(5) Comparison for Alternative Plans by Cost

The comparison for alternative plans by cost is shown in Table-II-4.8. The conditions of cost estimate are as follows.

- The cost estimate is based on the costs and prices of the average values in 2004. Exchange rates of Indonesian "Rupiah" to US$ and Japanese Yen is as follows: (Average: May/04 – April/05).
  - US$ 1 = Rp. 9,260 = JP¥ 106.97.
- To estimate the depreciation cost of each, following life years are employed:
  - Dam and reservoir (80years), - Building (50years),
  - Pipeline (40years), - Pump (15years).
- To estimate O&M costs of each facility, the actual O&M data in Indonesia is referred.
- O&M cost for dam and reservoir is 0.5% of construction cost.
- Electric power rate is 8.5yen/kwh.

Table-II-4.8 Comparison for Alternative Plans by Cost

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 Env.	-	-	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	120.2	108.2	240.4	174.6	232.1	232.1	77.8	62.6	85.5	86.2	69.4
2.1 Dam & Reservoir	-	-	42.9	42.9	-	-	-	24.0	-	-	-	-	-
2.2 Deep Wells	-	-	-	-	-	68.9	37.9	37.9	-	-	-	-	-
2.3 Measures for Env.	-	-	2.2	2.2	-	-	-	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	177.5	175.8	633.6	614.4	566.5	289.9	77.1	75.0	137.0	128.6	86.1
3.1 Dam & Reservoir	-	-	17.2	17.2	-	-	-	9.6	-	-	-	-	-
3.2 Deep Wells	-	-	-	-	-	160.5	105.8	-	-	-	-	-	-
3.3 Measures for Env.	-	-	0.9	0.9	-	-	-	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	297.7	284.0	874.0	789.0	798.6	442.3	154.9	137.6	222.5	214.8	155.5
5. Production (Mil. m^3/ 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/m^3)	6.1	7.9	5.2	5.0	15.4	13.9	14.1	7.8	6.1	5.5	8.8	8.5	6.2
- For Construction	2.3	2.9	2.1	1.9	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	3.1	3.1	11.2	10.8	10.0	5.1	3.0	3.0	5.4	5.1	3.4

(6) Total Evaluation of Alternative Plans

Western System

Alternative W2 is selected as Western Water Supply System. Considerations in selection are as follows: (See Table-II-4.9)

- The construction costs of both alternatives are almost same cost.
- As the depreciation cost and O&M cost of Alternative-W2 are bit higher than those of Alternative-W1, the water cost of Altrnative-W2 is 16% higher than that of Alternative-W1.

- ◆ From social aspect (namely arrangement water right with downstream users), Alternative-W1 is critical. Generally it is very difficult to take water from the river in which SUBAK has water right for irrigation without big enough water storage facilities (such as reservoirs and ponds).

Central System

Alternative C2 is selected as Central Water Supply System. Considerations in selection are as follows: (See Table-II-4.9)

- ◆ Among the alternatives, the depreciation cost of Alternative-C2 (With Dam – Downstream Intake by Pump) is lowest and that of Alternative-C3 (Without Dam – Surface Water Development) is highest.
- ◆ The water costs of Alternative-C3, C4 and C5 (Alternatives without dam) is around 2.5 times higher than those of Alternative C1 and C2 (Alternative with dam).
- ◆ The construction of dam will not give a critical impact to environment and social.

Eastern System

Alternative E4 is selected as Western Water Supply System. Considerations in selection are as follows: (See Table-II-4.9)

- ◆ The water cost of Alternative-E2 is lowest. But, from social aspect (arrangement water right with downstream users), Alternative-E1, E2, E5 will be critical.
- ◆ Comparing with alternative E3 and E4, the score makes no difference. However, there is difference on water cost 8.5 yen/m^3 for E4, whereas 8.8 yen/m^3 for E3.
- ◆ Alternative-E4 gives first evaluation result among the 5 alternatives.

Table-II-4.9 Evaluation of Alternative Plans

Items		Western S 300 lit/s		Central System 1.800 lit/s						Eastern System 800 lit/s				
		W1	W2	C1	C2	C3	C4	C5	C6	E1	E2	E3	E4	E5
(1) Average Score for Economic Aspect		**3.0**	**2.5**	**4.0**	**4.0**	**0.5**	**1.5**	**1.0**	**3.0**	**3.0**	**3.5**	**2.5**	**2.5**	**3.0**
Depreciation Cost (A) (Mil¥/year)	Specific (A) = a (Mil¥/year/100lit/s)	7.4	9.2	6.7	6.0	13.4	9.7	12.9	8.5	9.7	7.8	10.7	10.8	8.7
	Score	3	2	4	4	0	2	1	3	2	3	2	2	3
O&M Cost (B) (Mil¥/year)	Specific (B) = b (Mil¥/year/100lit/s)	12.0	15.5	9.9	9.8	35.2	34.1	31.5	16.1	9.6	9.4	17.1	16.1	10.8
	Score	3	3	4	4	1	1	1	3	4	4	3	3	3
(2) Average Score for Environmental & Social Aspect		**2.8**	**3.6**	**2.8**	**3.0**	**3.4**	**3.2**	**3.2**	**2.8**	**3.0**	**2.6**	**4.0**	**4.0**	**2.8**
◆ Natural Environment		4	4	2	2	4	3	3	2	4	4	4	4	4
◆ Resettlement		4	4	4	4	4	4	4	4	4	4	4	4	4
◆ Land Acquisition		3	3	3	3	3	3	3	3	3	3	3	3	3
◆ Water Right Arrangement		0	4	3	3	4	4	4	3	0	0	4	4	0
◆ Impact to Social Activities from Const. Work		3	3	2	3	2	2	2	2	2	2	4	4	3
Total Score		**5.8**	**6.1**	**6.8**	**7.0**	**3.9**	**4.7**	**4.2**	**5.8**	**6.0**	**6.1**	**6.5**	**6.5**	**5.8**
Water Cost (Yen/m^3)		6.1	7.9	5.2	5.0	15.4	13.9	14.1	7.8	6.1	5.5	8.8	8.5	6.2
(Total Evaluation)		2	1	2	1	6	4	5	3	4	3	2	1	5

- Point 4: Good or no problem, Point 2: Average or some small problems included, Point 0: Bad or some critical problems included, Point 3: Between Point 4 and Point 2, Point 1: Between Point 1 and Point 0
- Score for Depreciation Cost: Point 4 (a<7), Point 3 (a<9), Point 2 (a<11), Point 1 (a<13), Point 0 (a>13), Refer to Table-II-4.8.
- Score for O&M Cost: Point 4 (a<10), Point 3 (a<20), Point 2 (a<30), Point 1 (a<40), Point 0 (a>40), Refer to Table-II-4.8.
- Total Score = Score (1) + Score (2)
- Number in Total Evaluation means priority order in each system.
- In case of same score, priority is evaluated by water cost, Refer to Table-II-4.8.

(7) Proposed Plan of Public Water Supply System for Metropolitan Area

The proposed Plan of Public Water Supply System for Metropolitan Area is shown in Figure-II-4.6 to Figure-II-4.12.

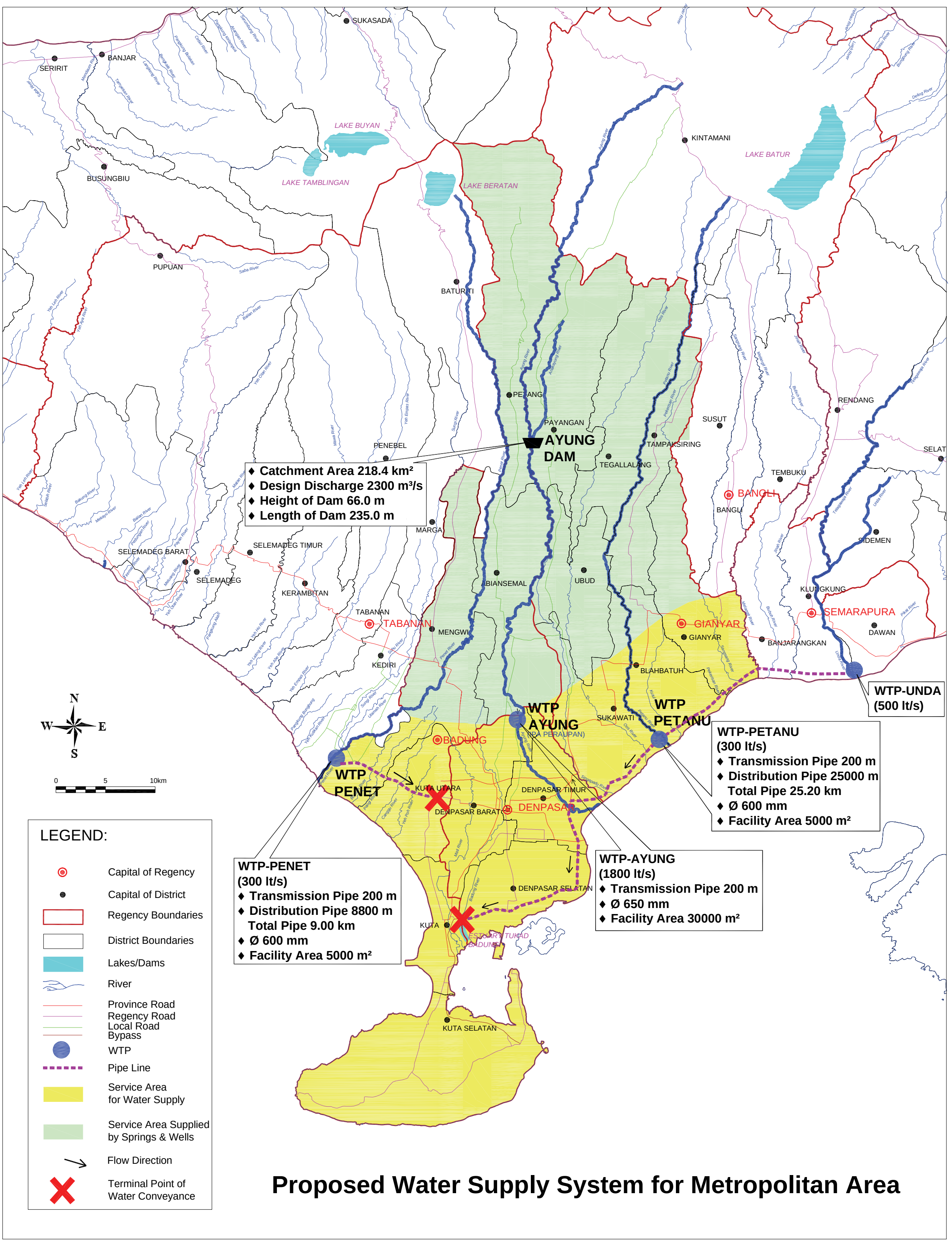


Figure-II-4.6 Proposed Integrated Water Supply System for Metropolitan Area

Main Points of Action for Denpasar-PDAM:

- ▲ Construction of Water Treatment – Waribang (Phase-2, 150lit/s): Existing Program
- ▲ No new deep well
- ▲ Buying Water (50lit/s) from Existing Water Treatment - Ayung1,2(PTTB owns)
- ▲ Introduction of Western W/S System (300lit/s) and return water (3@100 = 300lit/s) to Badung-PDAM after completion of Central W/S system
- ▲ Introduction of Central W/S System (3@500 = 1,500lit/s)

DENPASAR - PDAM	2005		2010		2015		2020		2025
Demand (lit/sec)	1,180		1,577		1,986		2,396		2,805
Capacity (lit/sec)	**1,115**		**1,615**		**2,015**		**2,415**		**2,815**
New Capacity (lit/sec)		500		400		400		400	
◆ Deep Well	315								
◆ Spring	0								
◆ WTP - Ayung3	550								
◆ WTP- Waribang1,2	150	150							
◆ From WTP - Ayung1,2	100	50							
◆ Western W/S System		300		(100)		(100)		(100)	
◆ Central W/S System				500		500		500	
Balance (lit/sec)	(65)		38		29		19		10

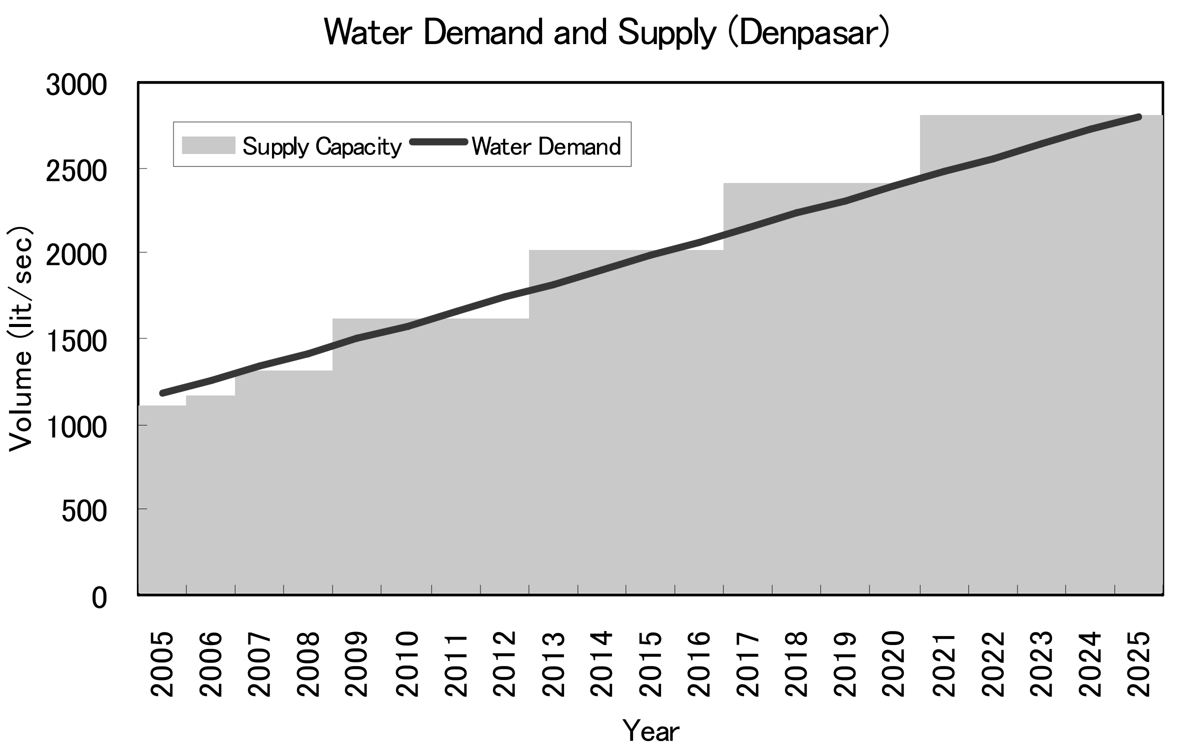


Figure-II-4.7 Water Supply Plan for Denpasar

Main Points of Action for Badung-PDAM:

- ▲ According to completion of Central P/W/S, introduce Western W/S system (3@100 = 300lit/s) (Return from Denpasar-PDAM) for the central parts of Badung regency
- ▲ According to increased demand, develop deep wells (90 + 3@20 =150lit/s) and/or springs (10 + 3@30 = 100 lit/s) for the northern parts of Badung regency

BADUNG-PDAM	2005		2010		2015		2020		2025
Demand (lit/sec)	273		399		549		700		851
Capacity (lit/sec)	296		396		546		696		846
New Capacity (lit/sec)		100		150		150		150	
◆ Deep Well	246	90		20		20		20	
◆ Spring	0	10		30		30		30	
◆ Tabanan-PDAM	50								
◆ Western W/S System				100		100		100	
Balance (lit/sec)	23		(3)		(3)		(4)		(5)

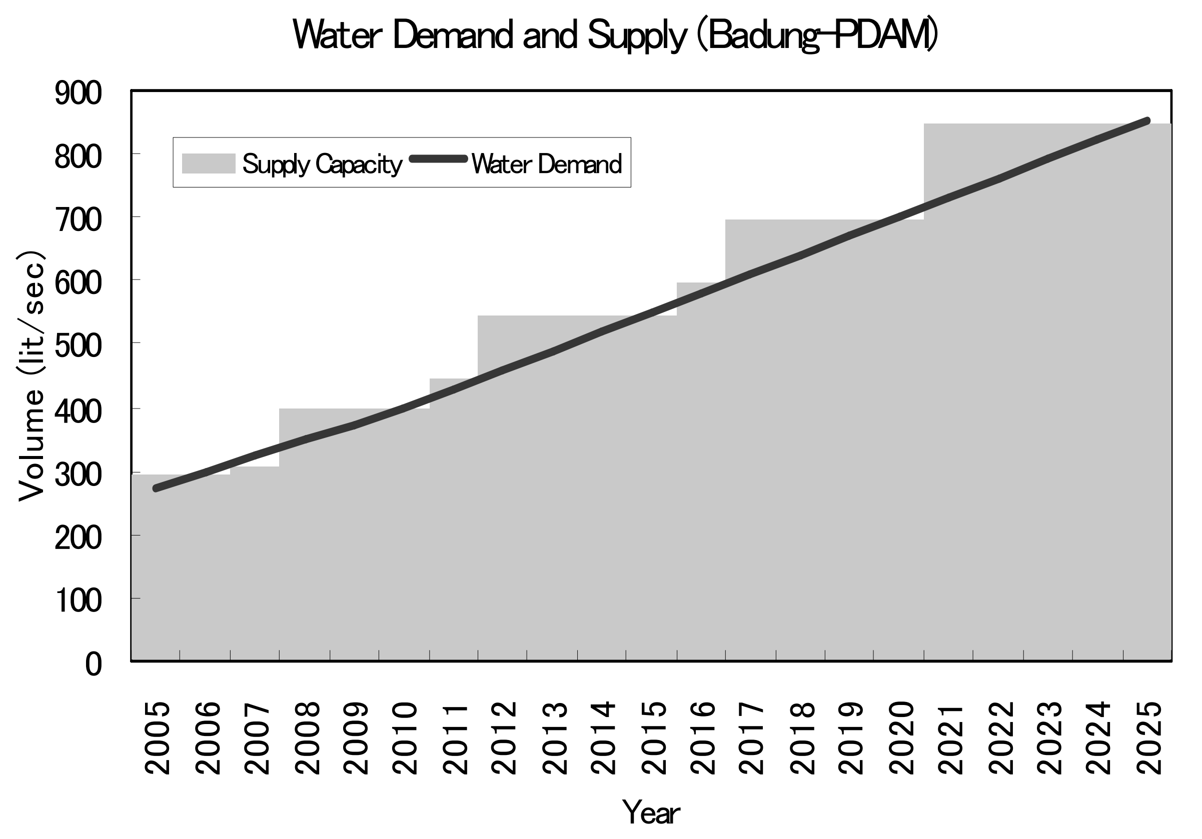


Figure-II-4.8 Water Supply Plan for Badung-PDAM

<u>Main Points of Action for Badung-PTTB:</u>

- ▲ Water supply from Existing Water Treatment - Ayung1,2(PTTB owns) to Denpasar-PDAM (Selling Water: 50lit/s)
- ▲ Introduction of Central W/S System (3@100 = 300lit/s) and Eastern W/S System (200 + 150 + 150 = 500lit/s) for the southern parts of Badung regency (Kuta area)

BADUNG-PTTB	2005		2010		2015		2020		2025
Demand (lit/sec)	444		604		849		1,094		1,338
Capacity (lit/sec)	**650**		600		900		1,150		1,400
New Capacity (lit/sec)		(50)		300		250		250	
◆ WTP - Ayung1,2	500	(50)							
◆ WTP - Estuary	250								
◆ Denpasar-PDAM	(100)								
◆ Central W/S System				100		100		100	
◆ Eastern W/S System				200		150		150	
Balance (lit/sec)	206		(4)		51		56		62

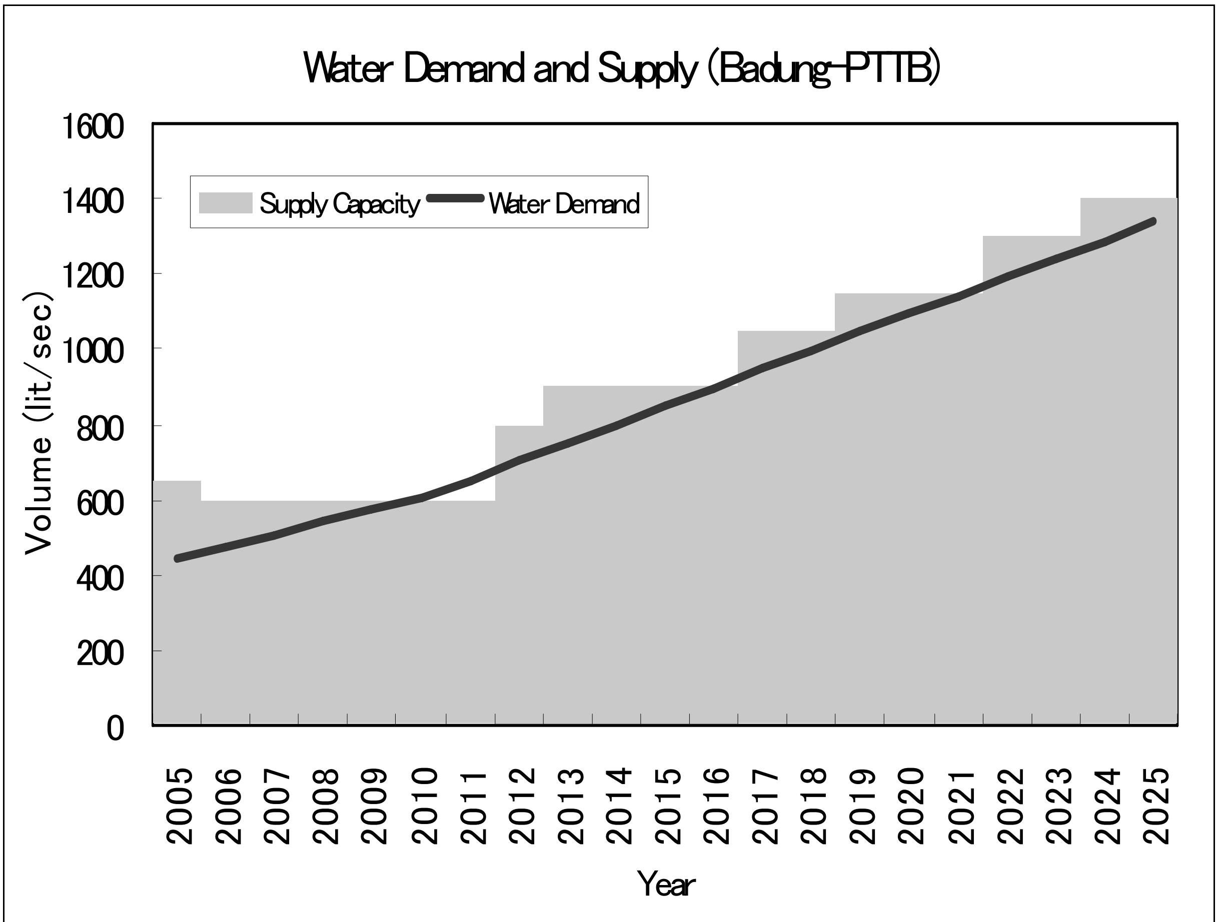


Figure-II-4.9 Water Supply Plan for Badung-PTTB

Main Points of Action for Gianyar-PDAM

▲ Water Supply for Southern Parts of Gianyar: Introduction of Eastern System (3@100 = 300 lit/s)
▲ Water Supply for Northern Parts of Gianyar: According to Demand, Develop Well (3@50 = 150 lit/s) and Spring (2@50 = 100 lit/s)

Gianyar - PDAM	2005		2010		2015		2020		2025
Water Demand (lit/s)	461		586		744		901		1,058
Supply Capacity (lit/s)	562		562		762		912		1,112
New Capacity (lit/s)		0		200		150		200	
◆ Deep Well	348			50		50		50	
◆ Spring	214			50				50	
◆ Eastern System				100		100		100	
Balance (lit/s)	101		(24)		18		11		54

Water Demand and Supply Plan for GianyarPDAM

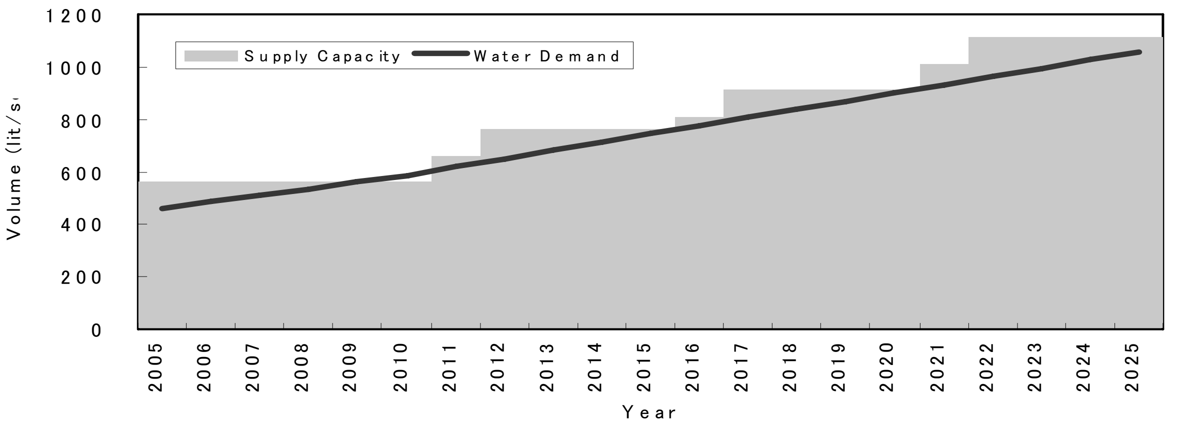


Figure-II- 4.10 Water Demand and Supply Plan for Gianyar

Main Points of Action for Tabanan-PDAM

▲ After completion of Telagatunjung DamProject, domestic water of 120 lit/s will be available.
▲ According to Demand, Develop Spring (Metaum Spring etc., 60 lit/s + 150 lit/s)

Tabanan - PDAM	2005		2010		2015		2020		2025
Water Demand (lit/s)	345		436		577		718		858
Supply Capacity (lit/s)	544								
New Capacity (lit/s)				120		60		150	
◆ Deep Well	5								
◆ Spring	458					60		150	
◆ Surface Wate	81								
◆ Telagatunjung Dam				120					
Balance (lit/s)	199								

Water Demand and Supply Plan for Tabanan PDAM

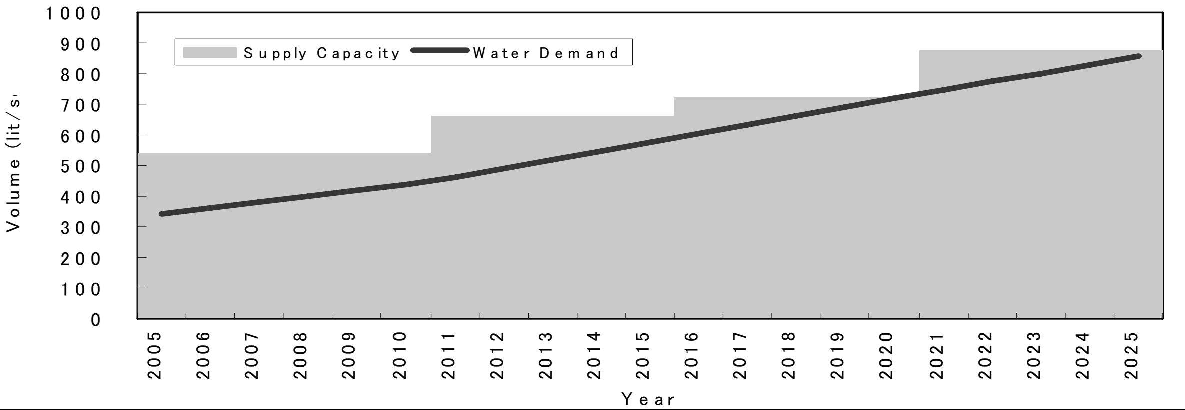


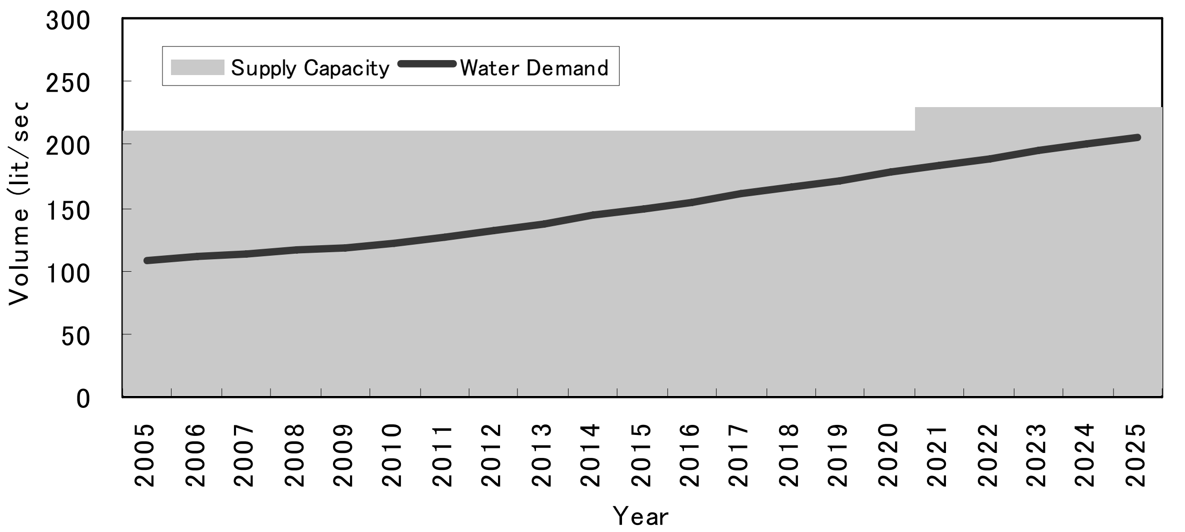
Figure-II-4.11 Water Demand and Supply Plan for Tabanan

Main Points of Action for Klungkung-PDAM

▲ According to Demand, Develop well and spring. Well is not recommendable at Penida Island.
▲ At Penida island, there are promising springs (Total capacity: 170 lit/s)

Klungkung - PDAM	2005		2010		2015		2020		2025
Klungkung (Bali)									
Water Demand (lit/s)	108		121		149		178		206
Supply Capacity (lit/s)	209		210		210		210		230
New Capacity (lit/s)		0		0		0		20	
◆ Deep Well	5							20	
◆ Spring	74								
◆ Surface Wate	130								
Balance (lit/s)	101		89		61		32		24
Klungkung (Penida)									
Water Demand (lit/s)	43		48		57		67		76
Supply Capacity (lit/s)	25		50		70		70		90
New Capacity (lit/s)		25		20				20	
◆ Deep Well	5								
◆ Spring	20	25		20				20	
Balance (lit/s)	-18		2		13		3		14

Water Demand and Supply Plan for Klungkung (Bali)



Water Demand and Supply Plan for Klungkung (Penida)

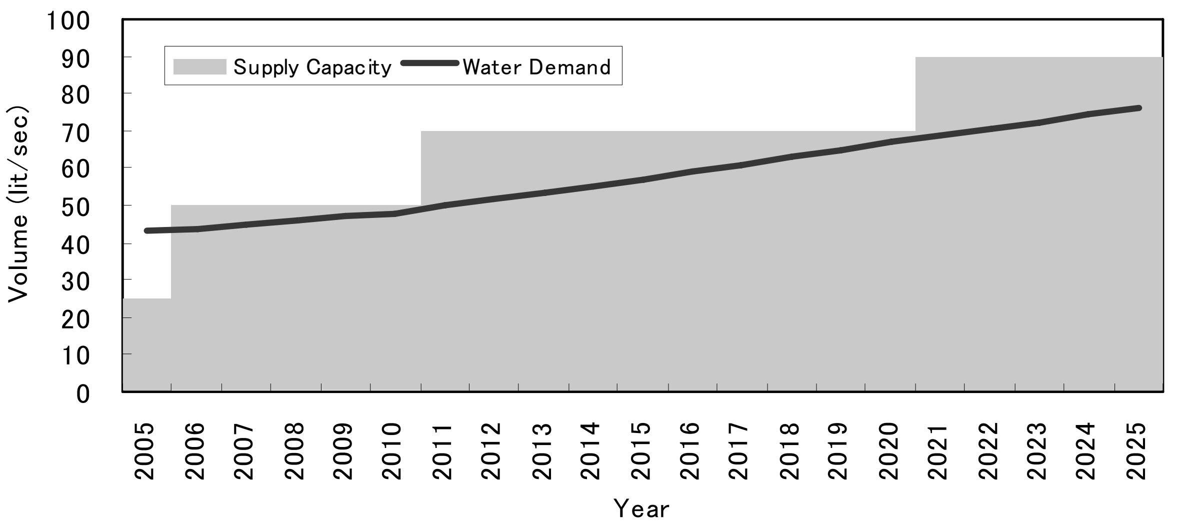


Figure-II-4.12 Water Demand and Supply Plan for Klungkung

(8) Review of Plans according to Water Demand Variation

As proposed in the Recommendation of Part-IV of the Main Report, the facility plans proposed in the Master Plan should be reviewed and modified or changed if necessary according to the change of socio-economic conditions including the water demand projections. For the public water supply plan targeting the metropolitan area, the water demand projection proposed in the Master Plan might be changeable. The alternative plan described below is tentative plan in case of lower water demand

As discussed in Chapter 2.2.5 of Part-II, in the lowest case of water demand for the metropolitan area, around 500 lit/s will be decreased than the projection done in the Master Plan. In this case the recommendable measure will be the cancel of the water supply system from Unda river (Refer to Table-II-4-10). Because the water cost of the Eastern System (Und a system) is higher than that of the Central System (Ayung system). It is another reason that the water is conveyed from the area outside of the consumer area. As discussed in Page II-3-6, "User's Territory and User' Basin" is basic requirement of water source.

Table-II-4.10 Public Water Supply System for the Metropolitan Area

Water Supply System	<Total>
＜Integrated System＞	*2,900 lit/s*
Western System	*300 lit/s*
- Intake at the mouth of Penut River (Pump Transport / Pump Distribution)	
Central System	*1,800 lit/s*
- Development by Ayung Dam (Gravity Transport / Gravity Distribution)	
Eastern System	*800 lit/s*
- Intake at the mouth of Petanu River (Pump Transport / Pump Distribution): Phase-1	*(300 lit/s)*
- Intake at the mouth of Petanu River (Pump Transport / Pump Distribution): Phase-2 &3	*(500 lit/s)*
＜Independent System＞	
Water supply to the areas near the water sources, by developing groundwater and spring water etc. according to the demand	*650 lit/s*
<Total>	*3,550 lit/s*

(shaded) : Facility to be cancelled in case of the lowest water demand

4.1.5 Water Supply Plan for Northern Bali Area

(1) Current Water Supply Capacity and Water Demand

The Current Water Supply Capacity and Water Demand are shown in Table-II-4.11.

Table-II-4.11 Water Supply Capacity and Water Demand in Northern Bali Area

Area	Water Supply Company	Items	2005	2010	2015	2020	2025
Northern Bali	(1) JembranaPDAM	Demand (lit/s)	152	184	254	324	395
		Capacity (lit/s)	139				
		Balance (lit/s)	-13	-45	-115	-185	-256
	(2) Buleleng PDAM	Demand (lit/s)	245	344	515	687	859
		Capacity (lit/s)	394				
		Balance (lit/s)	149	50	-121	-293	-465
	(3) Bangli PDAM	Demand (lit/s)	89	123	180	232	287
		Capacity (lit/s)	120				
		Balance (lit/s)	31	-3	-60	-112	-167
	(4) Karangasem PDAM	Demand (lit/s)	166	236	333	430	526
		Capacity (lit/s)	224				
		Balance (lit/s)	58	-12	-109	-206	-302
	Total [1+2+3+4]	Demand (lit/s)	652	887	1,282	1,673	2,067
		Capacity (lit/s)		235	395	391	394
		Balance (lit/s)	877				
		Demand (lit/s)	225	-10	-405	-795	-1,190

(2) Water Source

As the consumer areas are relatively distributed and demands are relatively small, spring water and groundwater are suitable for water sources in these areas. Water sources shall be developed at the upstream locations from consumer area to distribute water by gravity. As the Multipurpose Benel Dam project is already registered in the National Development Program and the preparation has started, the project plan prepared by the Bali Government is entered into the Master Plan. The current use and potential of spring and groundwater are shown in Table-II-4.12. In these areas, spring water and groundwater are well utilized. However, few spring water is used in Jembrana and few groundwater is used in Bangli.

Table-II-4.12 Spring/Groundwater Use and Potential (Northern Bali Area)

Items / Regency	Spring (lit/s)			Groundwater (lit/s)		
	Potential	Current Use	Remaining	Potential	Current Use	Remaining
Jembrana	119	3	116	1,126	581	545
Buleleng	6,173	2,934	3,239	2,093	411	1,682
Bangli	3,393	692	2,701	1,551	9	1,542
Karangasem	9,956	4,533	5,423	2,090	206	1,884
Total	19,641	8,162	11,479	6,860	1,207	5,656

(3) Proposed Water Supply Plan in Northern Bali Area

The outline of the propose water supply plan by regency is shown I Table-II-4.13. Refer to Figure-II-4.13 – Figure-II-4.16.

Table-II-4.13 Outline of Water Supply Plans for Northern Bali Area

Items / Regency	Current Capacity（lit/s）	Extention Capacity（lit/s）	Water Source（lit/s）			Explanation
			Surface Water	Ground Water	Spring Water	
Jembrana	139	260	160	100		Benel Dama (2@50lit/s) and Well (2@50lit/s)
Buleleng	394	450		150	300	Well (3@50lit/s)＋Spring (3@100lit/s)
Bangli	120	170			170	Spring (20lit/s + 3@50lit/s)
Karangasem	224	320		20	300	Well (20lit/s)＋Spring (3@100lit/s)
Total	877	1,200	160	270	770	

Main Points of Action for Jembrana-PDAM

▲ Benel Dam Project：Surface Water Development (60 lit/s for Water Supply)

▲ According to demand, develop deep wells (50 lit/s +100 lit/s + 50 lit/s = 200 lit/s)

Jembrana PDAM	2005		2010		2015		2020		2025
Water Demand (lit/s)	152		184		254		324		395
Supply Capacity (lit/s)	139		189		269		349		399
New Capacity (lit/s)		50		80		80		50	
◆ Deep Well	139	50				100		50	
◆ Spring									
◆ Benel Dam Project				60					
Balance (lit/s)	-13		5		15			25	4

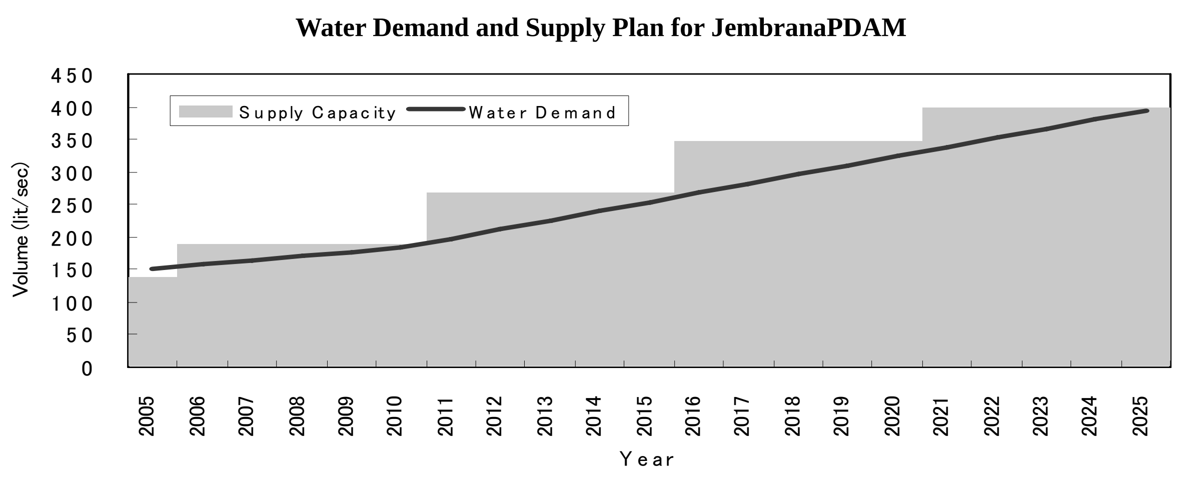


Figure-II-4.13 Water Demand and Supply Plan for Jembrana

<u>Main Points of Action for Buleleng-PDAM</u>

▲ According to demand, develop deep wells (3@50 lit/s=150 lit/s + 3@100= 300 lit/s)

Buleleng-PDAM	2005		2010		2015		2020		2025
Water Demand (lit/s)	245		344		515		687		859
Supply Capacity (lit/s)	394		394		544		744		944
New Capacity (lit/s)		0		150					
◆ Deep Well	82			50		50		50	
◆ Spring	319			100		100		100	
◆ SurfaceWater									
Balance (lit/s)	149		50		29		57		85

Water Demand and Supply Plan for Buleleng PDAM

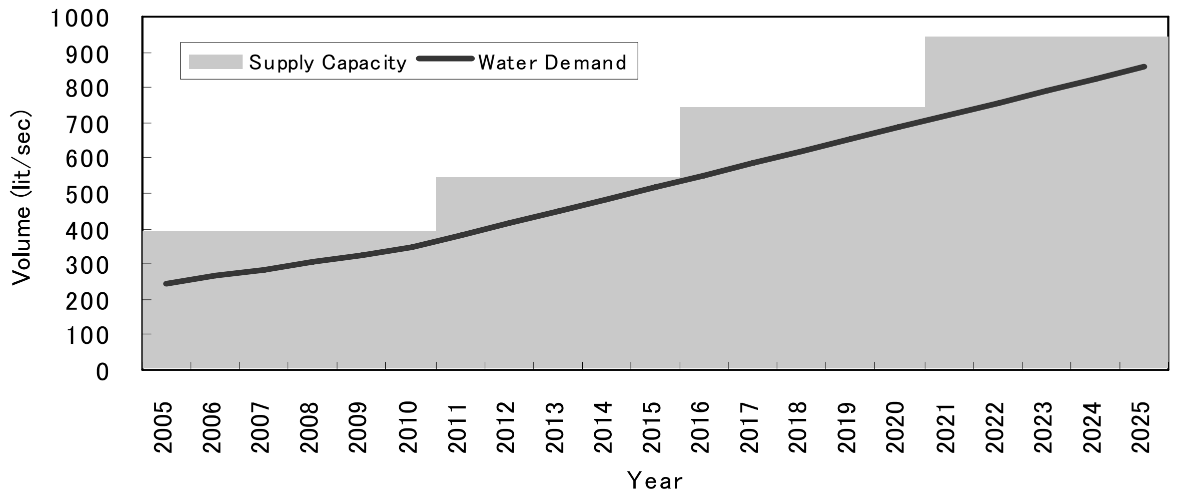


Figure-II-4.14 Water Demand and Supply Plan for Buleleng

<u>Main Points of Action for Bangli-PDAM</u>

▲ According to demand, develop spring (20 lit/s +3@50 lit/s=150 lit/s)

Bangli PDAM	2005		2010		2015		2020		2025
Water Demand (lit/s)	89		123		180		232		287
Supply Capacity (lit/s)	120		140		190		240		290
New Capacity (lit/s)		20		50		50		50	
◆ Deep Well									
◆ Spring	120	20		50		50		50	
◆ SurfaceWater									
Balance (lit/s)	31		17		10		8		3

Water Demand and Supply Plan for Buleleng PDAM

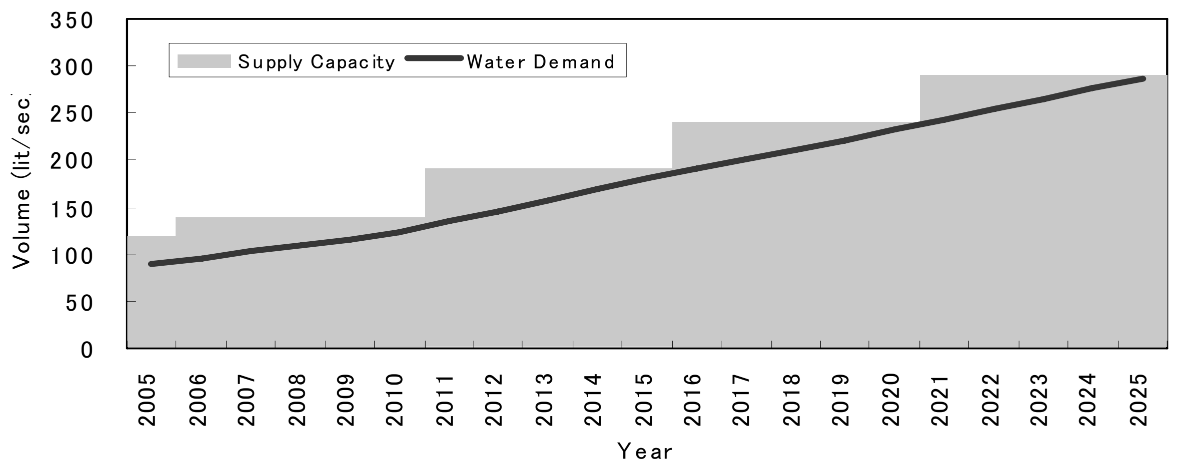


Figure-II-4.15 Water Demand and Supply Plan for Bangli

<u>Main Points of Action for Kalangasem-PDAM</u>

▲ According to demand, develop spring (3@50 lit/s=150 lit/s) and well (20 lit/s)

kalangasemi PDAM	2005		2010		2015		2020		2025
Water Demand (lit/s)	166		236		333		430		526
Supply Capacity (lit/s)	224		244		344		444		544
New Capacity (lit/s)		20		100		100		100	
◆ Deep Well	69	20							
◆ Spring	155			100		100		100	
◆ SurfaceWater									
Balance (lit/s)	58		8		11		14		18

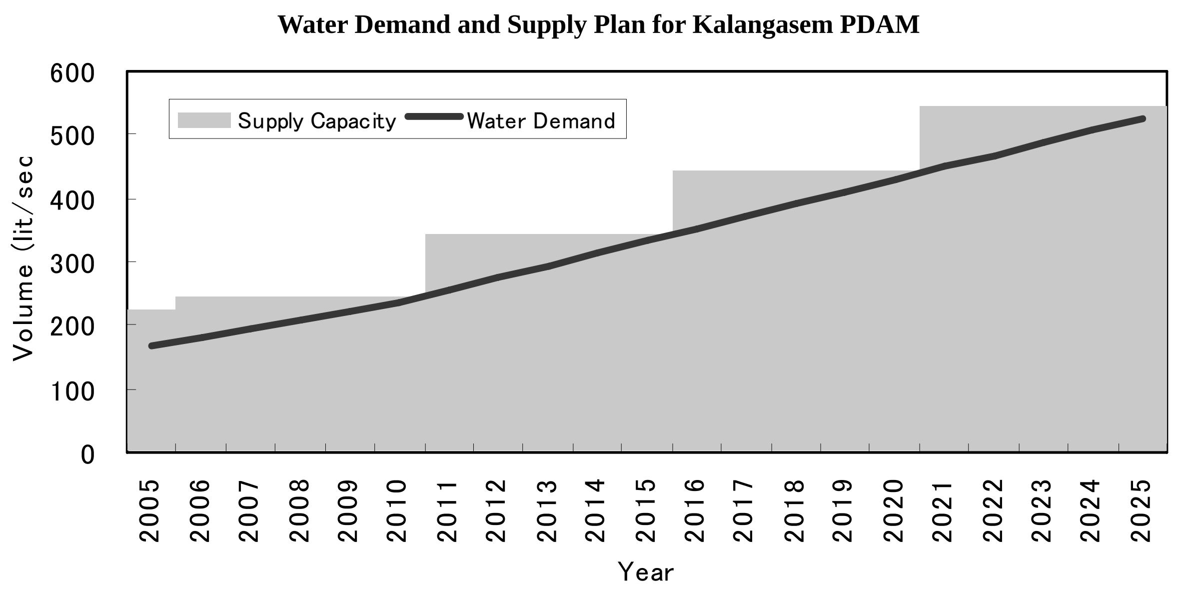


Figure-II-4.16 Water Demand and Supply Plan for Buleleng PDAM

4.1.6 Water Supply for Isolated Areas

Generally, people in urban areas and rural areas are receiving water supply service through water distribution network. However, some people in remote and isolate areas can not receive this service through the public water supply system. In these cases, organization responsible for public water supply has to examine the method and to distribute domestic water to those who are waiting service and living in the remote and isolated areas.

In Bali Province there are two typical areas as shown in Table-II-4.14. Namely, the areas are 1) Northeaster Bali (Karangasem) and 2) Nusa Penida (Klungkung). In these areas the public water sources are located at the limited and people are suffering from water shortage during dry seasons.

Table-II-4.14 Isolated Areas Suffering from Water Shortage

Area	Regency	Sub-District	Villages being Suffered from Water Shortage
1. Northeastern Bali	Karangasem	Kubu	8 villages out of 9 villages
2. Nusa Penida	Klungkung	Nusapenida	9 villages out of 16 villages

(1) Northeaster Bali (Karangasem)

Water sources and volumes in the area are limited. There is no perennial river in the areas. There are few springs in number and the yields of springs are small and limited. Groundwater table is very deep in the high altitude area. Main water sources are production wells located in the coastal areas. Townships are distributed along the coastal line. These conditions explained above are caused by the hydro-geological and topographical features of the area. New village users in the mountain slopes (far from water source near coastal area) are waiting public water supply not to be suffered from water shortage in dry season. Usually those people are using spring water with small capacities. To reply the people's request, PDAM has to take action.

Only one village (Desa Baturinggit) out of nine villages at Kubu Sub-District obtains water supply from the public water supply system (PDAM). The communities of Tianyar Barat, Tianyar Tengah and Tianyar Timur in this village are served by deep pump well from Proyek Air Tanah Bali dan Masyarakat Ekonomi-Eropa (MEE). Currently, in Kubu Sub-District, only 1.096 household or 10 % of overall population are receiving water from PDAM. Around 40,000 populations in Kubu Sub-District are not served by the public water supply system.

There are some small discharge spring which still can serve several group of household, but most of community in this area consumed rain water from traditional water tank (CUBANG) for water reserve at dry season. Also they buy clean water from mobile water tank which distribute to community. Water sources at 9 villages in Kubu Sub-District for domestic use are shown in Table-II-4.15

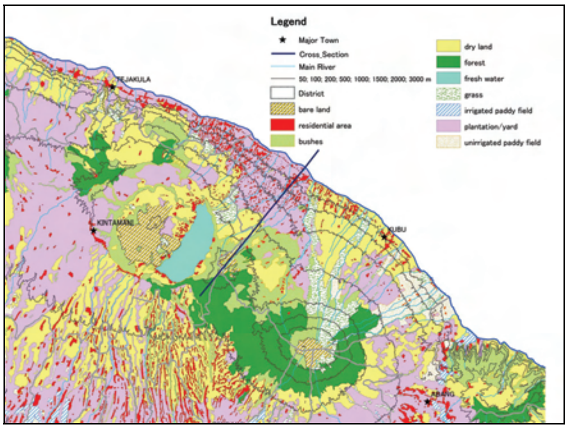
Table-II-4.15 Water Sources for Domestic Use in Kubu Sub-District

Water Sources	PDAM	Well	Spring	Rain water	Buying	Total
Number of Villages	1	3	1	7	8	20
Percentage	11%	33%	11%	78%	89%	222

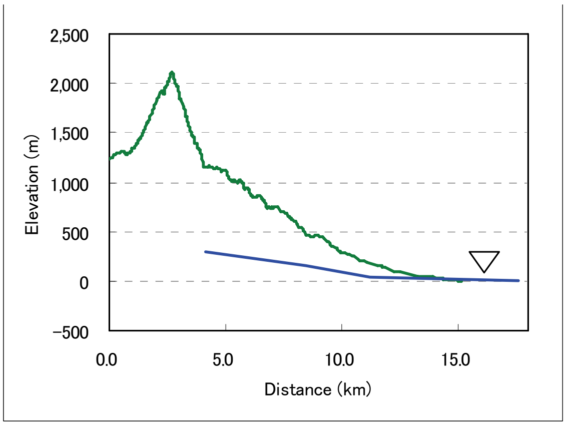
Sources: BPS Bali Province, 2005

From the above table it can be seen that the plural water sources are utilized for domestic use in these communities. The problem is happened on the dry season which starts from July to October, the water reserves are inadequate for cooking, drinking, bathing, washing, toilet as well as cattle need.

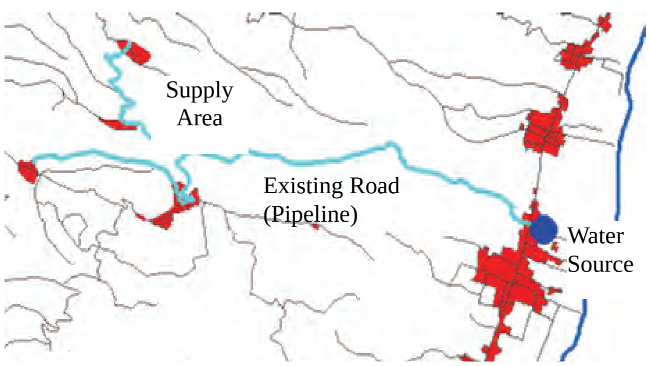
To cope with this situation in the areas, PDAM or responsible governmental agencies have to take appropriate measures such as 1) Expansion of existing network and 2) Water delivery by Water-Tank-Car. See Figure-II-4.17.



KUBU Area - Kalangasem



Cross-Section of Kubu Area



<Water Supply for Remote & Isolated Area>

- Water Source (Groundwater) is located at the coastal areas
- New users are in the mountain slopes。
- Distribution methods
  - Distribution by pipelines
  - Distribution by water tank cars

Figure-II-4.17 Water Supply Plan for Kubu Area

(2) Nusa Penida (Klungkung)

The service areas for water supply in Nusa Penida are located in the relatively high land. The main water sources are springs. It is confirmed that the total capacity of these springs is more than 500 lit/s. Refer to Table-II-4.14 However, almost springs discharge at the foot of the cliff. Some high potential springs have been developed. Which are Penida, Guyangan and Seganing. To expand the water supply service, spring water has to be pumped up to the reservoir in the high land. Refer to Table-II-4.16.

Table-II-4.16 Potential Springs in Nusa Penida

No	Spring	Discharge (lit./s)	Elevation (m)	Explanation
1	Angkel	1	+1	
2	Wates	1	+41	
3	Sekartaji	1	+19	
4	Tambuanan	38	+16	
5	Guyangan	180	+13	Under Development
6	Batumadeg	26	+19	
7	Seganing	79	+13	Under Development
8	Penida	200	+2	Under Operation
	<Toral>	**526**		

Source: Bali Water Resources Development and Management Project 2003

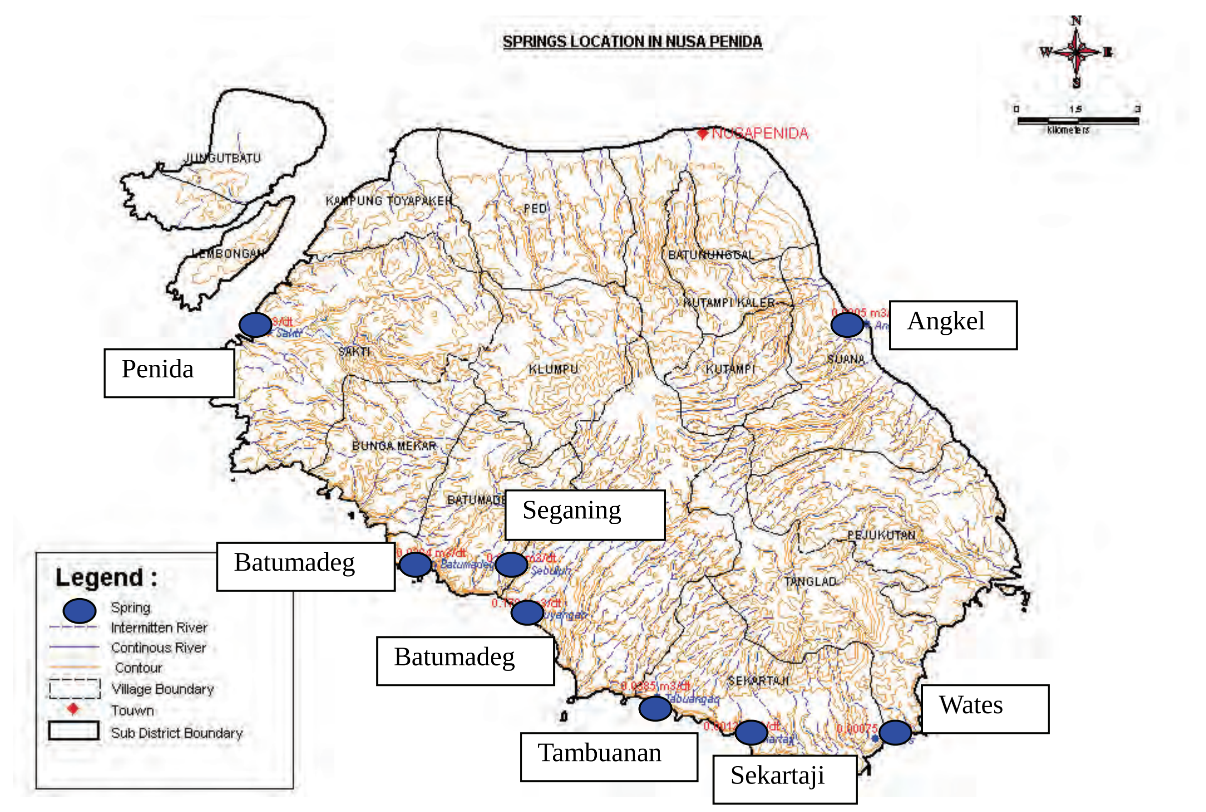


Figure-II-4.18 Water Supply Plan for Nusa Penida

The current service of water supply for the communities in Nusa Penida is as shown in Table-II-4.17

Table-II-4.17 Potential Springs in Nusa Penida

Water Resource	PDAM	Well	Spring	River	Rain Water	Total
Household	778	2.625	-	-	4.712	8.115
Percentage	10%	32%	-	-	58%	100%

Source: BPS Bali Province, 2005

As seen from the above table, around 28,000 people (58% of total population 48,000) depend still on the rainfall. These people belong to the villages, namely Sakti, Bunga Mekar, Batu Madeg, Klumpu, Batukandik, Sekartaji, Tanglad, Pejukutan and Kutampi. The annual average rainfall in Nusa Penida reaches 1,094 mm/year (Sampalan Station) with its distribution from November to April. The access difficulties toward the water supply are mostly on September up to November before the rainy season.

The plans of water resources development in this area include: 1) Piped Water Supply System using the springs of Guyangan and Penida, 2) Development of Conservation Check Dam to increase intake water volume from river and 3) Construction of New Water Tanks.

4.2 Irrigation Plan

4.2.1 Alternative Plans for Water Supply

<Issues Associated with Present Irrigation System>

Although the paddy culture in Bali has already achieved high crop intensities and high productivity with intensive and extensive irrigation, there are still some issues as summarized below. These issues need to be mitigated for the future irrigation.

Irrigation Efficiency

The excess use of water resources should be mitigated by improving the irrigation efficiency so that the residual water can be utilized to increase productivity/production of crops. 14 % of irrigation area (paddy field) equipped with primitive irrigation facilities are the first priority for an improvement of irrigation efficiency.

Volume Control of Intake Discharge

Technical irrigation schemes, which measure and regulate the intake discharge, cover only 32 % of the irrigation area in Bali. Therefore, the volume of water cannot be controlled in the rest of irrigation schemes, 68 % of the irrigation area. Considering effective and efficient water use, the irrigation schemes require to be upgraded to the technical irrigation system so as to control the volume of water, particularly the irrigation system in Tabanan Regency, where the technical irrigation system is rare despite its superiority of paddy irrigation.

Unit of Irrigation Water

Subak uses the flow area (tektek) for allocation and distribution of water, instead of discharge. This unit of irrigation water makes hard to optimize the water use with other sectors and introduce the concept of water right. As the water balance between demand and supply is already tight, particularly in urban areas, a common sense to measure water by discharge needs to be understood by Subak with detailed technical assessment of exact irrigation water requirement and promotion through public consultation meetings.

Irrigation Management

Subak is a model of the water users association in terms of O/M of irrigation facilities and water allocation. However, the optimization of water use among all water sectors requires more precise volume control of water because the tight water balance between demand and supply is anticipated.

For the precise volume control, it is necessary to identify the location and area of irrigation schemes with a network from intake to drainage, discharges from an intake to field inlets, volumes of drained water/return flow and so on. However, the availability of those data is very limited. Public Works Service of Bali Province is recently conducting a study for identification of irrigation schemes by regency. This study is expected to cover the whole Bali Province and target to identify the above factors in details.

Decrease in Paddy Field

The recent decreasing tendency of paddy field needs to be mitigated and controlled because the paddy field benefits not only self-sufficiency of staple food (paddy) but also many factors, such as flood control, groundwater recharge, stabilization of river flow, water quality control, eco-system and tourism. Besides, the paddy culture is associated with tradition and religion through Subak. Thus, the rapid decrease in the paddy field will affect the Balinese culture and tradition.

<Strategy for Future Irrigation>

Based on the two agricultural plans (the spatial plan and RENSTRA) and present issues regarding irrigation, the following is the strategy for the future irrigation development in Bali.

- Bali Barat National Park (BBNP) or Taman Nasional Bali Barat located in the western region of Bali including the coastal marine areas around Gilimanuk Bay and Menjangan Island and hence incorporates coastal mangrove vegetation and coral reefs as well

- Considering the importance of paddy in Bali, the decreasing tendency of paddy field needs to be mitigated and the mitigation will probably follow the rates below.

Period	Provincial Average of Decreasing Rates
2003 – 2005:	Transition period from 1.01 % to 0.45 % (RENSTRA target)
2005 – 2015:	Decreasing rate of 0.45 %
2015 – 2025:	Decreasing rate of 0.23 %

- The large surface water development, such as dam, will not be applied just for irrigation schemes because of rare feasibility in terms of cost vs. benefit. However, if the surface water development targets the multiple functions, including irrigation, it might be economically feasible and will contribute to increase in crop intensities.
- The potential area for a new irrigation scheme is very limited in terms of availability of arable land and water resources. Thus, new irrigation schemes for fruit culture and horticulture by groundwater development will be promoted but at limited scale in terms of area and volume of water consumed.
- Crop diversification will progress and selection of crop culture will be market oriented. Since the crop diversification will extend in the dry land and paddy field during the dry season by the rain-fed culture, the significance of paddy culture with irrigation will be maintained.
- Potential arable dry land will be utilized for palawija/horticulture/fruit culture but application of irrigation will be limited.
- Rehabilitation works of irrigation facilities will be applied continuously to improve irrigation efficiency, resulting in mitigation of water loss, improvement of crop intensities and improvement of O/M of irrigation facilities. The target to improve irrigation efficiency for wetland paddy is from 50% (present) to 60%.

4.2.2 Evaluation of Alternative Irrigation Plans for Water Supply

As shown in Table-II-4.18, the residual water in the year of 2025 amounts to approximately 387 million m^3 because of improvement in irrigation efficiency and area decrease in paddy field. Improvement in irrigation efficiency and area decrease in paddy field contribute to 247 million m^3 and 140 million m^3 reduction of irrigation water respectively. Besides, 10% increase in irrigation efficiency (from 50% to 60%) save 17% of water compared to the irrigation water requirement in 2025 with 50% efficiency.

With this residual water, the crop intensities of paddy will be improved from one paddy cropping to two paddy cropping followed by other crops (palawija/vegetables). Although the cropping pattern is a function of not only available water but also other factors such as soil properties, topographic characteristics, agro-business and so on, an improvement of crop intensities was examined in terms of water resources because a main concern of the Study is the water resources development. Assumptions and conditions made for assessment of residual water effect on increase in crop intensities of paddy are as follows.

- An increase in crop intensities considers only paddy because maximization of paddy production is the government policy and paddy culture dominates irrigation in Bali.
- Two paddy cropping followed by palawija/vegetables is the target cropping pattern by using the residual water. As a result, the crop intensities including paddy and other crops will be 300%.

Table-II-4.18 Effect of Irrigation Efficiency Improvement & Paddy Area Decrease

Unit: million m^3

No.	Regency	Residual Water by Paddy Area Decrease = Q2003 – Q2025	Irrigation Water Demand in 2025		Residual Water by IEI = 1) – 2)
			1) 50% Irrigation Efficiency	2) 60% Irrigation Efficiency	
01	Jembrana	16.60	66.37	55.31	11.06
02	Tabanan	35.86	440.83	367.44	73.39
03	Badung	46.20	246.41	205.37	41.04
04	Gianyar	10.04	258.03	215.08	42.95
05	Klungkung	2.44	54.59	45.45	9.14
06	Bangli	0.00	55.43	46.17	9.26
07	Karangasem	4.68	78.82	65.78	13.04
08	Buleleng	14.05	246.18	205.07	41.11
71	Denpasar	9.71	38.39	32.04	6.35
Total		139.58	1,485.05	1,237.71	247.34

Q2003: Irrigation Water Demand in 2003, Q2025: Irrigation Water Demand in 2025, IEI: Irrigation Efficiency Improvement

Table-II-4.19 shows the target area of crop intensity improvement for paddy. Since twice or three times paddy culture is dominant in Tabanan (famous as rice storage), Badung, Gianyar and Bangli regencies, the target area is less than 12% of total paddy area in regency.

Table-II-4.19 Target Area for Crop Intensity Improvement

No.	Regency	Paddy Area In 2003 (ha)	Ratio of Area less than 2 Paddy Cropping	Target Area to be improved (ha)	Cropping Pattern To be improved
01	Jembrana	7,013	0.647	4,537	A
02	Tabanan	22,639	0.085	1,924	A
03	Badung	10,334	0.033	341	A
04	Gianyar	14,937	0.113	1,688	A
05	Klungkung	3,932	0.462	1,817	A
06	Bangli	2,888	0.111	321	A
07	Karangasem	7,034	0.550	3,869	B
08	Buleleng	11,011	0.232	2,555	B
71	Denpasar	2,856	0.385	1,100	A
	Total	82,644		18,152	

Less than 2 paddy cropping: 1 paddy followed by palawija/vegetables/fallow
A: 1 Paddy (Nov.-Feb.) + 2 Paddy (Mar.-Jun.) + Other Crops without Irrigation
B: 1 Paddy (Dec.-Mar.) + 2 Paddy (Apr.-Jul.) + Other Crops without Irrigation

(1) Alternative 1 (without Storage Facilities of Residual Water)

Since one paddy cropping is practiced in the most of area, the residual water is used for the second paddy starting from March or April depending on regency. The residual water during the cropping season of second paddy is applicable to increase the crop intensities of paddy. On the other hand, the residual water in the rest of season is not useful because of no storage facilities of water. Thus, the residual water during the second paddy season divided by the irrigation water requirement of second paddy is area increase of two paddy cropping. The result is summarized in Table-II-4.20.

With the Alternative 1 Plan, the target areas in Tabanan, Badung, Gianyar and Bangli regencies would be improved. As a result, crop intensities of paddy in those regencies would be more than 200% because 3 paddy cropping is also practiced. Although the residual water is enough to improve 10,800 ha, the improvement of crop intensities cannot reach to the maximum without an inter-region conveyance system to transfer the excess water from one region to another. In fact, the crop intensities in only 7,274 ha would be improved and the excess water would drain to the downstream.

Since the Alternative 1 Plan is the result of rehabilitation works of irrigation facilities and area decrease in paddy field, the crop intensities of paddy can be improved from one paddy cropping to two paddy cropping without any water resources development. Besides, paddy area to be improved by this plan (7,274 ha) equivalent to 10% of the paddy area in 2025 (75,619 ha) is significant. Therefore, the Alternative 1 Plan is considered effective and feasible.

(2) Alternative 2 (with Storage Facilities of Residual Water)

An idea of the Alternative 2 Plan is to store the residual water in the rest of second paddy season. The residual water stored is used to increase paddy culture. For the estimate of paddy area to be improved, the residual water stored was divided by the total irrigation water requirement for the second paddy ranging at 0.009 – 0.014 million m3/ha.

The result is summarized in Table-II-4.20. With the Alternative 2 Plan, 200% crop intensities of paddy would be achieved in Buleleng and Denpasar regencies. 200% crop intensities of paddy could cover all regencies if the stored residual water was shared by all regencies; however, it is not feasible considering the cost for storage facilities and inter-region water conveyance.

Table-II-4.20 Effect of Alternative Plans on Increase in Crop Intensities

No.	Regency	Target Area to be improved (ha)	Potential Area to be improved by Alternative 1 (ha)	Potential Area to be improved by Alternative 2 (ha)	Plan to achieve 200% crop intensities of paddy
01	Jembrana	4,537	***300***	2,300	none
02	Tabanan	***1,924***	3,700	10,900	Alternative 1
03	Badung	***341***	1,600	7,900	Alternative 1
04	Gianyar	***1,688***	2,000	5,900	Alternative 1
05	Klungkung	1,817	***400***	1,200	none
06	Bangli	***321***	500	1,000	Alternative 1
07	Karangasem	3,869	***500***	1,400	none
08	Buleleng	2,555	***1,600***	3,900	Alternative 2
71	Denpasar	1,100	***200***	1,200	Alternative 2
	Total	18,152	10,800	35,700	

Total of Italics: Area to be improved by the Alternative 1 without inter-region conveyance system of water. 7,274ha.

The Alternative 2 Plan requires the development of storage facilities. The large storage facilities are not economically feasible as long as their purpose is irrigation. Instead, small farm ponds should be applied to use as much residual water as possible. Since the scale and location of farm ponds can be adjusted in accordance with the economic and technical evaluation, its feasibility is considered high despite the fact that development of small farm ponds would not be sufficient to store all residual water.]

4.2.3 Proposed Plans for Water Supply

Based on evaluation of two alternative plans, proposed plans for water supply are summarized as follows. Proposed plans are basically applicable to the whole Bali but particularly areas that require the Alternative 2 Plan for improvement of crop intensities as shown in Figure-II-4.19. Those areas extend in Buleleng, Karangasem, Klungkung, Denpasar and Jembrana;

- ◆ Small farm ponds would not have sufficient capacity to store all residual water but they are useful for maximum use of residual water and drought countermeasures. Thus, small farm ponds should be promoted.
- ◆ Crop diversification might require the irrigation system for fruit culture ad horticulture on the dry land. In this case, the residual water is the first priority to be used.
- ◆ The surface water development just for irrigation is not economically feasible. Therefore, the surface water development with multiple purposes including irrigation should be considered for improvement of crop intensities and drought countermeasures.
- ◆ The groundwater development is applicable to extend new irrigation schemes for fruit/vegetables culture. But the area of new irrigation schemes is limited because the most of arable land has been already used.
- ◆ For the poverty alleviation, mitigation of economic disparity in region and rural development, irrigation is effective but requires a subsidy. Since those purposes are subject to social matters, they cannot be examined by economic aspects. Thus, irrigation is promoted by the water resources development for those purposes.