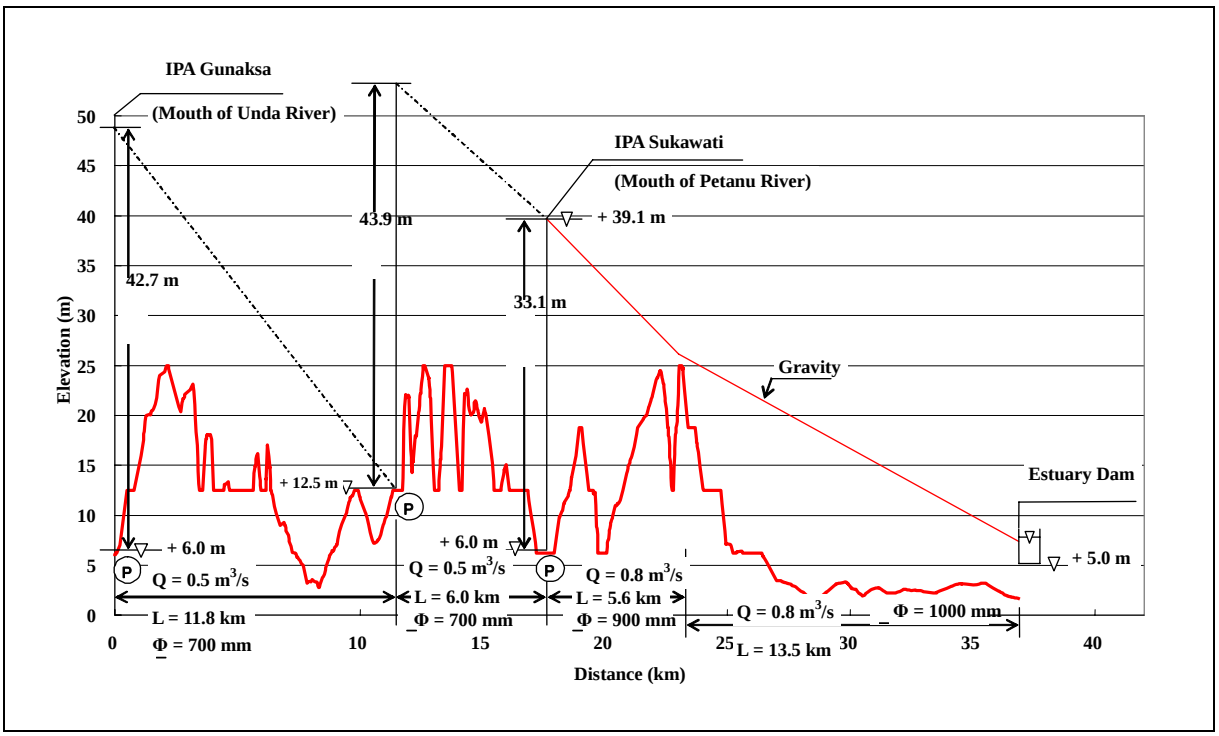

Figure-H.12 Longitudinal Section and hydraulic Gradient Line of Alternative E4

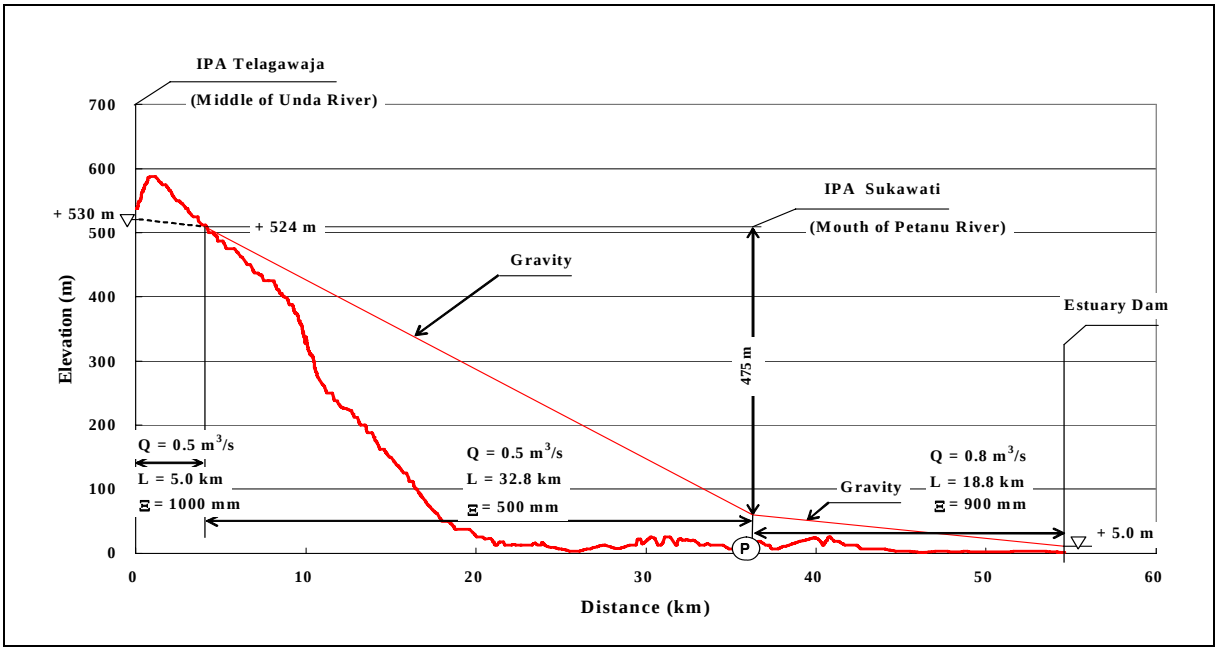

Figure-H.13 Longitudinal Section and hydraulic Gradient Line of Alternative E5

H-1.1.2 Comparison of Alternative Water Supply Plans for SARBAGI Areas

Construction costs of each alternatives are shown in the Table-H.3. Comparison results are shown in Table-H.4.

Table-H.3 Construction Cost of Alternatives

Alt.	Item	Unit	Quantities	Unit Cost (Yen)	Const. Cost (Million Yen)
W1	**Upstream Intake**				
	<Water Pipeline>				**266**
	Raw Water Transmission Pipe (D:500mm)	m	16,000	16,600	266
	<Buster Pump>				**120**
	6m3/min x 25m x 45kw x 4P x 4Units	LS	1	120,000,000	120
	<Water Treatment Plant (300lit/s)>	m3	25,920	13,000	**337**
	<Water Distribution>	/100lit/s	3	22,100,000	**66**
W2	**Downstream Intake**				
	<Water Pipeline>				**212**
	Raw Water Transmission Pipe (D:500mm)	m	2,000	16,600	33
	Raw Water Transmission Pipe (D:600mm)	m	7,500	20,500	154
	Pipe Bridge (D:500mm)	LS	2	4,300,000	9
	Pipe Bridge (D:600mm)	LS	3	5,400,000	16
	<Buster Pump>				**252**
	6m3/min x 40m x 55kw x 4P x 4Units	LS	1	132,000,000	132
	6m3/min x 25m x 45kw x 4P x 4Units	LS	1	120,000,000	120
	<Water Treatment Plant (300lit/s)>	m3	25,920	13,000	**337**
	<Water Distribution>	/100lit/s	3	22,100,000	**66**
C1	**Large Dam + Upstream Intake**				
	<Dam and Reservoir> W/Supply:1,800lit/s				**2,744**
	Dam Construction Cost: 553,748mil Rp -->				
	553,748/86.57=6,397mil yen				
	Water Supply Portion: 42.9 %				
	-->6,397*42.9%=2,744 mil yen				
	<Measures for Environment> : 5% of Dam Cost				**137**
	<Water Pipeline>				**567**
	Raw Water Transmission Pipe (D:1100mm)	m	9,000	63,000	567
	<Water Treatment Plant (1,800lit/s)>	m3	155,520	13,000	**2,022**
	<Water Distribution>	/100lit/s	18	22,100,000	**398**
C2	**Large Dam + Downstream Intake**				
	<Dam and Reservoir>				**2,744**
	<Measures for Environment> : 5% of Dam Cost				**137**
	<Water Treatment Plant (1,800lit/s)>	m3	155,520	13,000	**2,022**
	<Water Distribution>	/100lit/s	18	22,100,000	**398**
C3	**No Dam & Surface Water**				
	<Water Pipeline>				**3,590**
	Raw Water Transmission Pipe (D:400mm)	m	8,500	14,000	119
	Raw Water Transmission Pipe (D:500mm)	m	14,700	16,600	244
	Raw Water Transmission Pipe (D:600mm)	m	16,600	20,500	340
	Raw Water Transmission Pipe (D:700mm)	m	8,000	24,500	196
	Raw Water Transmission Pipe (D:800mm)	m	12,800	32,200	412
	Raw Water Transmission Pipe (D:1000mm)	m	41,000	50,200	2,058
	Pipe Bridge (D:500mm)	LS	6	4,300,000	26
	Pipe Bridge (D:1000mm)	LS	10	19,400,000	194
	<Buster Pump>				**2,006**
	9m3/min x 62m x 160kw x 4P x 3Units	LS	1	46,000,000	138
	9m3/min x 40m x 110kw x 4P x 3Units	LS	1	42,000,000	126
	9m3/min x 54m x 132kw x 4P x 3Units	LS	1	44,000,000	132
	6m3/min x 50m x 90kw x 4P x 3Units	LS	1	40,000,000	120
	6m3/min x 47m x 90kw x 4P x 3Units	LS	1	40,000,000	120
	6m3/min x 44m x 75kw x 4P x 3Units	LS	1	33,000,000	99
	3m3/min x 42m x 45kw x 4P x 3Units	LS	1	20,000,000	60
	6m3/min x 42m x 75kw x 4P x 3Units	LS	1	33,000,000	99
	8m3/min x 48m x 110kw x 4P x 4Units	LS	1	42,000,000	168

Alt.	Item	Unit	Quantities	Unit Cost (Yen)	Const. Cost (Million Yen)
	18m3/min x 63m x 375kw x 4P x 4Units	LS	1	50,000,000	200
	18m3/min x 57m x 375kw x 4P x 4Units	LS	1	50,000,000	200
	18m3/min x 70m x 375kw x 4P x 4Units	LS	1	50,000,000	200
	24m3/min x 22m x 150kw x 4P x 4Units	LS	1	30,000,000	120
	26m3/min x 51m x 450kw x 4P x 4Units	LS	1	56,000,000	224
	<Water Treatment Plant (1,800lit/s)>	m3	155,520	13,000	**2,022**
	<Water Distribution>	/100lit/s	18	22,100,000	**398**
C4	**No Dam & Groundwater**				
	<Deep Wells>	Unit	9	360,000,000	**3,240**
	Well + Pump (20 wells per unit) Type-I & Type-II	well	20	5,400,000	108
	Conection Pipe (D:200mm) per unit	m	20,000	10,000	200
	Conection Pipe (D:250mm) per unit	m	4,000	11,000	44
	Reservoir per unit	LS	1	8,000,000	8
	Total of One Unit				360
	<Water Pipeline>				**1,654**
	Raw Water Transmission Pipe (D:400mm)	m	4,500	14,000	63
	Raw Water Transmission Pipe (D:500mm)	m	4,500	16,600	75
	Raw Water Transmission Pipe (D:600mm)	m	4,500	20,500	93
	Raw Water Transmission Pipe (D:800mm)	m	4,500	32,200	145
	Raw Water Transmission Pipe (D:1000mm)	m	13,500	50,200	678
	Raw Water Transmission Pipe (D:1100mm)	m	8,000	63,000	504
	Pipe Bridge (D:500mm)	LS	3	4,300,000	13
	Pipe Bridge (D:800mm)	LS	4	11,200,000	45
	Pipe Bridge (D:1000mm)	LS	2	19,400,000	39
	<Buster Pump>				**1,147**
	6m3/min x 38m x 75kw x 4P x 3Units	LS	1	23,000,000	69
	12m3/min x 46m x 132kw x 4P x 3Units	LS	1	30,000,000	90
	12m3/min x 41m x 132kw x 4P x 4Units	LS	1	30,000,000	120
	16m3/min x 69m x 375kw x 4P x 4Units	LS	1	36,000,000	144
	20m3/min x 58m x 375kw x 4P x 4Units	LS	1	36,000,000	144
	18m3/min x 64m x 375kw x 4P x 5Units	LS	1	28,000,000	140
	21m3/min x 8m x 90kw x 4P x 5Units	LS	1	28,000,000	140
	24m3/min x 12m x 150kw x 4P x 5Units	LS	1	30,000,000	150
	27m3/min x 25m x 150kw x 4P x 5Units	LS	1	30,000,000	150
	<Water Treatment Plant (1,800lit/s)>				**162**
	Reservoir + Disinfection Facility	/100lit/s	18	9,000,000	162
	<Water Distribution>	/100lit/s	18	22,100,000	**398**
C5	**No Dam & Surface Water + Groundwater**				
	<Deep Wells>	Unit	9	198,000,000	**1,782**
	Well + Pump (10 wells per unit) Type-I	well	10	6,800,000	68
	Conection Pipe (D:200mm) per unit	m	10,000	10,000	100
	Conection Pipe (D:250mm) per unit	m	2,000	11,000	22
	Reservoir per unit	LS	1	8,000,000	8
	Total of One Unit				198
	<Water Pipeline>				**2,011**
	<for wells>				**618**
	Raw Water Transmission Pipe (D:300mm)	m	2,500	13,000	33
	Raw Water Transmission Pipe (D:400mm)	m	2,500	14,000	35
	Raw Water Transmission Pipe (D:500mm)	m	7,500	16,600	125
	Raw Water Transmission Pipe (D:600mm)	m	5,000	20,500	103
	Raw Water Transmission Pipe (D:700mm)	m	2,500	24,500	61
	Raw Water Transmission Pipe (D:800mm)	m	7,000	32,200	225
	Pipe Bridge (D:500mm)	LS	3	4,300,000	13
	Pipe Bridge (D:700mm)	LS	3	8,000,000	24
	<for surface water>				**1,393**
	Raw Water Transmission Pipe (D:400mm)	m	8,500	14,000	119

Alt.	Item	Unit	Quantities	Unit Cost (Yen)	Const. Cost (Million Yen)
	Raw Water Transmission Pipe (D:500mm)	m	14,700	16,600	244
	Raw Water Transmission Pipe (D:600mm)	m	16,600	20,500	340
	Raw Water Transmission Pipe (D:700mm)	m	8,000	24,500	196
	Raw Water Transmission Pipe (D:800mm)	m	12,800	32,200	412
	Pipe Bridge (D:600mm)	LS	9	5,400,000	48
	Pipe Bridge (D:800mm)	LS	3	11,200,000	34
	<Buster Pump>				**2,254**
	<for wells>				**758**
	3m3/minx25mx18.5kWx4Px3units	LS	1	9,000,000	27
	6m3/minx23mx18.5kWx4Px3units	LS	1	9,000,000	27
	6m3/minx17mx15kWx4Px4units	LS	1	7,000,000	28
	8m3/minx27mx55kWx4Px4units	LS	1	22,000,000	88
	10m3/minx39mx110kWx4Px4units	LS	1	28,000,000	112
	12m3/minx24mx75kWx4Px4units	LS	1	23,000,000	92
	14m3/minx31mx132kWx4Px4units	LS	1	30,000,000	120
	16m3/minx20mx150kWx4Px4units	LS	1	30,000,000	120
	18m3/minx34mx220kWx4Px4units	LS	1	36,000,000	144
	<for surface water>				**1,496**
	9m3/minx62mx160kWx4Px3units	LS	1	46,000,000	138
	9m3/minx40mx110kWx4Px3units	LS	1	42,000,000	126
	9m3/minx54mx132kWx4Px3units	LS	1	44,000,000	132
	9m3/minx43mx110kWx4Px3units	LS	1	42,000,000	126
	6m3/minx50mx90kWx4Px3units	LS	1	40,000,000	120
	6m3/minx47mx90kWx4Px3units	LS	1	40,000,000	120
	6m3/minx44mx75kWx4Px3units	LS	1	33,000,000	99
	10m3/minx47mx132kWx4Px4units	LS	1	44,000,000	176
	10m3/minx27mx75kWx4Px4units	LS	1	33,000,000	132
	3m3/minx42mx45kWx4Px3units	LS	1	20,000,000	60
	6m3/minx42mx75kWx4Px3units	LS	1	33,000,000	99
	8m3/minx48mx110kWx4Px4units	LS	1	42,000,000	168
	<Water Treatment Plant (1,800lit/s)>				**1,092**
	Reservoir + Disinfection Facility (900lit/s)	/100lit/s	9	9,000,000	81
	Water Treatment (900lit/s)	m3	77,760	13,000	1,011
	<Water Distribution>	/100lit/s	18	22,100,000	**398**
C6	**Medium Dam and Groundwater**				
	<Dam and Reservoir> W/Supply:900lit/s				**1,922**
	Dam Construction Cost: 4,480 mil yen				
	Water Supply Portion: 42.9 %				
	-->4,480*42.9%=1,922 mil yen				
	<Measures for Environment> 5% of Dam Cost				**96**
	<Water Treatment Plant>				**1,092**
	Water Treatment (900lit/s)	m3	77,760	13,000	1,011
	Reservoir + Disinfection Facility (900lit/s)	/100lit/s	9	9,000,000	81
	<Deep Wells>	Unit	9	198,000,000	**1,782**
	Well + Pump (10 wells per unit) Type-I	well	10	6,800,000	68
	Conection Pipe (D:200mm) per unit	m	10,000	10,000	100
	Conection Pipe (D:250mm) per unit	m	2,000	11,000	22
	Reservoir per unit	LS	1	8,000,000	8
	Total of One Unit				198
	<Water Pipeline for wells>				**618**
	Raw Water Transmission Pipe (D:300mm)	m	2,500	13,000	33
	Raw Water Transmission Pipe (D:400mm)	m	2,500	14,000	35
	Raw Water Transmission Pipe (D:500mm)	m	7,500	16,600	125
	Raw Water Transmission Pipe (D:600mm)	m	5,000	20,500	103
	Raw Water Transmission Pipe (D:700mm)	m	2,500	24,500	61
	Raw Water Transmission Pipe (D:800mm)	m	7,000	32,200	225

Alt.	Item	Unit	Quantities	Unit Cost (Yen)	Const. Cost (Million Yen)
	Pipe Bridge (D:500mm)	LS	3	4,300,000	13
	Pipe Bridge (D:700mm)	LS	3	8,000,000	24
	<Buster Pump for Wells>				**758**
	Pump St: 3m3/minx25mx18.5kWx4Px3units	LS	1	9,000,000	27
	Pump St: 6m3/minx23mx18.5kWx4Px3units	LS	1	9,000,000	27
	Pump St: 6m3/minx17mx15kWx4Px4units	LS	1	7,000,000	28
	Pump St: 8m3/minx27mx55kWx4Px4units	LS	1	22,000,000	88
	Pump St: 10m3/minx39mx110kWx4Px4units	LS	1	28,000,000	112
	Pump St: 12m3/minx24mx75kWx4Px4units	LS	1	23,000,000	92
	Pump St: 14m3/minx31mx132kWx4Px4units	LS	1	30,000,000	120
	Pump St: 16m3/minx20mx150kWx4Px4units	LS	1	30,000,000	120
	Pump St: 18m3/minx34mx220kWx4Px4units	LS	1	36,000,000	144
	<Water Distribution>	/100lit/s	18	22,100,000	**398**
E1	**Unda Upstream + Gravity + via Ubud**				
	<Water Pipeline>				**2,340**
	Raw Water Transmission Pipe (D:600mm)	m	15,800	20,500	324
	Raw Water Transmission Pipe (D:700mm)	m	15,000	24,500	368
	Raw Water Transmission Pipe (D:800mm)	m	38,200	32,200	1,230
	Raw Water Transmission Pipe (D:1000mm)	m	5,000	50,200	251
	Pipe Bridge (D:700mm)	LS	20	8,400,000	168
	<Water Treatment Plant (800lit/s)>	m3	69,120	13,000	**899**
	<Water Distribution>	/100lit/s	8	22,100,000	**177**
E2	**Unda Upstream + Gravity + via Sunrise Road**				
	<Water Pipeline>				**1,625**
	Raw Water Transmission Pipe (D:600mm)	m	23,000	20,500	472
	Raw Water Transmission Pipe (D:700mm)	m	28,600	24,500	701
	Raw Water Transmission Pipe (D:1000mm)	m	5,000	50,200	251
	Pipe Bridge (D:700mm)	LS	24	8,400,000	202
	<Water Treatment Plant (800lit/s)>	m3	69,120	13,000	**899**
	<Water Distribution>	/100lit/s	8	22,100,000	**177**
E3	**Unda Downstream + Pump + via Sunrise Road**				
	<Water Pipeline>				**1,563**
	Raw Water Transmission Pipe (D:900mm)	m	11,800	42,000	496
	Raw Water Transmission Pipe (D:900mm)	m	11,600	42,000	487
	Raw Water Transmission Pipe (D:1000mm)	m	13,500	50,200	678
	Pipe Bridge (D:900mm)	LS	21	16,200,000	340
	Pipe Bridge (D:1000mm)	LS	3	19,400,000	58
	<Buster Pump>				**480**
	16m3/minx33mx160kWx4Px4units	LS	1	240,000,000	240
	16m3/minx38mx160kWx4Px4units	LS	1	240,000,000	240
	<Water Treatment Plant (800lit/s)>	m3	69,120	13,000	**899**
	<Water Distribution>	/100lit/s	8	22,100,000	**177**
E4	**Putanu & Unda (D) + Pump + via Sunrise Road**				
	<Water Pipeline>				**1,623**
	Raw Water Transmission Pipe (D:700mm)	m	11,800	24,500	289
	Raw Water Transmission Pipe (D:700mm)	m	6,000	24,500	147
	Raw Water Transmission Pipe (D:900mm)	m	5,600	42,000	235
	Raw Water Transmission Pipe (D:1000mm)	m	13,500	50,200	678
	Pipe Bridge (D:700mm)	LS	16	8,400,000	134
	Pipe Bridge (D:900mm)	LS	5	16,200,000	81
	Pipe Bridge (D:1000mm)	LS	3	19,400,000	58
	<Buster Pump>				**468**
	10m3/minx43mx110kWx4Px4units	LS	1	200,000,000	200
	10m3/minx44mx110kWx4Px4units	LS	1	200,000,000	200
	6m3/minx33mx55kWx4Px4units	LS	1	68,000,000	68
	<Water Treatment Plant (800lit/s)>	m3	69,120	13,000	**899**
	<Water Distribution>	/100lit/s	8	22,100,000	**177**

Alt.	Item	Unit	Quantities	Unit Cost (Yen)	Const. Cost (Million Yen)
E5	**Putanu & Unda (U) + P&G + via Sunrise Road**				
	<Water Pipeline>				**1,783**
	Raw Water Transmission Pipe (D:500mm)	m	32,800	16,600	544
	Raw Water Transmission Pipe (D:900mm)	m	18,800	42,000	790
	Raw Water Transmission Pipe (D:1000mm)	m	5,000	50,200	251
	Pipe Bridge (D:500mm)	LS	16	4,300,000	69
	Pipe Bridge (D:900mm)	LS	8	16,200,000	130
	<Buster Pump>				**68**
	6m3/minx33mx55kWx4Px4units	LS	1	68,000,000	68
	<Water Treatment Plant (800lit/s)>	m3	69,120	13,000	**899**
	<Water Distribution>	/100lit/s	8	22,100,000	**177**

Table-H.4 Comparison of Alternatives

Items	Western S.		Central System						Eastern System				
	W1	W2	C1	C2	C3	C4	C5	C6	E1	E2	E3	E4	E5
1. Construction Cost (Mil. Yen)	789	867	5,868	5,301	8,016	6,601	7,537	6,666	3,416	2,700	3,119	3,166	2,927
1.1 Dam & Reservoir	-	-	2,744	2,744	-	-	-	1,922	-	-	-	-	-
1.2 Deep Wells	-	-	-	-	-	3,240	1,782	1,782	-	-	-	-	-
1.3 Measures for Environment	-	-	137	137	-	-	-	96	-	-	-	-	-
1.4 Water Pipeline	266	212	567	-	3,590	1,654	2,011	618	2,340	1,625	1,563	1,623	1,783
1.5 Buster Pump	120	252	-	-	2,006	1,147	2,254	758	-	-	480	468	68
1.6 Water Treatment	337	337	2,022	2,022	2,022	162	1,092	1,092	899	899	899	899	899
1.7 Water Distribution	66	66	398	398	398	398	398	398	177	177	177	177	177
2. Depreciation Cost (Mil. Yen/year)	22.1	27.7	111.1	99.1	240.4	174.6	232.1	152.4	77.8	62.6	85.5	86.2	69.4
2.1 Dam & Reservoir	-	-	34.3	34.3	-	-	-	24.0	-	-	-	-	-
2.2 Deep Wells	-	-	-	-	-	68.9	37.9	37.9	-	-	-	-	-
2.3 Measures for Environment	-	-	1.7	1.7	-	-	-	1.2	-	-	-	-	-
2.4 Water Pipeline	5.6	4.5	12.0	-	76.3	35.1	42.7	13.1	49.7	34.5	33.2	34.5	37.9
2.5 Buster Pump	6.0	12.7	-	-	101.0	57.7	113.5	38.2	-	-	24.2	23.6	3.4
2.6 Water Treatment	9.1	9.1	54.6	54.6	54.6	4.4	29.5	29.5	24.3	24.3	24.3	24.3	24.3
2.7 Water Distribution	1.4	1.4	8.5	8.5	8.5	8.5	8.5	8.5	3.8	3.8	3.8	3.8	3.8
3. O&M Cost (Mil. Yen/year)	35.9	46.6	173.8	172.1	633.6	614.4	566.5	289.9	77.1	75.0	137.0	128.6	86.1
3.1 Dam & Reservoir	-	-	13.7	13.7	-	-	-	9.6	-	-	-	-	-
3.2 Deep Wells	-	-	-	-	-	160.5	105.8	-	-	-	-	-	-
3.3 Measures for Environment	-	-	0.7	0.7	-	-	-	0.5	-	-	-	-	-
3.4 Water Pipeline	0.8	0.6	1.7	-	10.8	5.0	6.0	1.9	7.0	4.9	4.7	4.9	5.4
3.5 Buster Pump	8.9	19.8	-	-	465.1	381.9	342.3	165.5	-	-	62.2	53.6	10.6
3.6 Water Treatment	19.9	19.9	119.6	119.6	119.6	28.9	74.3	74.3	53.2	53.2	53.2	53.2	53.2
3.7 Water Distribution	6.3	6.3	38.1	38.1	38.1	38.1	38.1	38.1	16.9	16.9	16.9	16.9	16.9
4. Annual Cost (Mil. Yen/year)	58.0	74.3	284.9	271.2	874.0	789.0	798.6	442.3	154.9	137.6	222.5	214.8	155.5
5. Production (Mil. m3/ year)	9.5	9.5	56.8	56.8	56.8	56.8	56.8	56.8	25.2	25.2	25.2	25.2	25.2
6. Water Cost (yen/m3)	***6.1***	***7.9***	***5.0***	***4.8***	***15.4***	***13.9***	***14.1***	***7.8***	***6.1***	***5.5***	***8.8***	***8.5***	***6.2***
- For Construction	2.3	2.9	2.0	1.7	4.2	3.1	4.1	2.7	3.1	2.5	3.4	3.4	2.8
- For O&M	3.8	5.0	3.0	3.1	11.2	10.8	10.0	5.1	3.0	3.0	5.4	5.1	3.4

Items	Annual Depreciation Cost	Annual O&M Cost
Dam & Reservoir	Depreciation: 80yearas	Construction Cost x 0.5%
Deep Wells	85% x Depreciation : 40years	Construction Cost x 0.3%+Well Operation
Measures for Environment	Depreciation: 80yearas	Construction Cost x 0.5%
Water Pipeline	85% x Depreciation : 40years	Construction Cost x 0.3%
Buster Pump	65% x Depreciation : 15years 35% x Depreciation : 50years	Construction Cost x 0.3% + Pump Operation (75%x Pump Number, 85% x Hour*Day)
Water Treatment	15% x Depreciation : 15years 85% x Depreciation : 50years	Construction Cost x0.3 % + Operation (Surface Water: 2yen/m^3, Groundwater: 0.5yen/m^3)
Water Distribution	85% x Depreciation : 40years	Construction Cost x 0.3% + Operation (0.65yen/m^3)

DIRECTORATE GENERAL OF WATER RESOURCES,
MINISTRY OF PUBLIC WORKS
PUBLIC WORKS SERVICE, BALI PROVINCE

THE COMPREHENSIVE STUDY
ON
WATER RESOURCES DEVELOPMENT
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IN
THE REPUBLIC OF INDONESIA

FINAL REPORT
SUPPORTING REPORT

[I] INSTITUTION

AUGUST 2006

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.

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I-1 INSTITUTIONS

I-1.1 Subaks

The Balinese society and agriculture are characterized by *subaks*, socio-religious agriculture communities dealing with water management and crop production, which have been in existence for centuries. Physical conditions in Bali as well as the perspective of the Hindu religion are said to have contributed to the development of the intricate system of irrigation on steep mountain slopes and valleys. A number of studies have already been conducted on the *subak* system by Indonesian and international researchers and this section provides a gist of observations and analyses made in some major literatures as well as interviews conducted during the study period.

I-1.1.1 Tradition of Subak

According to the information in the *Subak* Museum[1] the origin of the irrigation system in Bali dates back to the ninth century. Historical records use such terminology as wet rice fields, dry fields, dikes, water diversion, tunnels, and a measurement of water distribution. The shallow valleys and the geological conditions characterized by soft, non-collapsable, and unsaturated rocks made it easier for early irrigators, who possessed only simple technology, to dig tunnels that were essential for channeling irrigation water. The rainfall patterns in Bali, determined by the mountains, are that the number of dry month with rainfall less than 100mm is more than six months in the northern area and the southern peninsula. The dry season necessitated irrigation and influenced the way people think about their work, cooperation, and structuring their society.[2]

Subaks organize and maintain intricate systems for taking and distributing irrigation water to final unit fields through site-specific adjustments. The intensive water management is supported by both techniques and spirituality, which is closely related to Hinduism. The Hindu value system and water administration in Bali is discussed in detail in an article by Wohlwend[3]. Hinduism centers around the doctrine of the supreme knowledge, of which all that is perceptible, materially or otherwise, constitutes a part. Individuality, therefore, represents nothing in absolute terms, but forms an essential constitutive element of the universe. A human being is regarded as an integral part of the community, communities as constitutive elements of humanity, and humanity together with minerals, plants, and animals make up the world, which is a microcosm of the universe. As a consequence, in the Hindu cosmology nothing is left apart nor remains individuality isolated from its environment, and the Hindu is aware of his/her effective participation in universal harmony.

This value system is reflected in the basic philosophy of *subak*, which is crystallized in the expression "*Tri Hita Karana*," meaning "three reasons to reach the prosperity." The three "reasons" refer to three types of relations: human beings and the god; human beings and their society; and human beings and the nature.

It must also be mentioned that water, in Hinduism, is regarded not only as a natural element but as the prototype of the universal substance and mother of existence because of its fluid and plastic nature. Water is symbolically equated with life, the sustainer of plant, animal and human life, and, spiritually, the support of divine influences. Rainwater collected in streams and discharging into the ocean is the manifestation of the divine influences. This symbolism leads to the image of *subak* as a human body, in which water of its irrigation networks is blood.[4]

I-1.1.2 Organization of Subak

The grouping of a *subak* is based on the same water source. All farmers possessing land within a reasonable distance from a stream worked together to construct a diversion weir and a network of canals

[1] Located in Tabanan, Tabanan Regency, Bali Province.
[2] KAYANE Isamu, SHIMMI Osamu, and Putu Djapa WINAYA, "Physical and Religious Background of Subak in Bali" in "Water Cycle and Water Use in Bali Island" (Institute of Geo-Science, University of Tsukuba, 1992).
[3] Bernard J. Wohlwend, "Hindu Water Law and Administration in Bali" (note dated).
[4] Bernard J. Wohlwend, ibid.

and feeders to bring the water to their fields. And all the participants in the process automatically became members of the *subak*. The area of a *subak* on average is 100ha, the largest being around 800ha and the smallest about 10ha. Large subaks are sub-divided into smaller units called *tempek*. According to the list prepared by each regency in 1993, there are a total of 1,600 *subaks* in Bali.[5]

Subaks exist in parallel with traditional villages called *banjar*[6] as well as administrative villages or *desa*[7]. Members of a *banjar* are often members of two ore more *subaks*, and the functions of *banjars* and *subaks* are completely separate. While *banjars* are communal organizations, *subaks* are dedicated to cooperative use of irrigation water.

The institution of *subak* is characterized by three elements: *awig-awig* or the customary law, the staff or the "management", and meetings for decision-making. *Awig-awig* is written as well as unwritten regulations governing the internal affairs of a given *subak* and sets out rules on water distribution, membership, staff, meetings, collection and use of funds, breaches and fines, and other matters. The management of a subak consists of a leader called *kelian subak* or *pekaseh, pangliman* or *kasinoman* (secretary), and *juru arah* or *saya* (expert). Other staff members of the management vary but often include *juru raksa* (treasurer) and *wakil* (assistant). In addition each *subak* usually has *pemangku* (priest), who is responsible for religious aspects of water allocation and distribution. The management is democratically elected by *subak* members. Generally the period of the assignment is five years and re-election is possible. The meeting is a supreme vehicle for operating the *subak* and is held monthly or seasonally. All main decisions must be approved by the meeting. The matters decided in the meeting include work activities, cropping patterns and schedules, religious ceremonies, and all aspects of *subak* activities and problems. An amendment to *awig-awig* requires a decision of the meeting as well. The resources of *subak* are monetary or in-kind contributions from members, which are used for operation and maintenance, construction, staff compensations, and loans to members, as well as collective work of members (*gotong-royong*).[8]

Physical changes in the irrigation systems brought by the Bali Irrigation Project that started in 1979 promoted development of federations of *subaks*. With the objective of increasing economies of scale, the project integrated many irrigation systems with their own intakes into single systems sharing a new common permanent weir, usually with a total command area of at least 150ha. As the new system created situations favourable to upstream *subaks*, there was a need to negotiate water allocation among the related *subaks* within the irrigation system. With the support of external facilitators led by Udayana University of Bali and later on with the own initiatives of *subaks*, federations called *subak-gede* were created. There are a total of 41 *subak-gedes* across Bali, many of them being located in Tabanan, Klungkung, Buleleng, and Gianyar. The table below shows distribution of *subaks* and *subak-gedes* in each regency/city.

[5] Bupati of each regency issued a decree in 1993 listing all the existing *subaks* and their areas. This was done in response to a request from ADB prior to the commencement of a *subak* strengthening project.

[6] *Banjar* is a traditional Balinese unit of social organization based on the territory and/or genealogy. It is a unit of communal activities and mutual aid. Each married man within a particular area is expected to become a member. Two or more *banjars* comprise a traditional village called *desa adat*, which is also independent of government administration.

[7] *Desa* was introduced across Indonesia by the Law No.5/1979 on Village Administration.

[8] Bali Provincial Public Service Department, "Subak in Bali", August 1997. N. Sutawan, M. Swara, W. Windia, W. Suteja, N. Arya and W. Tjatera, "Community Based Irrigation System in Bali, Indonesia" in W. Gooneratne and S. Hirashima, ed., "Irrigation and Water Management in Asia" (Sterling Publishers Private Ltd. year?)

Table-I.1 Distribution of *Subaks* and *Subak-gedes*

Regency/City	No. of *subak-gedes*	No. of *subaks* belonging to *subak-gedes*	Total No. of *subaks*
Tabanan	9	95	348
Bangli	2	30	51
Klungkung	10	39	46
Jembrana	5	56	95
Buleleng	7	64	296
Badung	2	21	113
Gianyar	6	79	465
Karangasem	0	0	140
Denpasar	0	0	46
Total	41	384	1,600

Sources: Study Team

In addition, a larger federation called *subak-agun* was organized in two places, in Tabanan and Buleleng.[9] The management structure of *subak-gede* and *subak-agun* is similar to the one for a *subak*: heads of member *subaks* elect the members of the management including a chair, a vice-chair, a secretary, and a treasurer.

I-1.1.3 Water Allocation and Distribution by Subak

In a *subak*, one share of water corresponds to one *subak* member and cannot be portioned by two or more members. Water use within a *subak* is by individuals members, not in a group. Used water is sent to rice lands belonging to other members or *subaks* in the downstream, then is returned to the river. The water shares of individual members of the *subak* are measured in "*tektek*," which is a volume of water flowing through an inlet of a specified depth and width on a wooden flow diversion structure. The size of rice land receiving one *tektek* varies among *subaks* and within *subak*, ranging from 0.20-0.80 hectare. For *subak* members, water is equitably allocated if one or more of the factors listed below has been considered and agreed upon by all *subak* members:

- initial investment of labour and other contributions such as money and materials provided by the farmer for construction of the irrigation system;
- soil conditions, with land of higher porosity usually entitled to receive an extra share of water;
- the distance of the plot from the intake, to compensate for the loss of water along the irrigation canals and ditches due to seepage, percolation, and evaporation;
- the position and role of the farmer in the *subak*, i.e. the *subak* head or officials may receive an extra share of water; and
- transaction of water rights that my increase or decrease a farmer's water share in a given period of time.

Subak members are expected to perform duties and responsibilities corresponding to the share of water they receive. However, the *subak* head and officials are exempt from the duties. Also, the additional water received as compensation for soil porosity, seepage, percolation, and evaporation is not taken account of in the water-duty equation.[10]

During the dry season, if available water is not sufficient for irrigating the entire area of the *subak*, two alternatives are usually implemented:

[9] The negation processes that led to the formation of *subak-gede* and *subak-agung* are elaborated in Nyoman Sutawan, "Negotiation of Water Allocation among Irrigators' Associations in Bali, Indonesia" in Bryan Randolph Bruns and Ruth S. Meinzen-Dick, ed., "Negotiating Water Rights" (IFPRI, 2000), and in more detail in "Negotiation of Water Allocation amongst Irrigators' Associations: A Note from Bali, Indonesia," a paper presented by the same author for the Water Rights Panel IASCP 96 on 5-8 June 1996 in Berkeley, California.

[10] Ibid.

- each *subak* member receives an amount of irrigation water reduced proportionally to the reduction in the available water, and as a result, each member reduces his own farming area accordingly; or
- the areas to be irrigated are decided based on crop rotations.

Also, the practice of staggering takes place in *subak* during the period of land preparation, when available water is not sufficient for carrying out the land preparation in all the rice fields. Rotational and staggering practices are implemented by using logs or wooden planks to close or reduce the openings at the water division and off-take structures.[11] When either of these arrangements is carried out, the group of farmers receiving the water first is called "*ngulu*" (head), the group after it is "*mawongin*" (neck), and the last group is "*ngesep*" (leg), which evokes the image of a *subak* as a human body.

I-1.1.4 Subak and the Government

The *subak* hydraulic system of conveying and distributing the irrigation water is based on the delicate equilibrium between physical and non-physical aspects and has been independent from government administration. This is in contrast to the situations in Java, where the irrigation system was brought under the central government's regulation in 1936 and the village (*desa*) administration became fully in charge of irrigation water management. Water distribution at desa was to follow the requirements of the cultivation plan formulated by the regency irrigation commission. Since 1950s, a realization of the needs to organize water users independently from desa administration led to the formation and strengthening of water users' associations (WUAs), and the process continues till today.

In Bali, the Provincial Regulation No.2/PD/DPRD/1972 on Irrigation was promulgated to reconcile the *subak* system with the central government legislation on irrigation. In this regulation, *subaks* were for the first time given official state recognition. A *subak* was defined as "a customary law society with socio-agrarian-religious nature which have developed into an organization of landowners for the purpose of managing water and related matters in connection with the irrigation of rice fields with the water originating from within a given water resources area." The regulation also refers to *awig-awig* and the organizational structure of *subak*. It specifies the responsibilities of the regional administration as preparing "annual plans for rehabilitation, construction and maintenance of irrigation structures and networks for obtaining financial assistance from the central budget, the provincial budget, the regency budget, and/or *gotong-royong* contributions of *subak* members (Art.18 and 19)." This regulation was followed by the formation of regency irrigation committee that started around 1973 with the aim of having better coordination among government agencies dealing with irrigation matters.[12] However, this committee has not been functioning as initially expected and now appears to have been forgotten by many including concerned government bodies.

There are basically three offices involved in the government's interface with *subaks*: public works (water resources), agriculture, and revenue. Public works is responsible for the irrigation systems that are under the government's responsibility.[13] Agriculture provides technical guidance and extension services to *subak* farmers. Revenue is responsible for collecting land taxes from the farmers. Until recently, there was a position of *sedahan agung* in each regency/city, who collected taxes from *subaks* and provided various support to *subak* activities. *Sedahang agungs* were traditionally "go-betweens"

[11] Bali Provincial Public Service Department, "Subak in Bali," ibid.

[12] The formation of regency irrigation committee was based on the Joint Instruction of Ministers of Home Affairs, Agriculture, Public Works, and Electric Power issued in 1973 and involves the offices of agriculture, police, and village community guidance. In Bali, a Decree of Governor No.180/1986 was issued on the formation and organization of an irrigation committee.

[13] The new Water Resources Law (No.7/2004) stipulates that primary and secondary irrigation systems are under the government's responsibility and tertiary systems under the responsibility of water users' associations. Due to unique topographic situations of Bali, it is often difficult to identify which systems fall under which. In addition, *subaks* are often requested by the government to provide *gotong royong* contributions for the maintenance of main systems, even though they fall under the responsibility of the government. Small Scale Irrigation Management Project (SSIMP), under its sub-project in Bali, is facilitating discussions and deliberations between government officials and subaks to determine the responsibilities in four regencies: Buleleng, Jembrana, Karangasem, and Klungkung.

between the king and farmers, collecting in-kind taxes from the farmers, organizing ceremonies for them and controlling irrigation water. They were appointed as official tax collectors during the Dutch administration period, and continued the responsibility of water allocation. In the 1972 Bali Provincial Regulation on Irrigation, which gave the first, post-independence official recognition to the roles of *sedahan agung*, their roles were mentioned as controlling of "the use, discharge and management of irrigation water and the maintenance of the irrigation networks" as well as settling "water disputes." Despite the regulation's focus on water, however, *sedahan agung* was placed in Dinas Revenue (DISPENDA) following the colonial tradition. But their roles over the years were marginalized and their positions have been abolished in most regencies (except Tabanan and Denpasar) in the wake of decentralization introduced in 2001. As a result, *subaks*, when faced with problems, are often uncertain as to which office in the government they should contact and rely on. In stakeholders' meetings, many *subaks* expressed their wishes to revive *sedahan agung*.

The government in recent years has been supporting *subaks* through provision of training on irrigation, agriculture production, and socio-economic-cultural aspects. Provincial Dinas PU, through the Bali Potential Irrigation Project, established *Subak* Training Center[14], where university professors, private sector specialists, and government officials are invited to organize training sessions. The relationship between *subaks* and the government is generally cordial and cooperative. As can be seen in the development of *subak-gedes* and *subak-agungs*, *subaks* today continue to demonstrate its excellent organizational capacity to cope with changing situations and make adjustments within the *subak* arrangement. However, increasing tensions between *subaks* and non-*subak* entities (such as PDAM) in recent years, indicate that the government may have to play more proactive roles in structuring water allocation and facilitating dispute resolution.

I-1.1.5 Issues Facing Subaks

As mentioned above, *subaks* have been quite capable of solving intra-*subak* or inter-*subak* conflicts by themselves by making adjustments to cropping patterns and schedules as necessary. In the event of conflicts between *subaks* across regencies, Dinas PU of the province and regencies/city often provide facilitation support for finding solutions.[15]

But in recent years, *subaks* have been experiencing increasing incidences of conflicts or tensions with other, non-*subak* institutions such as PDAM. Conflicts with non-*subak* institutions are more difficult to resolve, as the internal rule and value system of *subaks* are not shared by non-*subak* entities. In stakeholders meetings during the current phase of the study, water scarcity and tensions with PDAMs were often mentioned by *subak* participants. While identification of the nature and real causes of the tensions requires in-depth interviews and field surveys,[16] the study team has so far learned about the following concrete cases of conflicts:

(a) Conflict with PDAM

In the Buleleng river (in Buleleng Regency), the government employed a top-down approach 20 years ago to allow PDAM to take water for drinking water supply. No public consultation was held but *subaks* were told by the government that rehabilitation and upgrading of the canal channeling water from the nearby Nangka river would ensure necessary water flow. The construction involving tunneling was done as part of the Bali Irrigation Project in 1980s. At the same time, the concerned *subaks* formed *subak-gede* to ensure fair water allocation among them. But a combination of factor as follows led to reemergence of the conflict in 2004: (i) due to severe drought during the dry season, farmers located in the downstream could not plan crops optimally; (ii) the prices of agricultural products

[14] Located in the compound of Subak Museum in Tabanan.

[15] For example, in the Luwus Carangsari irrigation scheme, irrigation water is used by *subaks* located in Luwus Village (Tabanan Regency) and Carangasari Village (Badung Regency). About four years ago, the *subaks* in the two villages had a dispute over the operation of a division structure located in Luwus. The *subaks* in Luwus blocked an inlet going to the *subaks* in Carangsari, as they felt (i) the water had become their right because the weir is located in Luwus, and (ii) the water in Luwus was insufficient. With the facilitation by the government, the *subaks* agreed to use the water together on the basis of irrigation area size.

[16] There are reports that some politicians pull strings behind *subaks* with political intentions.

were not favorable; and (iii) the farmers thought PDAM took water much more than allowed in the plan. Also, it is believed that democratization in the country gave confidence to the farmers to make a complaint to the government entity (PDAM). *Bupati* of Buleleng has invited *subak* chairmen a number of times to seek solutions. The government has suggested to divide the water into one third for PDAM and two thirds for the *subaks*, but the *subaks* continue to ask for the removal of one of the two pipes installed in the water sources (as the removal will provide more assurance for future water availability for the *subaks*).

(b) Conflict with Another Community

Subaks getting water from the Grokgak dam in the western part of Buleleng Regency has been experiencing reduction in the irrigation water, since a community in the upland area started to take water from a spring in the upper area. According to the *subaks*, the community claims that they have obtained "license" from the forestry office (though the *subaks* have not seen the license). There is currently a plan to expand the dam and reservoir capacity for enlarging the irrigation area. However, as a result of the water taking by the community in the upstream area, the expansion will not bring any benefit to the downstream *subaks*. The government once tried to solve the problem by conducting a study in 2001, but the suggestion was only about improvement of the agriculture technologies in relation to water management.

(c) Conflict over Pollution

Pollution is another cause of conflicts, which are also between *subaks* and non-*subak* entities. In the upstream of the Ho river in Tabanan, pollutants are flowing from chicken farms. The dung of the chickens is thrown into the canal, causing the canal to be full of sedimentation. Other *subaks* in Tabanan, on the Yeh Empas Selatan river, are affected by pollutants coming from pig farms. In Denpasar City and Badung Regency, *subaks* are facing pollution coming from industries such as automobile workshops and garment factories as well as from garbage. There is virtually no law enforcement against polluting activities.

Another source of pollution is garbage. Throwing garbage in canals widely takes place in Bali, which is increasingly becoming problems for *subaks*. The impacts of the garbage throwing are: (i) blocking the canal, making the water spilling to the road; (ii) creating disturbances on the division structure and disturbing water allocation; and (iii) polluting the rice field and causing pests to develop. The local governments have been trying to address the issue by placing garbage tanks along the street near a canal or drainage and informing village heads. But the awareness of the people is still relatively low and the practice of garbage throwing continues. More fundamental issue is that the canals are used as drainages for houses as well. *Subaks* cannot manage the problem, as people who throw garbage are outside of the *subak* areas. As in the case of pollution, law enforcement against garbage throwing is weak or almost non-existent.

(d) Conflict due to Construction

Another type of conflict is disturbance of irrigation water flow due to construction. For example, *subaks* of Jero, Tegal, and Banyumala in Buleleng have experienced the flow disturbance in the canals, as the canals became narrower and dirty as a result of construction activities. Consequently, floods occur during the rainy season, and the rice fields are intruded with garbage as well, which hampers the growth of their rice. The problems remain after construction in some cases. Through coordination with the contractors, the *subaks* have had them repair the damaged canals and construct other drainages to keep the garbage away from the rice fields. The issue was not anticipated during the process of construction permit issuance by the government.

I-2 NATIONAL LEVEL DEVELOPMENTS OF GOVERNMENT INSTITUTIONS

I-2.1 Water Resources Law No.4/2004

The Law No.7/2004 on Water Resources was approved by DPR in February 2004 and signed by the President in March 2004. The Water Sector Adjustment Loan (WATSAL) by the World Bank provided backgrounds to the law. A statement of GOI issued prior to the commencement of WATSAL in 1999 referred to such concepts as the introduction of a comprehensive water use rights framework both for surface and groundwater and the reinforcement of the principle of beneficiary contribution toward the government costs of public water supply and irrigation services. During the course of some three years of debate on the draft law, the emphasis on the economic principle was moderated and the law that was finally adopted stresses, among others, (i) the protection of traditional communities and weaker economic groups and (ii) the water use rights without license for basic daily needs and small-scale irrigation systems. Also, the law takes account of the new administration structure under regional autonomy for setting out water resources management arrangements. These and other key aspects of the new Water Resources Law are summarized below.[17]

Principles

- Control of water resources shall be carried out by the government and/or the regional Government while always recognizing the rights possessed by local traditional communities and any other similar rights as long as they are not in conflict with national interests and regulations. (Article 6)

Water resources management structure

- Water resources management shall be based on river basin under the principle of integration between surface water and ground water. The modality of water resources management shall involve extensive roles of the community and business world. (Article 11)
- River basins and ground water basins in one regency/city, across regencies/cities, across provinces and nationally strategic river basins shall be determined by the president based on the recommendation of National Water Resources Council. (Article 13)
- Authorities of the regional government for water resources management shall be undertaken by the government of a higher level if (a) the regional government does not or is not able to carry out part of the authorities, or (b) there is an inter-provincial or inter-regency/city dispute. (Article 19. Note: the basic authorities and responsibilities of the central, provincial, and regency/city governments are listed respectively in Articles 14 – 16.)

Water resources utilization

- Water allocation at water sources shall be determined based on (a) the water source's supporting capacity, the number and distribution of population and projected growth, demand calculation and projection, and existing water usages. (Article 28)
- Water supply to serve the daily basic needs and irrigation for people's agriculture in the existing irrigation system shall be given the top priority. (Article 29)
- The development of drinking water supply systems shall be under the responsibility of the government and the regional governments and state and/or regional owned enterprises shall be in charge. Private sector enterprises and communities may take role in the development of drinking water supply. (Article 40)
- The development of primary and secondary irrigation systems shall be under the responsibility of the government and the regional government. The systems across regencies/cities are under the responsibility of the provincial government. Those within on regency/city under the authority of the regency/city. (Article 41)
- The development of tertiary irrigation systems shall be under the responsibility of water users associations. The development of primary and secondary irrigation systems may be done by water users associations or other parties according to the requirement and capacity. (Article 41)

[17] Based on draft English translation of the law.

Water use rights and permits

- Water use right may be obtained without license for basic daily needs of individuals and public agriculture located within an irrigation system. (Article 8) Water use rights shall not be leased out or handed over partly or wholly. (Article 7).
- A permit is required for methods of changing water resources' natural condition, for water required in a big quantity, and for agriculture outside the existing irrigation systems. The permits are issued by the government or the regional government. (Article 8)
- Water exploitation right[18] may be given to individuals or enterprises based on a permit by the government or the regional government. (Article 9)
- The government or the regional government shall determine the water allocation for water resources exploitation by enterprises or individuals, based on a water allocation plan, which in turn is derived from water resources management plan of the concerned river basin. (Article 46)

Flood control

- Control of water's destructing power shall comprise prevention, management, and improvement efforts, giving priority on prevention and in an integrated and comprehensive manner with the water resources management scheme. It shall be executed by involving the participation of the community. (Article 51)

Planning

- Water resources management plan shall be prepared based on procedures and requirements to be elaborated in a government regulation, and shall be inputs for spatial plan for the respective governments. (Articles 59-60)
- A draft water resources management plan shall be published to the community. The community shall have the right to raise objections to the draft during a certain period, based on which the authorized institution may review the water resources management plan. (Article 62)

Information system

- The government and the regional government shall develop a water resources information system on hydrological, hydro-meteorological and hydro-geological conditions as well as water resources policies, infrastructure, technology, environment, and any related activities of the community in the vicinity. The information system shall be a network managed by various institutions and shall be accessible by various parties. (Articles 65-69)

Financing

- The costs of water resources management shall be born by the government, the regional governments, state-owned/regional enterprises, cooperatives, and/or other businesses and individuals either separately or jointly. (Article 78)
- Financing for the construction and O&M of tertiary irrigation systems shall be the responsibilities of the farmers and may be assisted by the government or the regional government, except for the weir, 50m canal of the weir, tertiary boxes as well as tertiary supplemental structures, for which the government or the regional government is responsible. (Article 78)
- Users of water resources for basic daily needs and for people's agriculture shall not be charged water resources management fee. (Article 80)
- The amount of water resources management fee shall be determined based on rationally acceptable economic calculation. The fee for non-commercial usage shall be exempt from rational economic calculation. (Article 80)

The rights of the community

- The community shall have the rights to (a) get information on water resources management, (b) obtain reasonable compensation for inflicted loss as a result of water resources management activities, (c) receive benefits on water resources management, and (d) raise

[18] "Water exploitation right" refers to the right to use water for commercial purpose and is obtained through a permit. This is in contrast to "water use right," which is granted without a permit for basic daily needs and existing small scale agriculture.

objections to the proposed water resources management plan. (Article 82)
- The community holding the water use right shall have obligations to observe public needs in realization of their roles in water resources conservation and infrastructure protection. (Article 83)

Coordination
- Water resources management shall require coordination by integrating the interests of various sectors, regions, and stakeholders. (Article 85)
- The coordination at the national level shall be carried out by National Water Resources Council, and by Provincial Water Resources Council (or in any other name decided by the provincial government) at the provincial level. (Article 87)
- A coordination body may be established at the regency/city level and in a river basin. (Article 87)

The law says that government regulations will be prepared on 35 subjects to spell out details of its implementation. According to DGWR officials, a total of 12 new or revised government regulations are needed for this purpose and the preparation is currently underway. The first priority has been given to the revision of the Government Regulation No.77/2001 on Irrigation, which called for significant transfer of irrigation management authority from the regional government to water users association and the introduction of a permit system for irrigation water use. In the meantime, Government Regulation on Drinking Water Supply System Development (No.16/2005) was adopted in 2005, based on which a Ministry of Public Works Regulation (No.294/2005) was issued. Provincial governments and regency/city governments will have to introduce corresponding regulations or measures to implement the new Water Resources Law and government regulations.

I-2.2 Central Government and Other Provinces

(a) Central Government Institutions

Since the introduction of regional autonomy, the authority of the central government focuses on deciding on policies and stipulating regulations, guidelines and standards. The central government also has the authority for water resources management in river territories that span provinces or states and territories determined as nationally strategic river basins. In addition, the central government is the financier of most of development projects as well as some of routine functions in provinces and regencies/cities, though the latter will soon become sole responsibility of regional governments.

The following organs share responsibility for different aspects of water resources management in the central government:

- Ministry of Public Works (Directorate General of Water Resources and Directorate General of Human Settlement for water supply and sewerage)
- National Planning and Development Agency (BAPPENAS)
- State Ministry of Environment
- Ministry of Mines and Energy (on ground water)
- Ministry of Forestry and Plantations[19]
- Ministry of Agriculture[20]
- Ministry of Industry and Trade
- Ministry of Health (on drinking water)

In addition, Ministry of Home Affairs guides and regulates the structures and functions of regional governments, which have relevance to the institutional aspect of regional water resources management. The amount and procedure of the central budget allocation are under the authority of Ministry of Finance.

[19] Directorate General of Land Rehabilitation and Social Forestry Affairs of MoFP regulates the use of forested watershed through Balai PDAS (Regional Office of Watershed Management) in each province.
[20] MoA is closely concerned with water resources management in irrigation through its provision of agricultural extension services. It also has responsibility for watershed and soil management in unforested areas.

During WATSAL, a National Coordination Team (Tim Koordinasi) was established under a presidential decree (No.123/2001) as a non-structural, coordination body for determining national policies on water resources. As mentioned above, the new Water Resources Law requires the establishment of a National Water Resources Council (NWRC) to ensure coordination on policies and management of water resources across sectors, regions, and stakeholders including non-government sector representatives. The preparation to establish the Council is currently at the final stage.

(b) Corporatization

Two state-owned corporations called Perum Jasa Tirta (PJT) have been established in Indonesia to be responsible for water resources management in two river territories: the Brantas River (East Java) and the Citarum River (West Java). The corporatization of river management aims at (i) improving the quality and efficiency of river basin O&M and (ii) reliving financial burden on the central and regional governments by recovering O&M costs and eventually investment costs.

PJT I, serving the Brantas River Basin basin, is a wholly state-owned corporation, originally established in 1990, responsible for a full range of in-stream functions. It supplies water for consumption and energy. A Presidential Decree (No.129/2000) has extended the jurisdiction of PJT I to the Bengawan Solo Basin. The total staffing is about 460 for the Brantas and about 150 for the Bengawan Solo. Its revenue sources are sales of water to PDAMs, PLN (the state electricity company), and industries. Its income statements show a healthy financial position, but a closer look reveals serious under-funding of O&M costs, with the expenditure at about 30-40% of the normally accepted level. Also, a number of environmental problems including upstream deforestation, increasing illegal settlement, and river pollution have been reported.[21]

PJT II, serving the Citarum River Basin, is also a wholly state-owned corporation, originally called Perum Otorita Jatiluhur (POJ) and established in 1970, responsible for managing selected rivers, associated river infrastructures, and all irrigation facilities in the river basin extending to West Java and Jakarta Provinces. The total staffing is about 2,300 (of which 1,100 are civil servants). The revenue sources include the sales of electricity (65% of the revenue), sales of raw water to PDAMS (25%), and income from operating tourism facilities. As in the case of PJT I, healthy income statements on the surface conceal serious under-funding of O&M costs (the expenditure is also at 30-40% of the accepted level). Also, as its responsibilities are limited to in-stream functions, off-stream functions are being neglected, resulting in sedimentation (caused by erosion in the upper catchment areas) and pollution (due to lack of regulatory enforcement).[22]

The government is in the process of establishing three additional basin corporations: Jeneberang, Jratunsela, and Surayu-Bogowanto. After examination of financial feasibility, consultancy teams have proposed to incorporate Jeneberang in PJTI and Way Seputih-Way Sekampung in PJT II, and remove Bengawan Solo from PJT I and put it under a new PJT III together with two other river basins. If accepted, the future configuration of PJTs will be as follows:

- PJT I: Brantas and Jeneberang
- PJT II: Citarum and Way Seputih-Way Sekampung
- PJT III (new): Bengawan Solo, Jratunseluna, and Serayu Bogowonto

(c) Basin Water Resources Management Office (Balai PSDA)

In small river basins and where revenue generating potential is less, the government has been establishing Basin Water Resources Management Office called Balai PSDA (Pengelolaan Sumber Daya Air) as part of the structure of Provincial Dinas (service office in the provincial government). Regulation of the Minister of Home Affairs No.179/1996 provided guidelines for establishing Balai PSDA under the Dinas responsible for water resources. After regional autonomy, Balai has been converted into UPTD (Technical Implementation Unit), a new structure introduced under Dinas, and

[21] Nippon Koei Co., Ltd. and associates for DGWR, MoSRI, Volume 3: Supporting Report, Way Sekampun Irrigation Project Study on Optimal Development of Water Infrastructure for Regional Development in Way Sekampung and Way Seputih Basins (March 2003).
[22] Ibid.

since then Balai PSDA is sometimes referred to as "UPTD Balai PSDA". The 1996 Home Affairs regulation mentions the following as the organizational structure and tasks of Balai PSDA:

Table-I.2 Structure and Functions of Balai PSDA

Structure	Functions
• Head	Responsible for the operations of Balai and reports directly to the head of Dinas. (The head has the same civil service status as the head of Sub-Dinas)
• Administration	General affairs, finance and personnel affairs, and supply and equipment management.
• Section for Operation Matters i) Data operation and management ii) Maintenance and rehabilitation iii) Control and security	i) Monitoring and processing of water quality and quantity data, allocation and distribution of water in order to fulfill needs, and to provide technical recommendations for issuance of water and water resources permits. ii) Monitoring and inventorying on condition and function of water resources infrastructure as well as execution of maintenance, rehabilitation and construction works. iii) Execution of flood control and drought management, water and water resources pollution control, water resources exploitation control, and public information services and advice on water resources.
• Functional Position Groups	Execution of part of functions of Dinas as required. (A group comprises of several number of experts of respective fields.)

The basic division of responsibilities between Dinas (or Sub-Dinas) in charge of water resources and Balai PSDA is that the former takes care of policy, regulatory and administrative matters, while the latter focuses on technical implementation. In reality, however, the roles and responsibilities of the two bodies often seem to be ambiguous and overlap. For example, there are five Balai PSDAs under Dinas Water Resources of the West Java Province, and their roles are very wide and encompass management and regulatory functions.[23] In South Sulawesi, Balai PSDA for Jeneberang River Basin Unit, with a total staff of 23, was until recently mainly concerned with hydrological data collection and monitoring. It is now expanding into some water allocation and maintenance in primary and secondary canals.[24] It can be said that Balai PSDA is undergoing an evolutionary process, pursuing incremental approaches to transform the traditional structure of water resources management.

Strengthening of selected Balai PSDAs has been funded by the World Bank and the Netherlands Government. The World Bank plans to continue the support to some Balai PSDAs in five Java and seven off-Java provinces under the new Water Resources and Irrigation Sector Management Project (WISMP). The WSIMP aims to support a wide range of water resources planning and management capacities and includes the establishment of national capacity building network. The EU Good Governance for Water Resources Project is another one that focuses on strengthening Balai PSDAs in three river basins (in South Sumatra, Yogyakarta, and East Java).

(d) Regional Coordination Mechanism

In an effort to address basin-wide issues in a systematic, coordinated manner, the Regulation of Minister of Public Works No.67/1993 provided for establishment of Provincial Water Resources Management Council (Panitia Tata Pengaturan Air or PTPA). According to the Regulation, PTPA is a consultative forum of water resources management established in every province, and assists the Governor on matters including priority plans and regulations of water resources utilization, regulations on disposal of waste water and other wastes, and regulation on irrigation and other facilities. Accordingly PTPA has been established in each province including Bali, and, in addition, Basin Water Resources Management Council (PPTPA) has been established in some major basins. It should be mentioned that the functions of Balai PSDA are institutional necessity for effective operation of PTPA and/or PPTPA, as their tasks must be supported by relevant data and analyses.

As mentioned earlier, the new Water Resources Law calls for the creation of coordination bodies at national, provincial, river basin, and regency/city levels. At provincial and basin levels, the

[23] Sanyu Consultants Inc. for the World Bank, Volume II (Annex), Draft Final Report, Indonesia: Water Use Rights Study (August 2004).

[24] Nippon Koei Co., Ltd. for DGWR, MoPW, Volume III-2, Supporting Report on Institutional Plan, The Study on Capacity Development for Jeneberang River Basin Management (January 2005).

PTPA/PPTPA, which is basically a governmental body, needs restructuring so as to include non-governmental stakeholders in the arrangement. Some provinces have gone ahead with the establishment of new councils in accordance with the Water Resources Law, without waiting for the government regulation. For example, Yogyakarta Province and Central Java Province have set up an inter-provincial water resources coordination council to discuss and coordinate on matters concerning inter-provincial river basins.[25]

I-3 EXISTING GOVERNMENT INSTITUTIONS IN BALI

I-3.1 Overview of Water Resources related Bodies in the Province

The following bodies are involved in water resources management at the provincial level in Bali:

[Central Government Bodies Represented in the Province]
- Balai Meteorological and Geophysics (BMG) of Ministry of Transportation
- Balai PDAS Unda Anyar under Directroate General of Land Rehabilitation and Social Forestry, Ministry of Forestry and Plantations

[Technical Boards of the Provincial Government]
- BAPPEDA (regional and spatial planning)
- BAPEDALDA (environmental monitoring and control)

[Service Offices (Dinas) of the Provincial Government]
- Dinas Public Works (Dinas PU)
  - Sub-Dinas Water Resources and Rural Infrastructure (Sub-Dinas SDAPP)
  - Sub-Dinas Spatial Planning and Settlement (Sub-Dinas TRP, development of water supply and drainage systems, construction permit and land use monitoring)
  - Sub-Dinas Mining (its ground water section is responsible for ground water technical assessment)
- Dinas Forestry
  - Sub-Dinas Forestry Development
  - Sub-Dinas Rehabilitation and Soil Conservation – Watershed Conservation Section
- Dinas Revenue (DISPENDA, collection of taxes on commercial use of raw water)
- Dinas Agriculture
  - Sub-Dinas Agriculture Infrastructure – Land and Irrigation Water Usage Section
- Dinas Plantation
- Dinas Public Health
  - Environmental Sanitation and Public Health – Water Quality Monitoring Section
- Dinas Fishery Service
- Dinas Industry
- Dinas Meteorology and Geophysics

I-3.2 Structure and Functions of Provincial Dinas PU and Sub-Dinas Water Resources

Dinas PU and particularly its Sub-Dinas on Water Resources and Rural Infrastructure (Sub-Dinas SDAPP) have the primary responsibility for water resources. The composition of this Sub-Dinas and other related Sub-Dinases as well as their main functions (according to the Decree of the Governor No.42/2001 on Job Descriptions of Dinas PU) are as follows:

[25] With regard to the membership of this council, concerned regencies/cities were asked to convene stakeholders' meetings to mutually select their non-government representatives to the council. Under the council, four committees have been established on different themes: irrigation, river, conservation and quality.

Table-I.3 Sub-Dinases and Sections of Dinas PU involved in Water Resources

Sub-Dinas	Section	Main Functions
Program and Control	Planning, Program and Standardization	Research and information gathering. Arrangements for programs and budget.
	Survey and Investigation	Research, survey and feasibility study. Environmental monitoring.
	Monitoring and Evaluation	Monitoring and control of programs. Guidance for any corrective actions. Documentation of PU activities.
	Legalization	Preparation of licenses for water uses, construction, etc. Monitoring of the implementation of the licenses and arranging for steps against any violations.
Water Resources& Rural Infrastructure (SDAPP)	Technical Planning	Survey, investigation, measurement, and mapping for technical plans for irrigation networks, water sources, and water infrastructure. Monitoring and control of construction and O&M activities.
	Irrigation, Raw Water and Rural Infrastructure	Implementation, monitoring and control of construction and rehabilitation of irrigation networks and other rural infrastructure.
	River, Coastal and Lake Management	Implementation of river, lake and beach management including construction and rehabilitation. Controlling and preventing floods and other national disasters.
	Utilization Guidance	O&M of water resources and rural infrastructures. Updating of inventory of the facilities.
Technical Guidance	Technical Assistance for Regency/City	Technical support to corresponding Dinas in Regencies/City.
	Digital Data Information	Collection of data/information on PU activities. Preparation of PU information system that can also be accessed by other concerned institutions.
Mining	Ground Water	Arranging data on ground water use and potential. Preparation of standards, guidelines and manuals for taking ground water. Monitoring and control of drilling activities and ground water taking.
Investigation and Equipment Unit (UPTD)[26]	Water Quality Examination	Water quality examination in response to requests and in exchange for service fees.

In addition to these units under "Dinas PU proper," central government funded projects are being implemented by the staff of Dinas PU. There are presently following five projects under the supervision of Sub-Dinas Water Resources:

- Bali Potential Irrigation Project
- Flood Control and Coastal Protection Project
- South Bali Beach Conservation Project
- Water Resources Development and Management Project
- Bali Raw Water Management Project

Table-I-4 shows that the budget of Sub-Dinas SDAPP (funded by the provincial government) is about 5% of the combined budget of these projects (funded by the central government). Nearly 75% of the civil servants of Sub-Dinas Water Resources, while belonging to the Sub-Dinas, are engaged in these projects. The projects are mainly for development (construction), but in some cases take care of routine activities such as water quantity and quality monitoring. As a result of a recently enacted law, [27] a project is now termed as a "working unit" and it is expected that Dinas operations and project activities will be more integrated in the near future.

[26] UPTD (Technical Implementation Unit) is a unit within Dinas that was introduced in Bali through the Bali Provincial Regulation No.4/2002 on Establishment of UPTD based on a corresponding national level regulation.
[27] Law No.33.2004 on Fiscal Balance between the Center and the Regional Administrations.

Table-I.4 Budget and Expenditure of Dinas PU and Projects

(unit: Rp.million)

	2003		2004	
	Budget	Expenditure	Budget	Expenditure
Provincial Government Budget (APBD)				
Salaries and Allowances			18,198	16,656
Office Maintenance	28,325	25,631	777	627
Administration			363	350
Sub-Dinas Program and Control	302	278	279	273
Sub-Dinas Spatial Planning & Settlement	7,021	5,322	2,883	2,815
Sub-Dinas Water Resources & Rural Infrastructure	**4,846**	**3,469**	**5,801**	**4,160**
Technical planning	n.a.	n.a.	216	213
Rehabilitation of irrigation networks	n.a.	n.a.	1,399	659
O&M of lakes, basins, and water sources	n.a.	n.a.	1,139	781
O&M for coastal safety	n.a.	n.a.	1,382	1,206
O&M of irrigation and disaster control facilities	n.a.	n.a.	685	355
O&M of cross-Kabupaten facilities	n.a.	n.a.	980	946
Sub-Dinas Roads and Urban Infrastructure	42,415	38,063	42,702	41,554
Sub-Dinas Technical Guidance	700	593	328	293
Sub-Dinas Mining	1,503	1,342	1,314	1,079
Conservation of ground and surface water	n.a.	n.a.	301	126
Dinas PU Total	**85,112**	**74,699**	**72,283**	**67,807**
Central Government Budget (APBN)				
Projects on water resources and rural infrastructure	**286,466**	**70,756**	**118,687**	**82,342**
Bali Potential Irrigation Project	25,662	24,843	43,495	41,278
Flood Control and Coastal Protecion Project	9,431	9,408	8,144	6,113
South Bali Beach Conservation Project	238,023	23,623	46,282	14,599
Water Resources Development and Management Project	6,225	6,218	3,768	3,753
Bali Raw Water Management Project	7,196	6,664	16,997	16,599
Projects on roads and urban infrastructure	64,057	57,582	63,640	63,640
Projects on spacial planning and settlement	87,326	34,032	144,125	81,467
Projects on mining	1,494	1,429	1,498	1,382
Dinas PU Total	**439,316**	**163,799**	**327,949**	**233,162**

The Ratio of APBD to APBN	2003		2004	
	Budget	Expenditure	Budget	Expenditure
for Sub-Dinas Water Resources and Rural Infrastructure	1.7%	4.9%	4.9%	5.1%
for Dinas PU	19.4%	45.6%	22.0%	29.1%

Source: Provincial Dinas PU, Bali

Table-I.5 shows the staffing structure in Dinas PU with particular focus on Sub-Dinas SDAPP.

Table-I.5 Staffing Structure of Dinas PU

Sub-Dinas	Section	Civil Servants by Category				Total
		IV	III	II	I	
Administration		1				1
	General Affairs	1	10	11	5	27
	Civil Service		9	5		14
	Finance		14	5		19
	Law & Public Information		6	2		8
Sub-Total		2	39	23	5	69
Investigation & Equipment Unit (UPTD)		1	5	1	3	10
	Construction Material & Soil		3	4		7
	Water Quality Examination		5	2		7
	Equipment		6	2		8
Sub-Total		**1**	**19**	**9**	**3**	**32**
Program and Control		1	1	1		3
	Planning, Program & Standardization		6	1		7
	Survey and Investigation		2			2
	Monitoring and Evaluation		5	1		6
	Licensing	1	7		1	9
Sub-Total		2	21	3	1	27
Spatial Planning and Settlement		1				1
	(Total four sections)	4	111	50	12	177
Sub-Total		5	111	50	12	178
Water Resources and Rural Infrastructure (SDAPP)		1				1
	Technical Planning		44	25		69
	Irrigation, Raw Water and Rural Infrastructure		29	32	4	65
	River, Coastal and Lake Management	3	34	26	5	68
	Utilization Guidance	1	22	37	8	68
Sub-Total		**5**	**129**	**120**	**17**	**271**
Road and Rural Infrastructure		1				1
	(Total four sections)	1	107	37	6	151
Sub-Total		2	107	37	6	152
Technical Guidance		1				1
	Technical Assistnace for Regencies/City	3	10	2		15
	Digital Data Information	2	3			5
	Construction Guidance		3	1		4
	Human Resources Development	1	2	4		7
Sub-Total		7	18	7	0	32
Mining		1				1
	Ground Water		9	2		11
	(Other three sections)		21	6		27
Sub-Total		1	30	8	0	39
Total		**25**	**474**	**257**	**44**	**800**

Source: Surat Keputusan Kepala Dinas Pekerjaan Umum Propinsi Bali, Nomor: 80/DPU-TU/2003

Projects funded by APBN (under Sub-Dinas SDAPP)		
	Civil servants	Contract
- Bali Irrigation	94	57
- Flood Control	27	23
- Bali WR Development	20	23
- Water Supply	22	13
Beach Conservation	35	11
Total	**198**	**127**

Category	Final education	Starting salary/mo	Highest salary/mo
III & IV	University	Rp. 905,400	Rp. 1,800,000
II	Senior high school	Rp. 725,600	Rp. 1,185,800
I	Elementary school	Rp. 575,000	Rp. 879,000

Notes: The civil service system including the salary scales and promotion policies are regulated by national level regulations, while the salaries are financed by the budget of the provincial government. Civil servants receive allowances including dependency allowances and "prosperity allowances," which are also financed by the provincial budget but controlled by provincial regulations.

Source: Dinas PU salary scale as of 25 February 2003 and additional information provided by Sub-Dinas SDAPP

I-3.3 Water Resources Bodies in the Regency/City Governments

The body primary responsible for water resources management at the regency/city level is Sub-Dinas Water Resources of the Dinas responsible for public works. Since regional autonomy, each regency/city government has named the concerned Dinas differently and the structure within the Dinas also varies. For example, in Badung the Dinas is "Dinas Roads, Bridges and Water Resources" and Sub-Dinas Water Resources under it has three sections: planning, development, and O&M. In Jembrana, under "Dinas Public Works and Environment," Sub-Dinas Water Resources has two sections: planning & development, and O&M.

The size of the Regency/City Sub-Dinases varies and the number of civil servants ranges from 7 (in Klungkung) to 48 (in Tabanan), supported by 10 to 40 contractual staff. Though all the staffing information was not available, the total number of Regency/City Sub-Dinas, by a rough estimate, would be around 240, supported by around the same number of contractual staff. In comparison, the Provincial Sub-Dinas SDAPP has 271 civil servants and 127 contractual staff.[28] This means that the combined forces of Regency/City Sub-Dinas in terms of civil service is about the same as the Provincial Sub-Dinas, and when contractual staff is added, the former is only about 20% larger than the latter. The budget of the Regency/City Sub-Dinases varies, and there is no discernable pattern in the proportions of APBN and ABPD. Most of the budget is for O&M or rehabilitation of irrigation networks. While some regencies recognize that certain rivers (within their jurisdictions) are under their responsibility, very little river management works are being undertaken in practice.

Table-I.6 is the staffing and budget information collected by the Study Team. It must be mentioned that such basic information is available only at each concerned regency/city, and nowhere at the provincial level. Moreover, information and data in the Dinas in the regencies/city can be obtained only after repeated visits and persistent requests, and despite best efforts, with some gaps and inconsistencies. This is a serious indication of disintegration effects of autonomy. While autonomy of regency/city governments should be respected, information system is needed on both administrative and technical matters in order for the provincial government to perform the roles of coordination and support effectively.

Table-I.6 (1/2) Staffing and Budget of Regency/City Sub-Dinas Water Resources

(Unit: Rp million.)

Regency/City, Dinas, Sub-Dinas, Section	Staff		Budget – FY2003			Budget – FY2004		
	Civil Service	Contract	APBN	APBD I	APBD II	APBN	APBD I	APBD II
Klungkung								
Sub-Dinas Pengairan	7	23	-	-	3,113	-	-	2,954
Irrigation Technical Planning			-	-	124	-	-	192
Irrigation Development			-	-	2,247	-	-	2,307
O&M			-	-	742	-	-	455
Tabanan	48	42						
Sub-Dinas Pengairan			3,500	-	443	210	-	704
Planning								
Rehabilitation								
O&M								
Bangli								
Sub-Dinas Pengairan	17	24	-	-	1,739	-	-	2,368
Development & Irrigation Maintenance			-	-		-	-	
Water use and irrigation			-	-		-	-	

Source: Interviews by Study Team with Regency/City Dinases and Sub-Dinases

[28] As of 2003.

Table-I.6 (2/2) Staffing and Budget of Regency/City Sub-Dinas Water Resources

(Unit: Rp million.)

Regency/City, Dinas, Sub-Dinas, Section	Staff		Budget – FY2003			Budget – FY2004		
	Civil Service	Contract	APBN	APBD I	APBD II	APBN	APBD I	APBD II
Gianyar								
Sub-Dinas Pengairan	28	37	1,500	-	220	1,050	-	798
Planning								
O&M								
Jemberana								
Sub-Dinas Pengairan	33	12	1,300	-	273	1,600	-	265
Planning								
O&M								
Buleleng								
Sub-Dinas Pengairan	33	12	-	1,250	6,070	n.a.	n.a.	n.a.
WR infrastructure development								
O&M								
Badung								
Sub-Dinas Pengairan	15	26	1,000	-	243	-	-	1,835
Engineering Design								
Implementation								
O&M								
Denpasar								
Sub-Dinas Pengairan	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Karangasem								
Sub-Dinas Pengairan	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Source: Interviews by Study Team with Regency/City Dinases and Sub-Dinases

I-3.4 Province – Regency/City Jurisdictions

As explained in Part-II-7.4 of the Main Report, there are confusions over the demarcation of the responsibilities between the province and the regencies/city, caused by two principles introduced in the regent legislation of the country. The more recent principle is provided in the Water Resources Law No.7/2004 that says province is responsible for water resources management in trans-regency river basins as well as technical assistance to regencies/city, while regency/city is responsible for water resources management in river basins located within the regency/city. Prior to the introduction of this Law, the principles of jurisdictional division between province and regency/city were outlined in the Law No.22/1999 on Regional Administration[29] and more specifically in the Government Regulation No.25/2000 on Autonomy and Decentralization. Articles 3 and 4 of the latter provided that:

(i) Provincial authority covers the authority in the field of government administration which crosses or covers two or more regencies/cities;
(ii) If minimal services that must be performed by regency/city cannot be executed or have not been executed by the regency/city, the province may conduct the authority;
(iii) Authority of regency/city in a certain field and certain part of obligatory authority may be performed by the province according to an agreement between the regency/city and the province;
(iv) Regency/city that cannot execute or has not executed one or some of the authorities can delegate to the province subject to the approval of the president; and
(v) If the province cannot execute the authority, it can hand it over to the central government subject to the approval of the president.

Article 3 Clause (5) Paragraph 14 specifies the responsibilities of the provincial public works as follows (partial extract for water sector):

- Establishing standards for the management of inter-regency/city surface water resources
- Providing support for inter-regency/city cooperation for the development of infrastructure and facilities, consisting of water resources, weir/dam…

[29] Recently amended by the Law No.32/2004 on Regional Administration.

- Providing support for the management of inter-regency/city surface water resources and O&M of irrigation and drainage canals and auxiliary structures from the intake structure to the model canal of 50 meters from the headworks
- Issuing permits for renovation or removal of inter-regency/city canals, infrastructures and facilities
- Construction and O&M of trans-regency/city primary irrigation systems and their auxiliary structures
- Arrangement for irrigation water supply

In the field of water resources, there are two aspects of province-regency/city jurisdiction: river basins and irrigation areas.

According to BAPEDALDA, there are a total of 21 cross-regency/city rivers, of which three do not have water flow during the dry season. BAPEDALDA monitors water quality of these rivers fully or partially (depending on the budget availability). On the other hand, laying the map of administrative boundaries on the map of rivers on GIS results in a total of 48 rivers that cross regency/city boundaries. As described in Part-II.7.4 of the Main Report, the Study Team recommended that Bali be considered as one river basin and one groundwater basin for both technical and administrative grounds. A consensus toward this arrangement is now emerging and it is imminent that a final decision is taken on this issue so as to clarify the water resources jurisdiction.

With regard to irrigation, construction, rehabilitation, and O&M of irrigation facilities are under the provincial responsibility where the areas cross two or more regencies/city. The new Water Resources Law has introduced an additional criterion to this demarcation as follows:

(i) Irrigation area of less than 1,000 hectares ("small IA") that is located in one regency/city is under the responsibility of the regency/city government;
(ii) Inter-regency/city irrigation area of 1,000 to 3,000 hectares ("medium IA") is under the responsibility of the provincial government; and
(iii) Inter-provincial, nationally strategic irrigation area of more than 3,000 hectares ("large IA") is under the responsibility of the central government.[30]

Accordingly, facilities in small IAs that are located in regencies/city are supposed to be transferred to the regency/city governments. There are nine such irrigation areas in Bali[31] and the transfer process is under way. On the other hand, O&M budget for two large IAs in Bali, Mambal and Kedewatan, is financed by the central government starting from 2005.

I-3.5 Coordination on Water Resources

In accordance with the Regulation of Minister of Public Works No.67/1993 on establishment of Provincial Water Resources Management Council (PTPA), a Decree of Governor was issued in Bali in 1996 (No.180/1996) stipulating the formation of PTPA and its secretariat. The task of the Bali PTPA is to assist the Governor in the following fields (Article 2 (2)):

- Formation of priority plan of water usage and water sources
- Deciding on priority sequences of water usage and water sources
- Arrangement of the procedure of disposal of waste water and other waste materials
- Arrangement for development of irrigation facilities and other facilities at water sources
- Arrangement on other problems that may arise

It is also stated that PTPA has the duty to accumulate, manage, and prepare materials for the coordination with respect to (Article 2 (3)):

- Data of surface and ground water quantity
- Data of surface and ground water quality

[30] Article 41, Paragraph (2) of the Elucidation to the Law No.7/2004 on Water Resources (unofficial English translation).
[31] The concerned small irrigation areas are: Apuan, Bekutel, Tembuku, Banjarangkan, Mertagangga, Oongan, Peraupan, Tukad Badung, and Cangi.

- Data of water conservation and water resources
- Data of water demands in different sectors
- Data of water resources that have been or will be exploited

The members of PTPA are limited to government representatives and are as follows:

- Assistant Regional Secretary (Chair)
- BAPPEDA (First Vice-Chair)
- Head of Regional Public Works Office (Second Vice-Chair) (Kanwil)
- Head of Regional Agriculture Office (Kanwil)
- Head of Regional Industry Office (Kanwil)
- Head of Regional Forestry Office (Kanwil)
- Head of Regional Foreign Investment Coordination Agency
- Head of Regional National Land Agency
- Head of Regional Food Crop Agriculture Service Office (Dinas)
- Head of Regional Plantation Service Office (Dinas)
- Head of Regional Mining and Energy Service Office (Dinas)
- Rector of Udayana University
- Head of Provincial Environmental Bureau
- Head of Provincial Police Office
- Head of Trade and Industrial Chamber

The heads of Regional Public Works Service Office (Dinas) and Provincial Water Resources Sub-Office (Sub-Dinas) serve as secretary and vice-sectary to PTPA. As the membership is based on the government structure before decentralization, it needs adjustment. As noted before, the new Water Resources Law calls for establishment of Provincial Water Resources Management Council (the name can be changed in accordance to the preference of each province) and PTPA provides a basis for the arrangement. However, in light of the fact that PTPA has rarely met in Bali, the structure and mandates of the new coordinating body require careful consideration before initiating another institution that may turn out existing only on paper.

A related development that must be noted is a proposal to establish Regency Irrigation Commissions. In the past, there were attempts to establish Regency Irrigation Committees in Bali in accordance with instructions from the central government. But partly thanks to the excellent organizational capacity of *subaks*, they never assumed a prominent role. The draft Government Regulation on Irrigation and accompanying draft ministerial guidelines include the concept and guidance for establishing Irrigation Commission. In Bali, discussions are being held in four Regencies, Buleleng, Jembrana, Karangasem, and Klungkung, with a view to creating Irrigation Commission. According to the draft guidelines, the areas of responsibility of the Commission are:

- sustainability and improvement of the irrigation conditions and functions
- determination of cropping plans
- annual plan of irrigation water supply
- annual plan of irrigation water division and distribution for agriculture and irrigation system used for other purposes
- recommendations for the priority in the irrigation management budget allocation

The expected membership includes offices of irrigation, agriculture, planning and development, and others as well as representatives of *subaks*. With regard to irrigation water supply, this will also be the mandate of the new Provincial Water Resources Management Council, or any subordinate body that may be created under it. How the proposed Irrigation Commission can be linked with the overall water resources management coordination mechanism needs to be clarified.

I-4 CUSTOMARY WATER RIGHTS

Conflicts over water allocation and use between *subaks* and non-*subak* entities such as PDAM are expected to increase in the future. In order to prevent conflicts and to facilitate conflict resolution, structured mechanisms will have to be introduced for water allocation (and re-allocation). The following three measures are needed for structuring water allocation: (i) introducing a measurement system for customary water use, based on which consultations and negotiations for water allocation and re-allocation will be conducted; (ii) formulating a water allocation plan on each of major rivers or river areas in consultation with stakeholders, based on which water use licenses will be issued; and (iii) introducing a streamlined public consultation process as part of technical assessment for water use licensing.

For reference of the first measure (introduction of a customary water use measurement system), the example of Japan is provided below.

In Japan, customary water uses were first recognized by the state under the River Law of 1896 and subsequently under the River Law of 1964. Under the River Law of 1964, customary users of water in Class I rivers (administered by the central government) and Class II rivers (administered by prefectural governments) were required to submit a format with the information on the purpose of the water use, the amount of water use, and the facilities used for taking and using water to the respective river administrators within two years of the enactment of the law. When other rivers were designated as either Class I or Class II, customary water users were required to submit the application within one year of the designation. In the wake of the adoption of the River Law 1964 and in view of increasing demands of water for urban and industrial uses, the (then) Ministry of Construction initiated a nation-wide survey to specify irrigation areas and water uses to identify the potential for diverting water uses. Based on this survey, the respective government river administrators initiated formulation of water use rationalization plans, taking account of calculated water demands for agriculture, needs for rehabilitating irrigation facilities, and demands from new or possible users of water. Under these plans and through guidance and coordination, irrigation water uses have been gradually being diverted to urban uses.

In Indonesia, a consultancy team hired by the World Bank presented a proposal in 2004 for the introduction of "Certificate of Water Entitlement (CWE)" system for customary users of irrigation water. The idea is to protect the interests of water users' associations by (i) measuring their water use, (ii) issuing CWE that specifies the entitled amount of water, period of water use, and purposes, and (iii) using the CWE as a basis of deciding on water allocation to industrial and commercial users.[32] The introduction of such a system would require considerable efforts for the necessary institution building. In the meantime, in Bali, a similar but more practical approach may be pursued, focusing on major rivers with higher demands for water use and where there are actual or potential disputes.

[32] Sanyu Consultants Inc. for the World Bank, "Indonesia: Water Use Rights Study" Draft Final Report (August 2004).

Appendices

Appendix-1
Institutions

Appendix-1 Institutions

List of Laws and Regulations Collected and Reviewed by Study Team

Acronyms

- Law *[Undang-Undang]*
- Government Regulation (GR) *[Peraturan Pemerintah=PP]*
- Presidential Decree (PD) *[Keputusan Presiden=Keppres]*
- Ministerial Decree (MD) *[Peraturan Menteri=Permen]*
- Provincial Regulation (PR) [*PERDA Propinsi*]
- Governor's Decree (GD) [*SK-Gub*]
- Regency Regulation (DR) [*PERDA Kabupaten/Kota*]
- Decree of Bupati (DB) [*SK-Bupati*]

No.	Laws and Regulations
Decentralization	
1	Law No. – 2004 on the Regional Administration
2	Law No. 22/1999 on Regional Administration
3	GR No.8/2003 on Organizational Structure of Regional Governments
4	GR No.25/2000 on Authorization of Central Government and Authorization of Provincial Government as an Autonomous Region
* A comprehensive database of laws and regulations related to decentralization and deconcentration including financial arrangements is available at the website of Ministry of Home Affairs and GTZ (http://www.gtzsfdm.or.id).	
State Finance	
5	Law No.33/2004 on Fiscal Balance between the Central Government and the Regional Governments
6	Law No.1/2004 on State Treasury
7	Law No.19/2003 on State Finance
8	Law No.34/2003 on Amendments to Law No.18-1997 on Regional Taxes and Levies
9	Law No.25/1999 on Financial Equilibrium between the Central Government and the Regional Administrations
10	GR No.66/2001 on Regional Levies
11	GR No.65/2001 on Regional Taxes
12	GR No.11/2001 on Information on Regional Finance
13	GR No.106/2001 on Financial Management and Accountability in the Implementation of Deconcentration and Supporting Duty
14	GR No.105/2000 on Management and Accountability of Regional Fund
15	GR on Equilibrium Fund
16	PD No.80/2003 on Implementation Guidelines of the Government's Goods/Services Procurement
17	PD No.42/2002 on Implementation Guidelines of State Revenues and Expenditures Budget
18	MD No. 35/2003 on Planning, Implementation/Administration and Monitoring of the Conveyance of Central Government Foreign Loans to Regional Governments
19	MD of Home Affairs No.29/2002 on Regional Finance
State-owned Enterprises, PJT, PDAM	
20	Law No.19/2003 on State Owned Enterprises
21	GR No.41/2003 on Delegation of Authority form Ministry of Finance to Minister of BUMN
22	GR No.94/1999 on Public Corporation of Jasa Tirta II
23	GR No. 93/1999 on Public Corporation of Jasa Tirta I
24	GR No.13/1998 on Public Corporation (PERUM)
25	PD No.129/2000 on Additional Working Area of Jasa Tirta I Public Corporation in Bengawan Solo River Basin
26	PD No.58/1990 on Determining Jasa Tirta Public Corporation as a Corporation that is Entitled to Collect and Receive Fees for Financing Exploitation and Maintenance of Irrigation Infrastructures
27	MD of Settlement and Regional Infrastructure No.291/KPTS/M/2003 on Determining Fee Tariff for Financing Exploitation and Maintenance of Water Resources Infrastructure for Raw Water Taking and Utilization for PLTA (Hydro Electric Power Plant) in the Working Area of PJT I
28	MD of Settlement and Regional Infrastructure No.244/KPTS/M/2003 on Determining Fee Tariff for Financing Exploitation and Maintenance of Water Resources Infrastructure for Raw Water Taking and Utilization for Industry in the Working Area of PJT I
29	MD of Settlement and Regional Infrastructure No. 309/KPTS/M/2004 on Formation of Establishment Team for Jratunseluna, Serayu Bogowanto and Jeneberang River Basin Management Corporation
30	MD of Settlement and Regional Infrastructure No.208/KPTS/M/2003 on Establishment of the Preparation Committee for Jratunseluna, Serayu Bogowanto and Jeneberang River Basin Management Corporation
31	MD of Settlement and Regional Infrastructure No.342/KPTS/M/2002 on Authorization of PJT I as Corporation Entitled to Collect and Receive Fees
32	MD of State Owned Enterprise No.102/MBU/2002 on Formation of Long-term Plan of State Owned Enterprise

No.	Laws and Regulations
33	MD of State Owned Enterprise No.101/MBU/2002 on Formation of Work Plan and Company Budget of State Owned Enterprise
34	MD of State Owned Enterprise No.100/MBU/2002 on Assessment of State Owned Enterprise
35	MD of Home Affairs on Management of Regional Owned Enterprise Body (BUMD)
36	MD of Regional Autonomy No.8/2000 on Guidelines for Accountancy (?) of Regional Water Enterprises (PDAM)
Ministry of Public Works, DGWR, and other Organizational Matters	
37	MD of Settlement and Regional Infrastructure No.72/KPTS/2004 on Dismissal, Assignment and Reassignment of Superior of Project Division Manager and Treasurer within the DGWR in Fiscal Year 2004
38	Regulation of Minister of Home Affairs No.58/PRT/1991 on Implementation of Technical Assistance Technical Controlling (?) in Public works Sector to the Public Works Agency (?)
39	Regulation of Minister of Public Works No.57/PRT/1999 on Execution of Transfer of Public Works Matters to Regional Government Lvel 1 and Regional Government Level II
40	Instruction of Minister of Public Works No.11/Inst/1984 on Implementation of Guidance and Development of Koperasi Unit Desa (KUD) in Public Works Area
41	Decree of DGWR No.110/KPTS/D/2002 on Organization Restructuring of INDUK
42	MD of (State Minister) Administration Reform No.106/1994 on Organizational Guidelines for Technical Implementation Unit (UPT), Regional Implementation Unit (UPD) and Technical Implementation Unit of Service (UPTD)
WR Basic Law	
43	Law No.7/2004 on Water Resources
44	Law No.11/1974 on Water Resources
Water Rights and Permits	
45	(Draft) GR on water use rights and water exploitation rights
46	(Draft) GR on WR exploitation
47	Regulation of Minister of Public Works No.49-PRT/1990 on Procedure and Permit Conditions of Water and Water Resources Utilization
Bali Province	
48	PR No.9/1998 on Licensing, Supervision and Control of Ground Water and Surface Water Taking
49	Buleleng: Draft Regulation on Procedure and Requirements for License for Use of Water and Water Source, 2003
WR Management Organization	
50	(Draft GR on Water Resources Management (RPP-PSDA)
51	(Draft) GR on corporatization of WRM
52	(Draft) MD (MSRI) on Roles and Involvement of Stakeholders in WRM
53	GR No.22/1982 on Water Management
54	Regulation of Minister of Public Works No.48/PRT/1990 on Water and Water Resources Management
55	Regulation of Minister of Public Works No.39/PRT/1989 on Division of River Basin
Bali Province	
56	RR No.15/1988 on Control of Ground Water and Surface Water Taking
57	GD No.445/1989 on Implementation of RR No.15/1998 on Control of Ground Water and Surface Water Taking
WR Conservation	
58	Law No.27/1997 on Environmental Management (Amendments to the Law No.4-1982 on Environmental Management)
59	GR No.51/1993 on Environmental Impact Assessment
60	GR No.81/2001 on Water Quality Standard Value
61	PD No.77/1994 Environmental Impact Management Agency
62	GR No.82/2001 on Management of Water Quality
63	GR No.20/1990 on Water Pollution Control
64	MD of Health No.55/1993 on Requirements and Control of Water Quality
65	Regulation of Minister of Public Works No.45/PRT/1990 on Water Quality Control on Water Sources
66	MD (State Minister) of Environment No.52/1995 on Effluent Standards - Hotels
67	MD (State Minister) of Environment No.58/1995 on Effluent Standards - Hospitals
68	MD (State Minister) of Environment No.17/2001 on Types of Businesses and Activities that require EIA
69	MD (State Minister) of Environment No.3/1994 on Types of Businesses and Activities that require EIA
70	MD (State Minister) of Environment No.14/1994 on Guidelines for Preparation of EIA
71	MD (State Minister) of Environment No.86-2002 on Guidelines for Environmental Management and Monitoring
72	MD (State Minister) of Environment No.13-1994 on Guidelines for Membership and Working Procedures for AMDAL Commissions

No.	Laws and Regulations
73	MD (State Minister) of Environment No.42-1994 on Guidelines for Implementation of Environmental Audit
74	MD (State Minister) of Living Environment No.13/MENLH/7/1995 on Clean River Program (PROKASIH)
75	MD (State Minister) of Living Environment No.51/MENLH/10/1995 on Quality Standard of Liquid Waste for Industrial Activity
76	MD (State Minister) of Living Environment No.52/MENLH/10/1995 on Quality Standard of Liquid Waste for Hotel Activity
77	MD (State Minister) of Living Environment No.58/MENLH/12/1995 on Quality Standard of Liquid Waste for Hospital Activity
78	MD of Public Health No.907/2002 on Standards and Control of Drinking Water Quality
79	Decree of Head of BAPEDAL No.Kep-105/1997 on Guidelines for Monitoring of Implementation of Environmental Management Plan (RKL) and Environmental Monitoring Plan (RPL)
Bali Province	
80	19/PD/DPRDGR/69 on Forest Protection (No.40/1971)
81	21/PD/DPRDGR/69 on Valley Protection (No.42/1971)
82	1/PD/DPRDGR/71 on Fish Protection (No.133/1972)
83	2/PD/DPRDGR/73 on Prohibition order taking sand, grovel, stone, limestone, coral, etc.
84	21/PD/DPRDGR/69 on Specific Environment (?) (No.3 series C No.3, 1977)
85	PR on mining of C class material (sand, limestone, gravel, stones, etc.) 1984
86	RR on licensing, supervision and control of mining C class material
87	RR No.16/1988 on Monitoring and Control of Environmental Pollution by Sewerage
88	GD No.89/1990 on Establishment and Member Structures of EIA Commission of Bali Province
89	GD No.174/1990 on Implementation of RR No.16/1988 on Monitoring and Control of Environmental Pollution by Sewerage
90	GD No.515/2000 on Environmental Quality Standards
91	Circular Letter of Governor No.660.1/13212/BKLH on Implementation of EIA (AMDAL)
WR Development and Use	
92	(Draft) GR No. - on Rivers (merged with draft GR on reservoirs)
93	GR No.35/1991 on Rivers
94	GR No.27/1991 on Swamp
95	Regulation of Minister of Public Works No.64/PRT/1993 on Swamp Reclamation
96	Decree of DGWR No.176/KPTS/A/1987 on Manual River Protection
97	MD of Public Works No.458/KPTS/1986 on Regulation of River Protection related to Activities of Mining on C-Class Mining Material
Drinking Water	
98	GR No.16-2005 on Development of Drinking Water Supply System
99	GR No.67-2005 on Government Cooperation with Enterprise Body for Infrastructure Provision
100	MD of Public Works No.294/PRT/M/2005 on Supporting Body for Development of Drinking Water Supply System
Bali Province	
101	(MoU of Directors/Main Directors of PDAMs Denpasar City, Badung Regency, Gianyar Regency, Tabanan Regency and Klungkung Regency on Cooperation of Drinking Water Supply System Development in SARBAGITAKU Area – December 2005)
Irrigation	
102	(Draft) GR on Irrigation
103	GR No.77-2001 on Irrigation
104	GR No.23-1982 on Irrigation
105	(Draft) Joint Regulation of Ministers of Home Affairs, Public Works and Agriculture): Guideline for Arrangement of Authority, Right and Responsibility for Irrigation Management Institutions
106	(Draft) Joint Regulation of Ministers of Home Affairs, Public Works and Agriculture): Guideline for Empowerment of Water Users' Associations
107	(Draft) Regulation of Minister of Public Works: Guideline for Financing Irrigation Management
108	(Draft) Regulation of Minister of Public Works: Guideline for Establishment of Commission and Implementation of Coordination Forum for Inter-Irrigation Commissions and Irrigation Scheme
109	(Draft) Regulation of Minister of Public Works: Guideline for Development and Management on Participative Irrigation System
110	PD No.2-1984 on Guidance on Water Users' Associations
111	PD No.1-1969 on Irrigation Management
112	MD of Home Affairs No.42-1995 on Implementation Guideline for Home Affairs No.12-1992 on Establishment and Guidance of Water User Association
113	MD of Home Affairs No.12-1992 on Establishment and Guidance of Water Users' Associations
114	Regulation of Minister of Public Works No.67-PRT-1993 on Guidance on Irrigation
115	(not yet obtained) MD of Public Works No.65-PRT-1993 on Irrigation Information

No.	Laws and Regulations
116	MD of Home Affairs No.50-1992 on Implementation of Irrigation Service Fees
117	Regulation of Minister of Home Affairs No.6-1992 on Irrigation Service Fees
118	Instruction of Minister of Public Works No.19-1992 on Implementation of the Decree of Home Affairs Minister No.50-1992 on Implementation of Irrigation Service Fees
119	MD of Home Affairs No.63-1989 on Irrigation Service Fees in the Experimental Region
120	Instruction of Minister of Home Affairs No.30-1989 on Implementation of Irrigation Service Fees in Experimental Region
121	Regulation of Minister of Public Works No.42-PRT-1989 on Procedure for Delegating Small Irrigation Schemes along with its Management Authority
122	Joint Instructions of Ministers of Home Affairs, Agriculture, Public Works and Electric Power No.4-1973, No.2-Inst-Um-3-1973 and No.13-In-1973 on Forming of Kabupaten Irrigation Committee
Bali Province	
123	Provincial Regulation No.02-PD/DPPD Irrigasi Daerah Proponsi Bali
124	Draft regulation on irrigation (1997) - has not been finalized
125	GD No.180/1986 on Formation and Composition of Irrigation Committee Membership
126	Governor's Instruction No.8/1991 on Management, Operation and Maintenance toward irrigation Network constructed by Bali Irrigation Project
127	GD No.426/1994 on Implementation of Irrigation Service Contribution (IPAIR) in Bali Province
128	Governor's Instruction No.2/1995 on Implementation of Irrigation Service Contribution (IPAIR)
129	GD No.509/1999 on Irrigation Service Fee
130	Inventory of Irrigation Areas in Bali (Rekapitulasi Inventarisasi Daerah Irigasi PU) 1989
131	Denpasar: Decree of Mayor No.188.45/200/HK/2001 on coordination body and permanent secretariat for irrigation water service fees
132	Bangli: DR No.16/1996 on Structure & Strengthening of Subaks
133	Buleleng: DB No.478/1997 on Formation of Tiying Tali Subak-Gede in Implementation of Irrigation Management Fee in Buleleng Regency
134	Buleleng: DB No.88/2001 on Formation of Subak-Gede of Penarukan I in Implementation of Irrigation Management Fee in Buleleng Regency
135	Buleleng: DB No.146/2001 on Formation of Subak-Gede of Silangjana I in Implementation of Irrigation Management Fee in Buleleng Regency
136	Buleleng: DB No.378/2002 on Formation of Gerokgak Subak-Gede in Implementation of Irrigation Management Fee in Buleleng Regency
137	Gianyar: DB No.382/1999 on Installation and Development of Subaks in Gianyar Regency
138	Kabupaten Gowa (South Sulawesi) No.394/2002 on Irrigation Commission
Flood Control	
139	New GR(s) on measures to prevent destruction and disaster and rehabilitation of the situations caused by water's destructive power
140	PD No.43-1990 on National Coordination Board for Disaster Management
141	PD No.28-1979 on National Coordination Board for Natural Disaster Management
142	Decree of Coordinating Minister for Social Welfare No.02-Kep-Menko-Kesra-III-1993 on General Guideline and Plan for Disaster Management Coordinating Minister for Social Welfare
143	MD of Public Works No.966-KPTS-1983 on Determining Costs for Natural Disaster Management (amended by No.15-KPTS-1984 and No.47-KPTS-1985)
144	Instruction of Minister of Home Affairs No.20/1997 on Management of Diaster Mitigation in Province and Regency/City
145	PD No.3/2001 on National Coordination Board for Disaster Mitigation and Refugee Handling
147	Guidance for Flood Prevention (presentation in Jakarta)
148	Management for Emergency Work for Flood/Disaster (presentation in Jakarta)
Construction and O&M	
149	MD of Public Works No.98-KPTS-1993 on Dam Safety Organization
"Empowerment" and the Role of the Community	
Kabupaten	
150	Regulation of Bangli Kabupaten No.16-1996 on the Structure and Strengthening of Subaks (the same regulation was issued by all the other Kabupatens)
151	Decree of Bupati Buleleng on Establishment of Subak-gede for Irrigation Service Fees
Financing	
152	(Draft) GR on financing management of WR
153	GR No.6-1981 on Fees of Exploitation and Maintenance of Water Resources Infrastructure

No.	Laws and Regulations
Bali Province	
154	Intake and exploitation of taxes on the use of ground water and surface water
155	GD No.30/2004 on Basic Prices of Water for Tax Imposition for Intake and Exploitation of Ground Water and Surface Water
156	GD No.31/2004 on Collection Procedure for Tax on Intake and Exploitation of Ground Water and Surface Water
Coordination	
157	PD No.123-2001 on Coordinating Team for WR Management (amended by PD No.83/2001?)
158	Decree of DGWR No. 116-KPTS-D-2004 on Establishment of Central Coordination Team
159	MD of Public Works No.67-PRT-1993 on Provincial Water Resources Coordination Committee (PTPA)
160	Decree of Coordination Minister for Social Welfare No.02-Kep-Menko-Kesra-I-1992 on National Coordination Board for Disaster Management
Bali Province	
161	Decree of Governor No.180-1996 on the Establishment of Water Management Committee (PTPA)
162	Chief Decree (?) of the Establishment of Water Management Committee in Bali Province No.SK-002-PTPA-1996 on the Formation of the Secretariat for the Water Management Committee
Land Use	
163	Regulation of Minister of Public Works No.63/PRT/1993 on River Border Lines, River Benefit Areas, River and Former River Control Areas
Bali Province	
164	Spatial Plan for Bali (updated in 2005)
165	Denpasar: Decree of Walikota on river border lines (1998)
166	Buleleng: Draft Regulation on Distance from Rivers for Construction
167	Buleleng: Draft Regulation on Distance from Beach for Construction

Courtesy to the Jeneberang River Basin Management JICA Study Team for many of the national level laws and regulations and their translations.

DIRECTORATE GENERAL OF WATER RESOURCES,
MINISTRY OF PUBLIC WORKS
PUBLIC WORKS SERVICE, BALI PROVINCE

THE COMPREHESIVE STUDY
ON
WATER RESOURCES DEVELOPMENT
AND MANAGEMENT IN BALI PROVINCE
IN
THE REPUBLIC OF INDONESIA

FINAL REPORT
SUPPORTING REPORT

[J] GIS DATABASE

AUGUST 2006

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.

THE COMPREHENSIVE STUDY
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SUPPORTING REPORT (J)
GIS DATABASE

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J-1 INTRODUCTION

Tremendous amount of information is needed to manage water resources. Since the information of different status is managed for various objectives, lots of time is consumed in evaluating and analyzing the information. In order to solve such problem, it is very important to collect and computerize various kind of information to be required, and to manage the information unitarily at the same dimension. Information collected for the database is used from various viewpoints. Since most of water resources information has location data, it is effective to introduce GIS (Geographic Information System) for managing water resources data. GIS can compare and analyze a lot of information, and can easily express the result on the maps for a certain purpose.

GIS is a powerful tool for explaining synthetic evaluation. In this study, the JICA Study Team had prepared the GIS database for water resources management in Bali province, parameter analyses by water balance model and map expression of water resources data.

GIS consists of map data and attribute data. Map data express the real world on a computer by points, polylines, and polygons. Attribute data is the data showing the specifications of map data. GIS can be utilized as a decision supporting tool through the management and the spatial analysis of map data and attribute data.

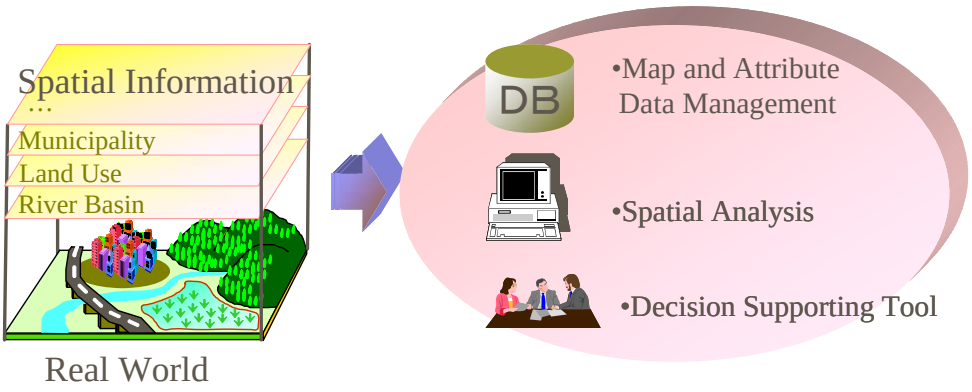

Figure-J.1 Image of GIS

J-2 CONFIGURATION OF GIS DATABASE

J-2.1 Projection

Map data is expressed two-dimensionally on paper or a computer, but, as the earth is an ellipse, it is necessary to apply a projection of which distortion becomes smallest for latitudes.

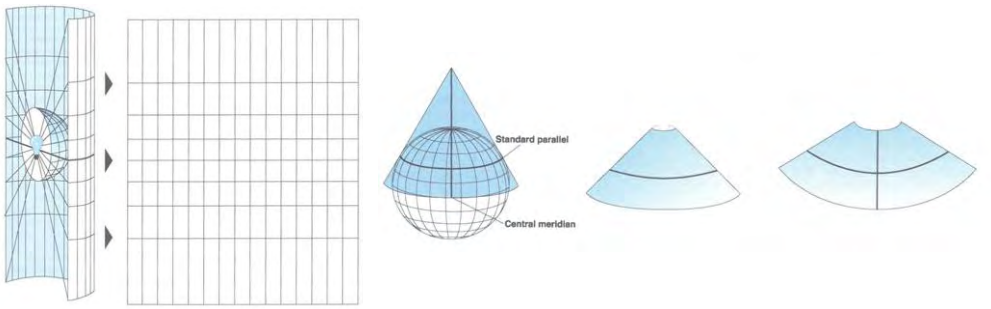

Figure-J.2 Map Distortion

In this GIS database, "UTM (Universal Transverse Mercator's) projection is applied to project map data. This projection is often applied to middle scale maps (1:25,000 or 1:50,000 and so on). In the projection by UTM, the earth, starting from the base longitude of 180^{o} , is vertically divided 60 zones that are compartmentalized by 6^{o} .

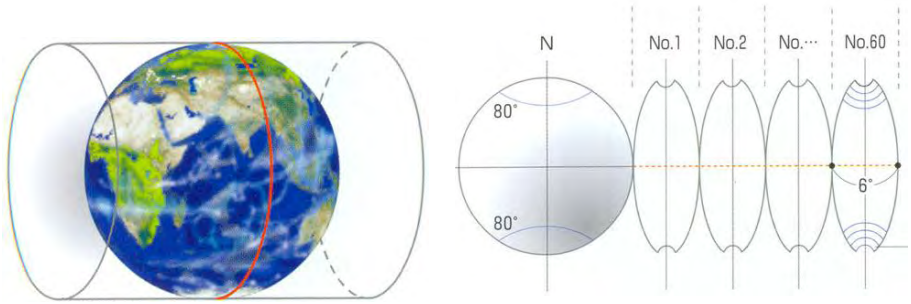

Figure-J.3 Definition of UTM Projection

Geographically, Bali Province is located in the range of the coordinate of 8^{o} 03'40" – 8^{o} 50'48" South Latitude and 114^{o} 25'53" – 115^{o} 42'40" East Longitude. Therefore, Bali province is included in "Zone 50 South" of UTM projection. The X-Y coordinate system is expressed as the point at Latitude 0^{o} and East Longitude 117^{o} is the X-Y coordinate at 500,000m of X and 1,000,000m of Y.

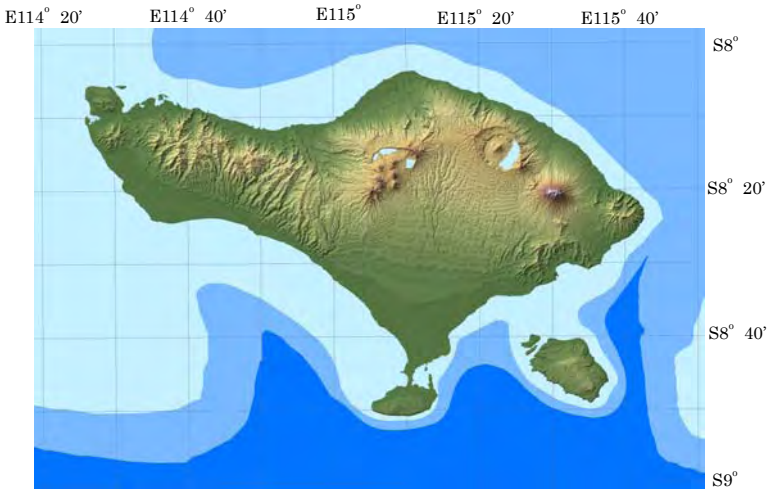

Figure-J. 4 Location of Bali Province

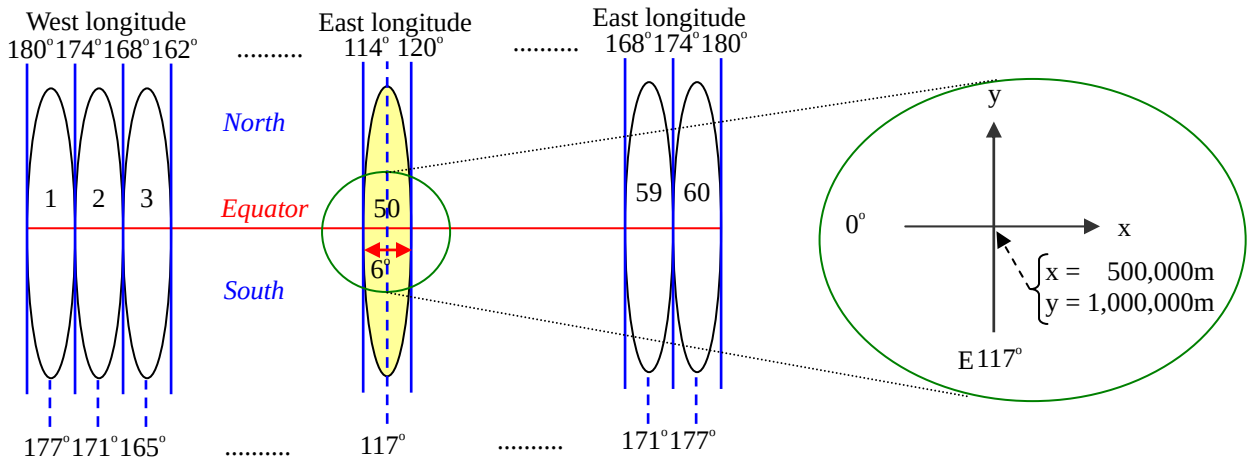

Figure-J.5 Definition of UTM Zone 50 South

J-2.2 Structure of GIS Database

Dinas-PU of Bali Province had prepared a database concerning with water resources. Based on it, the new GIS database had constructed through this study. The JICA Study Team had added and revised the data and created new function on the GIS database. The base map is the topographical maps with the scale of 1:25,000 prepared by Survey Coordination and National Mapping Board, consisting of 51 sheets of maps in Bali Province. Those topographical maps were compiled based on aero photographs which were taken on 1993-1994 with the scale of 1:50,000 and based on the revision by the field survey on 1999-2000.

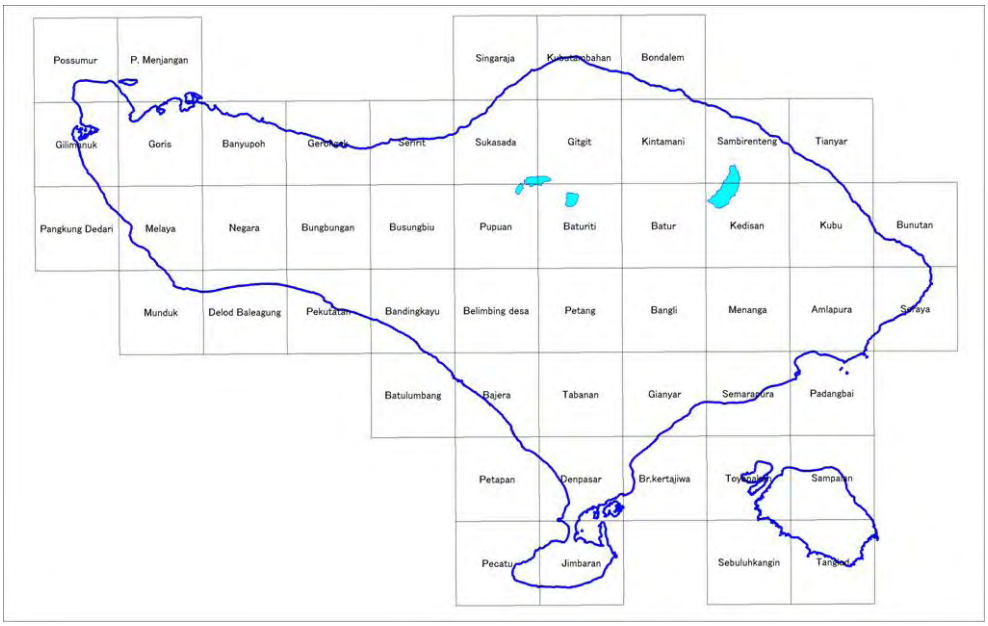

Figure-J.6 Tiles of Topographical Maps

The GIS database includes three file formats such as MapInfo, Microsoft Access and Jpeg which are managed by MapInfo version 7.5. MapInfo files consist of map data and attribute data that are corresponded to map data one to one. Topographical maps are scanned and stored as Jpeg files. Ms-Access files include socio-economic data, irrigation data and observational data. Such Ms-Access files are external files, which are linked to map data through data code such as a regency code, a station code and so on.

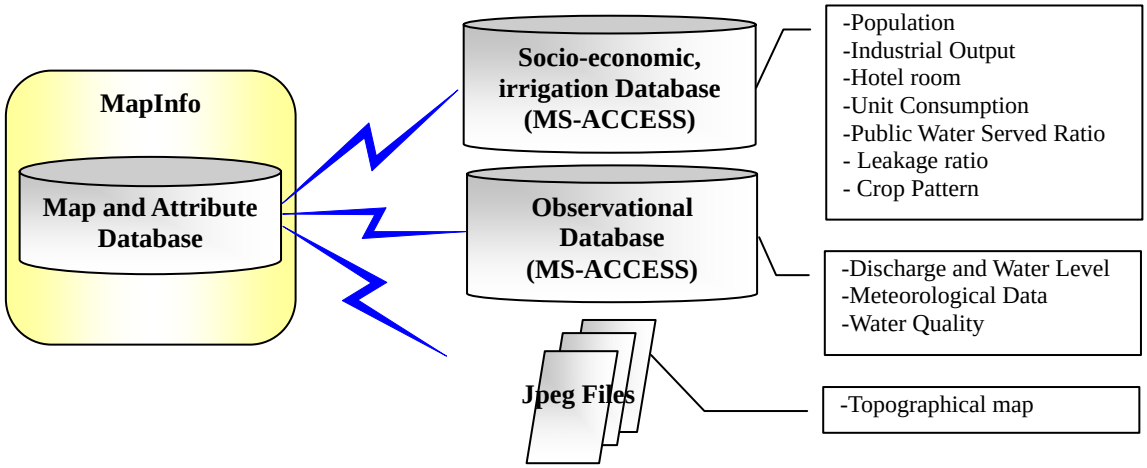

Figure-J.7 Configuration of GIS Database

As a nature, some numerical data have *"one to one relationship"* with map data, others have *"one to many relationship"* such as time-series data. Map data and *"one to one relationship"* data are compiled in GIS database, while *"one to many relationship"* data are constructed in the separate database. In order to arrange data systematically, the united code system in the province level or nation level shall be applied. In Indonesia, united code system has been applied for river basins, hydrology and meteorology gauging stations, administrative units and so on. Besides, Bali Province has set code

system for rivers. Although each data exists independently, they are linked by code data. As an example, the image figure which fixes hydrology data is shown in Figure-J.8

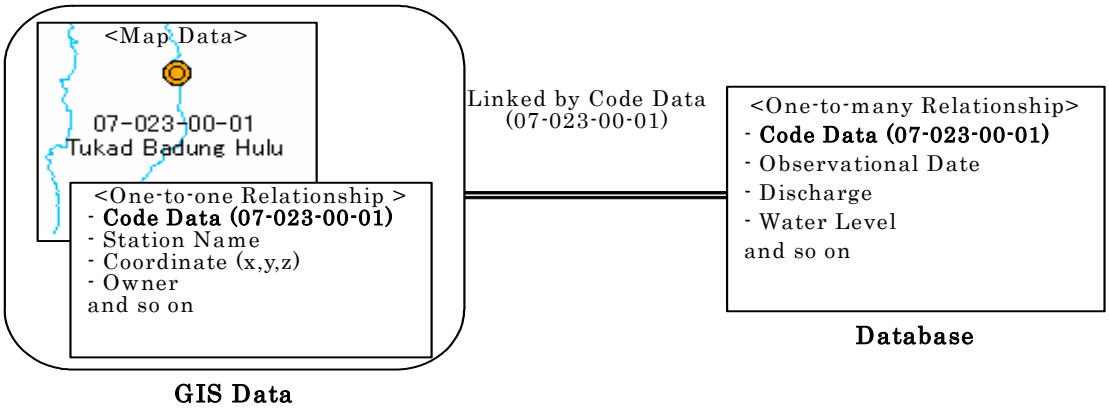

Figure-J.8 Example of Data Character (hydrological data)

J-2.3 Content of GIS Database

The GIS database prepared by the JICA Study Team is shown are Table-J.1 and Table-J.2. Refer to appendix "GIS Database Definition" in detail.

Table-J.1(1/3) MapInfo Data

No.	Layer Name	Data Type	Number	Data Source	Notes
Public Administration					
1	Bali	polygon	1	MAP	boundary of Bali Province
2	Regency	polygon	10	MAP	boundary of regency (Penida islands are to be independent)
3	District	polygon	55	MAP	boundary of district
4	Village	polygon	687	MAP	boundary of village
5	Capital of Regency	point	9	MAP	location of capital of regency
6	Capital of District	point	55	MAP	location of capital of district

PU : Data provided by Public Works Service of Bali Province
HUT : Data provided by Forestry Service of Bali Province
BMG : Data provided by Meteorological and Geophysical Agency
MAP : Topographic map (scale 1:25,000) prepared by Survey Coordination and National Mapping Board
GEO : Reconnaissance hydrogeological map prepared by the Geological of Indonesia (scale 1:250,000 on 1972)
AGR : Soil map prepared by Ministry of Agriculture (scale 1:250,000 on 1970)
Study Team: Inventory survey or created by JICA Study Team
Landsat: Landsat7 on 2003

Table-J. 1(2/3) MapInfo Data

No.	Layer Name	Data Type	Number	Data Source	Notes
Topographical and Natural Condition					
7	Sub Basin	polygon	20	Study Team	boundary of sub-basin area (newly proposed)
8	Old Sub Basin	polygon	20	PU	boundary of old sub-basin area
9	River Basin	polygon	550	MAP	boundary of river basin area
10	Lakes	polygon	4	MAP	boundary of lakes
11	Springs	point	744	PU & Study Team	location of springs
12	Rivers	polyline	-	Landsat & MAP	centerline of rivers
13	Contours	polyline	-	MAP	over 200m: interval 12.5m under 200m: interval or 6.5m
14	Index Contour	polyline	-	MAP	main contour; interval 50m
15	Land use	polygon	-	Landsat	boundary of land use (17 categories)
16	Irrigation Area	polygon	-	Landsat	boundary of irrigation area abstracted from land use
17	Geology	polygon	-	GEO	boundary of geology (17 categories)
18	Hydrogeology	polygon	-	GEO	boundary of hydrogeology (7 categories)
19	Soil	polygon	-	AGR	boundary of soil (15 categories)
20	Isohyet	polyline	-	Study Team	isohyetal map (annual rainfall)
21	Natural Protect Area	polygon	-	HUT	boundary of natural protect area (4 categories)
Institutional Condition					
22	Existing Dams	polygon	4	PU	boundary of dam reservoir
23	Existing Dams Catchment Area	polygon	4	PU	boundary of dam catchment area
24	Wells	point	321	PU & Study Team	location of wells
25	Weirs	point	443	PU & Study Team	location of weirs
26	Hydrological station	point	42 (49)	PU	location of water level and discharge station(include 7 old stations)
27	Hydrological Catchment	polygon	44	Study Team	boundary of station's catchment area
28	Rainfall Station(PU)	point	32	PU	location of rainfall stations managed by PU
29	Rainfall Station(BMG)	point	104	BMG	location of rainfall stations managed by BMG
30	Meteorological Station(PU)	point	9	PU	location of meteorological stations managed by PU
31	Meteorological Station(BMG)	point	4	BMG	location of meteorological stations managed by BMG
32	Water Quality	point	81	PU & Study Team	location of water quality sampling point
Transportation					
33	Roads	polyline	-	MAP	centerline of roads
34	Port	point	16	MAP	location of ports
35	Airport	point	1	MAP	location of airport
36	Bus terminal	point	6	MAP	location of bus terminals

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AGR : Soil map prepared by Ministry of Agriculture (scale 1:250,000 on 1970)
Study Team: Inventory survey or created by JICA Study Team
Landsat: Landsat7 on 2003

Table-J. 1 (3/3) MapInfo Data

No.	Layer Name	Data Type	Number	Data Source	Notes
History and Culture					
37	Historical place	point	9	MAP	location of historical place
38	Cultural facility	point	24	MAP	location of cultural facility
Disaster History					
39	Flood area	point	121	Study Team	location of flood area
40	Debris flow area	point	10	Study Team	location of debris flow area
41	Slope failure	point	6	Study Team	location of slope failure
42	Landslides	point	73	Study Team	location of landslides
Plan					
43	Proposed Dam	point	29	PU	location of proposed dam by PU
44	DamSite	point	2	Study Team	location of proposed dam by JICA Study Team
45	Reservoir Area	polygon	1	Study Team	boundary of Ayung dam reservoir area
46	AyungDamCacthmentArea	polygon	1	Study Team	boundary of Ayung dam catchment area
47	TerminalPoint	point	2	Study Team	location of water terminal point
48	Pipeline	polyline	2	Study Team	centerline of pipeline
49	Water Treatment Plant	point	3	Study Team	location of water treatment plant
50	River Improvement	polyline	10	Study Team	river improvement zone
Flood Simulation Model					
51	tArea	polygon	1	Study Team	flood simulation area for Badung, Mati river
52	Flood_Elv	point	1343	Study Team	elevation data for flood simulation model
Others					
53	Topographical map	raster	51	MAP & Study Team	scanned files (jpeg)
54	Grids	polygon	51	MAP	boundary of grids of topographical map

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BMG : Data provided by Meteorological and Geophysical Agency
MAP : Topographic map (scale 1:25,000) prepared by Survey Coordination and National Mapping Board
GEO : Reconnaissance hydrogeological map prepared by the Geological of Indonesia (scale 1:250,000 on 1972)
AGR : Soil map prepared by Ministry of Agriculture (scale 1:250,000 on 1970)
Study Team: Inventory survey or created by JICA Study Team
Landsat: Landsat7 on 2003

Table-J.2 Ms-Access Data

No.	Table Name	Data Source	Notes
Observational data			
1	Hydrological Data	PU	daily discharge and water level from 1968 to 2003
2	Meteorological Data (BMG)	BMG	daily rainfall, temperature, evapotranspiration, wind from 1961 to 2003
3	Meteorological Data (PU)	PU	daily temperature, evapotranspiration, wind from 1993 to 2003
4	Water Quality	PU & Study Team	BOD, COD, Ph, temperature and so on
5	Subak	PU & Study Team	Subak list
Socio-economic data			
6	Population	Study Team	population by regencies and Nusa Penida
7	Domestic Unit Consumption	Study Team	domestic water unit consumption by regencies and Nusa Penida
8	CMRatio	Study Team	ratio to domestic water demand
9	Industrial Output	Study Team	industrial output by regencies and Nusa Penida
10	Industry Unit Consumption	Study Team	industry water unit consumption by regencies and Nusa Penida
11	Hotel Room	Study Team	hotel rooms by regencies and Nusa Penida
12	Hotel Unit Consumption	Study Team	hotel water unit consumption by regencies and Nusa Penida
13	Served Ratio	Study Team	public water served ratio by regencies and Nusa Penida
14	Leakage Ratio	Study Team	leakage ratio by regencies and Nusa Penida
Irrigation data			
15	Irrigation Area	Study Team	irrigation area by regencies
16	Crop Pattern	Study Team	crop Pattern by regencies
17	Crop coefficient	Study Team	crop Pattern by regencies and crops
18	Effective Rainfall	Study Team	effective Rainfall by regencies
19	Evapotranspiration	Study Team	crop evapotranspiration by regencies
20	Irrigation others	Study Team	other data for irrigation water demand parameter
Water Balance System			
21	C_DemandArea	Study Team	code number of regencies and Nusa Penida
22	C_PlanDemandArea	Study Team	code number of public water service area
23	C_Regency	Study Team	code number of regencies
24	Water Potential	Study Team	water potential by sub-basins
25	Supply Plan	Study Team	public water supply planning data by public water service area
26	Irrigation Area Ratio	Study Team	irrigation area ratio by regencies and sub-basins

PU : Data provided by Public Works Service of Bali Province
BMG : Data provided by Meteorological and Geophysical Agency
Study Team: Inventory survey or created by JICA Study Team

J-3 GIS DATABASE FOR WATER RESOURCES MANEGEMENT

Although it is absolutely impossible to figure out all of any motion within water cycle under the complicated natural and social condition, to develop analytical model and system of evaluation and analysis of the result obtained from the model is a great help for decision making of measures to water-related issues with reasonable view point. Furthermore, it becomes important to gain common recognition and consensus with stakeholders for water-related issues through information disclosures and explanations.

For these purpose, it is necessary to effectively utilize information technology such as database, numerical model, GIS, Web and so on. However, an information technology is a tool to the last, and engineers or experts need to examine and judge item and accuracy of data to input, concept of a model, and accuracy verification of results.

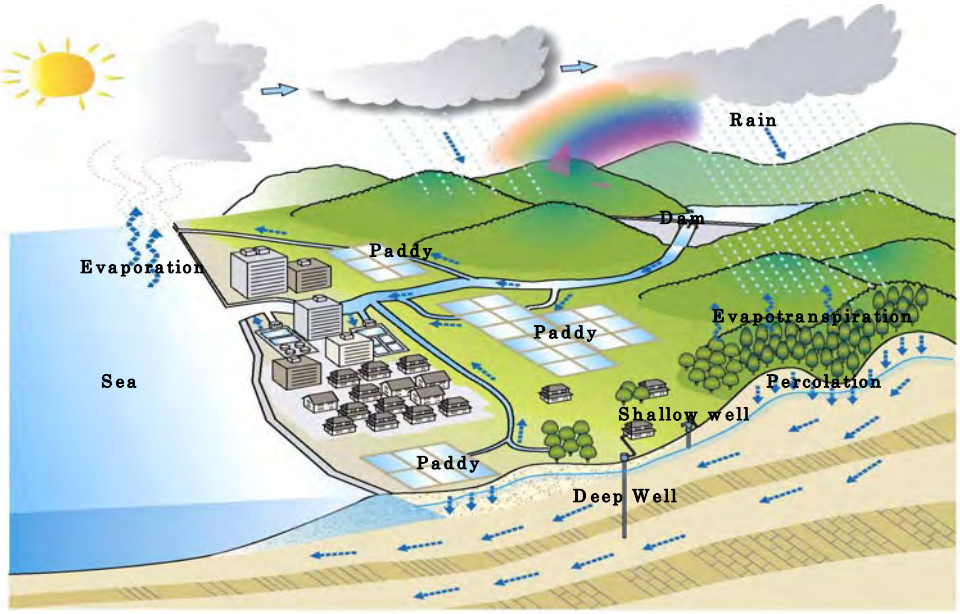


Figure-J. 9 Water Cycle

In order to grasp a water problem with sufficient accuracy and quantitatively, careful investigation of actual conditions of nature and society related water and is essential to minimize uncertainty. Since the results of an investigation become huge, it is need to utilize database technology for management data systematically.

The GIS database which is developed in the Study is necessary to be updated. The data item especially important to be updated and their purposes are shown in Figure-J.10.

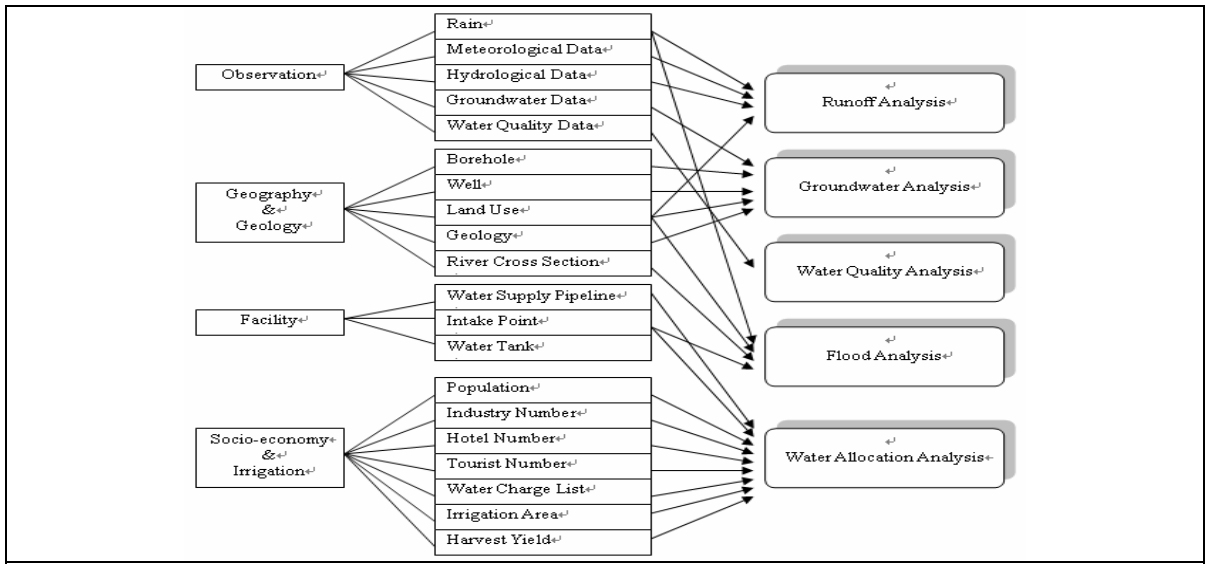


Figure-J.10 Update Data and Purpose

The GIS data base developed in the Study is an effective tool in interlocking a database and an analysis models by means of extracting parameters form database through GIS to analysis models and showing the results of analysis visually by GIS. By visualizing, GIS can support to carry out accountability.

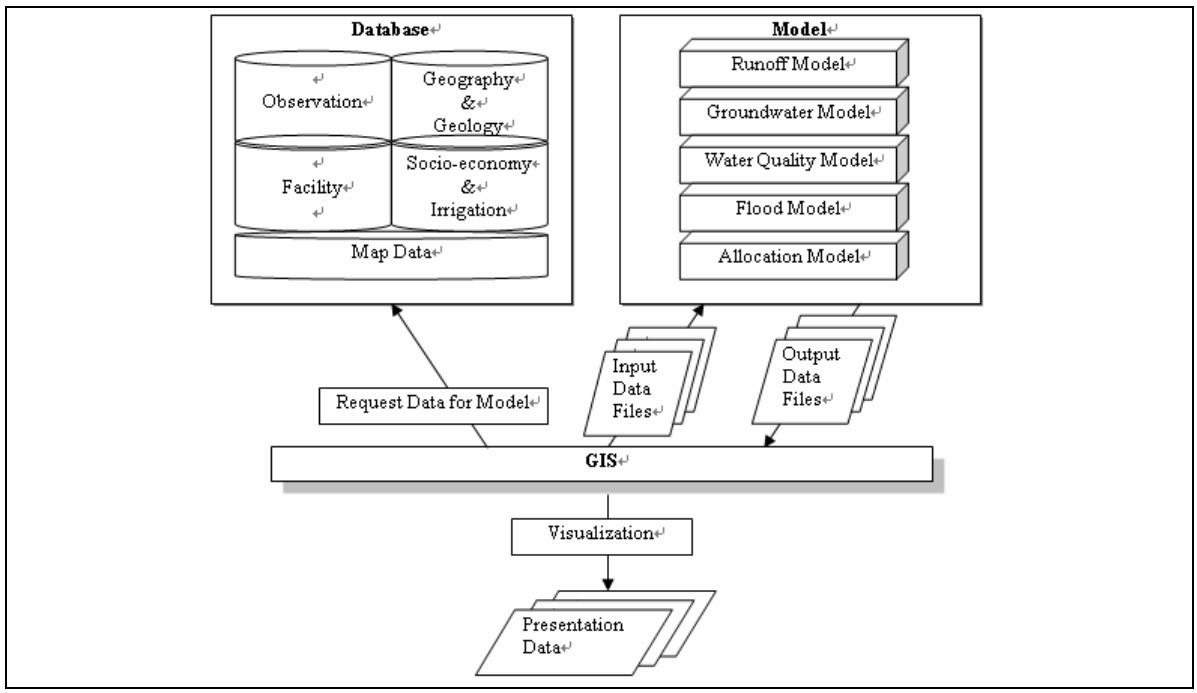


Figure-J. 11 Cooperation of Database and Analysis Model

J-4 DEVELOPMENT OF WATER BALANCE SYSTEM

J-4.1 Outline of Water Balance System

The Study Team had developed the programs as a supporting tool called "Water Balance System" for water resources management. Using this system, user can simulate about water balance (refer to Table-J.1and Table-J. 4

Table-J.3 Outline of Water Balance System

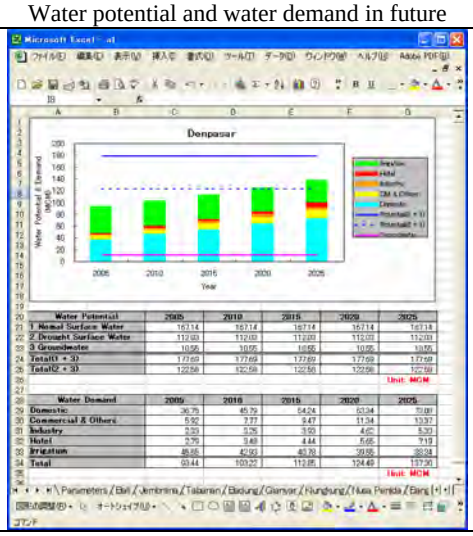
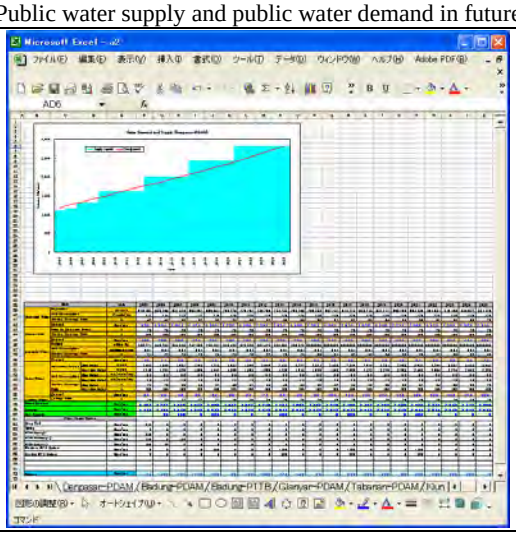
Simulation Item	Contents	Output
Water potential and water demand in future	Compare water potential and water demand in future in whole Bali, regencies and sub-basins. Water potential ● surface water included spring water ● ground water Water demand in 2005, 2010, 2015, 2020 and 2025 ● domestic water ● commercial/institutional water ● industry water ● hotel water ● irrigation water	Tables and Graphs as an excel file. ● Whole Bali (1 sheet) ● Regency and Nusa Penida (10 sheets) ● Sub basin (20 sheets)
Public water supply and public water demand in future	Compare public water supply in future and public water demand in future in public water service areas. Public water supply in 2005 to 2025 ● existing ● planning	Tables and Graphs as an excel file. ● Public water service area (11 sheets)
	Public water demand in 2005 to 2025 ● domestic water ● commercial/institutional water ● industry water ● hotel water	

Note: refer to Table-J.4 for regency and Nusa Penida, s**u**b-basin and public water service area.
refer to Table-J.3 for example output.

Table-J. 4 Target Area

Regency and Nusa Penida	Sub basin	Public water service area
		

Table-J. 5 Example Output

Water potential and water demand in future	Public water supply and public water demand in future
	

The system has 3 main functions, i.e. setting parameter data, calculating water demand in future and output results of calculation. The parameters and results data are saved to the database as a project data, and user can read these data according to need. Refer toFigure-J.12. For further simulation, user can use both default parameters and the previously entered data from the database, revise the parameters according to need. The default values of parameters are estimated in the Study. Refer to Figure-J.13 for the system flow.

Since the system is built by “Microsoft Visual Basic”, user has to install the application for using the system. Necessary computer specification is;

- Windows 2000/ Windows XP
- Installed Microsoft Excel2000/ XP

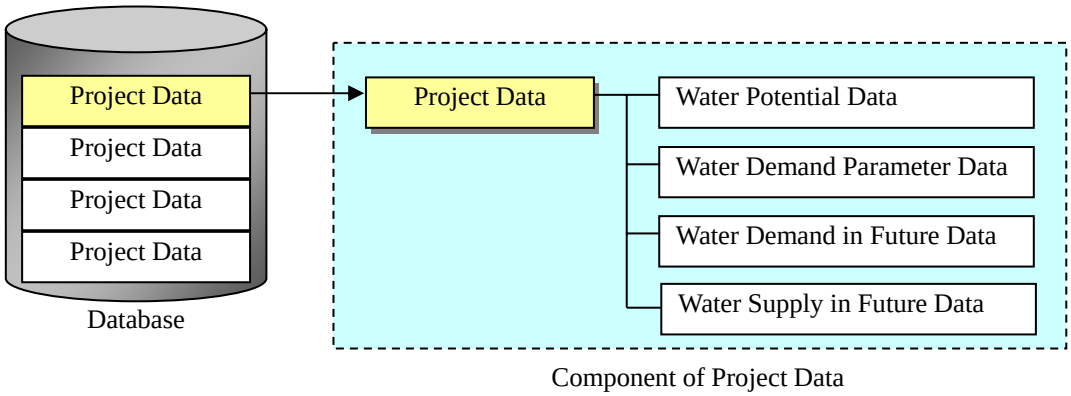


Figure-J.12 Structure of Project Data

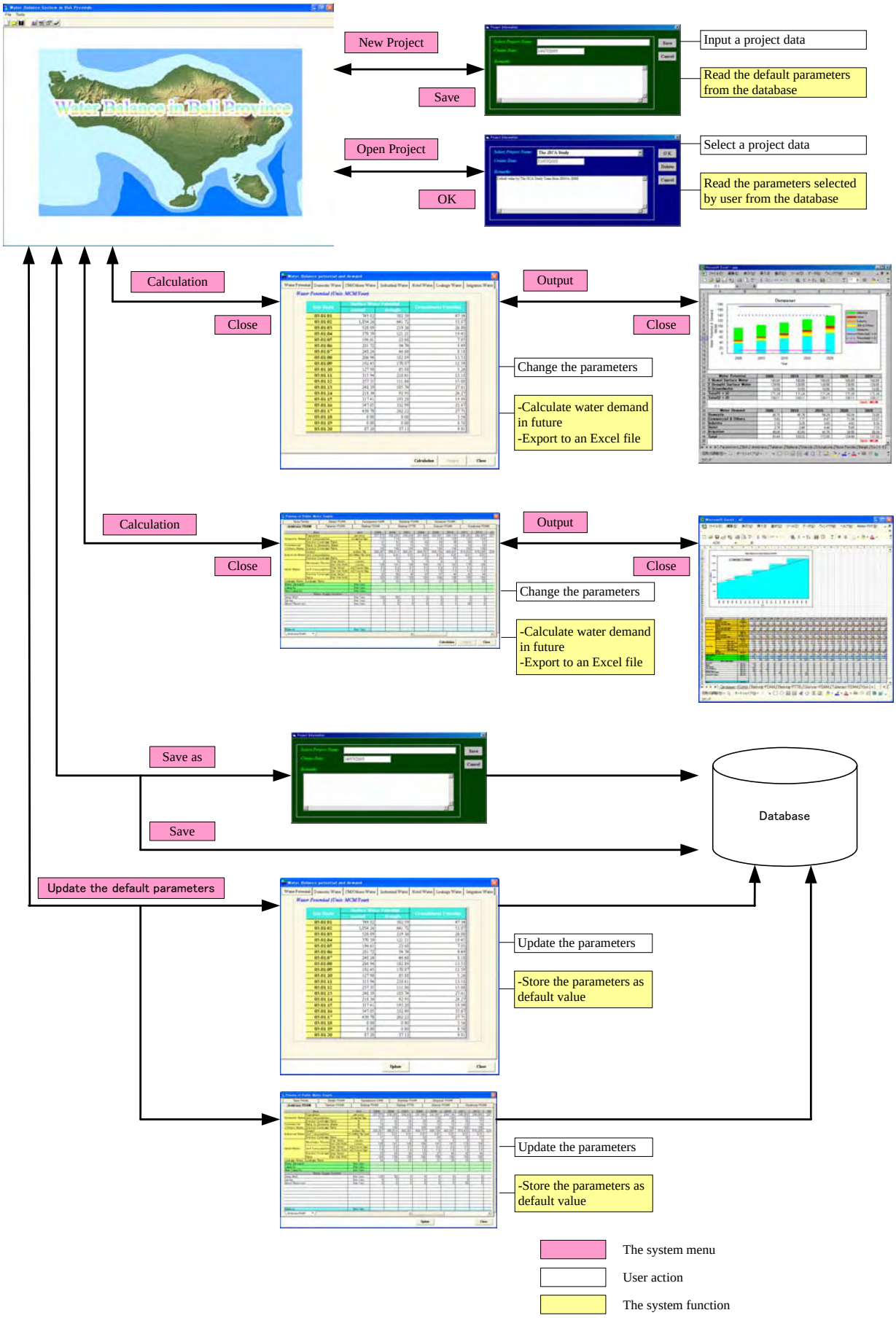


Figure-J.13 Water Balance System Flow

J-4.2 Specific Water Balance System

J-4.2.1 Water Potential and Water Demand in Future

(1) Water Potential

Water potential consists of surface water and groundwater. Surface water can be calculated for both normal level and drought level by arranging parameters. Spring water is included in surface water. As a basis, water potential is calculated by each sub-basin as shown in Table-M.4.

(2) Water Demand in Future

Water demand consists of domestic water, commercial/institutional water, industrial water, hotel water and irrigation water with considering water losses. As a basis, water potential is calculated by each regency and Nusa Penida as shown in Table-M4. Parameters for water demand calculation are set for each 5 years from 2005 to 2025.

Estimation methods for each water demand are as follows.

(a) Domestic Water Demand

Domestic water demand is estimated by multiplying population by unit water consumption. Water consumer is divided into PDAM user and non-PDAM user, unit water consumption for each user is different.

DWD (20XX) = POP (20XX) x SR (20XX) x UC1 (20XX) / (1-LKG (20XX))
+ POP (20XX) x (1-SR (20XX)) x UC2 (20XX)

Where,
DWD: domestic water demand (l/day)
POP: population
SR: service ratio of PDAM (%)
UC1: unit water consumption by PDAM user (l/capita/day)
UC2: unit water consumption by non-PDAM user (l/capita/day)
LKG: leakage ratio (%)
20XX: 2005, 2010, 2015, 2020 or 2025

(b) Commercial/Institutional Water Demand

Commercial/institutional water demand is estimated by multiplying domestic water demand by a certain ratio.

CWD (20XX) = DWD (20XX) x R (20XX) x SR (20XX) / (1-LKG (20XX))
+ DWD (20XX) x R (20XX) x (1 - SR (20XX))

Where,
CWD: commercial/institutional water demand (l/day)
DWD: domestic water demand (l/day)
R: ratio of commercial/institutional water demand against domestic water demand (%)
SR: service ratio of PDAM (%)
LKG: leakage ratio (%)
20XX: 2005, 2010, 2015, 2020 or 2025

(c) Industrial Water Demand

Industrial water demand is estimated by multiplying industrial output by unit water consumption.

IWD (20XX) = IO (20XX) x UC (20XX) x SR (20XX) / (1 – LKG (20XX))
+ IO (20XX) x UC (20XX) x (1 - SR (20XX))

Where,
IWD: industrial water demand (m^3/day)
IO: industrial output (million rupiah)
UC: unit water consumption by PDAM user (m^3/million rupiah/day))

SR: service ratio of PDAM (%)
LKG: leakage ratio (%)
20XX: 2005, 2010, 2015, 2020 or 2025

(d) Hotel Water Demand

Hotel water demand is estimated by multiplying number of necessary hotel rooms by unit water consumption.

HWD (20XX) = HR1 (20XX) x UC1 (20XX) x SR1 (20XX) / (1 – LKG (20XX))
+ HR1 (20XX) x UC1 (20XX) x (1 - SR1 (20XX))
+ HR2 (20XX) x UC2 (20XX) x SR2 (20XX) / (1 – LKG (20XX))
+ HR2 (20XX) x UC2 (20XX) x (1 – SR2 (20XX))

Where,
HWD: hotel water demand (m^3/day)
HR1: number of necessary star hotel rooms
HR2: number of necessary low class hotel rooms
UC1: unit water consumption by star hotel (m^3/room/day)
UC2: unit water consumption by low class hotel (m^3/room/day)
SR1: service ratio of PDAM (%)
SR2: service ratio of PDAM (%)
LKG: leakage ratio (%)
20XX: 2005, 2010, 2015, 2020 or 2025

(e) Irrigation Water Demand

Irrigation water demand is estimated by multiplying irrigation area by requirement water, and dividing by irrigation efficiency.

IWD (20XX) = IA (20XX) x RW / E

Where,
IWD: irrigation water demand (m^3/day)
IA: irrigation area (ha)
RW: requirement water (m^3/day/ha))
E: irrigation efficiency (%)
20XX: 2005, 2010, 2015, 2020 or 2025

(f) Water Balance

The system can output results of water balance in whole Bali, in each regency and Nusa Penida and in each sub-basin. Parameters for calculation are also shown as output. Each result data are divided by sheets, are indicated by graph and table. Refer to Figure-J.14.

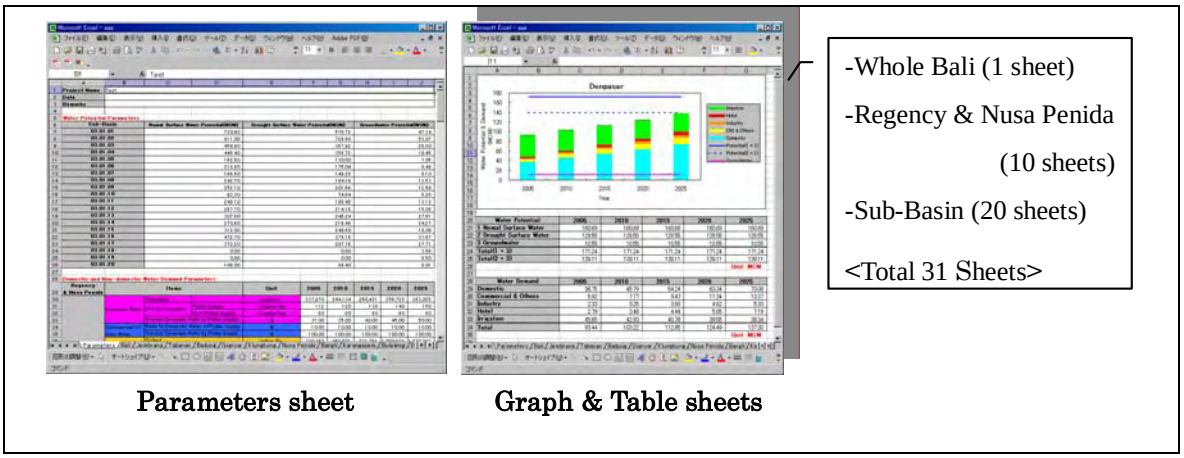


Figure-J.14 Output from Water Balance System

Since water potential is set by sub-basin and water demand is estimated by regency and Nusa Penida, conversion to each other is necessary for calculation of water balance. Water potential in a sub-basin is simply allocated by ratio of overlapping sub-basin and each regency. However, land use pattern is considered for estimating water demand by sub-basin. Domestic, commercial, industrial, hotel water

demand are allocated by ratio of overlapping sub-basin and residential area of each regency and irrigation water demand is allocated by ratio of overlapping sub-basin and irrigated paddy field of each regency. Refer to Figure-J.15andFigure-J.16.

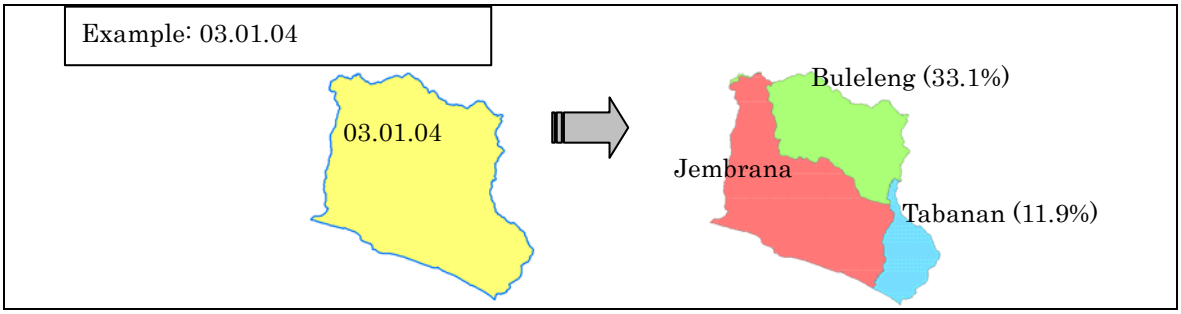


Figure-J.15 Allocation Water Potential from Sub-Basin to Regency

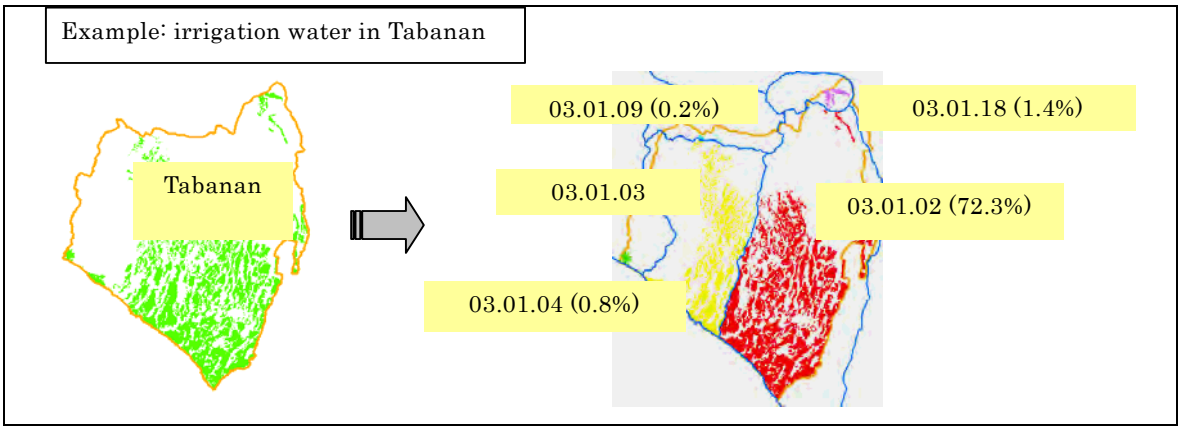


Figure-J.16 Allocation Water Demand from Regency to Sub-Basin

J-4.2.2 Public Water Demand and Public Water Supply in Future

(1) Public Water Demand in Future

Public Water demand consists of domestic water, commercial/institutional water, industrial water, and hotel water served by PDAM or PTTB, are calculated by each public water sevice area as shown in . Parameters for water demand calculation are set for each 1 year from 2005 to 2025.

Estimation methods for each water demand are as follows.

(a) Domestic Water Demand

Domestic water demand is estimated by multiplying population by unit water consumption. Water consumer is divided into PDAM or PTTB user.

DWD (20XX) = POP (20XX) x SR (20XX) x UC (20XX) / (1-LKG (20XX))

Where,

DWD: domestic water demand (l/day)
POP: population
SR: service ratio of PDAM or PTTB (%)
UC: unit water consumption by PDAM or PTTB user (l/capita/day)
LKG: leakage ratio (%)
20XX: 2005 to 2025

(b) Commercial/Institutional Water Demand

Commercial/institutional water demand is estimated by multiplying domestic water demand by a certain ratio.

CWD (20XX) = DWD (20XX) x R (20XX) x SR (20XX) / (1-LKG (20XX))

Where,

CWD: commercial/institutional water demand (l/day)
DWD: domestic water demand (l/day)
R: ratio of commercial/institutional water demand against domestic water demand (%)
SR: service ratio of PDAM or PTTB (%)
LKG: leakage ratio (%)
20XX: 2005 to 2025

(c) Industrial Water Demand

Industrial water demand is estimated by multiplying industrial output by unit water consumption.

$$IWD(20XX) = IO(20XX) \times UC(20XX) \times SR(20XX) / (1 - LKG(20XX))$$

Where,
IWD: industrial water demand (m^3/day)
IO: industrial output (million rupiah)
UC: unit water consumption by PDAM user (m^3/million rupiah/day))
SR: service ratio of PDAM or PTTB (%)
LKG: leakage ratio (%)
20XX: 2005 to 2025

(d) Hotel Water Demand

Hotel water demand is estimated by multiplying number of necessary hotel rooms by unit water consumption.

$$HWD(20XX) = HR1(20XX) \times UC1(20XX) \times SR1(20XX) / (1 - LKG(20XX)) + HR2(20XX) \times UC2(20XX) \times SR2(20XX) / (1 - LKG(20XX))$$

Where,
HWD: hotel water demand (m^3/day)
HR1: number of necessary star hotel rooms
HR2: number of necessary low class hotel rooms
UC1: unit water consumption by star hotel (m^3/room/day)
UC2: unit water consumption by low class hotel (m^3/room/day)
SR1: service ratio of PDAM or PTTB (%)
SR2: service ratio of PDAM or PTTB (%)
LKG: leakage ratio (%)
20XX: 2005 to 2025

(e) Public Water Supply

Plannings of public water supply are set for each 1 year from 2005 to 2025, for public water service area. Refer toFigure-J.17.

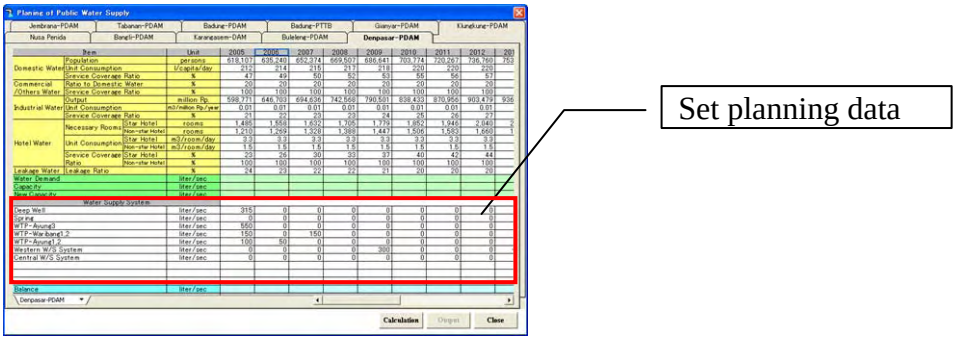


Figure-J.17 Setting Planning Data

(f) Water Balance

The system can output results of water balance in public water service area. Parameters for calculation are also shown as output. Each result data are divided by sheets, are indicated by graph and table. Refer to Figure-J. 18.

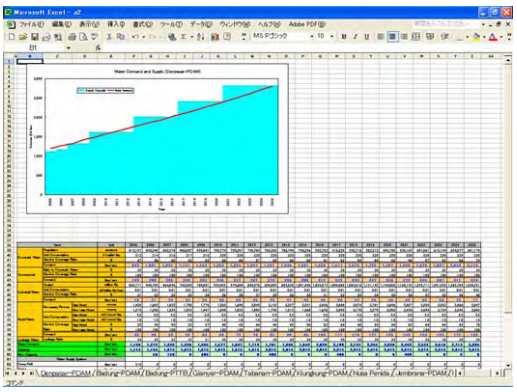


Figure-J. 18 Output from Water Balance System