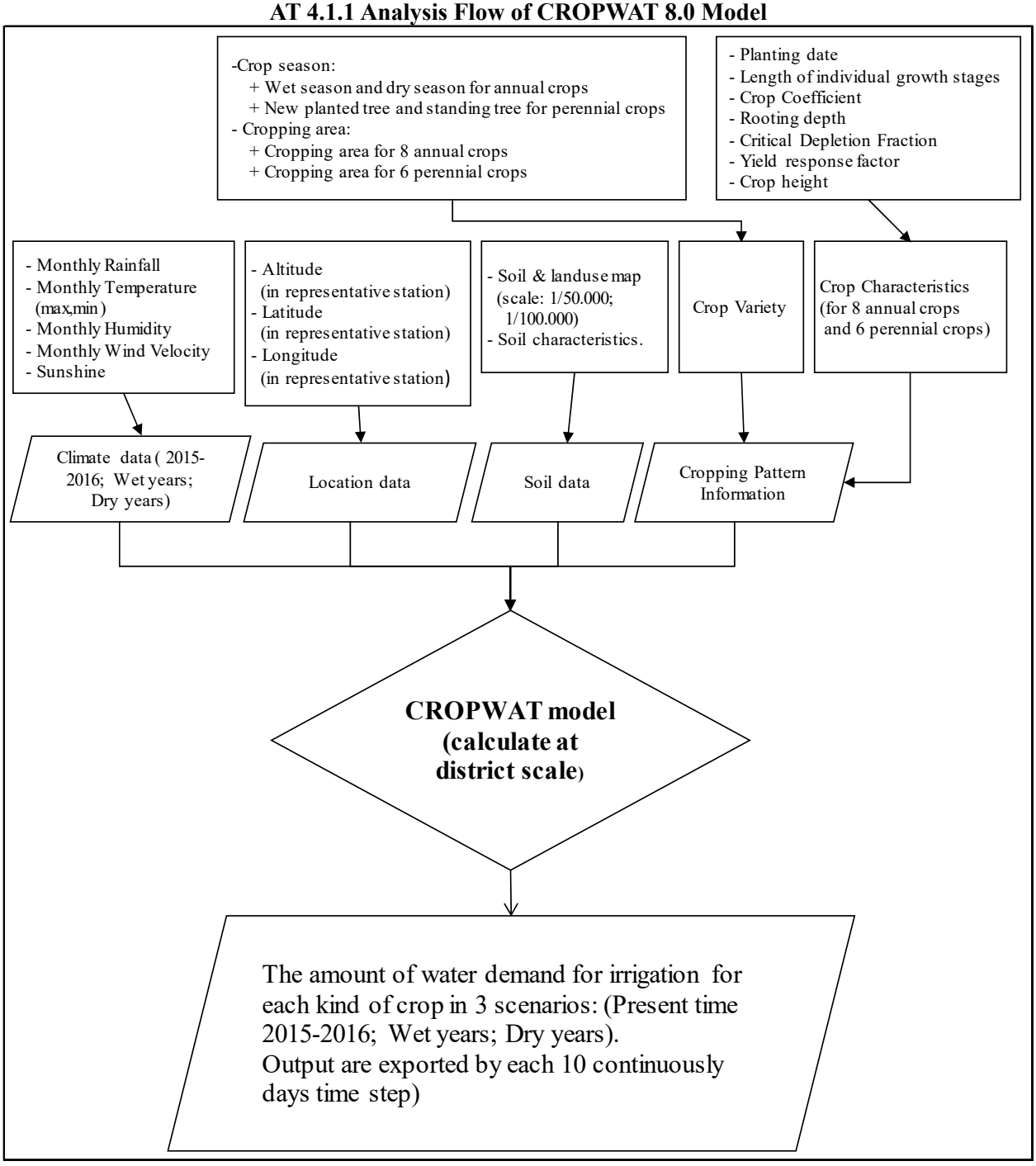
AT 4.1.1 Analysis Flow of CROPWAT 8.0 Model



Source: Prepared by JICA Survey Team based on the Decrees mentioned in the table.

AT 4.1.2 Soil Characteristic

No	Soil Type	Soil Characteristic			
		Total available soil moisture (mm/meter)	Maximum rain infiltration rate (mm/day)	Initial soil moisture depletion (%)	Initial available soil moisture (mm/meter)
1	Red Loamy Soil	180	30	0	180
2	Gray Loamy Soil	160	40	0	160
3	Eroded Gray Soil	100	40	0	100

Source: baotangdat.blogspot.com

AT 4.1.3 Soil Type Distribution per District Scale

No.	Province/ District	Soil Type	No.	Province/ District	Soil Type
Dak Lak Province			**Kon Tum Province**		
1	Buon Ma Thuot City	Red Loamy Soil	1	Kon Tum City	Gray Loamy Soil
2	Ea H'leo	Gray Loamy Soil	2	Dak Glei	Gray Loamy Soil
3	Ea Sup	Gray Loamy Soil	3	Ngoc Hoi	Gray Loamy Soil
4	Krong Nang	Gray Loamy Soil	4	Dak To	Gray Loamy Soil
5	Krong Buk	Red Loamy Soil	5	Kon Plong	Gray Loamy Soil
6	Buon Don	Gray Loamy Soil	6	Kon Ray	Gray Loamy Soil
7	Cu M'Gar	Red Loamy Soil	7	Dak Ha	Gray Loamy Soil
8	Ea Kar	Gray Loamy Soil	8	Sa Thay	Gray Loamy Soil
9	M' Drak	Gray Loamy Soil	9	Tu Mo Rong	Gray Loamy Soil
10	Krong Pak	Red Loamy Soil	10	La H'Drai	Gray Loamy Soil
11	Krong Bong	Gray Loamy Soil	**Dak Nong Province**		
12	Krong Ana	Gray Loamy Soil	1	Gia Nghia	Red Loamy Soil
13	Lak	Gray Loamy Soil	2	Dak G'long	Gray Loamy Soil
14	Cu Kuin	Red Loamy Soil	3	Cu Jut	Gray Loamy Soil
15	Buon Ho	Red Loamy Soil	4	Dak Mil	Red Loamy Soil
Gia Lai Province			5	Krong No	Gray Loamy Soil
1	Pleiku City	Red Loamy Soil	6	Dak Song	Red Loamy Soil
2	An Khe	Gray Loamy Soil	7	Dak R'lap	Red Loamy Soil
3	Ayun Pa	Eroded Gray Soil	8	Tuy Duc	Red Loamy Soil
4	Kbang	Gray Loamy Soil	**Lam Dong Province**		
5	Dak Doa	Red Loamy Soil	1	Da Lat City	Gray Loamy Soil
6	Chu Pah	Gray Loamy Soil	2	Bao Loc City	Gray Loamy Soil
7	La Grai	Red Loamy Soil	3	Dam Rong	Gray Loamy Soil
8	Mang Yang	Gray Loamy Soil	4	Lac Duong	Gray Loamy Soil
9	Kong Chro	Gray Loamy Soil	5	Lam Ha	Gray Loamy Soil
10	Duc Co	Red Loamy Soil	6	Don Duong	Gray Loamy Soil
11	Chu Prong	Gray Loamy Soil	7	Duc Trong	Gray Loamy Soil
12	Chu Se	Red Loamy Soil	8	Di Linh	Gray Loamy Soil
13	Dac Po	Gray Loamy Soil	9	Bao Lam	Gray Loamy Soil
14	La Pa	Gray Loamy Soil	10	Da Huoai	Gray Loamy Soil
15	Krong Pa	Gray Loamy Soil	11	Da The	Gray Loamy Soil
16	Phu Thien	Gray Loamy Soil	12	Cat Tien	Gray Loamy Soil
17	Chu Puh	Gray Loamy Soil			

Source: Exported from land use and soil maps provided by MONRE

AT 4.1.4 List of Crop Parameters

No	Crop	K_c nursery	K_c land prep	K_c int	K_c mid	K_c end	Maximum Rotting Depth (m)	Critical depletion fraction	Yield Response	Crop height (optional)
1	Paddy (Kc dry)	0.7	0.3	0.5	1.1	0.7	0.6	0.2	0.5 - 1.32	1.0
	Paddy (Kc wet)	1.2	1.1	1.1	1.2	0.9				
2	Maize			0.3	1.2	0.4	1.3	0.5 - 0.8	0.4 - 1.3	2.0
3	Sweet Potato			0.3	1.2	0.7	1.0	0.55 - 0.8	0.4 - 1.3	2.0
4	Cassava			0.3	0.8	0.3	0.6	0.25 - 0.5	0.4 - 1.1	1.8
5	Vegetable			0.7	1.1	1.0	0.6	0.3 - 0.5	0.4 - 1.2	0.3
6	Sugarcane			0.4	1.3	0.8	1.5	0.7	0.1 - 1.2	3.0
7	Soybeans			0.4	1.2	0.5	1.0	0.5 - 0.9	0.4 - 1.0	0.6
8	Beans			0.4	1.2	0.5	0.9	0.45 - 0.6	0.2 - 1.1	0.4
9	Coffee			0.6	1.1	0.9	1.2	0.2	1.05 - 1.2	2.5
10	Pepper			0.6	1.1	0.9	0.7	0.2 - 0.3	0.6 - 1.1	2.0
11	Rubber			0.6	1.1	0.9	2.5	0.2	1.1	10.0
12	Cashew			0.3	0.9	0.5	1.5	0.4	0.4 - 0.85	5.0
13	Fruits			0.5	1.1	1.0	0.9	0.45 - 0.55	1.0	5.0
14	Tea			0.5	1.0	1.0	0.9	0.45 - 0.5	0.6 - 1	1.2

Source: FAO & JICA Survey Team

AT 4.1.5 Duration of Crop Development Stages for Various Planting Periods

No	Crop	Land prep	Init. (L_{ini})	Dev. (L_{dev})	Mid (L_{mid})	Late (L_{late})	Total
1	Paddy summer-autumn crop season	20	25	25	30	20	120
	Paddy spring-winter crop season	20	20	25	30	20	115
2	Maize summer-autumn crop season		25	30	30	30	115
	Maize spring-winter crop season		25	30	30	25	110
3	Sweet Potato		25	30	30	25	110
4	Cassava		60	75	70	55	260
5	Vegetable		20	30	30	15	95
6	Sugarcane		30	60	180	85	355
7	Soybeans		15	20	40	20	95
8	Beans		20	30	40	20	110
9	Coffee		85	85	85	110	365
10	Pepper		30	40	110	185	365
11	Rubber		70	80	75	140	365
12	Cashew		150	50	125	40	365
13	Fruits		90	165	45	65	365
14	Tea		40	40	250	35	365

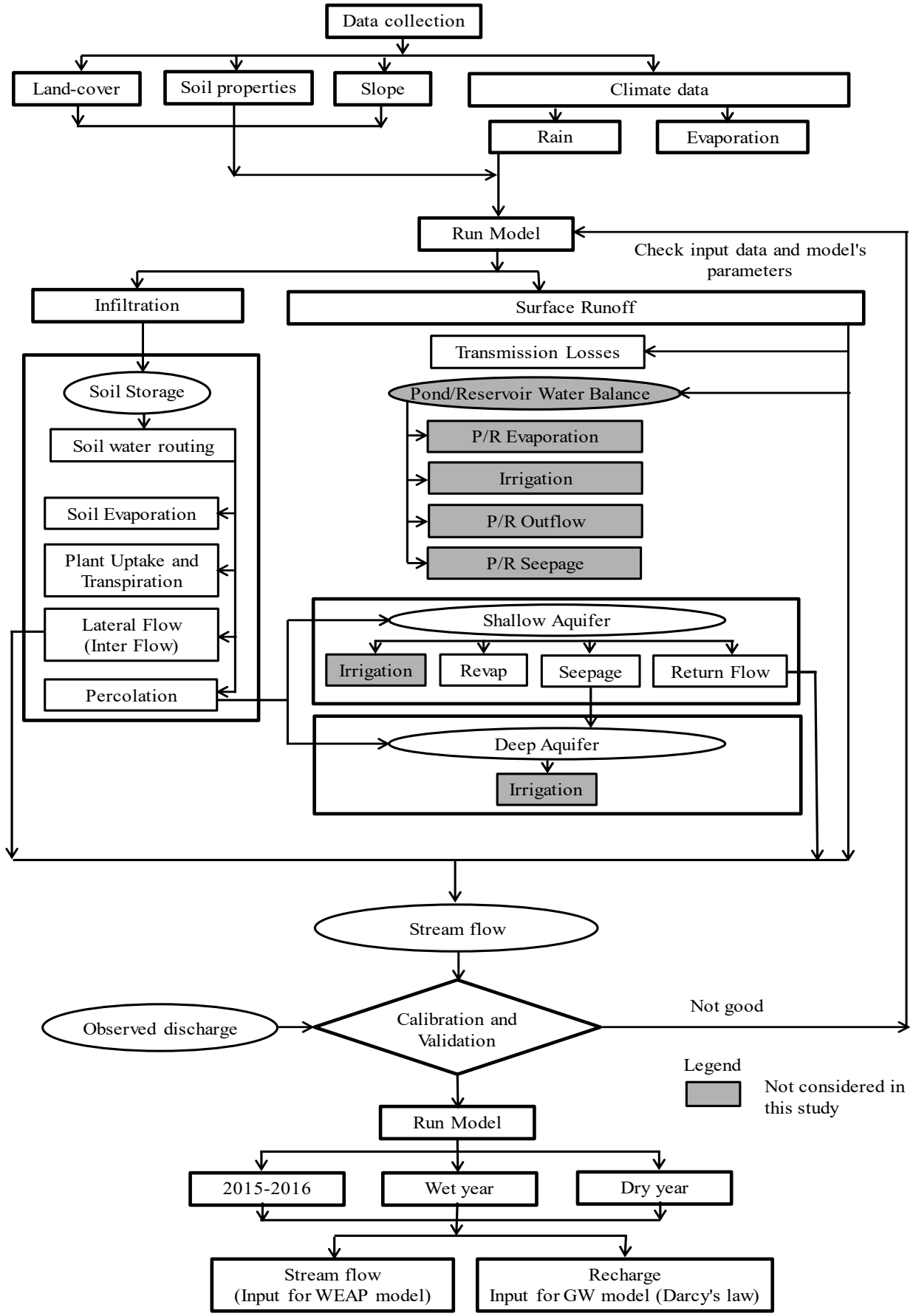
Source: JICA Survey Team

AT 4.1.6 CROPWAT Parameter Explanation

Feature	Parameters	Unit	Meanings
Crop Characteristic	Critical depletion fraction		Represents the critical soil moisture level where first drought stress occurs affecting crop evapotranspiration and crop production
	Yield Response		Relates relative yield decrease to relative evapotranspiration deficit
	Crop height (optional)	m	Maximum height of crops
Soil Characteristic	Total available soil moisture	mm/meter	Represents the total amount of water available to the crop
	Maximum rain infiltration rate	mm/day	Represents the water depth that can infiltrate in the soil over a 24-hours period, as a function of soil type, slope class and rain or irrigation intensity
	Initial soil moisture depletion	%	The Initial soil moisture depletion indicates the dryness of the soil at the start of the growing season that is at seeding in case of non-rice crops, or at the beginning of land preparation, in case of rice.
	Initial available soil moisture	mm/meter	Defined as the soil moisture content at the start of the growing season

Source: FAO

AT 4.1.7 Analysis Flow of the SWAT Model



Source: JICA Study Team

AT 4.1.8 Recorded Period of Daily Rainfall and Daily Water Level/Discharge in the Central Highland Districts

ID No.	Name of Station	Longtitude	Latitude	District	Province	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
RKT01	Dak To	107.83	14.65	Dak To	Kon Tum																																						
RKT02	Kon tum	108.00	14.33	Kon Tum	Kon Tum																																						IC		
RKT03	Dak Mot	107.77	14.75	Dak To	Kon Tum																																							
RKT04	Kom Plong	108.13	14.47	Kon Ray	Kon Tum					IC							IC									IC	IC																	
RKT05	Dak Glei	107.75	15.08	Dak Glei	Kon Tum								IC																															
RKT06	Sa Thay	107.78	14.42	Sa Thay	Kon Tum																																							
RGL01	An khe	108.66	13.95	An Khe	Gia Lai																																							
RGL02	Ayunpa	108.45	13.38	Ayun Pa	Gia Lai																																							
RGL03	Pleiku	108.02	13.97	Pleiku	Gia Lai																																							
RGL04	Ya Ly	107.75	14.20	Chu Pah	Gia Lai																																							
RGL05	Po Mo Re	108.35	14.03	Mang Yang	Gia Lai																																							
RGL06	Chu Prong	107.85	13.65	Chu Prong	Gia Lai				IC																																			
RDL01	Buon Ma Thuot	108.1	12.7	Buon Ma Thuot	Dak Lak																																							
RDL02	Buon Ho	108.3	12.9	Buon Ho	Dak Lak																																							
RDL03	EaHleo	108.2	13.2	Ea H'leo	Dak Lak													IC																											
RDL04	Ea Kmat	108.1	12.7	Krong Pak	Dak Lak																																							
RDL05	Lak	108.2	12.4	Lak	Dak Lak																																							
RDL06	M'DRak	108.8	12.7	M'Drak	Dak Lak	IC																																						
RDL07	Krong Pach	108.4	12.8	Krong Pak	Dak Lak					IC	IC				IC	IC	IC	IC																											
RDL08	Ban Don	107.8	12.9	Buon Don	Dak Lak																																							
RDL09	Giang Son	108.2	12.5	Krong Bong	Dak Lak																																							
RDL10	Krong Bong	108.4	12.6	Krong Bong	Dak Lak												IC			IC																								
RDL11	Buon Dray	108.0	12.5	Krong Ana	Dak Lak										IC																													
RDL12	Buon Trap	108.0	12.5	Krong Ana	Dak Lak																																							
RDL13	Buon Triet	108.1	12.4	Lak	Dak Lak																																							
RDL15	Ea Hding	108.1	12.9	Cu M'gar	Dak Lak																																							
RDL16	Ea Knop	108.4	12.8	Ea Kar	Dak Lak																																							
RDL17	Ea Sup	107.9	13.1	Ea Sup	Dak Lak																																							
RDL18	Krong Buk	108.4	12.8	Krong Pak	Dak Lak																																							
RDN01	Dak Nong	107.68	12.00	Gia Nghia	Dak Nong	IC																																						
RDN02	Dak Mil	107.62	12.45	Dak Mil	Dak Nong				IC																																			
RDN03	Duc Xuyen	107.98	12.28	Krong No	Dak Nong																																							
RDN04	Cau 14	107.90	12.60	Cu Jut	Dak Nong																																							
RLD01	Bao Loc	107.82	11.53	Bao Loc	Lam Dong																																							
RLD02	Da Lat	108.45	11.95	Da Lat	Lam Dong																																							
RLD03	Lien Khuong	108.38	11.75	Duc Trong	Lam Dong																																							
RLD04	Dai Nga	107.87	11.53	Bao Loc	Lam Dong	IC																																						
RLD05	Dai Ninh	108.30	11.65	Duc Trong	Lam Dong							IC																		IC														
RLD06	Thanh Binh	108.28	11.78	Duc Trong	Lam Dong																																							

Legend: : Complete Data IC : Incomplete Data

Discharge Data

ID_Name	Name of Station	Longtitude	Latitude	District	Province	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
HKT01	Dak Mot	107.77	14.75	Dak To	Kon Tum																																						
HKT02	Kon Plong	108.13	14.47	Kon Ray	Kon Tum																																						
HKT03	Kon Tum	108.02	14.33	Kon Tum	Kon Tum																																						
HGL01	An Khe	108.65	13.95	An Khe	Gia Lai																																						
HGL02	AyunPa	108.47	13.47	Ia Pa	Gia Lai																																						
HGL03	Po Mo Re	108.35	14.03	Mang Yang	Gia Lai																																						
HDL01	Ban Don	107.77	12.90	Buon Don	Dak Lak																																						
HDL02	Gang Son	108.20	12.50	Krong Bong	Dak Lak																																						
HDL03	Krong Buk	108.40	12.77	Krong Pak	Dak Lak																						IC							IC									
HDN01	Duc Xuyen	107.98	12.28	Krong No	Dak Nong																																						
HDN02	Cau 14	107.90	12.60	Cu Jut	Dak Nong																																						
HDN03	Dak Nong	107.68	12.00	Gia Nghia	Dak Nong																																						
HLD01	Dai Nga	107.87	11.53	Bao Loc	Lam Dong																																						
HLD02	Dai Ninh	108.30	11.65	Duc Trong	Lam Dong																																						
HLD03	Thanh Binh	108.28	11.78	Duc Trong	Lam Dong																																						

Source: JICA Study Team Legend: : Complete Data IC : Incomplete Data

Source: JICA Study Team, based on Observed data by MONRE

AT 4.1.9 List of Hydrological Stations in Central Highlands

Station Name	Catchment Area (km^2)	Location	River Basin	Longitude	Latitude	Measurement Factor
Dak Mot	1640	Dak To District, Kon Tum Province	Sesan	$107^0$46'00"	$14^0$45'00"	Water Level, Discharge, Rainfall
Kon Plong	965	Kon Ray District, Kon Tum Province	Sesan	$108^0$08'00"	$14^0$28'00"	Water Level, Discharge, Rainfall
Kon Tum	3056	Kon Tum City, Kon Tum Province	Sesan	108°01'40"	14°22'37"	Water Level, Discharge, Rainfall
Dak To	580	Dak To district, Kon Tum Province	Sesan	107°50'53"	14°42'13"	Water Level, Rainfall
An Khe	1368	An Khe town, Gia Lai Province	Ba	$108^0$40'00"	13°57'35"	Water Level, Discharge, Rainfall
AyunPa	6914	Ayun Pa town, Gia Lai Province	Ba	108°27'00"	13°31'00"	Water Level, Discharge, Rainfall
Po Mo Re	311	Mang Yang District, Gia Lai Province	Ba	108°21'00"	14°02'00"	Water Level, Discharge, Rainfall
Cau 14	8610	Cư Jut District Dak Nong Province	Srepok	107°36'00"	12°57'00"	Water Level, Discharge, Rainfall
Giang Sơn	3020	Cu Kuin District, Dak Lak Province	Srepok	108°12'00"	12°30'00"	Water Level, Discharge, Rainfall
Krong Buk	527	Krong Pak District, Dak Lak Province	Srepok	108°23'48"	12°45'12"	Water Level, Discharge, Rainfall
Bản Đôn	10.600	Buon Don District, Dak Lak Province	Srepok	107°44'00"	12°54'00"	Water Level, Discharge, Rainfall
Duc Xuyen	2620	Krong No District, Dak Nong province	Srepok	107°59'00"	12°18'00"	Water Level, Discharge, Rainfall
Thanh Binh	294	Duc Trong District, Lam Dong	Dong Nai	108°18'00"	11°46'00"	Water Level, Discharge, Rainfall
Dak Nong	300	Dak Nong Town, Dak Nong Province	Dong Nai	107°41'16"	12°00'03"	Water Level, Discharge, Rainfall
Dai Ninh	1848	Duc Trong District, Lam Dong Province	Dong Nai	108°18'34"	11°39'57"	Water Level, Rainfall

Source: MONRE

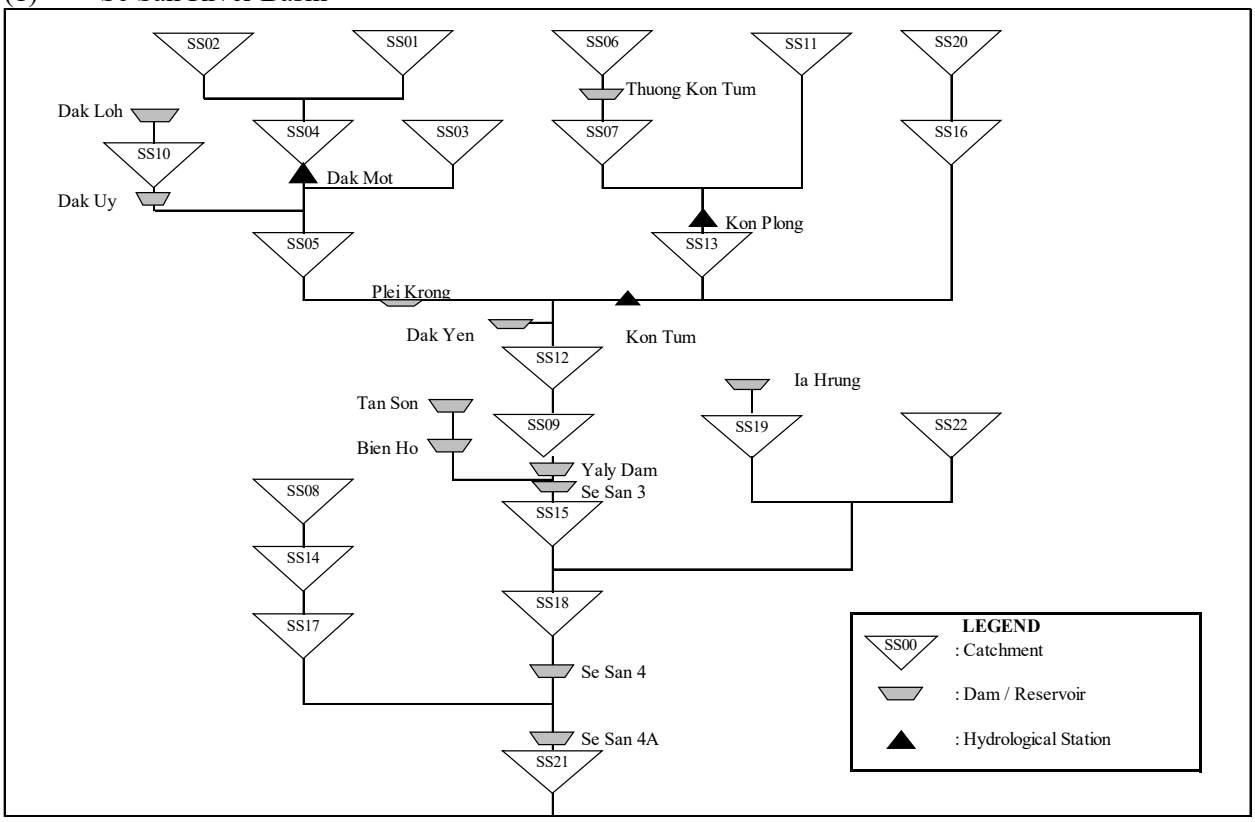
AT 4.1.10 List of Groundwater Level Observation Wells in Central Highlands

No.	Well	Coordinate		Elevation	Layer	Depth of Screen (m)		Location	Start Time
		X	Y	Z (m)		From	To		
1	LK137	1,616,402	810,801	607,498	N	0.0	24.0	Dien Binh-Dak To-Kon Tum	Sep-93
2	LK140	1,596,061	820,208	563,026	N	5.7	21.0	Vinh Quang–Kon Tum–Kon Tum	Mar-93
3	LK155	1,624,276	794,544	597,787	Ar–S	7.7	18.0	Plei Can-Ngoc Hoi-Kon Tum	Jun-99
4	LK63	1,569,142	809,809	599,217	N2–QI	10.0	17.0	Ia Mo Nong-Chu Pah-Gia Lai	Mar-96
5	LK163	1,531,490	801,968	471,719	N_2–Q_I	11.7	57.0	Ia Din-Chu Prong-Gia Lai	Jun-09
6	LK166	1,524,588	780,769	360,081	Q_{II}	20.9	37.0	Ia Dom–Duc Co–Gia Lai	Jun-09
7	LK66	1,515,620	183,708	516,102	N_2–Q_I	4.0	16.0	Chu Se–Chu Se–Gia Lai	Mar-93
8	LK69	1,469,879	192,203	522,732	N_2–Q_I	15.5	27.5	Ea Ral–EaH Leo–Dak Lak	Mar-94
9	LK64	1,542,190	175,137	755,044	Q_{II}	1.5	17.5	P. Hoi Phu–Pleiku–Gia Lai	Mar-94
10	LK71	1,438,153	199,313	786,970	Q_{II}	18.0	27.0	Pong Drang-Krong Buk-Dak Lak	Mar-93
11	LK37T	1,472,338	239,880	123,844	N	12.0	27.0	Chu Rcam-Krong Pa-Gia Lai	Dec-93
12	LK39	1,474,043	241,928	128,354	N	3.0	15.0	Chu Rcam-Krong Pa-Gia Lai	Jun-94
13	LK54	1,417,742	231,531	425,363	Ar–S	0.0	12.0	TT.Ea Knop–Ea Kar–Dak Lak	Sep-92
14	CB–II	1,415,099	191,212	596,219	Q_{II}	11.0	47.0	Cuor Dang–Ca M'gar–Dak Lak	Mar-94
15	LK74	1,382,253	181,394	464,106	Q_{II}	0.0	18.0	Ea Ktur–Cu Kuin–Dak Lak	Mar-93
16	LK40	1,378,056	785,678	724,268	Q_{II}	2.9	17.0	Dak Lak-Dak Mil-Dak Nong	Mar-96
17	LK47	1,396,122	818,128	306,692	N_2–Q_I	0.0	17.0	Hoa Phu-Buon Ma Thuot-Dak Lak	Jan-92
18	LK82	1,345,830	813,281	818,956	N_2–Q_I	12.0	27.5	Quang Son - Dak Glong - Dak Nong	Mar-95
19	BB1	1,287,515	811,671	784,438	N_2–Q_I	10.0	33.0	Loc Ngai-Bao Lam-Lam Dong	Aug-09
20	C100	1,279,158	805,258	857,943	N_2–Q_I	153.0	197.0	P.2-Bao Loc-Lam Dong	Mar-97
21	LK128	1,613,153	809,659	611,151	N	6.0	17.0	Dak Hrinh-Dak Ha-Kon Tum	Sep-93

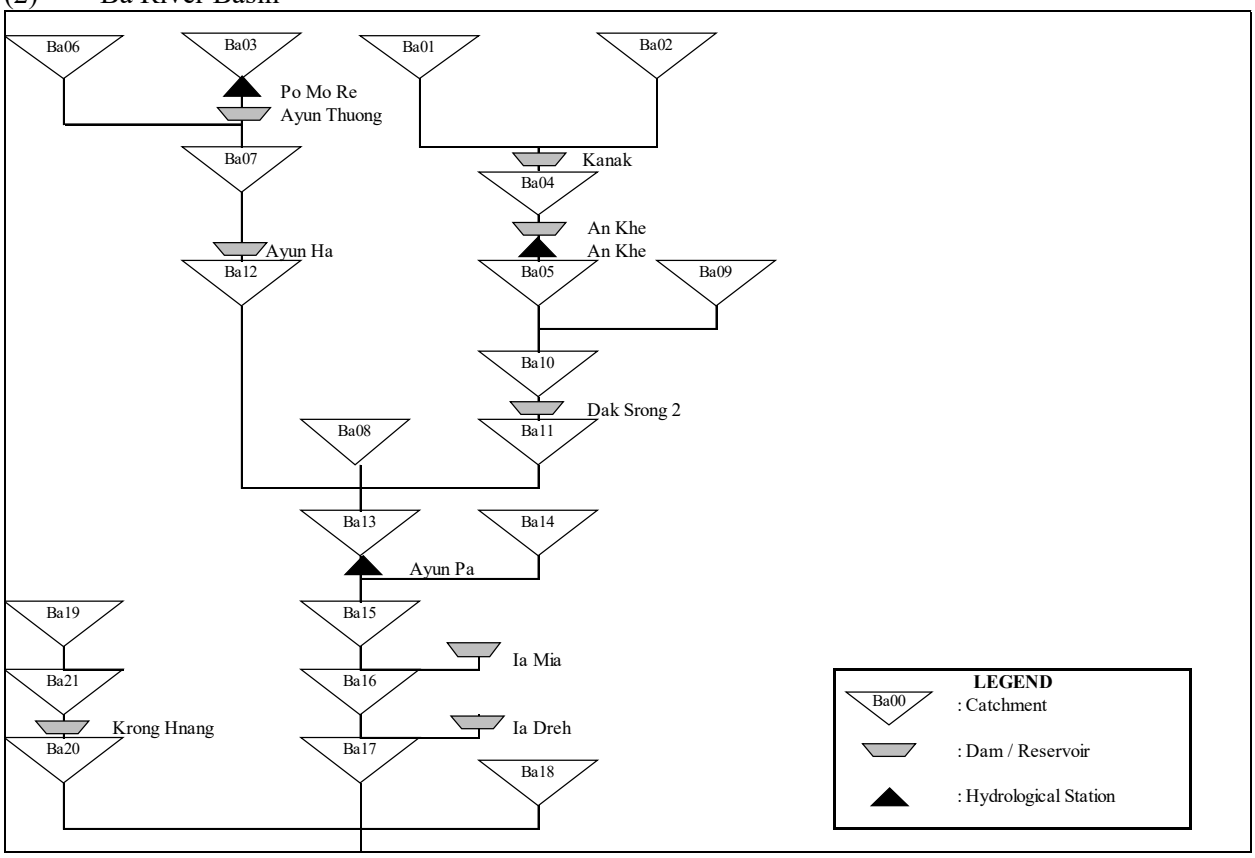
Source: National Center for Water Resources Planning and Investigation (NAWAPI)

AT 4.1.11 Flow Diagram of River Basin

(1) Se San River Basin

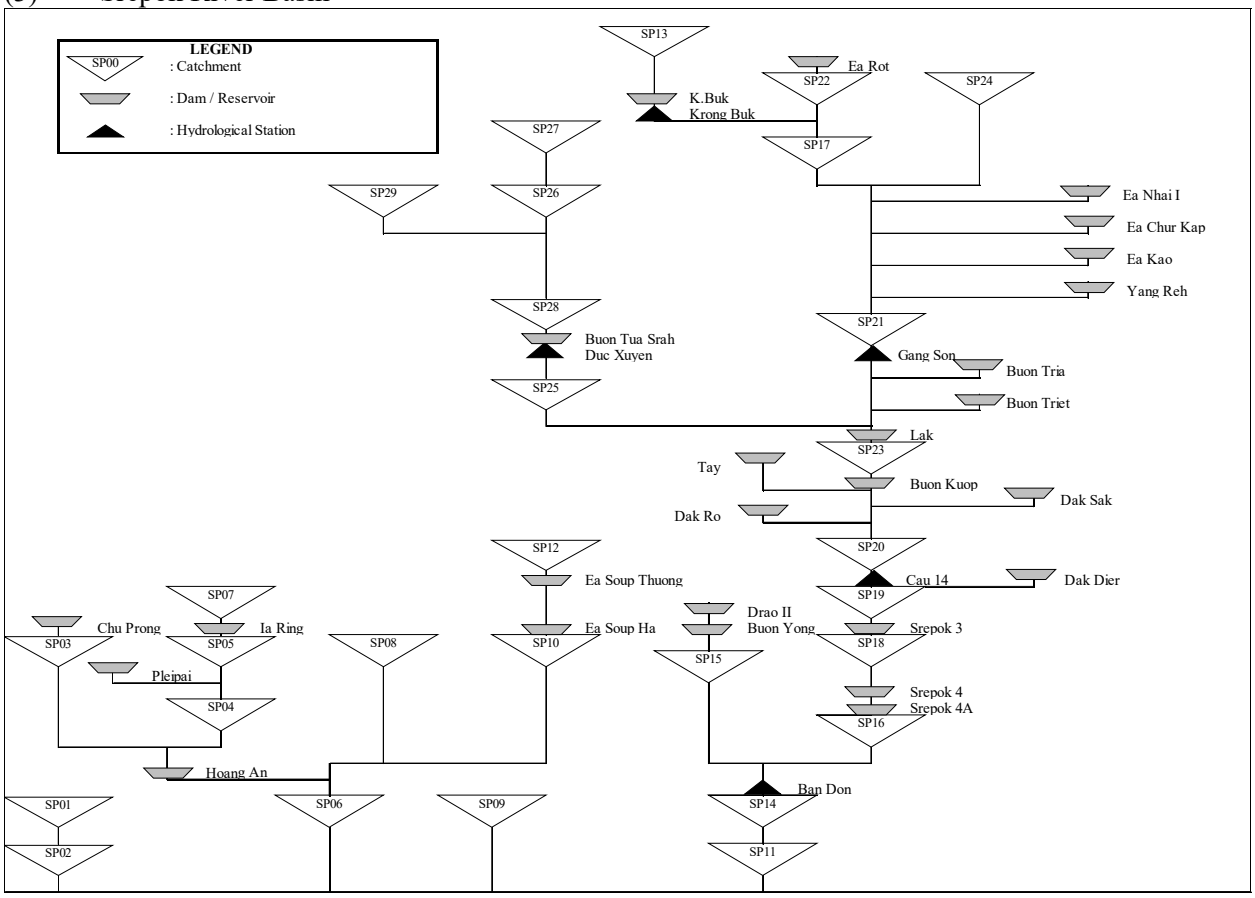


(2) Ba River Basin

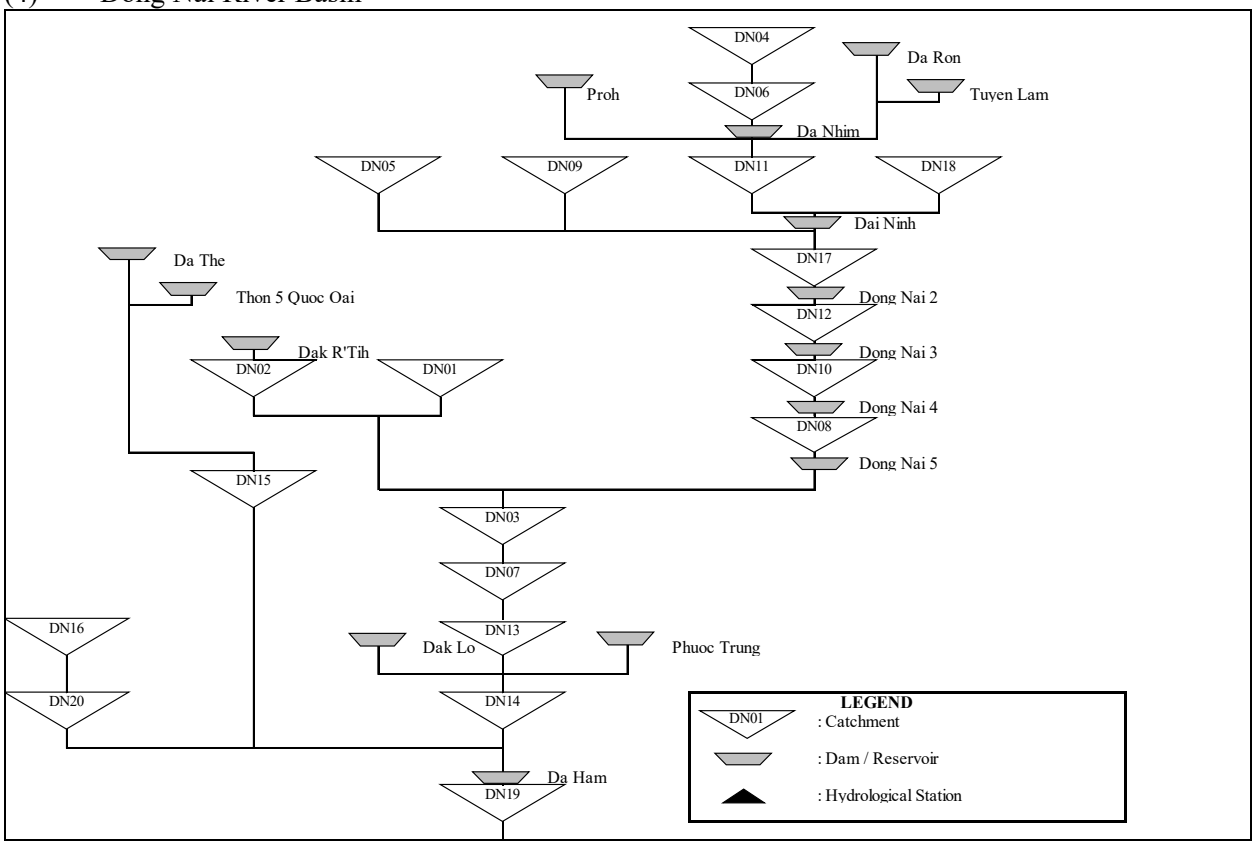


Source: JICA Study Team

(3) Srepok River Basin



(4) Dong Nai River Basin



Source: JICA Study Team

AT 4.1.12 Main Parameters and Input Data of SWAT Model

(1) Se San River Basin

No.	Sub-Basin Name	Area [km²]	Slope [m/m]	Available Water Capacity (mm/mm)	Saturated hydraulic conductivity [cm/sec]	Main Channel			Tributary			CN
						Length [km]	Slope	Width [m]	Length [km]	Slope	Width [m]	
1	SS02	324.5	0.341	0.05	5.56E-04	11.75	0.002	41.43	37.04	0.026	41.43	56
2	SS01	729.2	0.330	0.05	5.56E-04	25.25	0.006	67.34	57.08	0.015	67.34	56
3	SS06	376.2	0.257	0.20	5.56E-04	6.68	0.003	45.27	43.55	0.014	45.27	52
4	SS04	587.1	0.224	0.05	5.56E-04	31.50	0.001	109.55	51.12	0.022	59.13	56
5	SS03	769.9	0.315	0.20	5.56E-04	3.08	0.001	69.57	73.15	0.024	69.57	52
6	SS10	83.5	0.298	0.20	5.56E-04	6.08	0.007	18.35	21.53	0.034	18.35	52
7	SS07	550.4	0.314	0.20	5.56E-04	33.49	0.016	77.76	50.92	0.022	56.89	52
8	SS11	499.9	0.318	0.20	5.56E-04	19.45	0.004	53.69	57.59	0.018	53.69	52
9	SS05	706.3	0.213	0.20	5.56E-04	33.99	0.002	163.57	72.73	0.021	66.07	52
10	SS08	650.6	0.266	0.20	5.56E-04	21.46	0.005	62.89	48.87	0.015	62.89	52
11	SS13	543.6	0.294	0.20	5.56E-04	31.76	0.005	122.26	48.94	0.020	56.46	52
12	SS16	396.9	0.230	0.05	5.56E-04	20.67	0.002	75.94	39.67	0.016	46.76	52
13	SS12	701.6	0.159	0.20	5.56E-04	31.14	0.002	256.25	58.49	0.011	65.80	52
14	SS09	639.1	0.189	0.20	5.56E-04	4.08	0.010	270.52	56.41	0.014	62.22	52
15	SS14	440.1	0.277	0.20	5.56E-04	24.06	0.001	85.75	51.87	0.018	49.74	52
16	SS20	493.8	0.134	0.05	5.56E-04	22.49	0.005	53.30	43.97	0.007	53.30	52
17	SS15	627.6	0.237	0.20	5.56E-04	40.40	0.006	284.06	91.56	0.013	61.54	52
18	SS18	526.4	0.188	0.20	5.56E-04	27.45	0.004	309.74	48.73	0.006	55.38	52
19	SS19	470.5	0.180	0.20	5.56E-04	8.07	0.005	51.78	49.75	0.010	51.78	52
20	SS17	445.5	0.157	0.20	5.56E-04	33.91	0.001	105.31	42.30	0.019	50.10	52
21	SS22	249.1	0.136	0.05	5.56E-04	8.97	0.012	35.35	50.61	0.015	35.35	52
22	SS21	565.0	0.142	0.20	5.56E-04	26.82	0.001	350.11	57.37	0.007	57.79	52

(2) Ba River Basin

No.	Sub-Basin Name	Area [km²]	Slope [m/m]	Available Water Capacity (mm/mm)	Saturated hydraulic conductivity [cm/sec]	Main Channel			Tributary			CN
						Length [km]	Slope	Width [m]	Length [km]	Slope	Width [m]	
1	BA01	276.2	0.178	0.30	6.94E-04	10.86	0.015	37.61	51.48	0.012	37.61	55
2	BA02	657.1	0.266	0.30	6.94E-04	33.09	0.006	63.27	72.47	0.013	63.27	55
3	BA03-1	310.8	0.252	0.30	6.94E-04	2.88	0.003	40.37	33.14	0.025	40.37	55
4	BA04	524.0	0.156	0.30	6.94E-04	36.77	0.001	102.03	54.12	0.013	55.23	55
5	BA03	354.8	0.180	0.30	6.94E-04	24.33	0.004	63.75	40.13	0.012	43.71	55
6	BA05	627.9	0.191	0.30	6.94E-04	32.97	0.002	126.50	53.44	0.018	61.56	55
7	BA09	706.9	0.257	0.40	5.56E-04	0.34	0.001	66.10	48.83	0.013	66.10	55
8	BA10	211.4	0.142	0.30	6.94E-04	20.13	0.007	157.46	40.69	0.019	32.04	55
9	BA06	332.4	0.125	0.30	6.94E-04	13.28	0.019	42.03	55.87	0.010	42.03	55
10	BA08	642.9	0.153	0.30	6.94E-04	42.08	0.009	109.56	74.61	0.008	62.44	55
11	BA07	458.2	0.186	0.30	6.94E-04	2.39	0.001	50.96	71.88	0.018	50.96	55
12	BA11	431.0	0.185	0.30	6.94E-04	25.54	0.001	170.65	42.27	0.008	49.12	55
13	BA12	749.4	0.116	0.30	6.94E-04	16.17	0.001	137.29	66.10	0.010	68.45	55
14	BA14	545.7	0.107	0.10	6.94E-04	14.69	0.001	257.74	76.81	0.010	56.59	55
15	BA13	336.8	0.274	0.10	6.94E-04	11.05	0.001	42.37	47.43	0.022	42.37	55
16	BA15	624.9	0.186	0.10	6.94E-04	20.39	0.004	278.95	64.03	0.016	61.38	55
17	BA16	669.9	0.211	0.10	6.94E-04	13.57	0.000	293.10	50.84	0.020	64.00	55
18	BA18	234.3	0.254	0.10	6.94E-04	12.19	0.005	34.07	61.40	0.017	34.07	55
19	BA17	575.9	0.171	0.10	6.94E-04	26.95	0.001	343.36	61.39	0.014	58.45	55
20	BA20	625.2	0.161	0.40	5.56E-04	24.99	0.005	113.61	69.82	0.011	61.40	55
21	BA21	594.2	0.144	0.40	5.56E-04	33.84	0.006	87.03	58.37	0.006	59.56	55
22	BA19	523.8	0.117	0.40	5.56E-04	38.01	0.004	55.22	74.72	0.011	55.22	55

(3) Srepok River Basin

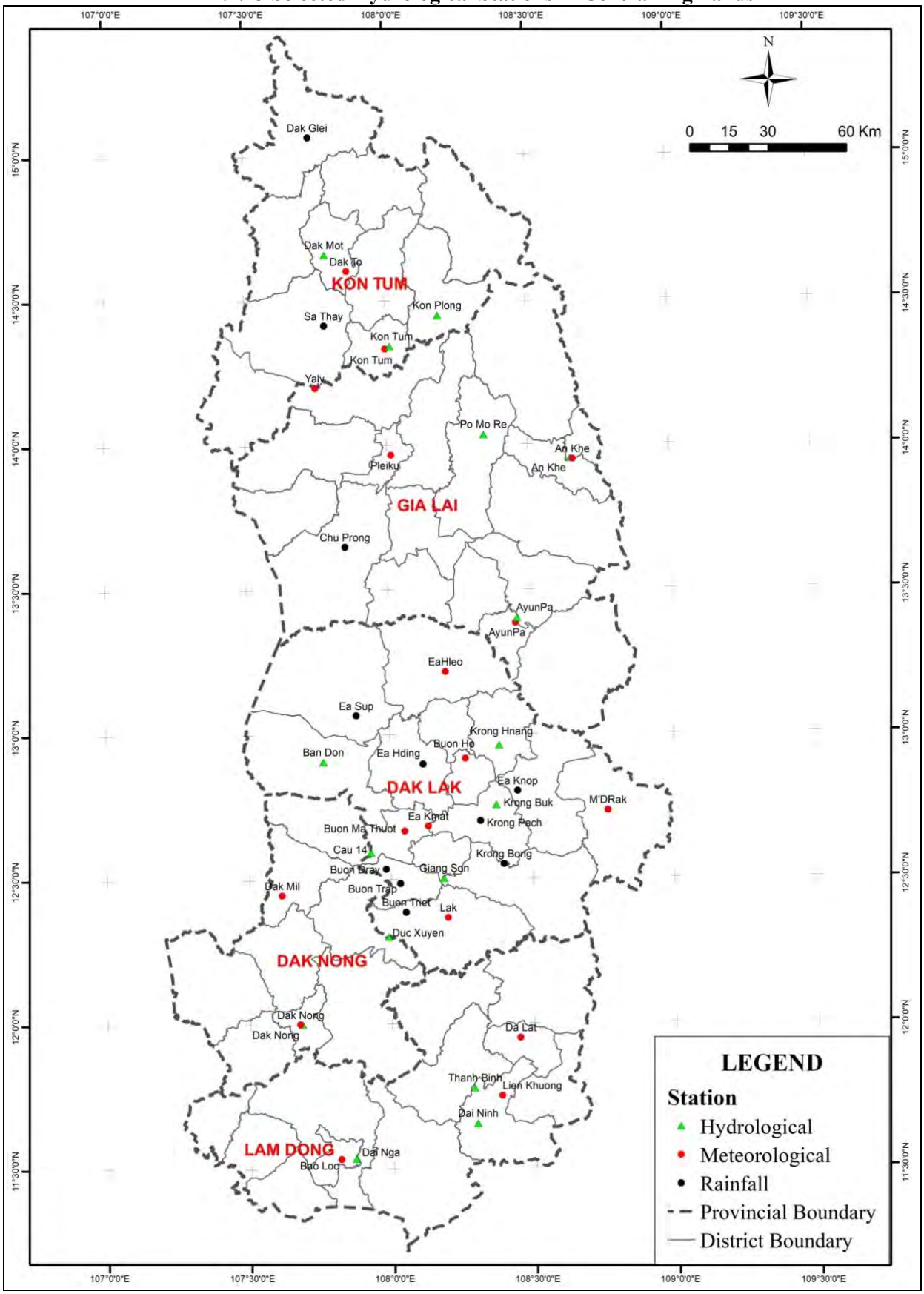
No.	Sub-Basin Name	Area [km²]	Slope [m/m]	Available Water Capacity (mm/mm)	Saturated hydraulic conductivity [cm/sec]	Main Channel			Tributary			CN
						Length [km]	Slope	Width [m]	Length [km]	Slope	Width [m]	
1	SP02	416.2	0.132	0.21	9.72E-04	12.77	0.001	80.67	53.32	0.011	48.10	55
2	SP01	569.0	0.128	0.21	9.72E-04	17.93	0.002	58.03	87.17	0.008	58.03	55
3	SP05	498.4	0.121	0.21	9.72E-04	26.56	0.002	79.91	73.37	0.007	53.59	55
4	SP07	471.5	0.144	0.21	9.72E-04	0.46	0.001	51.84	60.70	0.008	51.84	55
5	SP03	585.4	0.108	0.21	1.53E-03	14.95	0.002	59.03	92.03	0.006	59.03	55
6	SP04	553.4	0.125	0.21	9.72E-04	23.63	0.001	104.77	84.30	0.006	57.07	55
7	outside	3,734.3	0.091	0.21	9.72E-04	51.42	0.001	539.51	153.01	0.005	179.44	55
8	SP06	961.6	0.090	0.21	9.72E-04	25.79	0.001	204.34	112.62	0.006	79.50	55
9	SP08	763.1	0.143	0.21	9.72E-04	5.46	0.001	69.21	100.71	0.007	69.21	55
10	SP10	297.5	0.098	0.21	9.72E-04	28.36	0.001	71.41	41.66	0.003	39.33	55
11	SP09	260.3	0.089	0.21	9.72E-04	17.25	0.002	36.29	40.59	0.004	36.29	55
12	SP12	506.5	0.145	0.21	9.72E-04	34.90	0.007	54.12	59.69	0.010	54.12	55
13	SP11	511.2	0.094	0.21	9.72E-04	26.55	0.001	392.63	47.68	0.002	54.42	55
14	outside	1,831.5	0.137	0.21	9.72E-04	38.62	0.004	117.02	111.87	0.007	117.02	55
15	SP14	486.7	0.106	0.21	9.72E-04	15.76	0.001	351.07	82.73	0.006	52.84	55
16	SP15	970.3	0.104	0.21	9.72E-04	1.29	0.077	342.02	83.73	0.007	79.94	55
17	SP16	533.8	0.123	0.21	9.72E-04	14.36	0.001	323.49	70.80	0.008	55.85	55
18	SP13	455.1	0.106	0.21	9.72E-04	43.33	0.005	50.75	67.20	0.006	50.75	55
19	SP18	152.2	0.088	0.21	9.72E-04	14.45	0.003	312.98	29.39	0.007	26.30	55
20	SP19	428.9	0.106	0.21	9.72E-04	18.70	0.004	309.95	56.71	0.009	48.98	55
21	SP22	255.7	0.264	0.21	9.72E-04	0.68	0.001	35.92	23.78	0.032	35.92	55
22	SP20	1,012.3	0.140	0.21	9.72E-04	17.34	0.004	301.28	76.40	0.008	81.99	55
23	SP17	956.5	0.116	0.21	9.72E-04	37.85	0.001	110.61	56.30	0.012	79.25	55
24	SP23	895.0	0.192	0.21	9.72E-04	40.23	0.002	280.12	77.89	0.017	76.15	55
25	SP21	863.8	0.159	0.21	9.72E-04	27.69	0.001	164.31	49.12	0.006	74.55	55
26	SP24	693.5	0.344	0.21	9.72E-04	23.90	0.001	65.34	64.82	0.019	65.34	55
27	SP25	741.1	0.228	0.21	9.72E-04	24.58	0.003	179.18	60.69	0.017	68.00	55
28	SP28	883.1	0.263	0.21	9.72E-04	26.07	0.004	156.85	75.16	0.006	75.54	55
29	SP27	687.1	0.370	0.21	9.72E-04	21.57	0.005	64.98	58.12	0.023	64.98	55
30	SP26	565.3	0.317	0.21	9.72E-04	44.77	0.003	93.16	61.85	0.027	57.80	55
31	SP29	848.8	0.241	0.21	9.72E-04	17.86	0.001	73.77	57.65	0.006	73.77	55

(4) Dong Nai River Basin

No.	Sub-Basin Name	Area [km²]	Slope [m/m]	Available Water Capacity (mm/mm)	Saturated hydraulic conductivity [cm/sec]	Main Channel			Tributary			CN
						Length [km]	Slope	Width [m]	Length [km]	Slope	Width [m]	
1	DN01	346.6	0.203	0.25	4.17E-04	55.36	0.004	43.10	68.78	0.006	43.10	55
2	DN03.1	288.3	0.232	0.25	4.17E-04	5.20	0.002	38.59	41.78	0.016	38.59	55
3	DN02	321.2	0.194	0.25	4.17E-04	3.86	0.013	41.18	46.62	0.008	41.18	55
4	DN04	476.7	0.322	0.25	4.17E-04	0.86	0.006	52.19	43.31	0.017	52.19	55
5	DN08	181.0	0.243	0.25	4.17E-04	6.95	0.003	204.41	25.09	0.018	29.19	55
6	DN03.2	203.1	0.220	0.25	4.17E-04	10.30	0.026	233.68	30.01	0.013	31.28	55
7	DN06	251.1	0.298	0.25	4.17E-04	16.77	0.006	67.27	43.45	0.028	35.53	55
8	DN10	180.0	0.328	0.25	4.17E-04	27.76	0.005	199.59	33.41	0.015	29.09	55
9	DN12	548.9	0.277	0.25	4.17E-04	32.46	0.004	194.72	43.51	0.033	56.79	55
10	DN09.1	325.8	0.207	0.30	1.11E-03	38.25	0.015	41.53	58.20	0.015	41.53	55
11	DN07	699.4	0.243	0.25	4.17E-04	41.03	0.005	250.20	57.77	0.022	65.68	55
12	DN05	762.5	0.249	0.25	4.17E-04	13.90	0.005	69.17	81.83	0.014	69.17	55
13	DN09.2	56.2	0.105	0.25	4.17E-04	9.47	0.003	45.69	18.49	0.006	14.47	55
14	DN17	708.9	0.178	0.25	4.17E-04	47.55	0.005	179.32	61.44	0.019	66.21	55
15	DN11	686.4	0.211	0.25	4.17E-04	52.60	0.003	100.21	59.40	0.014	64.94	55
16	DN18	462.6	0.232	0.25	4.17E-04	27.79	0.003	51.25	47.23	0.009	51.25	55
17	DN13	473.9	0.223	0.25	4.17E-04	39.78	0.000	260.99	56.52	0.008	52.00	55
18	DN14	710.9	0.217	0.25	4.17E-04	8.48	0.002	276.65	56.19	0.011	66.32	55
19	DN15	547.4	0.283	0.25	4.17E-04	0.53	0.009	56.70	50.70	0.025	56.70	55
20	DN16	443.7	0.274	0.25	4.17E-04	4.15	0.005	49.99	55.06	0.020	49.99	55
21	DN19	248.9	0.221	0.25	4.17E-04	18.86	0.002	308.93	26.74	0.015	35.33	55
22	DN20	312.0	0.347	0.25	4.17E-04	2.01	0.040	68.81	44.75	0.030	40.47	55

Source: JICA Study Team

AT 4.1.13 Selected Hydrological Stations in Central Highlands



Source: JICA Study Team

AT 4.1.14 Classification of Hydrogeology in Central Highlands

Geological type	Lithological description	Average Thickness (m)	Hydraulic conductivity (*K*, cm/s)		Storage (*S*)			
			Range of *K* (cm/s)	Average *K* (cm/s)	Specific Yield: S_y	Specific Storage Coefficient: *Ss* (1/m)	Effective porosity	Total porosity
Quaternary (Q)	Alluvium sand, silty clay, gravel	5 ÷ 10	2.3E-05 ÷ 1.8E-02	2.10E-03	9.30E-02	1.00E-05	7.50E-02	9.40E-02
Neogen (N)	Sandstone, gravelstone, agrilitxe with peat, diatomit and tholeit basalt	50	3.0E-05 ÷ 1.5E-02	1.90E-03	8.80E-02	1.00E-05	7.10E-02	8.90E-02
Basalt Pleistocen (bQ_{II})	Weathering basalt and porous basalt with tuf	70	1.2E-07 ÷ 6.9E-01	8.80E-03	8.80E-02	1.00E-05	7.00E-02	8.80E-02
Basalt Neogen-lower Pleistocen (bN_2-Q_I)	Basalt compact alternate with porous basalt	30	4.6E-05 ÷ 9.9E-03	1.70E-03	7.50E-02	1.00E-05	6.00E-02	7.60E-02

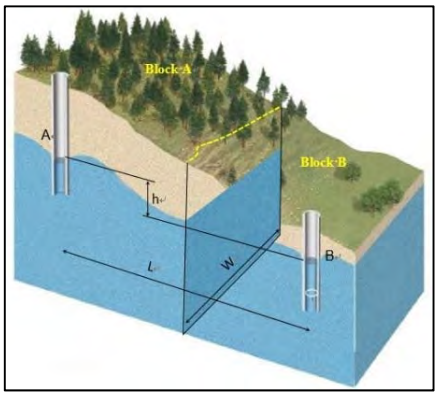
Source: JICA Study Team based on pumping test data from National Center for Water Resources Planning and Investigation (NAWAPI)

The sub-basin block wise GW Model was build based on the Darcy's law;

Darcy's Law

$$Q = A \times v$$
$$v = -K \times i$$
$$i = \Delta h / L$$
$$\Delta h = h_a - h_b$$

Where: Q: groundwater flow [m^3/s]
A: sectional area [m^2] $A = W \times \{(h_a - h_b)/2\} - \text{El\_base}\}$
v: velocity [m/s]
K: hydraulic conductivity [m/sec] or [cm/sec]
i: hydraulic gradient [m/m]
L: distance to downstream block [m]
W: width of groundwater contact line to downstream [m]
h_a: groundwater level AThis block [El.m]
h_b: groundwater level at downstream block [El.m]
El_base: elevation of basement lock [El.m]



Source: JICA Study Team

Conceptual Diagram of Groundwater Flow

[Safety Groundwater Potential]

$$SGWP_{today} = (GWFlow_{today} - GWFlow_{\min}) \times Safety\_Factor$$
$$GW\ FLow\_today = \{(h\_(a\_today) - h\_b)/2 - El\_base\} \times W \times K \times i$$
$$GW\ FLow\_min = \{(h\_(a\_min) - h\_b)/2 - El\_base\} \times W \times K \times i$$
$$i = \Delta h / L$$
$$\Delta h = h_a - h_b$$

Where:
$SGWP_{today}$: safety groundwater potential of today [m^3/s]
$GWFlow_{today}$: groundwater flow AToday [m^3/sec]
$GWFlow_{min}$: minimum groundwater flow at most draught year [m^3/sec]
$Safety\_Factor$: safety factor for groundwater usage at 0.5
h_{a_today} : groundwater level of this block AToday [El.m]
h_{a_min} : minimum groundwater level of this block at most drought year [El.m]
h_b : groundwater level of downstream block [El.m]
El_base : elevation of basement lock [El.m]
K : hydraulic conductivity [m/sec] or [cm/sec]
i : hydraulic gradient [m/m]
L : distance to downstream block [m]
W : width of groundwater contact line to downstream block [m]

The *Safety Factor*[1] of 0.5 was decided based on the consideration of aquifer characteristics, status of groundwater exploitation, requirement of groundwater management of each area, the province's people committee could define the admissible drawn down of water level but not exceed a half of aquifer for unconfined aquifers and not exceed 50m of water level from surface for confined aquifers.

MODFLOW

The genreral equation in MODFLOW model for inhomogeneous anisotropic confined aquifer can be shown as:

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)-W=S_s\frac{\partial h}{\partial t}$$

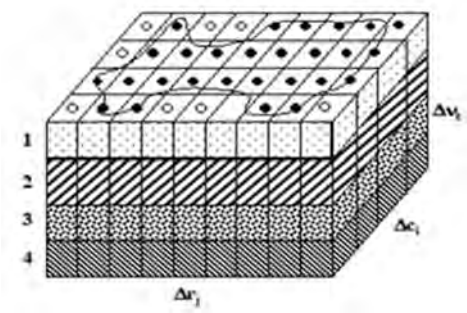
Where: Kxx, Kyy, Kzz: hydraulic conductivity in x, y, z dierctions
h: piezometric head at location (x,y,z)
W: groundwater modul at current time (t) at location (x,y,z). W = W (x,y,z,t)
Ss: specific storage

[1] "Define groundwater exploitation registration, document sample for water resources license demand, extend, refine or renew", Ministry of Natural Resources And Environment (MONRE), Code: 27/2014/TT-BTNMT

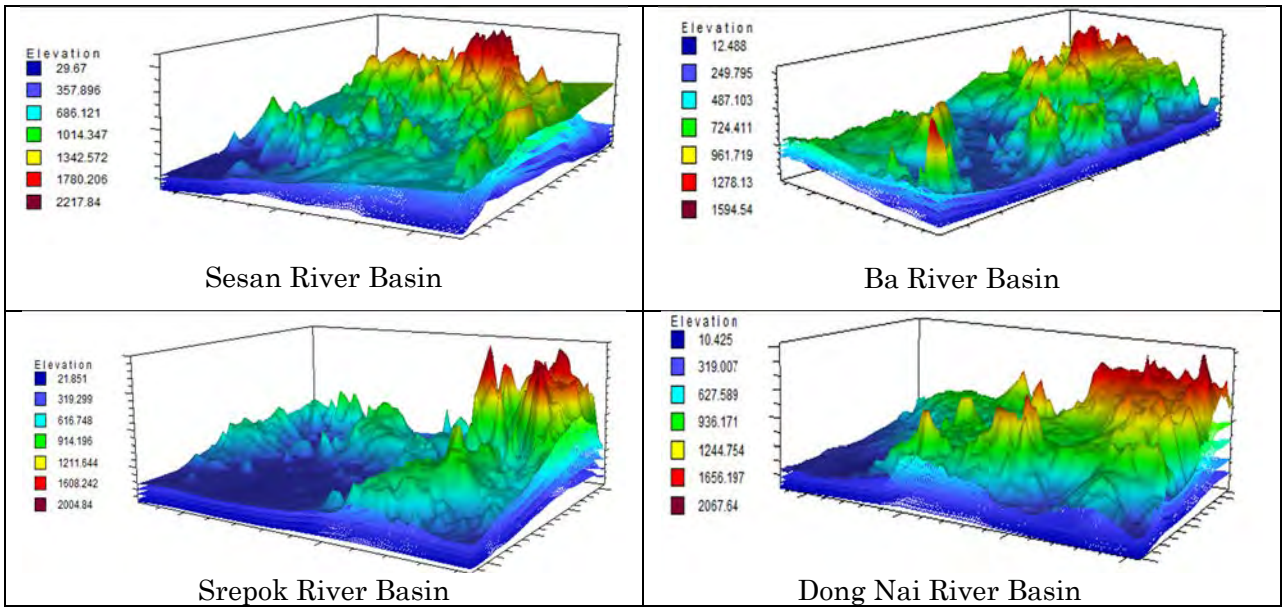
To solve this equation above, infinite difference method is applied to find approximate result. In this method, the calculated area is divided into a mesh. The finer mesh will archive the better result; however, the process should take more time and more complicated. In this project, cell size for 4 river basins was choisen is 5km x 5km. It based on the time consumsion and detail willing result.

The figure on the left side shows the description of model structure. The area is divided into several layers. Each layer can be impermeable or permeable. Each layer is divided into cells. In the model, there are active cells and inactive cells, which present by back dots and white dots, respectively. The active cell will be calculated in the process while the intactive cells will not. The black line is the calculated boundary area.

Depend on the hydro-geological condition, the boundary in Modflow model can be presented by 3 types of cell. The no-flow (1) is the cell without flow. The constant-head (2) is the cell has ground water does not vary in time. The last type is variable-head is cell which groundwater head vary in time.



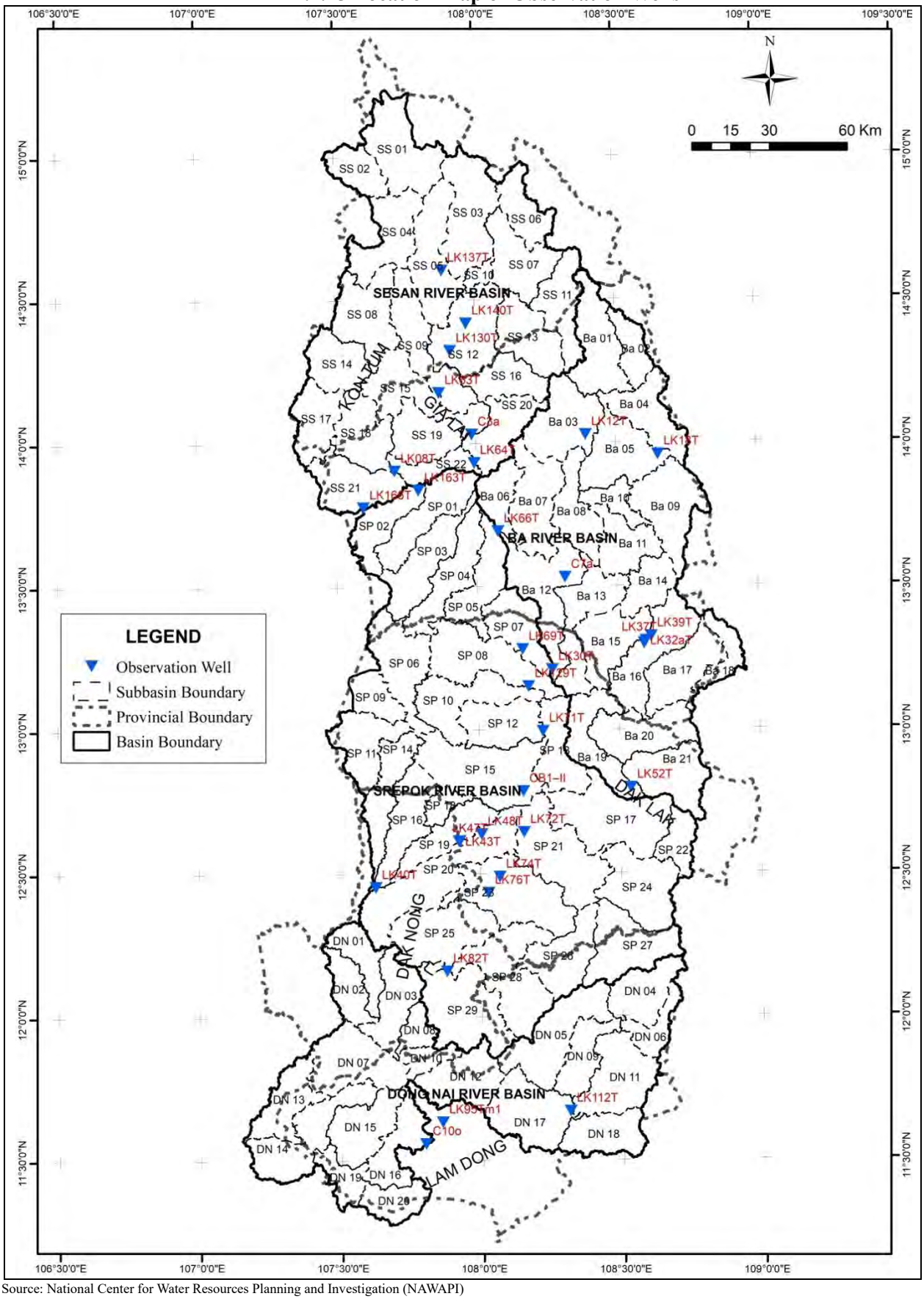
Structure of grid cells



Source: JICA Study Team

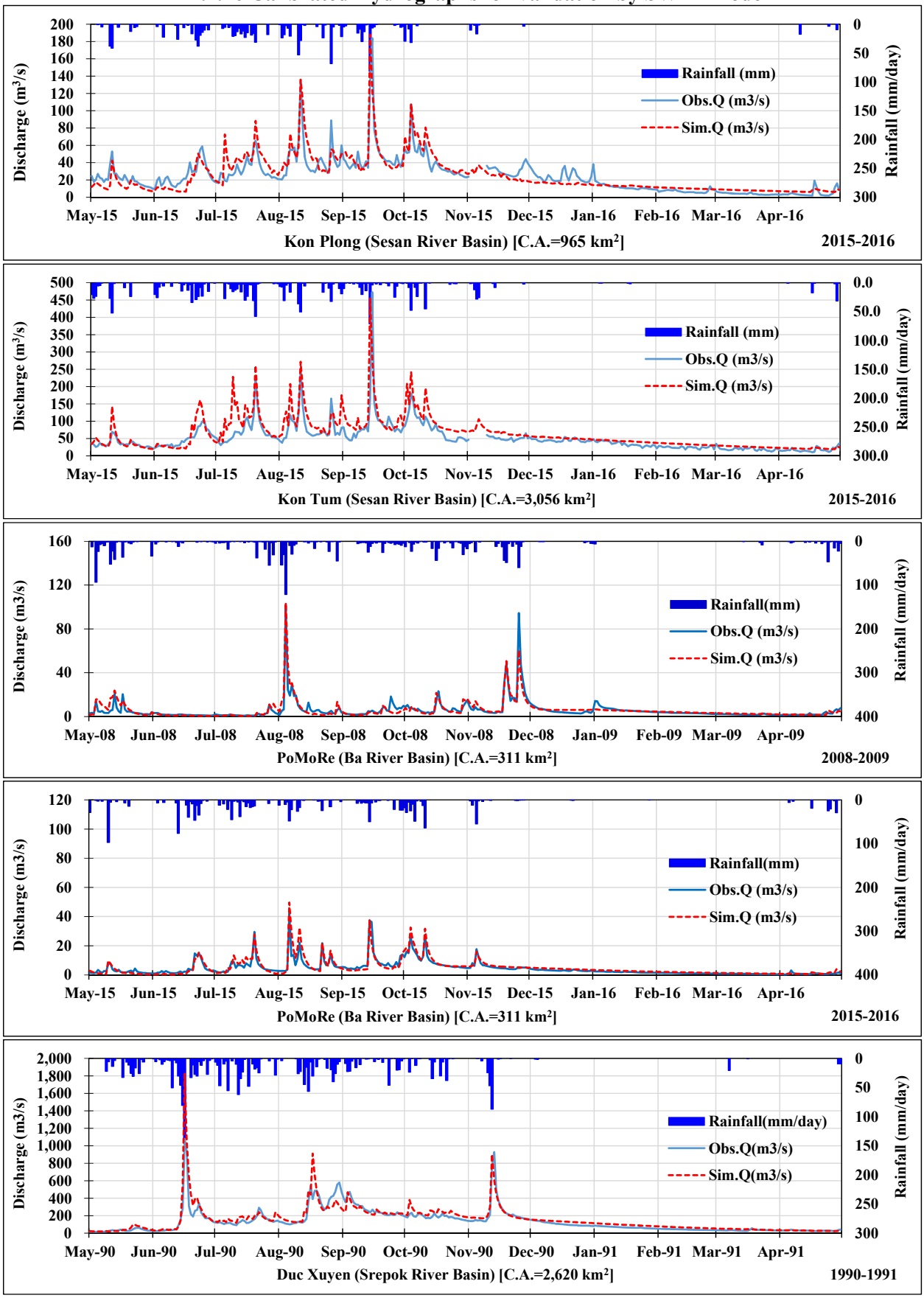
3D Visualization of Built Model Grid

AT 4.1.15 Location Map of Observation Wells

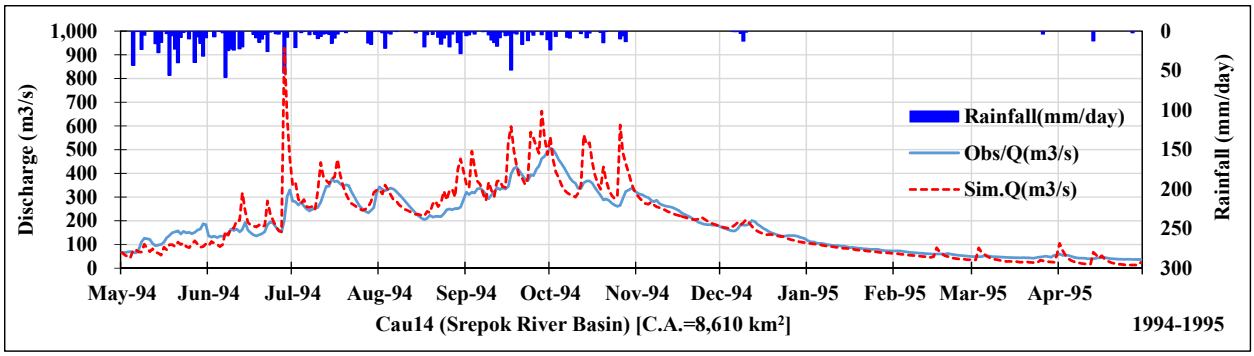


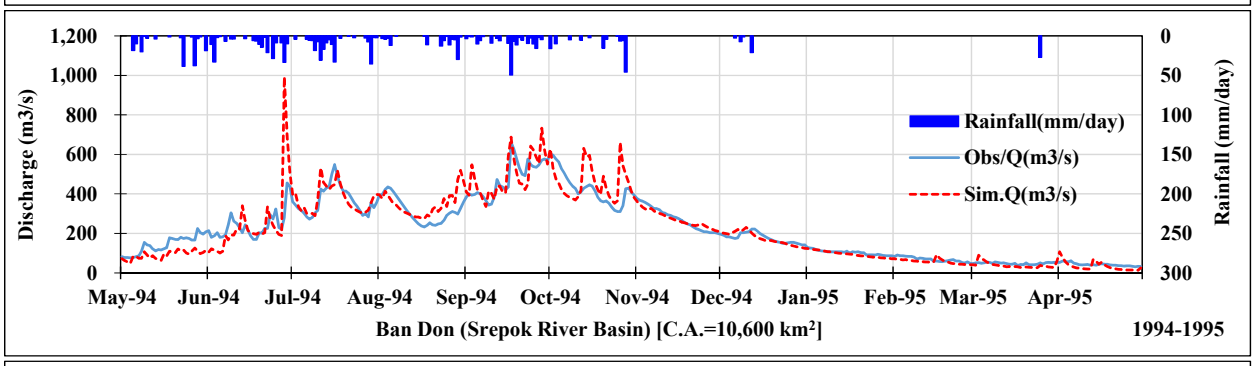
Source: National Center for Water Resources Planning and Investigation (NAWAPI)

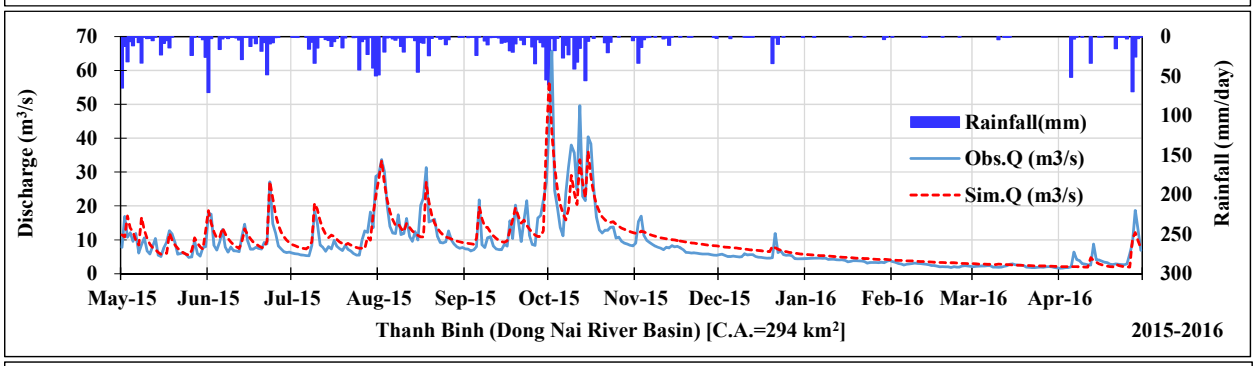
AT 4.1.16 Calibrated Hydrographs for Validation by SWAT Model

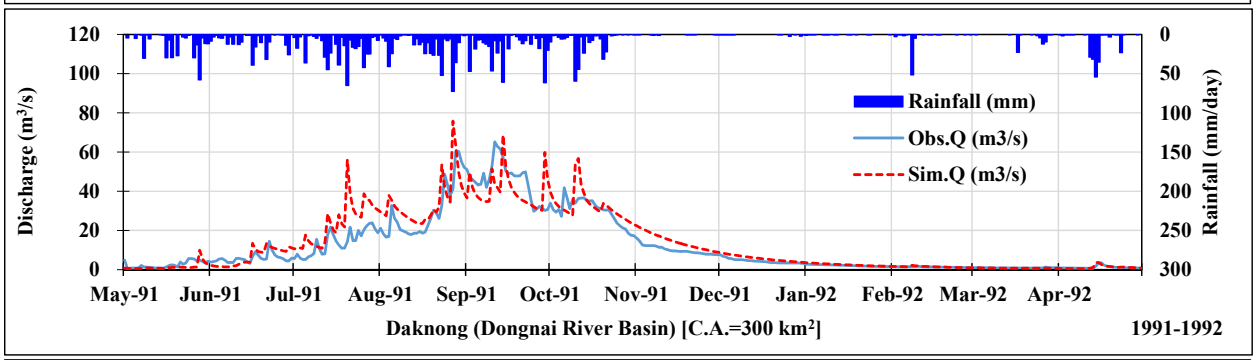


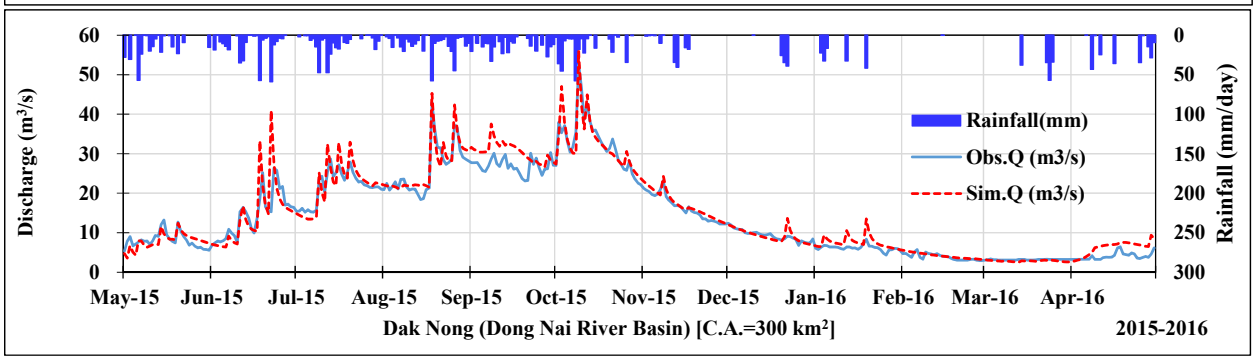
Source: JICA Study Team





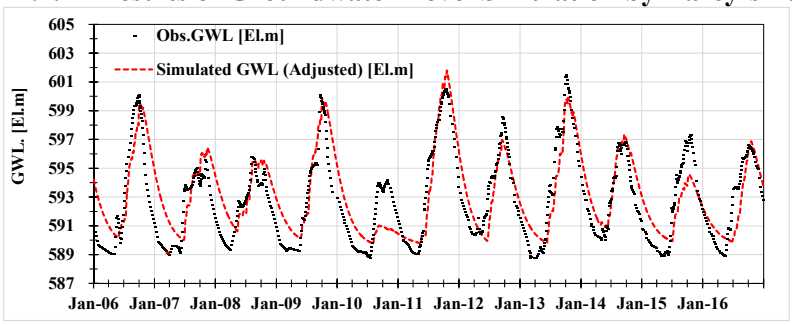




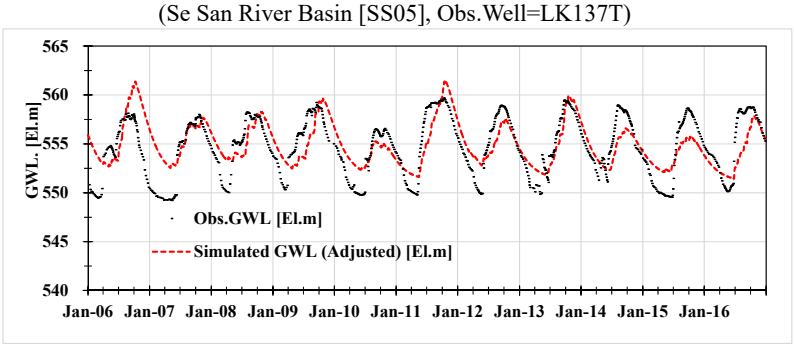


Source: JICA Study Team

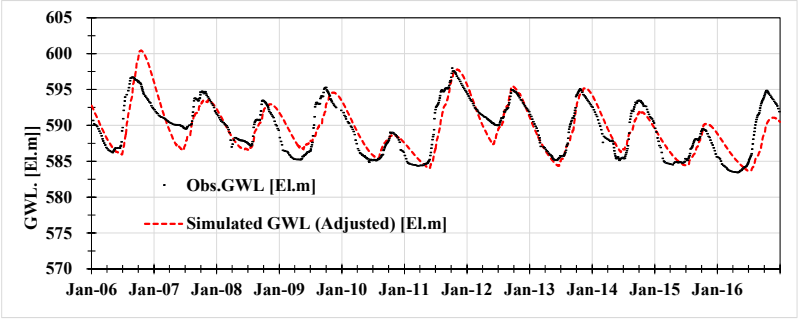
AT 4.1.17 Results of Groundwater Level Simulation by Darcy's Law



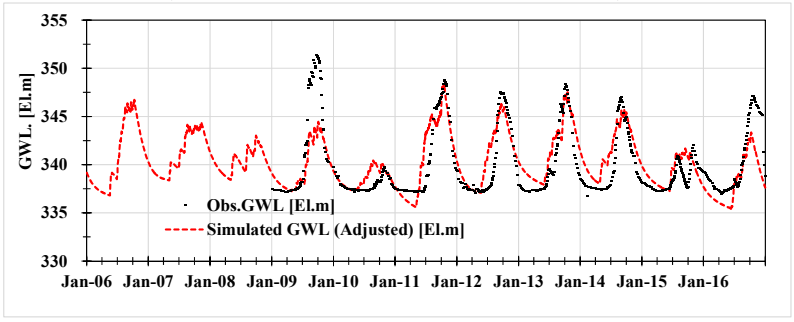
(Se San River Basin [SS05], Obs.Well=LK137T)



(Se San River Basin [SS12], Obs.Well=LK140T)



(Se San River Basin [SS09], Obs.Well=LK63T)



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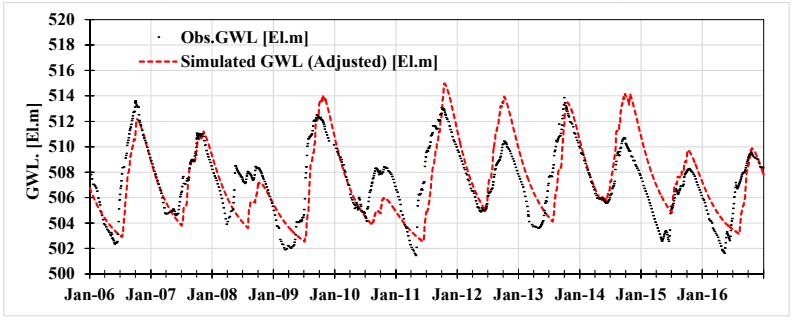
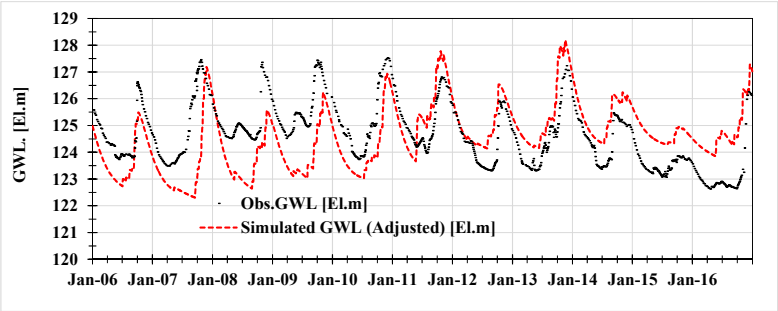
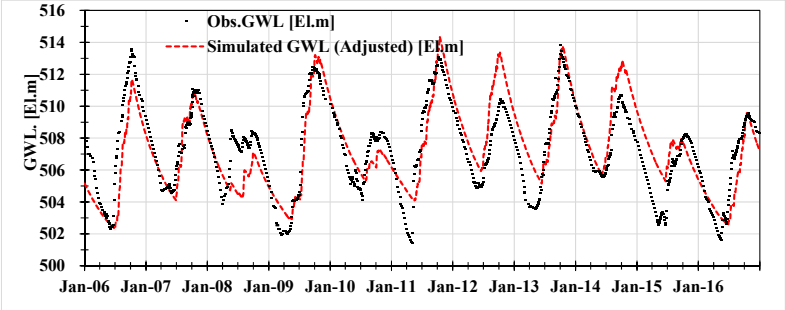


(Ba River Basin [Ba06], Obs.Well=LK66T)

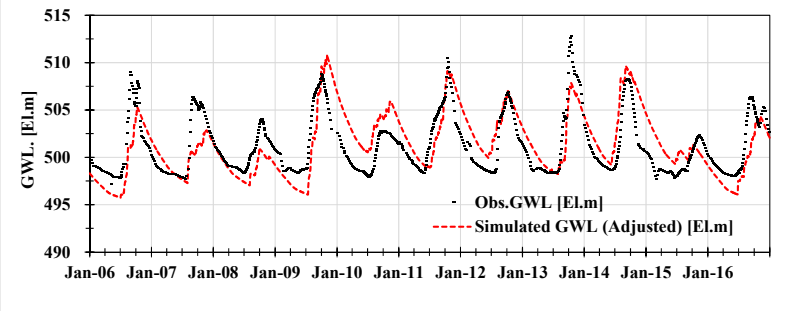
Source: JICA Study Team



(Ba River Basin [Ba16], Obs.Well=LK39T)



(Srepok River Basin [SP05], Obs.Well=LK66T)



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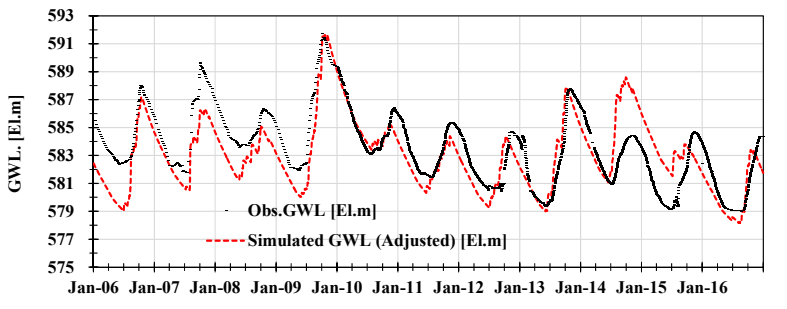
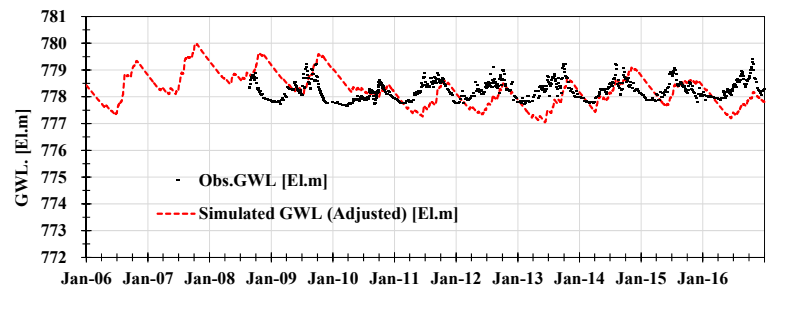


(Srepok River Basin [SP15], Obs.Well=CB12-II)



(Dong Nai River Basin [DN12], Obs.Well=LK95Tm1)

Source: JICA Study Team

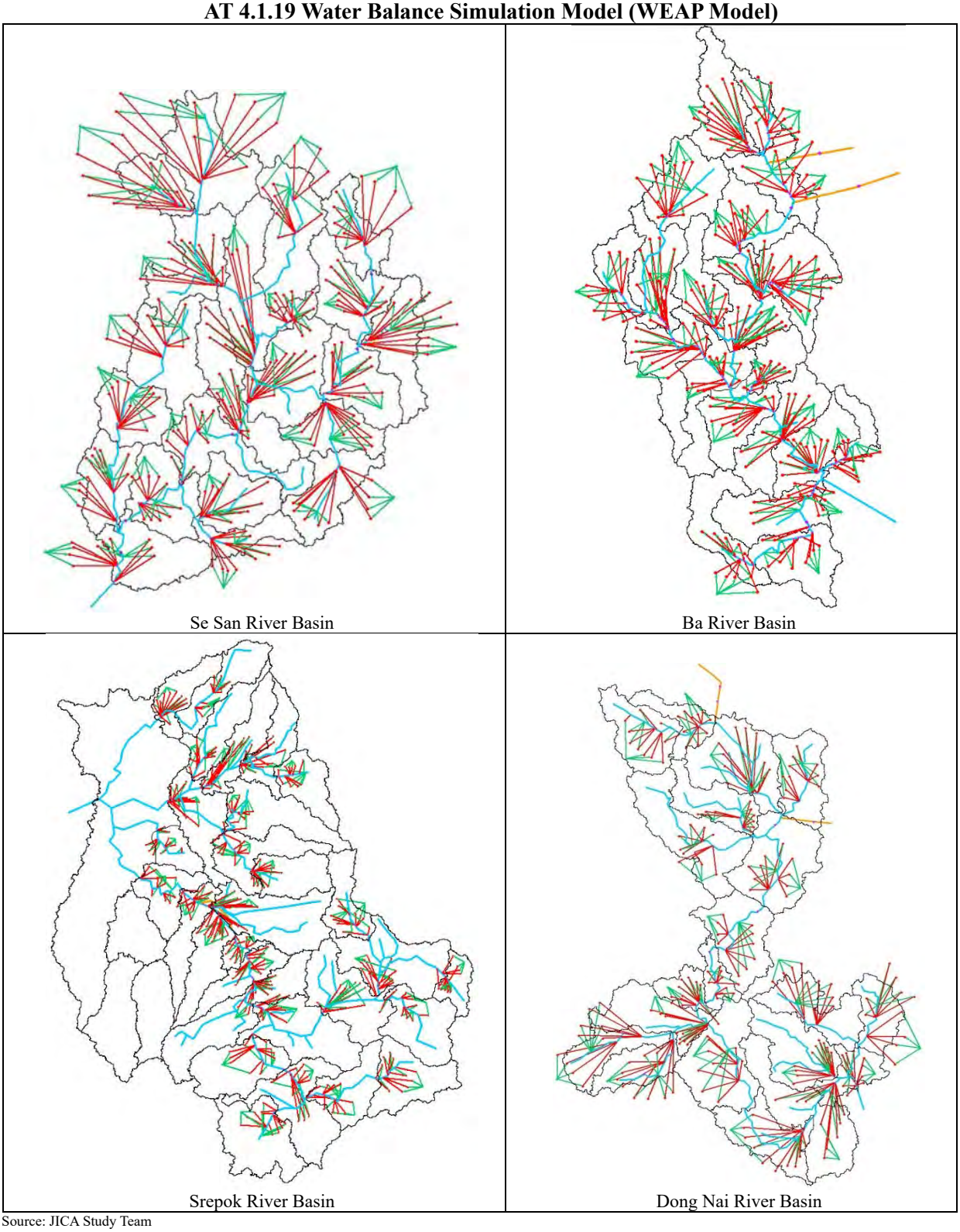
AT 4.1.18 Annual Water Availability

(Unit: mm/year)

Year	SeSan	Ba	Srepok	Dong Nai
1977 - 1978	1,276	1,175	1,508	1,320
1978 - 1979	1,776	1,399	1,869	1,930
1979 - 1980	2,051	1,599	1,960	2,167
1980 - 1981	1,987	1,837	1,963	1,953
1981 - 1982	1,890	1,716	2,016	2,126
1982 - 1983	1,684	1,220	1,585	1,801
1983 - 1984	1,784	1,814	1,774	1,994
1984 - 1985	2,245	1,827	2,229	1,968
1985 - 1986	1,527	1,377	1,606	1,670
1986 - 1987	1,727	1,612	1,702	1,995
1987 - 1988	1,379	1,369	1,818	1,944
1988 - 1989	1,558	1,700	1,943	1,590
1989 - 1990	1,687	1,370	1,916	1,872
1990 - 1991	1,818	1,900	2,225	2,013
1991 - 1992	1,643	1,364	1,543	1,701
1992 - 1993	1,564	1,671	1,989	1,678
1993 - 1994	1,586	1,718	1,911	1,961
1994 - 1995	1,716	1,275	1,475	1,691
1995 - 1996	1,685	1,502	1,691	2,002
1996 - 1997	2,027	2,146	2,263	2,237
1997 - 1998	1,525	1,241	1,623	1,983
1998 - 1999	1,408	1,759	2,054	2,245
1999 - 2000	1,912	1,965	2,026	2,096
2000 - 2001	1,975	1,738	2,100	2,774
2001 - 2002	2,024	1,311	1,810	1,746
2002 - 2003	1,798	1,296	1,674	1,920
2003 - 2004	1,995	1,556	1,680	2,251
2004 - 2005	1,664	1,181	1,342	1,683
2005 - 2006	2,030	1,776	2,038	2,026
2006 - 2007	2,171	1,517	1,936	1,932
2007 - 2008	1,935	1,840	2,170	2,098
2008 - 2009	1,726	1,829	1,872	1,901
2009 - 2010	1,986	1,710	2,291	1,910
2010 - 2011	1,272	1,580	1,653	1,723
2011 - 2012	2,450	1,953	2,244	2,025
2012 - 2013	1,752	1,515	1,745	1,736
2013 - 2014	2,254	1,864	2,058	2,247
2014 - 2015	1,643	1,369	1,815	1,814
2015 - 2016	1,326	1,177	1,537	1,703
Min	1,272	1,175	1,342	1,320
Max	2,450	2,146	2,291	2,774
Mean	1,781	1,584	1,863	1,934
Standard deviation	276	258	244	246
Coefficient of Variation	15%	16%	13%	13%

Source: JICA Study Team

AT 4.1.19 Water Balance Simulation Model (WEAP Model)



Se San River Basin

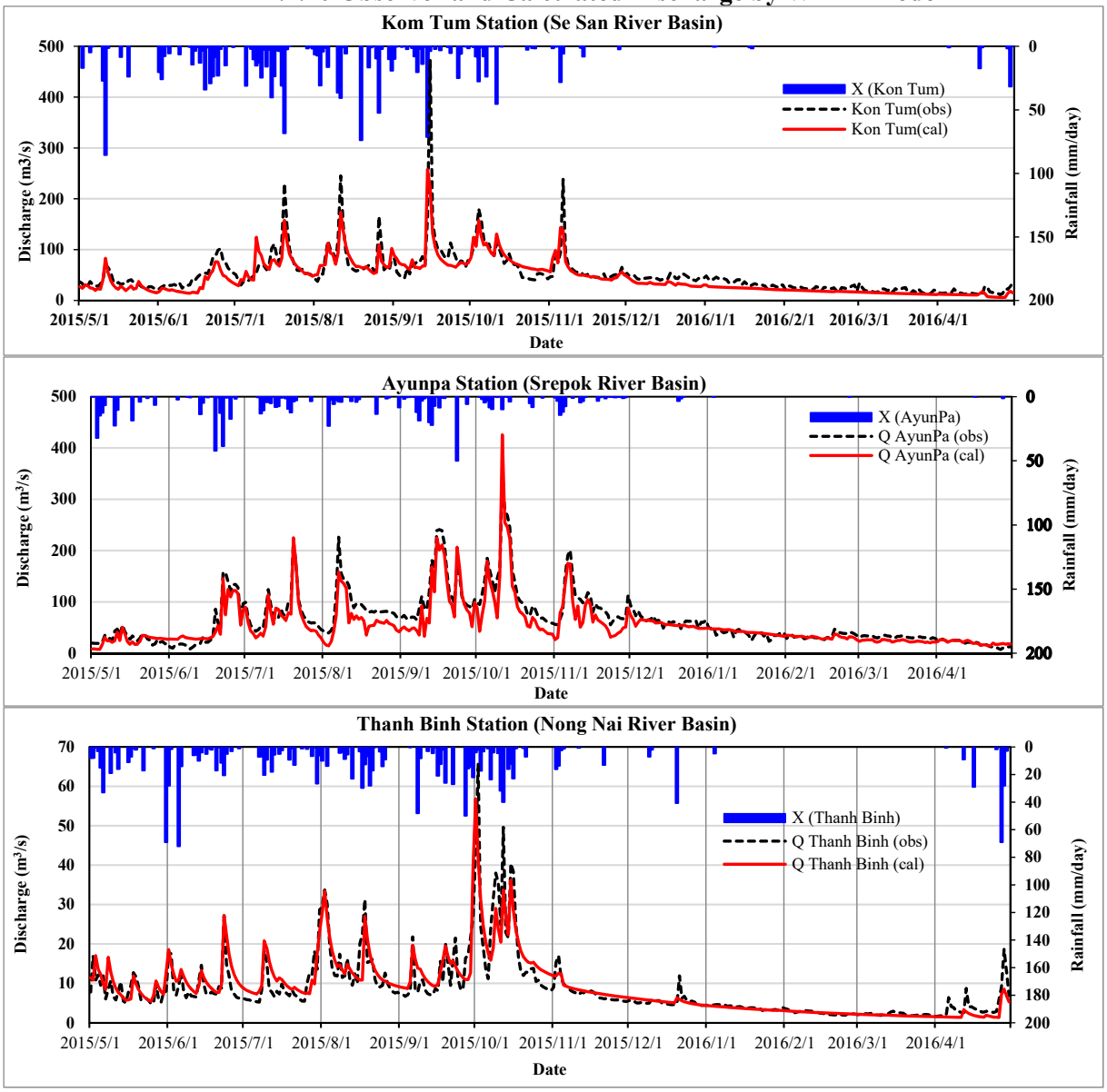
Ba River Basin

Srepok River Basin

Dong Nai River Basin

Source: JICA Study Team

AT 4.1.20 Observer and Calculated Discharge by WEAP Model



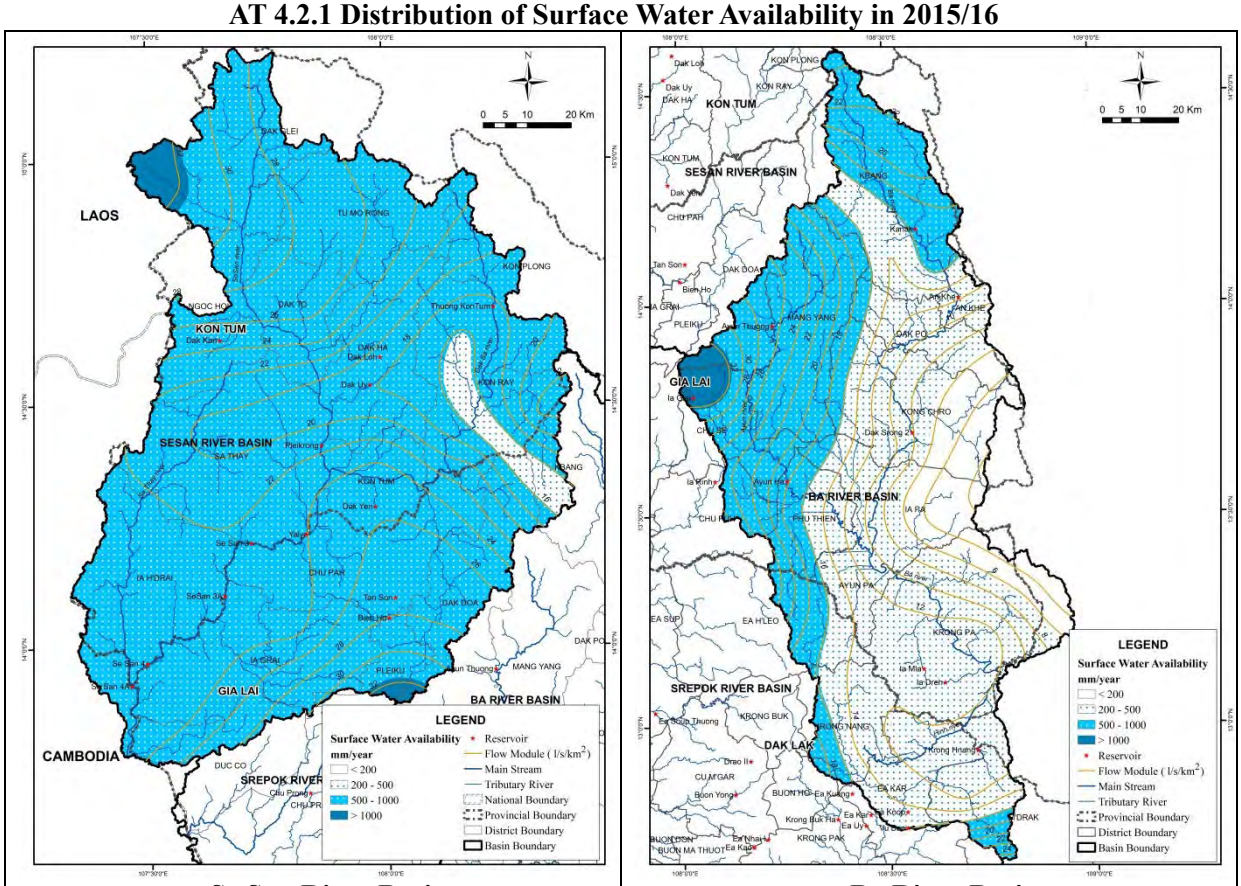
Source: JICA Study Team based on observed discharge by MONRE

AT 4.1.21 Validation Result of WEAP Model in 2015/16

Basin	Station	Nash	PVE	R2
SeSan	Kon Plong	71%	25%	88%
	Kon Tum	74%	12%	76%
	Dak Mot	75%	17%	79%
Ba	An Khe	85%	4%	88%
	AyunPa	86%	7%	88%
	PoMoRe	83%	18%	88%
Srepok	Krong Buk	91%	17%	95%
	Giang Son	85%	8%	86%
	Duc Xuyen	90%	2%	90%
	Cau 14	90%	0%	90%
	Ban Don	90%	2%	99%
Dong Nai	Dak Nong	87%	0%	89%
	Thanh Binh	81%	4%	81%

Source: JICA Study Team

AT 4.2.1 Distribution of Surface Water Availability in 2015/16

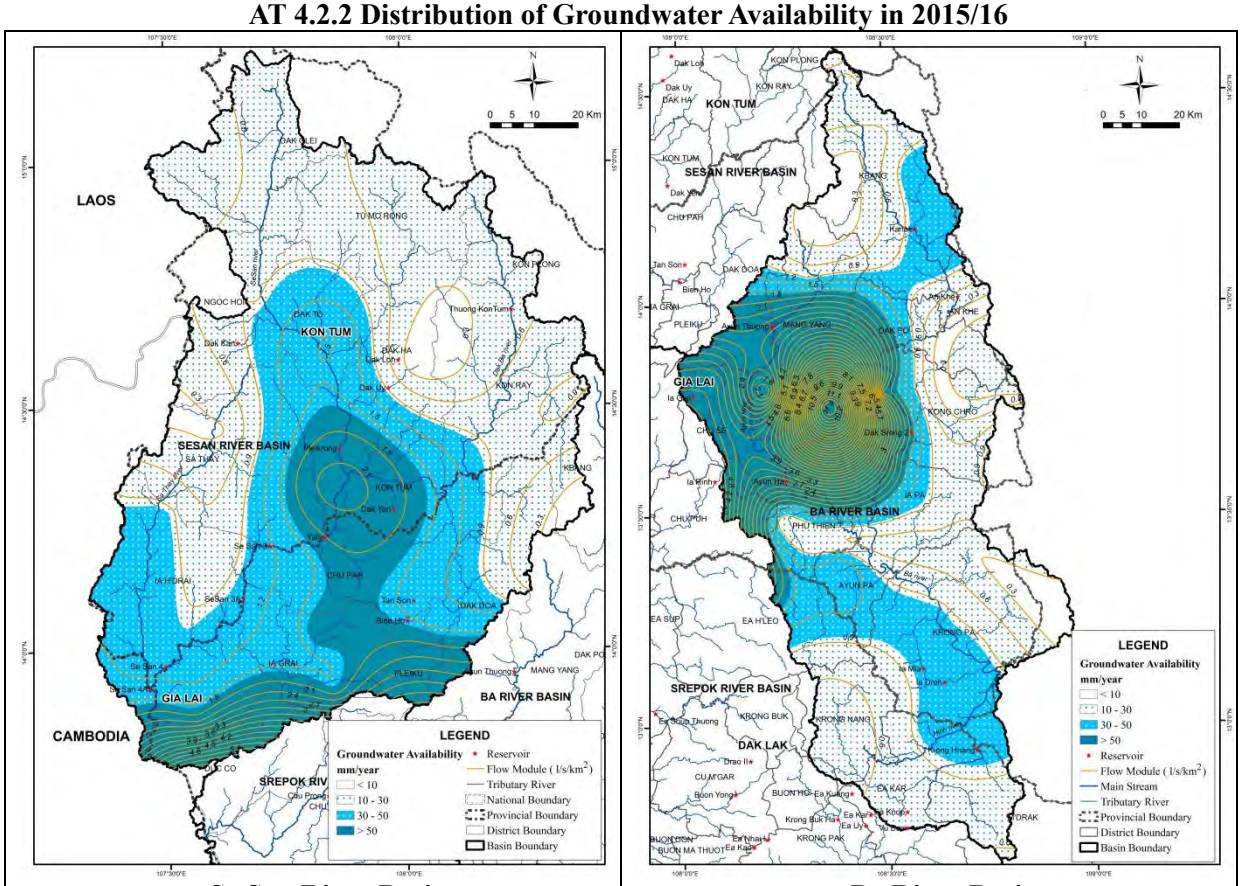


Se San River Basin | Ba River Basin

Srepok River Basin | Dong Nai River Basin

Source: JICA Study Team

AT 4.2.2 Distribution of Groundwater Availability in 2015/16

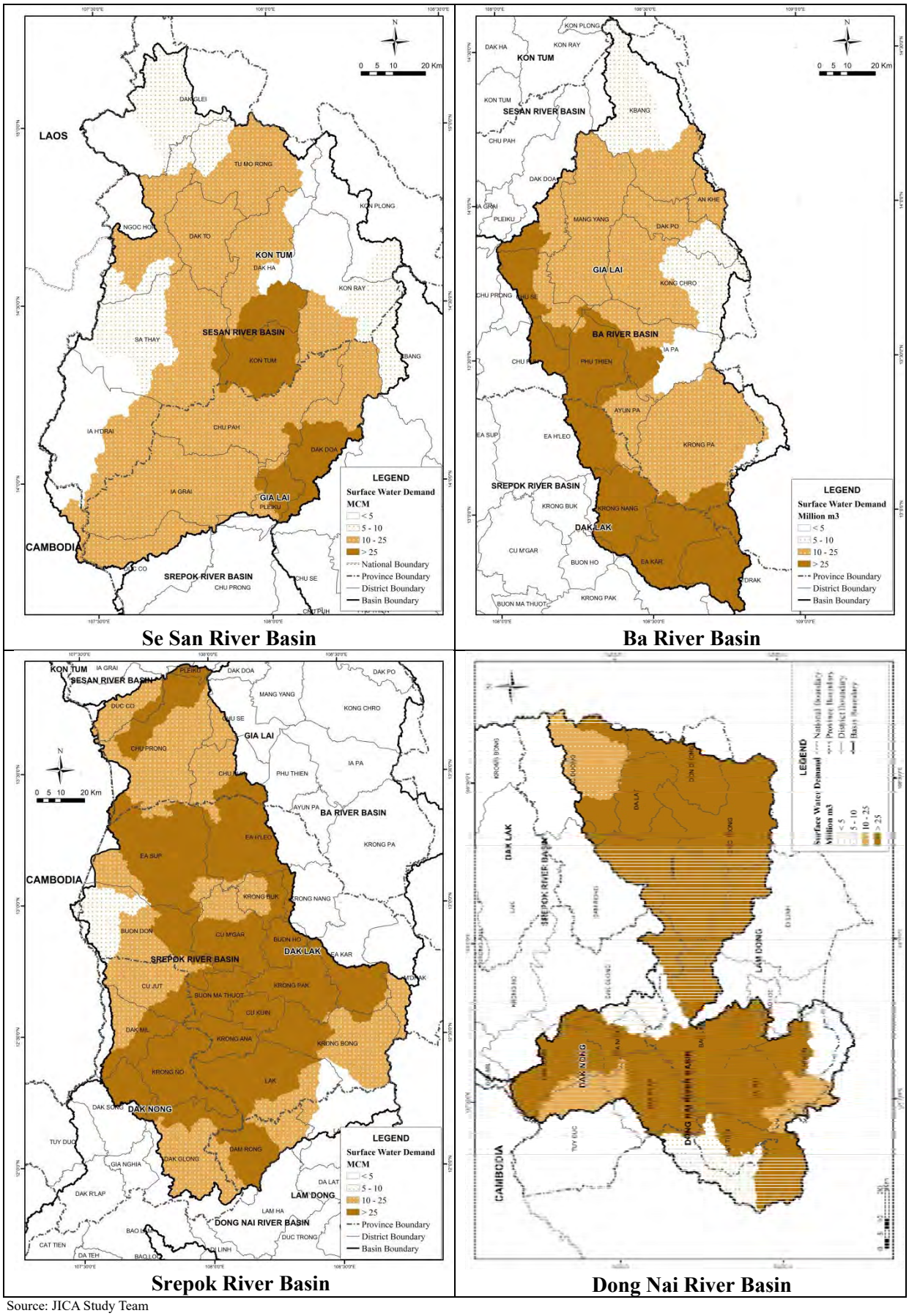


Se San River Basin | Ba River Basin

Srepok River Basin | Dong Nai River Basin

Source: JICA Study Team

AT 4.2.3 Distribution of Total Surface Water Demand in 2015/16

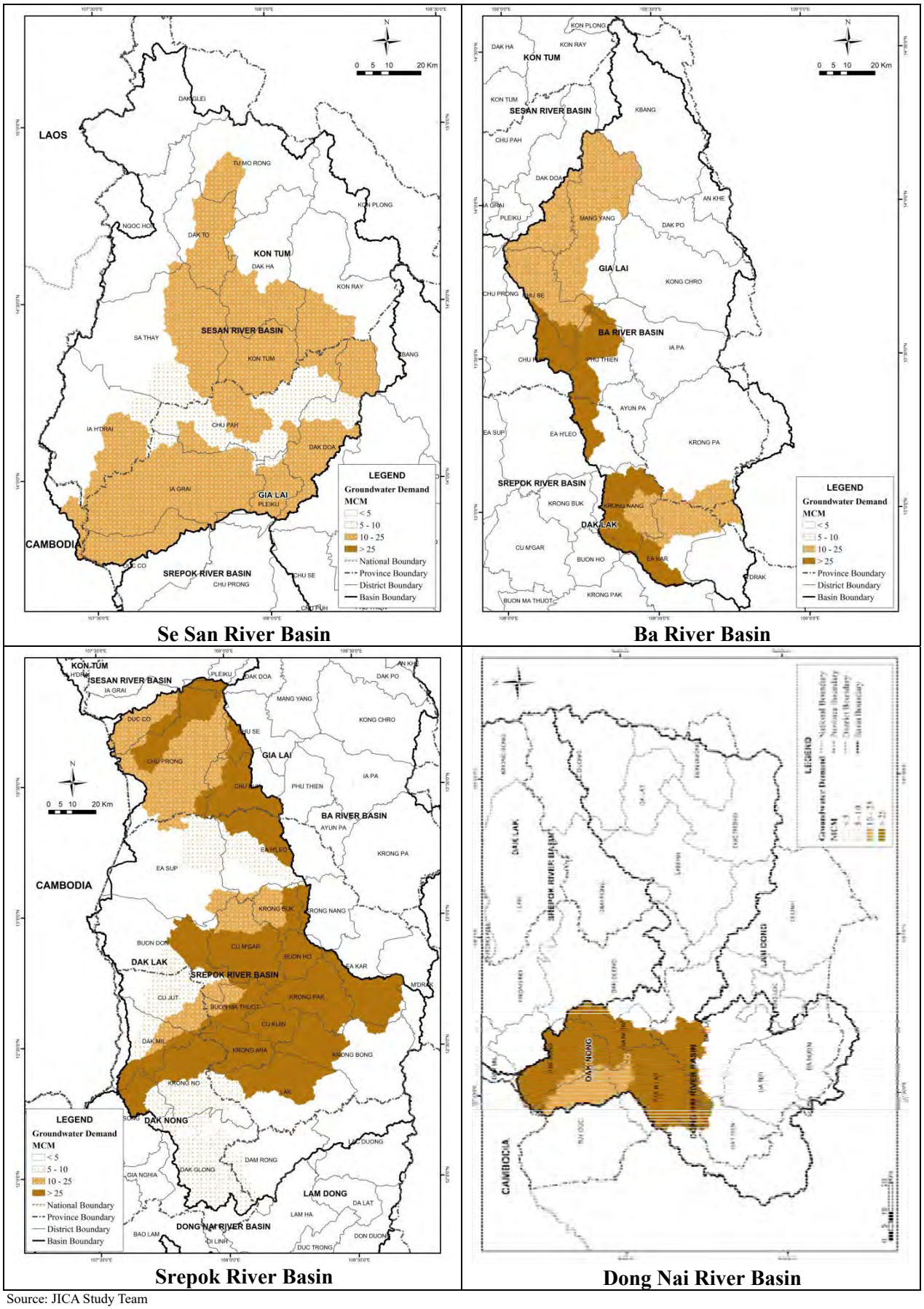


Se San River Basin | Ba River Basin

Srepok River Basin | Dong Nai River Basin

Source: JICA Study Team

AT 4.2.4 Distribution of Total Groundwater Demand in 2015/16



Source: JICA Study Team

AT 4.2.5 Estimated Water Demand in Central Highlands in 2015/16

(unit: MCM/year)

CODE	District	Province	Area (km^2)	Domestict, Industrial, Live Stock, Fihery			Irrigation		
				Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
3901	Kon Tum	Kon Tum	432	9.63	1.35	10.98	23.57	2.01	25.58
3902	Dak Glei	Kon Tum	1,497	2.29	0.65	2.95	19.33	3.10	22.43
3903	Ngoc Hoi	Kon Tum	849	9.30	0.59	9.88	17.08	2.76	19.84
3904	Dak To	Kon Tum	508	4.04	0.52	4.56	14.80	3.88	18.67
3905	Kon Plong	Kon Tum	1,376	1.13	0.62	1.76	22.86	1.14	24.01
3906	Kon Ray	Kon Tum	919	1.91	0.40	2.30	22.05	11.67	33.72
3907	Dak Ha	Kon Tum	844	5.94	0.81	6.75	47.85	20.97	68.82
3908	Sa Thay	Kon Tum	1,399	3.98	0.63	4.62	16.75	3.49	20.24
3909	Tu Mo Rong	Kon Tum	860	1.02	0.58	1.61	11.80	1.75	13.54
3910	Ia H'Drai	Kon Tum	1,014	0.61	0.11	0.73	0.16	0.05	0.21
4001	Pleiku	Gia Lai	262	10.53	2.66	13.19	23.12	10.16	33.28
4002	An Khe	Gia Lai	200	4.94	1.08	6.02	9.53	0.00	9.53
4003	Ayun Pa	Gia Lai	289	2.28	0.61	2.89	22.67	0.00	22.67
4004	KBang	Gia Lai	1,843	2.08	0.88	2.96	32.04	6.63	38.67
4005	Dak Doa	Gia Lai	984	7.89	1.68	9.57	79.51	37.69	117.20
4006	Chu Pah	Gia Lai	981	1.98	1.03	3.02	46.40	23.85	70.25
4007	Ia Grai	Gia Lai	1,118	2.78	1.43	4.20	78.23	39.20	117.42
4008	Mang Yang	Gia Lai	1,129	8.11	1.76	9.87	33.77	12.56	46.33
4009	Kong Chro	Gia Lai	1,449	1.83	0.96	2.79	51.55	0.00	51.55
4010	Duc Co	Gia Lai	722	2.72	1.36	4.08	37.90	19.47	57.37
4011	Chu Prong	Gia Lai	1,699	13.68	1.82	15.49	76.88	47.89	124.77
4012	Chu Se	Gia Lai	646	10.75	1.72	12.47	59.31	35.52	94.84
4013	Dak Po	Gia Lai	503	1.65	0.89	2.54	16.06	0.00	16.06
4014	Ia Pa	Gia Lai	871	1.88	1.46	3.35	74.67	0.00	74.67
4015	Krong Pa	Gia Lai	1,629	13.12	1.51	14.63	52.47	0.00	52.47
4016	Phu Thien	Gia Lai	506	3.80	1.35	5.15	97.70	0.04	97.74
4017	Chu PuH	Gia Lai	719	2.75	1.40	4.15	27.25	41.60	68.84
4101	Buon Ma Thuot	Dak Lak	382	63.31	11.77	75.09	44.04	5.60	49.64
4102	Ea H'leo	Dak Lak	1,337	5.40	2.58	7.98	125.99	80.50	206.49
4103	Ea Sup	Dak Lak	1,769	54.88	2.81	57.69	117.79	0.13	117.92
4104	Krong Nang	Dak Lak	617	15.52	2.11	17.63	105.67	61.47	167.14
4105	Krong Buk	Dak Lak	356	13.18	1.55	14.73	68.46	48.13	116.59
4106	Buon Don	Dak Lak	1,410	25.54	1.86	27.40	44.58	12.94	57.51
4107	Cu M'gar	Dak Lak	826	5.27	2.77	8.04	133.72	91.58	225.30
4108	Ea Kar	Dak Lak	1,044	28.77	3.20	31.98	128.67	18.09	146.76
4109	M'Drak	Dak Lak	1,347	7.17	1.18	8.34	51.82	3.77	55.60
4110	Krong Pak	Dak Lak	630	8.99	3.49	12.49	135.57	38.31	173.88
4111	Krong Bong	Dak Lak	1,259	33.56	3.31	36.87	60.17	7.54	67.71
4112	Krong Ana	Dak Lak	354	14.34	2.39	16.73	132.75	33.75	166.50
4113	Lak	Dak Lak	1,252	16.51	1.51	18.02	85.92	7.30	93.22
4114	Cu Kuin	Dak Lak	292	22.46	1.60	24.06	73.65	33.96	107.62
4115	Buon Ho	Dak Lak	284	5.81	2.93	8.73	74.80	41.68	116.48
4201	Gia Nghia	Dak Nong	285	8.81	0.31	9.12	28.74	20.58	49.32
4202	Dak Glong	Dak Nong	1,450	9.72	0.85	10.57	29.96	15.60	45.56
4203	Cu Jut	Dak Nong	723	4.60	0.98	5.58	43.60	13.96	57.56
4204	Dak Mil	Dak Nong	684	13.99	1.40	15.38	69.84	43.00	112.83
4205	Krong No	Dak Nong	815	7.20	0.94	8.14	67.32	28.04	95.35
4206	Dak Song	Dak Nong	808	6.97	1.26	8.23	84.35	58.03	142.37
4207	Dak R'Lap	Dak Nong	637	6.07	0.96	7.03	67.54	44.24	111.79
4208	Tuy Duc	Dak Nong	1,121	3.36	0.64	4.00	56.08	38.00	94.08
4301	Da Lat	Lam Dong	395	50.80	2.91	53.71	27.87	0.00	27.87
4302	Bao Loc	Lam Dong	234	12.86	2.57	15.43	39.52	0.04	39.56
4303	Dam Rong	Lam Dong	865	9.23	1.08	10.31	47.07	0.03	47.09
4304	Lac Duong	Lam Dong	1,268	5.57	0.52	6.09	19.86	0.00	19.86
4305	Lam Ha	Lam Dong	984	10.11	1.69	11.81	191.85	0.47	192.32
4306	Don Duong	Lam Dong	613	9.32	1.39	10.70	85.58	0.02	85.60
4307	Duc Trong	Lam Dong	908	6.69	2.28	8.97	172.05	0.68	172.73
4308	Di Linh	Lam Dong	1,621	7.32	1.93	9.25	177.60	0.63	178.24
4309	Bao Lam	Lam Dong	1,467	5.47	1.93	7.40	117.85	0.30	118.15
4310	Da Huoai	Lam Dong	497	1.64	0.46	2.10	14.85	0.05	14.91
4311	Da Teh	Lam Dong	528	13.53	1.39	14.92	39.71	0.07	39.78
4312	Cat Tien	Lam Dong	427	3.93	0.55	4.47	51.84	0.07	51.91
Total			**54,737**	**650.54**	**100.96**	**751.50**	**3,831.98**	**1,074.00**	**4,905.99**

Source: JICA Study Team

AT 4.2.6 Annual Water Demand by District in 2015/16

Type	Province	< 5 MCM/ Year	5-10 MCM/ Year	10-25 MCM/ Year	>=25 MCM/ Year
Surface water	Kon Tum	Ia H'Drai		Dak Glei, Dak To, Kon Plong, Kon Ray, Sa Thay, Tu Mo Rong	Kon Tum, Ngoc Hoi, Dak Ha
	Gia Lai			An Khe, Ayun Pa, Dak Po	Pleiku, KBang, Dak Doa, Chu Pah, Ia Grai, Mang Yang, Kong Chro, Duc Co, Chu Prong, Chu Se, Ia Pa, Krong Pa, Phu Thien, Chu PuH
	Dak Lak				Buon Ma Thuot, Ea H'leo, Ea Sup, Krong Nang, Krong Buk, Buon Don, Cu M'gar, Ea Kar, M'Drak, Krong Pak, Krong Bong, Krong Ana, Lak, Cu Kuin, Buon Ho
	Dak Nong				Gia Nghia, Dak Glong, Cu Jut, Dak Mil, Krong No, Dak Song, Dak R'Lap, Tuy Duc
	Lam Dong			Da Huoai	Da Lat, Bao Loc, Dam Rong, Lac Duong, Lam Ha, Don Duong, Duc Trong, Di Linh, Bao Lam, Da Teh, Cat Tien
Ground water	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Kon Plong, Sa Thay, Tu Mo Rong, Ia H'Drai		Kon Ray, Dak Ha	
	Gia Lai	An Khe, Ayun Pa, Kong Chro, Dak Po, Ia Pa, Krong Pa, Phu Thien	KBang	Pleiku, Chu Pah, Mang Yang, Duc Co	Dak Doa, Ia Grai, Chu Prong, Chu Se, Chu PuH
	Dak Lak	Ea Sup, M'Drak	Lak	Buon Ma Thuot, Buon Don, Ea Kar, Krong Bong	Ea H'leo, Krong Nang, Krong Buk, Cu M'gar, Krong Pak, Krong Ana, Cu Kuin, Buon Ho
	Dak Nong			Gia Nghia, Dak Glong, Cu Jut	Dak Mil, Krong No, Dak Song, Dak R'Lap, Tuy Duc
	Lam Dong	Da Lat, Bao Loc, Dam Rong, Lac Duong, Lam Ha, Don Duong, Duc Trong, Di Linh, Bao Lam, Da Huoai, Da Teh, Cat Tien			

Source: JICA Study Team

AT 4.2.7 Total Water Balance of River Basins in Central Highlands in 2015/16

Items	Se San	Ba	Srepok	Dong Nai
Catchment Area in Central Highlands (km^2)	11,377	10.779	17,887	9,236
Rainfall (mm)	1,509	1,477	1,618	2,102
Evapotranspiration (mm)	611	777	797	980
Surface Runoff (mm)	78	150	102	119
Infiltration (mm)	607	337	579	789
Subsurface (inter) flow (mm)	193	136	133	6.9
Recharge to River (mm)	476	277	529	582
Seepage to Deep Aquifers (mm)	109	16.9	37.6	205.9
River Intake for Irrigation (mm)	21.0	40.3	44.3	64.7
River Intake for Domestic Water, etc. (mm)	11.5	14.1	5.73	6.9
Groundwater Demand for Domestic, etc. (mm)	0.7	1.12	1.16	1.36
Groundwater Demand for Irrigation (mm)	13.3	14.8	25.2	12.9
Groundwater Outflow to Downstream Basin (mm)	779	403	484	565

Source: JICA Study Team

AT 4.2.8 Annual Water Shortage by District in 2015/16

Type	Province	< 0.5 MCM/ Year	0.5-10 MCM/ Year	10-25 MCM/ Year	>=25 MCM/ Year
Surface water	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Dak Ha, Sa Thay, Tu Mo Rong, Ia H'Drai	Kon Plong, Kon Ray		
	Gia Lai	An Khe, Ayun Pa, Chu Pah, Ia Pa, Krong Pa, Phu Thien	Pleiku, KBang, Dak Doa, Ia Grai, Mang Yang, Kong Chro, Duc Co, Chu Prong, Chu Se, Dak Po, Chu PuH		
	Dak Lak	Buon Don, Cu M'gar	Buon Ma Thuot, Ea H'leo, Ea Sup	Krong Nang, Krong Buk, M'Drak, Krong Bong, Lak, Buon Ho	Ea Kar, Krong Pak, Krong Ana, Cu Kuin
	Dak Nong	Gia Nghia, Cu Jut, Dak R'Lap, Tuy Duc	Dak Glong, Dak Mil, Dak Song	Krong No	
	Lam Dong	Da Teh, Cat Tien	Bao Loc, Dam Rong, Lac Duong, Bao Lam, Da Huoai	Da Lat, Don Duong, Di Linh	Lam Ha, Duc Trong
Ground water	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Kon Plong, Kon Ray, Sa Thay, Tu Mo Rong, Ia H'Drai	Dak Ha		
	Gia Lai	An Khe, Ayun Pa, KBang, Kong Chro, Chu Prong, Dak Po, Ia Pa, Krong Pa	Pleiku, Chu Pah, Ia Grai, Mang Yang, Duc Co, Chu Se, Phu Thien	Dak Doa, Chu PuH	
	Dak Lak	M'Drak, Krong Ana, Lak	Buon Ma Thuot, Krong Bong, Cu Kuin	Ea H'leo, Buon Don, Ea Kar, Krong Pak	Ea Sup, Krong Nang, Krong Buk, Buon Don, Cu M'gar, Buon Ho
	Dak Nong		Gia Nghia, Dak Glong, Cu Jut, Dak Mil, Krong No, Dak R'Lap, Tuy Duc	Dak Song	
	Lam Dong	Da Lat, Bao Loc, Dam Rong, Lac Duong, Lam Ha, Don Duong, Duc Trong, Di Linh, Bao Lam, Da Huoai, Da Teh, Cat Tien			
Total	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Sa Thay, Tu Mo Rong, Ia H'Drai	Kon Plong, Kon Ray, Dak Ha		
	Gia Lai	An Khe, Ayun Pa, Ia Pa, Krong Pa	Pleiku, KBang, Chu Pah, Ia Grai, Mang Yang, Kong Chro, Duc Co, Chu Prong, Chu Se, Dak Po, Phu Thien	Dak Doa, Chu PuH	
	Dak Lak		Buon Ma Thuot	Ea H'leo, Buon Don, M'Drak, Lak	Ea Sup, Krong Nang, Krong Buk, Cu M'gar, Ea Kar, Krong Pak, Krong Bong, Krong Ana, Cu Kuin, Buon Ho
	Dak Nong		Gia Nghia, Dak Glong, Cu Jut, Dak R'Lap, Tuy Duc	Dak Mil, Krong No, Dak Song	
	Lam Dong	Da Teh, Cat Tien	Bao Loc, Dam Rong, Lac Duong, Bao Lam, Da Huoai	Da Lat, Don Duong, Di Linh	Lam Ha, Duc Trong

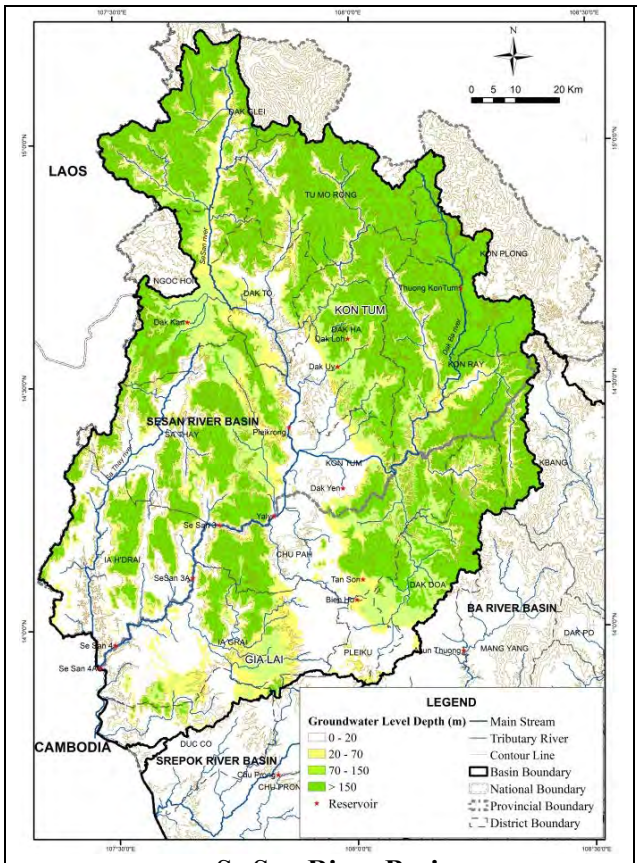
Source: JICA Study Team

AT 4.2.9 Water Shortage by District in Central Highlands in 2015/16

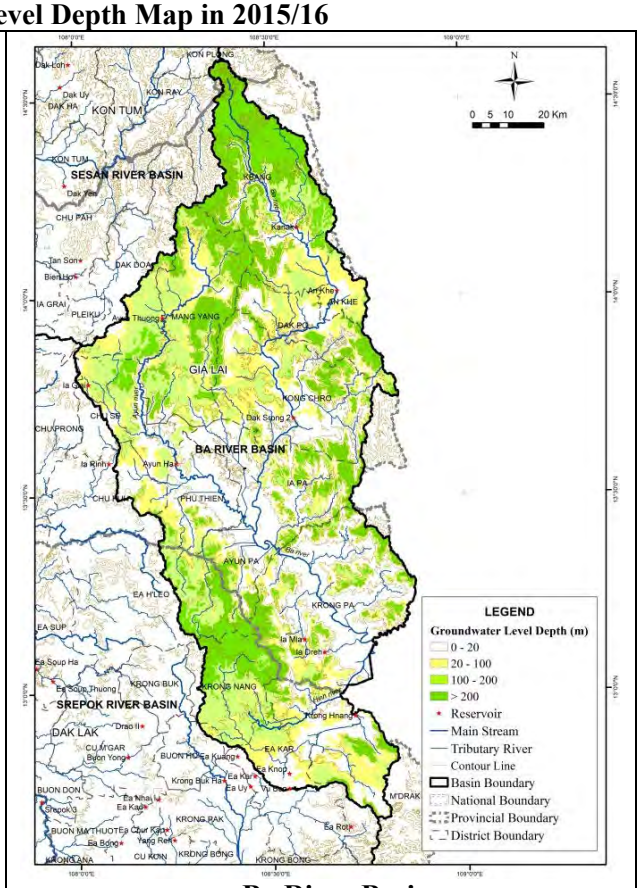
CODE	Province	District	2015/16 Total	2015/16 SW	2015/16 GW	2015/16 Total	2015/16 SW	2015/16 GW	2015/16 Total	2015/16 SW	2015/16 GW
			Unit: MCM			Unit: MCM			Unit: MCM		
3901	Kon Tum	Kon Tum	0.00	0.00	0.00	36.6	33.2	3.4	0.0%	0.0%	0.0%
3902	Kon Tum	Dak Glei	0.00	0.00	0.00	25.4	21.6	3.8	0.0%	0.0%	0.0%
3903	Kon Tum	Ngoc Hoi	0.00	0.00	0.00	29.7	26.4	3.4	0.0%	0.0%	0.0%
3904	Kon Tum	Dak To	0.00	0.00	0.00	23.2	18.8	4.4	0.0%	0.0%	0.0%
3905	Kon Tum	Kon Plong	6.55	6.55	0.00	25.8	24.0	1.8	25.4%	27.3%	0.0%
3906	Kon Tum	Kon Ray	1.35	1.28	0.06	36.0	24.0	12.1	3.7%	5.4%	0.5%
3907	Kon Tum	Dak Ha	1.21	0.00	1.21	75.6	53.8	21.8	1.6%	0.0%	5.6%
3908	Kon Tum	Sa Thay	0.00	0.00	0.00	24.9	20.7	4.1	0.0%	0.0%	0.0%
3909	Kon Tum	Tu Mo Rong	0.34	0.24	0.10	15.1	12.8	2.3	2.3%	1.9%	4.5%
3910	Kon Tum	Ia H'Drai	0.03	0.03	0.00	0.9	0.8	0.2	3.5%	4.3%	0.0%
4001	Gia Lai	Pleiku	3.63	0.74	2.89	46.5	33.6	12.8	7.8%	2.2%	22.6%
4002	Gia Lai	An Khe	0.00	0.00	0.00	15.5	14.5	1.1	0.0%	0.0%	0.0%
4003	Gia Lai	AyunPa	0.00	0.00	0.00	25.6	25.0	0.6	0.0%	0.0%	0.0%
4004	Gia Lai	Kbang	2.46	2.41	0.04	41.6	34.1	7.5	5.9%	7.1%	0.6%
4005	Gia Lai	Dak Doa	11.98	1.72	10.27	126.8	87.4	39.4	9.5%	2.0%	26.1%
4006	Gia Lai	Chu Pah	1.37	0.39	0.99	73.3	48.4	24.9	1.9%	0.8%	4.0%
4007	Gia Lai	Ia Grai	7.48	1.94	5.54	121.6	81.0	40.6	6.2%	2.4%	13.6%
4008	Gia Lai	Mang Yang	5.41	1.16	4.25	56.2	41.9	14.3	9.6%	2.8%	29.7%
4009	Gia Lai	Kong Chro	2.01	1.90	0.11	54.3	53.4	1.0	3.7%	3.6%	11.3%
4010	Gia Lai	Duc Co	3.12	1.05	2.06	61.5	40.6	20.8	5.1%	2.6%	9.9%
4011	Gia Lai	Chu Prong	0.60	0.60	0.00	140.3	90.6	49.7	0.4%	0.7%	0.0%
4012	Gia Lai	Chu Se	8.99	1.49	7.50	107.3	70.1	37.2	8.4%	2.1%	20.1%
4013	Gia Lai	DaK Po	1.27	1.20	0.07	18.6	17.7	0.9	6.8%	6.8%	7.8%
4014	Gia Lai	Ia Pa	0.05	0.05	0.00	78.0	76.6	1.5	0.1%	0.1%	0.0%
4015	Gia Lai	Krong Pa	0.40	0.00	0.40	67.1	65.6	1.5	0.6%	0.0%	26.4%
4016	Gia Lai	Phu Thien	1.20	0.00	1.20	102.9	101.5	1.4	1.2%	0.0%	86.2%
4017	Gia Lai	Chu Puh	24.06	4.88	19.18	73.0	30.0	43.0	33.0%	16.3%	44.6%
4101	Dak Lak	Buon Ma Thuot	7.29	5.45	1.84	124.7	107.4	17.4	5.8%	5.1%	10.6%
4102	Dak Lak	Ea H'leo	21.72	5.74	15.98	214.5	131.4	83.1	10.1%	4.4%	19.2%
4103	Dak Lak	Ea Sup	30.36	2.87	27.48	175.6	172.7	2.9	17.3%	1.7%	932.8%
4104	Dak Lak	Krong Nang	52.06	18.89	33.17	184.8	121.2	63.6	28.2%	15.6%	52.2%
4105	Dak Lak	Krong Buk	46.50	14.97	31.53	131.3	81.6	49.7	35.4%	18.3%	63.5%
4106	Dak Lak	Buon Don	13.00	0.00	13.00	84.9	70.1	14.8	15.3%	0.0%	87.8%
4107	Dak Lak	Cu M'Gar	44.61	0.18	44.43	233.3	139.0	94.3	19.1%	0.1%	47.1%
4108	Dak Lak	Ea Kar	83.60	63.60	20.00	178.7	157.4	21.3	46.8%	40.4%	93.9%
4109	Dak Lak	M'Drak	12.60	12.14	0.46	63.9	59.0	4.9	19.7%	20.6%	9.4%
4110	Dak Lak	Krong Pak	107.99	84.03	23.96	186.4	144.6	41.8	57.9%	58.1%	57.3%
4111	Dak Lak	Krong Bong	30.36	24.67	5.68	104.6	93.7	10.9	29.0%	26.3%	52.3%
4112	Dak Lak	Krong Ana	31.44	31.12	0.32	183.2	147.1	36.1	17.2%	21.2%	0.9%
4113	Dak Lak	Lak	15.17	15.17	0.00	111.2	102.4	8.8	13.6%	14.8%	0.0%
4114	Dak Lak	Cu Kuin	46.10	39.30	6.80	131.7	96.1	35.6	35.0%	40.9%	19.1%
4115	Dak Lak	Buon Ho	43.61	10.39	33.22	125.2	80.6	44.6	34.8%	12.9%	74.5%
4201	Dak Nong	Gia Nghia	2.01	0.36	1.65	58.4	37.5	20.9	3.4%	1.0%	7.9%
4202	Dak Nong	Dak Glong	3.36	2.14	1.22	56.1	39.7	16.4	6.0%	5.4%	7.4%
4203	Dak Nong	Cu Jut	4.43	0.00	4.43	63.1	48.2	14.9	7.0%	0.0%	29.7%
4204	Dak Nong	Dak Mil	13.82	9.04	4.78	128.2	83.8	44.4	10.8%	10.8%	10.8%
4205	Dak Nong	Krong No	19.90	18.46	1.45	103.5	74.5	29.0	19.2%	24.8%	5.0%
4206	Dak Nong	Dak Song	17.89	7.34	10.55	150.6	91.3	59.3	11.9%	8.0%	17.8%
4207	Dak Nong	Dak R'lap	0.55	0.00	0.55	118.8	73.6	45.2	0.5%	0.0%	1.2%
4208	Dak Nong	Tuy Duc	3.02	0.00	3.02	98.1	59.4	38.6	3.1%	0.0%	7.8%
4301	Lam Dong	Da Lat	16.76	16.76	0.00	81.6	78.7	2.9	20.5%	21.3%	0.0%
4302	Lam Dong	Bao Loc	2.99	2.99	0.00	55.0	52.4	2.6	5.4%	5.7%	0.0%
4303	Lam Dong	Dam Rong	5.08	5.08	0.00	57.4	56.3	1.1	8.8%	9.0%	0.0%
4304	Lam Dong	Lac Duong	1.30	1.30	0.00	26.0	25.4	0.5	5.0%	5.1%	0.0%
4305	Lam Dong	Lam Ha	27.15	27.15	0.00	204.1	202.0	2.2	13.3%	13.4%	0.0%
4306	Lam Dong	Don Duong	14.67	14.67	0.00	96.3	94.9	1.4	15.2%	15.5%	0.0%
4307	Lam Dong	Duc Trong	37.67	37.67	0.00	181.7	178.7	3.0	20.7%	21.1%	0.0%
4308	Lam Dong	Di Linh	16.46	16.46	0.00	187.5	184.9	2.6	8.8%	8.9%	0.0%
4309	Lam Dong	Bao Lam	5.62	5.41	0.21	125.5	123.3	2.2	4.5%	4.4%	9.3%
4310	Lam Dong	Da Huoai	3.14	3.14	0.00	17.0	16.5	0.5	18.4%	19.0%	0.0%
4311	Lam Dong	Da Teh	0.00	0.00	0.00	54.7	53.2	1.5	0.0%	0.0%	0.0%
4312	Lam Dong	Cat Tien	0.01	0.00	0.01	56.4	55.8	0.6	0.0%	0.0%	1.7%
		TOTAL	865.74	524.12	341.63	5657.48	4482.52	1174.96	15.3%	11.7%	29.1%
	Kon Tum		9.49	8.11	1.38	293.18	236.10	57.09	0.37	0.39	0.11
	Gia Lai		74.02	19.52	54.50	1,210.03	911.82	298.21	1.00	0.49	3.03
	Dak Lak		586.41	328.53	257.89	2,234.15	1,704.32	529.83	3.85	2.80	15.21
	Dak Nong		64.98	37.34	27.64	776.93	508.14	268.78	0.62	0.50	0.88
	Lam Dong		130.84	130.63	0.22	1,143.19	1,122.13	21.06	1.21	1.23	0.11
	Total		865.74	524.12	341.63	5,657.48	4,482.52	1,174.96	7.05	5.42	19.33

Source: JICA Study Team

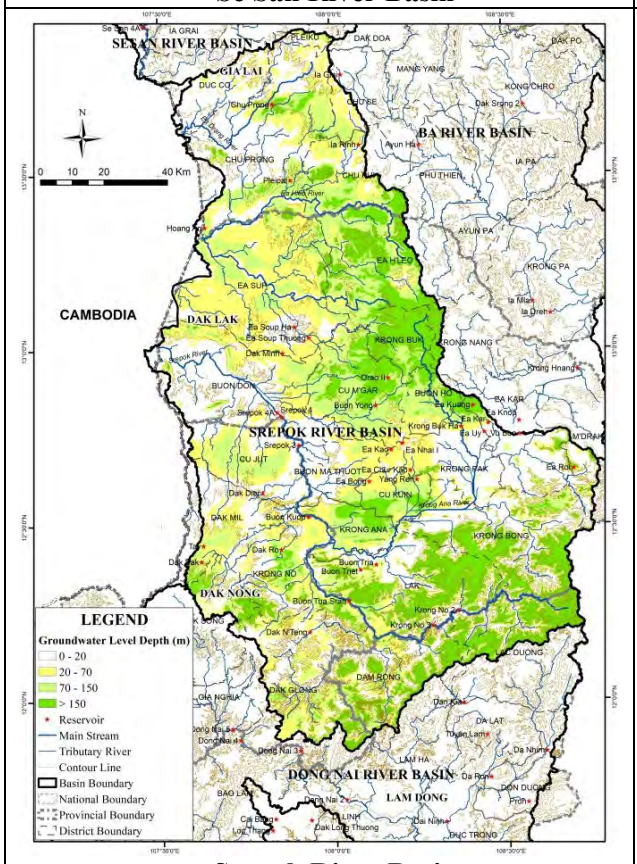
AT 4.2.10 Groundwater Level Depth Map in 2015/16



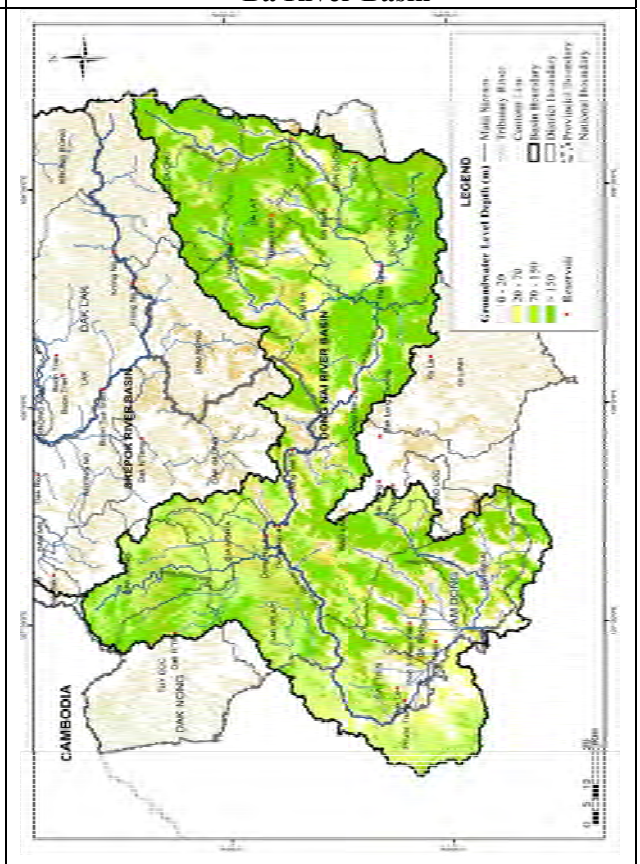
Se San River Basin



Ba River Basin



Srepok River Basin



Dong Nai River Basin

Source: JICA Study Team

AT 4.3.1 Return Period of Annual Rainfall of River Basins

River Basin **Sesan River Basin**
ID_Number RKT02
Name of Station Kon tum
Longitude 108.00
Latitude 14.33
District Kon Tum
Province Kon_Tum

No.	Hydrological Year (Period)	Annual Rainfall (mm/yr)	Rank	Non-Excess Probability (Hazen)	Return Period (Year)	Dry/ Wet Year
1	1977.May-1978.Apr.	1,223.5	39	98.7%	78.00	Max.Dry
2	1978.May-1979.Apr.	1,721.0	24	60.3%	2.52	
3	1979.May-1980.Apr.	1,904.8	15	37.2%	1.59	
4	1980.May-1981.Apr.	2,085.2	8	19.2%	1.24	
5	1981.May-1982.Apr.	1,862.6	17	42.3%	1.73	
6	1982.May-1983.Apr.	1,523.2	30	75.6%	4.11	
7	1983.May-1984.Apr.	2,115.9	7	16.7%	1.20	
8	1984.May-1985.Apr.	1,860.6	18	44.9%	1.81	
9	1985.May-1986.Apr.	1,528.8	29	73.1%	3.71	
10	1986.May-1987.Apr.	2,181.7	6	14.1%	1.16	
11	1987.May-1988.Apr.	1,515.7	31	78.2%	4.59	
12	1988.May-1989.Apr.	1,428.5	35	88.5%	8.67	
13	1989.May-1990.Apr.	1,924.9	13	32.1%	1.47	
14	1990.May-1991.Apr.	1,924.3	14	34.6%	1.53	
15	1991.May-1992.Apr.	1,507.3	32	80.8%	5.20	
16	1992.May-1993.Apr.	1,486.9	33	83.3%	6.00	
17	1993.May-1994.Apr.	1,658.3	27	67.9%	3.12	
18	1994.May-1995.Apr.	1,842.4	19	47.4%	1.90	
19	1995.May-1996.Apr.	1,730.9	23	57.7%	2.36	
20	1996.May-1997.Apr.	2,247.9	4	9.0%	1.10	
21	1997.May-1998.Apr.	1,676.7	26	65.4%	2.89	
22	1998.May-1999.Apr.	1,250.3	38	96.2%	26.00	2nd Dry
23	1999.May-2000.Apr.	1,760.3	22	55.1%	2.23	
24	2000.May-2001.Apr.	2,196.0	5	11.5%	1.13	
25	2001.May-2002.Apr.	1,887.9	16	39.7%	1.66	
26	2002.May-2003.Apr.	1,841.5	20	50.0%	2.00	Medium Year
27	2003.May-2004.Apr.	1,578.0	28	70.5%	3.39	
28	2004.May-2005.Apr.	1,838.5	21	52.6%	2.11	
29	2005.May-2006.Apr.	2,038.6	10	24.4%	1.32	25%Wet Year
30	2006.May-2007.Apr.	2,367.4	2	3.8%	1.04	
31	2007.May-2008.Apr.	2,033.0	11	26.9%	1.37	
32	2008.May-2009.Apr.	2,064.4	9	21.8%	1.28	
33	2009.May-2010.Apr.	1,941.5	12	29.5%	1.42	
34	2010.May-2011.Apr.	1,355.3	36	91.0%	11.14	
35	2011.May-2012.Apr.	2,755.8	1	1.3%	1.01	Max.Wet
36	2012.May-2013.Apr.	1,700.3	25	62.8%	2.69	
37	2013.May-2014.Apr.	2,257.4	3	6.4%	1.07	
38	2014.May-2015.Apr.	1,306.9	37	93.6%	15.60	3rd Dry
39	2015.May-2016.Apr.	1,434.1	34	85.9%	7.09	85%Dry Year

Max.	2,755.8				
Average	1,809.2				
Min.	1,223.5				

Hazen Plot : P =(2i-1)/(2n) ; P : Non-Excess Probability, i: Rank, n: Number of data.
Return Period = 1/(1-P)

River Basin **Ba River Basin**
ID_Number RGL01
Name of Station An khe
Longitude 108.66
Latitude 13.95
District An Khe
Province Gia_Lai

No.	Hydrological Year (Period)	Annual Rainfall (mm/yr)	Rank	Non-Excess Probability (Hazen)	Return Period (Year)	Dry/ Wet Year
1	1977.May-1978.Apr.	1,497.1	21	52.6%	2.11	
2	1978.May-1979.Apr.	1,375.4	26	65.4%	2.89	
3	1979.May-1980.Apr.	1,495.0	22	55.1%	2.23	
4	1980.May-1981.Apr.	2,120.2	4	9.0%	1.10	
5	1981.May-1982.Apr.	1,528.3	19	47.4%	1.90	
6	1982.May-1983.Apr.	688.7	39	98.7%	78.00	
7	1983.May-1984.Apr.	1,482.0	23	57.7%	2.36	
8	1984.May-1985.Apr.	1,622.5	16	39.7%	1.66	
9	1985.May-1986.Apr.	1,319.5	28	70.5%	3.39	
10	1986.May-1987.Apr.	1,895.6	10	24.4%	1.32	25%Wet Year
11	1987.May-1988.Apr.	1,363.7	27	67.9%	3.12	
12	1988.May-1989.Apr.	1,533.3	18	44.9%	1.81	
13	1989.May-1990.Apr.	1,139.4	35	88.5%	8.67	
14	1990.May-1991.Apr.	1,955.4	7	16.7%	1.20	
15	1991.May-1992.Apr.	1,159.2	32	80.8%	5.20	
16	1992.May-1993.Apr.	1,597.3	17	42.3%	1.73	
17	1993.May-1994.Apr.	1,654.8	15	37.2%	1.59	
18	1994.May-1995.Apr.	1,150.4	34	85.9%	7.09	85%Dry Year
19	1995.May-1996.Apr.	1,477.3	24	60.3%	2.52	
20	1996.May-1997.Apr.	1,980.9	6	14.1%	1.16	
21	1997.May-1998.Apr.	1,002.4	37	93.6%	15.60	
22	1998.May-1999.Apr.	2,303.0	1	1.3%	1.01	Max.Wet
23	1999.May-2000.Apr.	1,841.2	12	29.5%	1.42	
24	2000.May-2001.Apr.	1,438.8	25	62.8%	2.69	
25	2001.May-2002.Apr.	1,174.2	31	78.2%	4.59	
26	2002.May-2003.Apr.	1,065.3	36	91.0%	11.14	
27	2003.May-2004.Apr.	1,158.6	33	83.3%	6.00	
28	2004.May-2005.Apr.	959.8	38	96.2%	26.00	Max.Dry
29	2005.May-2006.Apr.	1,860.0	11	26.9%	1.37	
30	2006.May-2007.Apr.	1,273.5	30	75.6%	4.11	
31	2007.May-2008.Apr.	2,120.2	5	11.5%	1.13	
32	2008.May-2009.Apr.	2,264.0	2	3.8%	1.04	2nd Wet
33	2009.May-2010.Apr.	1,694.3	14	34.6%	1.53	
34	2010.May-2011.Apr.	1,757.3	13	32.1%	1.47	
35	2011.May-2012.Apr.	1,928.6	8	19.2%	1.24	
36	2012.May-2013.Apr.	1,905.8	9	21.8%	1.28	
37	2013.May-2014.Apr.	2,214.8	3	6.4%	1.07	
38	2014.May-2015.Apr.	1,510.8	20	50.0%	2.00	Medium Year
39	2015.May-2016.Apr.	1,287.7	29	73.1%	3.71	

Max.	2,303.0				
Average	1,558.9				
Min.	688.7				

Hazen Plot : P =(2i-1)/(2n) ; P : Non-Excess Probability, i: Rank, n: Number of data.
Return Period = 1/(1-P)

River Basin **Srepok River Basin**
ID_Number RDL04
Name of Station Ea Kmat
Longitude 108.13
Latitude 12.68
District Krong Pak
Province Dak Lak

No.	Hydrological Year (Period)	Annual Rainfall (mm/yr)	Rank	Non-Excess Probability (Hazen)	Return Period (Year)	Dry/ Wet Year
1	1977.May-1978.Apr.	1,784.8	20	50.0%	2.00	Medium Year
2	1978.May-1979.Apr.	1,759.9	23	57.7%	2.36	
3	1979.May-1980.Apr.	1,920.3	16	39.7%	1.66	
4	1980.May-1981.Apr.	2,022.6	11	26.9%	1.37	
5	1981.May-1982.Apr.	2,441.8	3	6.4%	1.07	
6	1982.May-1983.Apr.	1,317.4	37	93.6%	15.60	
7	1983.May-1984.Apr.	1,706.3	26	65.4%	2.89	
8	1984.May-1985.Apr.	1,998.7	13	32.1%	1.47	
9	1985.May-1986.Apr.	1,432.2	35	88.5%	8.67	
10	1986.May-1987.Apr.	1,816.9	18	44.9%	1.81	
11	1987.May-1988.Apr.	1,816.5	19	47.4%	1.90	
12	1988.May-1989.Apr.	2,052.0	10	24.4%	1.32	25%Wet Year
13	1989.May-1990.Apr.	1,643.2	30	75.6%	4.11	
14	1990.May-1991.Apr.	2,441.8	2	3.8%	1.04	
15	1991.May-1992.Apr.	1,564.6	32	80.8%	5.20	
16	1992.May-1993.Apr.	2,366.4	4	9.0%	1.10	
17	1993.May-1994.Apr.	2,019.4	12	29.5%	1.42	
18	1994.May-1995.Apr.	1,193.6	38	96.2%	26.00	
19	1995.May-1996.Apr.	1,394.9	36	91.0%	11.14	
20	1996.May-1997.Apr.	2,199.4	7	16.7%	1.20	
21	1997.May-1998.Apr.	1,562.4	33	83.3%	6.00	
22	1998.May-1999.Apr.	2,318.4	5	11.5%	1.13	
23	1999.May-2000.Apr.	2,734.7	1	1.3%	1.01	Max.Wet
24	2000.May-2001.Apr.	2,095.4	9	21.8%	1.28	
25	2001.May-2002.Apr.	1,965.9	15	37.2%	1.59	
26	2002.May-2003.Apr.	1,568.8	31	78.2%	4.59	
27	2003.May-2004.Apr.	1,824.2	17	42.3%	1.73	
28	2004.May-2005.Apr.	1,144.7	39	98.7%	78.00	Max.Dry
29	2005.May-2006.Apr.	1,973.4	14	34.6%	1.53	
30	2006.May-2007.Apr.	1,763.7	22	55.1%	2.23	
31	2007.May-2008.Apr.	2,228.0	6	14.1%	1.16	
32	2008.May-2009.Apr.	1,754.1	24	60.3%	2.52	
33	2009.May-2010.Apr.	1,666.6	29	73.1%	3.71	
34	2010.May-2011.Apr.	1,776.2	21	52.6%	2.11	Medium Year
35	2011.May-2012.Apr.	2,119.5	8	19.2%	1.24	
36	2012.May-2013.Apr.	1,515.6	34	85.9%	7.09	85%Dry Year
37	2013.May-2014.Apr.	1,711.0	25	62.8%	2.69	
38	2014.May-2015.Apr.	1,706.1	27	67.9%	3.12	
39	2015.May-2016.Apr.	1,669.0	28	70.5%	3.39	

Max.	2,734.7				
Average	1,845.9				
Min.	1,144.7				

Hazen Plot : P =(2i-1)/(2n) ; P : Non-Excess Probability, i: Rank, n: Number of data.
Return Period = 1/(1-P)

River Basin **Dong Nai River Basin**
ID_Number RLD03
Name of Station Lien Khuong
Longitude 108.38
Latitude 11.75
District Duc Trong
Province Lam Dong

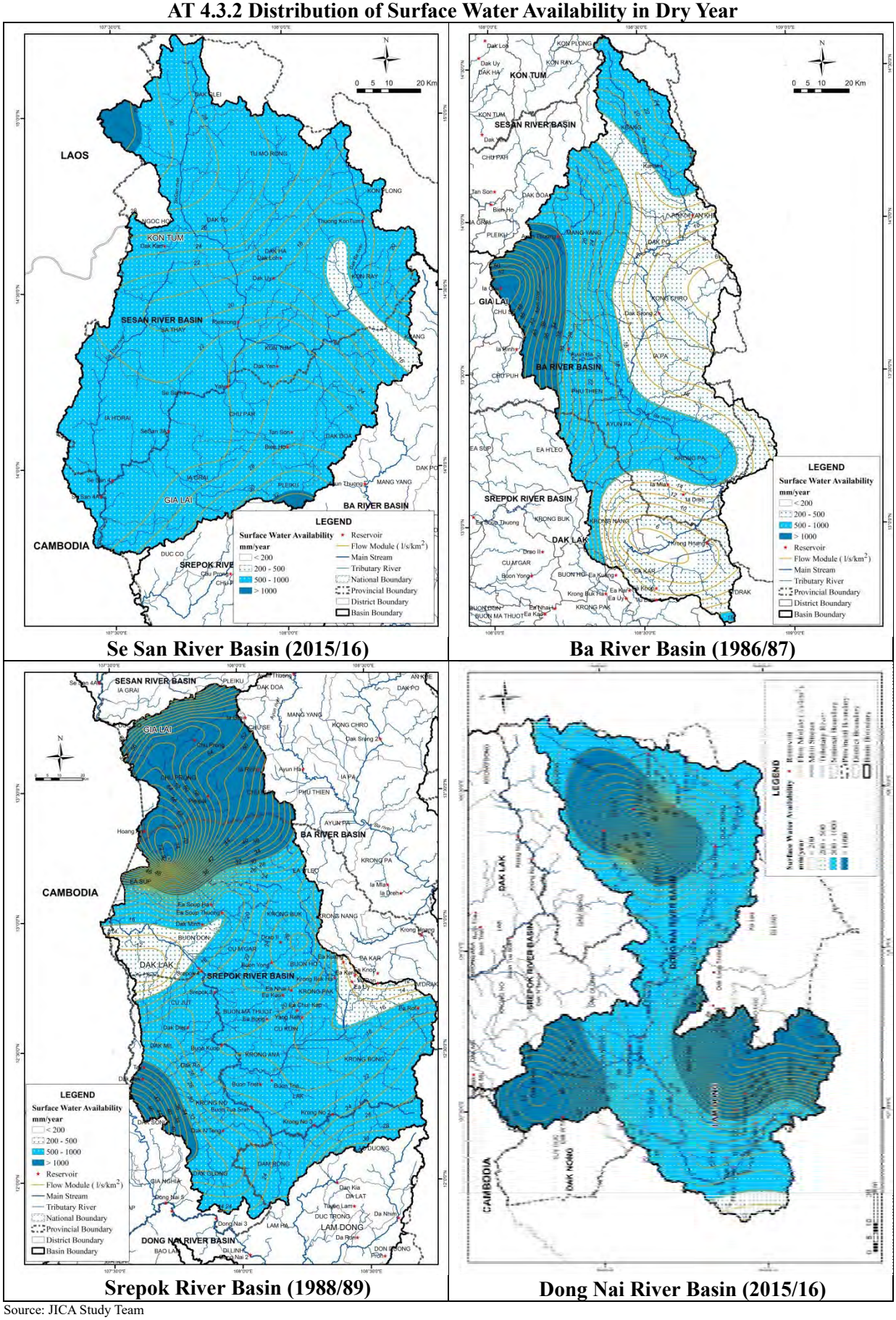
No.	Hydrological Year (Period)	Annual Rainfall (mm/yr)	Rank	Non-Excess Probability (Hazen)	Return Period (Year)	Dry/ Wet Year
1	1977.May-1978.Apr.	1,336.5	33	83.3%	6.00	
2	1978.May-1979.Apr.	1,609.1	18	44.9%	1.81	
3	1979.May-1980.Apr.	2,744.8	1	1.3%	1.01	Max.Wet
4	1980.May-1981.Apr.	1,469.6	27	67.9%	3.12	
5	1981.May-1982.Apr.	1,747.1	8	19.2%	1.24	
6	1982.May-1983.Apr.	1,280.5	36	91.0%	11.14	
7	1983.May-1984.Apr.	2,111.7	2	3.8%	1.04	
8	1984.May-1985.Apr.	1,605.3	19	47.4%	1.90	
9	1985.May-1986.Apr.	1,169.2	39	98.7%	78.00	
10	1986.May-1987.Apr.	1,688.6	14	34.6%	1.53	
11	1987.May-1988.Apr.	1,460.4	28	70.5%	3.39	
12	1988.May-1989.Apr.	1,674.0	15	37.2%	1.59	
13	1989.May-1990.Apr.	1,879.2	5	11.5%	1.13	
14	1990.May-1991.Apr.	1,470.3	26	65.4%	2.89	
15	1991.May-1992.Apr.	1,533.4	23	57.7%	2.36	
16	1992.May-1993.Apr.	1,378.0	30	75.6%	4.11	
17	1993.May-1994.Apr.	1,312.5	35	88.5%	8.67	
18	1994.May-1995.Apr.	1,652.5	17	42.3%	1.73	
19	1995.May-1996.Apr.	1,746.2	9	21.8%	1.28	
20	1996.May-1997.Apr.	1,697.0	13	32.1%	1.47	
21	1997.May-1998.Apr.	1,654.3	16	39.7%	1.66	
22	1998.May-1999.Apr.	2,107.3	3	6.4%	1.07	3rd.Wet
23	1999.May-2000.Apr.	1,360.6	31	78.2%	4.59	
24	2000.May-2001.Apr.	1,890.9	4	9.0%	1.10	
25	2001.May-2002.Apr.	1,509.5	25	62.8%	2.69	
26	2002.May-2003.Apr.	1,276.5	37	93.6%	15.60	
27	2003.May-2004.Apr.	1,827.3	7	16.7%	1.20	
28	2004.May-2005.Apr.	1,266.7	38	96.2%	26.00	Max.Dry
29	2005.May-2006.Apr.	1,711.3	11	26.9%	1.37	
30	2006.May-2007.Apr.	1,594.6	20	50.0%	2.00	Medium Year
31	2007.May-2008.Apr.	1,730.6	10	24.4%	1.32	25%Wet Year
32	2008.May-2009.Apr.	1,536.0	22	55.1%	2.23	
33	2009.May-2010.Apr.	1,706.4	12	29.5%	1.42	
34	2010.May-2011.Apr.	1,585.5	21	52.6%	2.11	
35	2011.May-2012.Apr.	1,331.8	34	85.9%	7.09	85%Dry Year
36	2012.May-2013.Apr.	1,356.9	32	80.8%	5.20	
37	2013.May-2014.Apr.	1,855.5	6	14.1%	1.16	
38	2014.May-2015.Apr.	1,522.1	24	60.3%	2.52	
39	2015.May-2016.Apr.	1,451.9	29	73.1%	3.71	

Max.	2,744.8				
Average	1,611.3				
Min.	1,169.2				

Hazen Plot : P =(2i-1)/(2n) ; P : Non-Excess Probability, i: Rank, n: Number of data.
Return Period = 1/(1-P)
Note: Deu to dry season's rainfall of 85% dry year (2011/12) has more high rainfall than 25% wet year. Thus, demand of 85% dry year (2011/12) used demand of 2015/16.

Source: JICA Study Team

AT 4.3.2 Distribution of Surface Water Availability in Dry Year

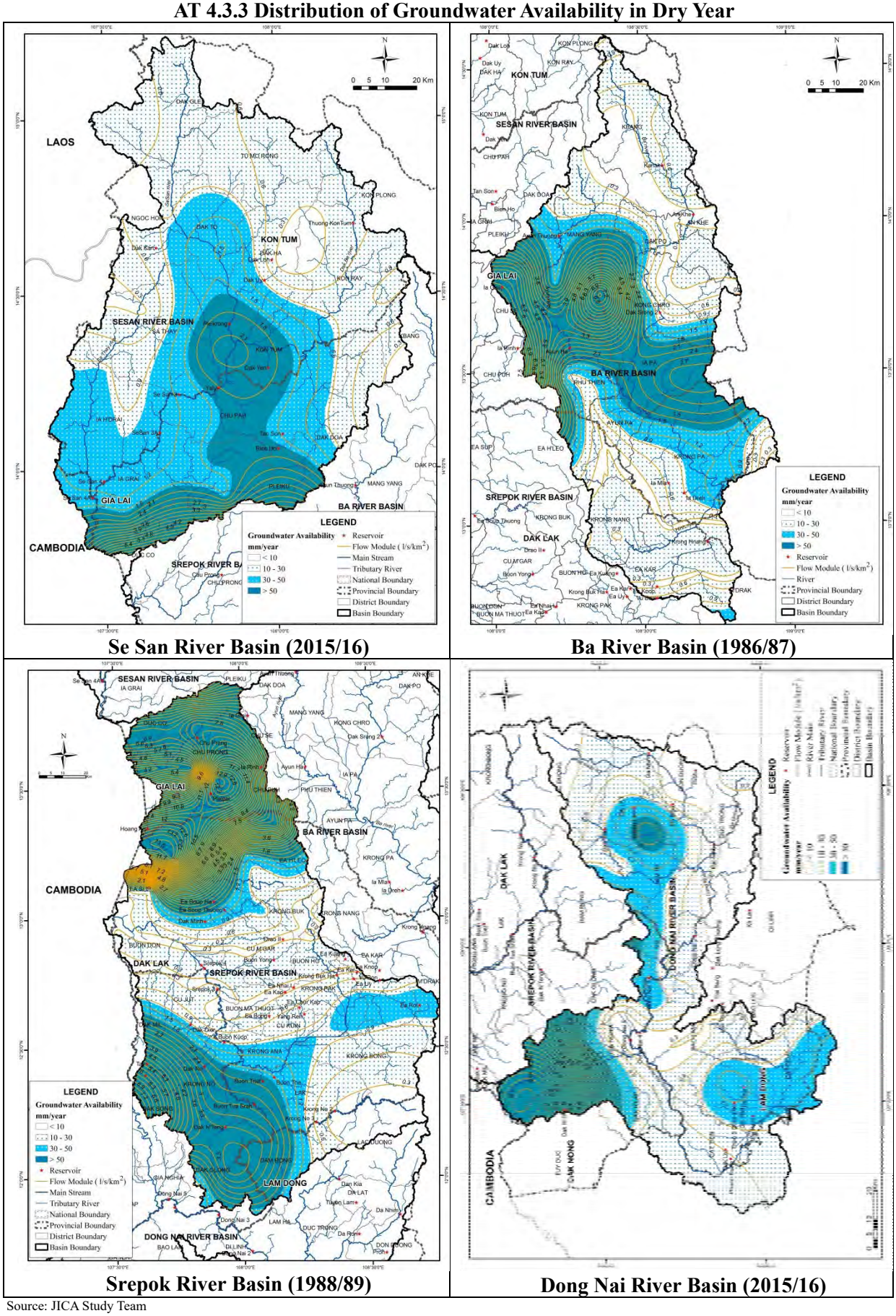


Se San River Basin (2015/16) | Ba River Basin (1986/87)

Srepok River Basin (1988/89) | Dong Nai River Basin (2015/16)

Source: JICA Study Team

AT 4.3.3 Distribution of Groundwater Availability in Dry Year

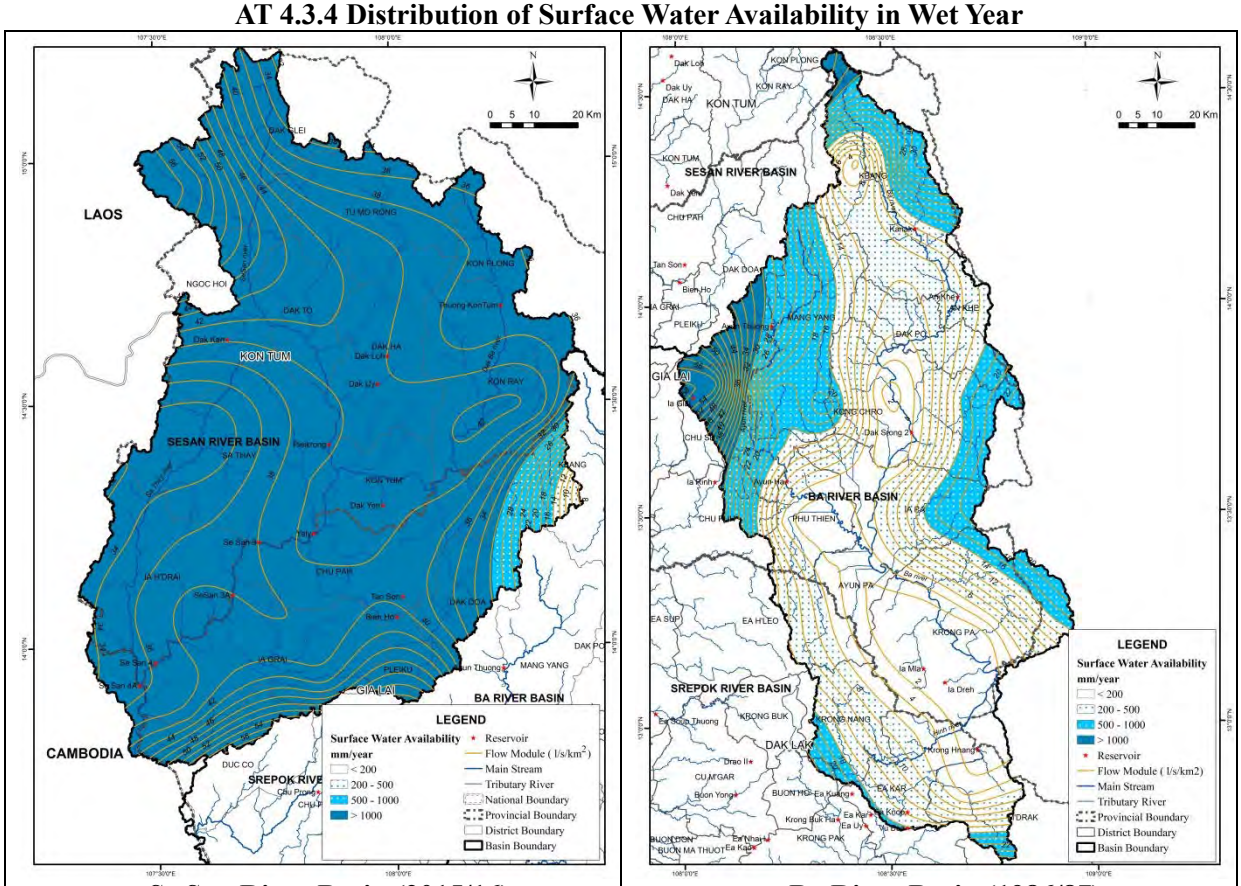


Se San River Basin (2015/16) | **Ba River Basin (1986/87)**

Srepok River Basin (1988/89) | **Dong Nai River Basin (2015/16)**

Source: JICA Study Team

AT 4.3.4 Distribution of Surface Water Availability in Wet Year

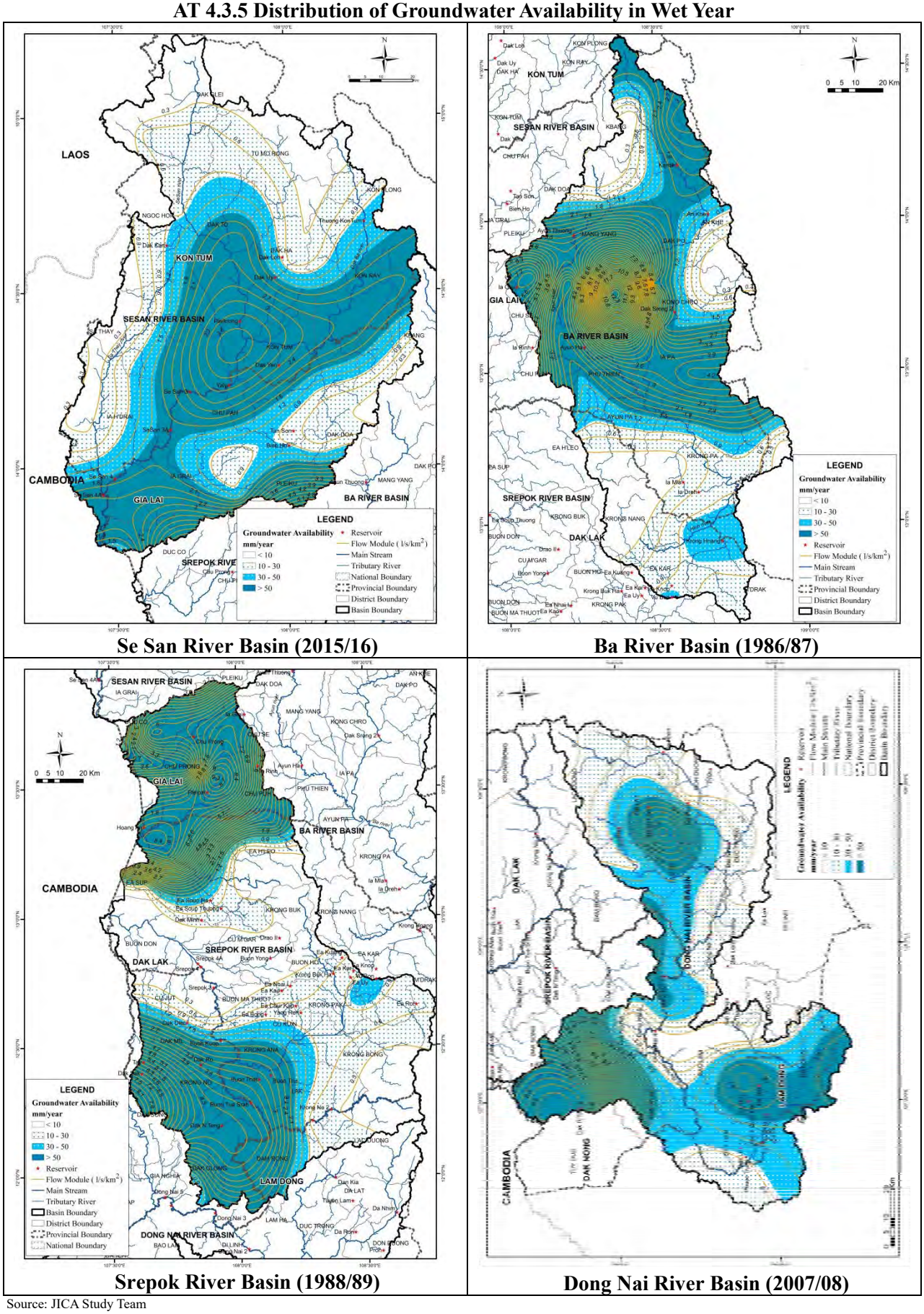


Se San River Basin (2015/16) | Ba River Basin (1986/87)

Srepok River Basin (1988/89) | Dong Nai River Basin (2007/08)

Source: JICA Study Team

AT 4.3.5 Distribution of Groundwater Availability in Wet Year



Se San River Basin (2015/16) | **Ba River Basin (1986/87)**

Srepok River Basin (1988/89) | **Dong Nai River Basin (2007/08)**

Source: JICA Study Team

AT 4.3.6 Annual Water Demand by District in Dry Year

Type	Province	< 5 MCM/ Year	5-10 MCM/ Year	10-25 MCM/ Year	>=25 MCM/ Year
Surface water	Kon Tum	Ia H'Drai		Dak Glei, Dak To, Kon Plong, Kon Ray, Sa Thay, Tu Mo Rong	Kon Tum, Ngoc Hoi, Dak Ha
	Gia Lai		Kong Chro	An Khe	Pleiku, Ayun Pa, KBang, Dak Doa, Chu Pah, Ia Grai, Mang Yang, Duc Co, Chu Prong, Chu Se, Dak Po, Ia Pa, Krong Pa, Phu Thien, Chu PuH
	Dak Lak				Buon Ma Thuot, Ea H'leo, Ea Sup, Krong Nang, Krong Buk, Buon Don, Cu M'gar, Ea Kar, M'Drak, Krong Pak, Krong Bong, Krong Ana, Lak, Cu Kuin, Buon Ho
	Dak Nong			Gia Nghia, Cu Jut, Tuy Duc	Dak Glong, Dak Mil, Krong No, Dak Song, Dak R'Lap
	Lam Dong			Da Huoai	Da Lat, Bao Loc, Dam Rong, Lac Duong, Lam Ha, Don Duong, Duc Trong, Di Linh, Bao Lam, Da Teh, Cat Tien
Ground water	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Kon Plong, Sa Thay, Tu Mo Rong, Ia H'Drai		Kon Ray, Dak Ha	
	Gia Lai	An Khe, Ayun Pa, Kong Chro, Dak Po, Ia Pa, Krong Pa, Phu Thien	KBang	Pleiku, Chu Pah, Mang Yang, Duc Co, Chu PuH	Dak Doa, Ia Grai, Chu Prong, Chu Se
	Dak Lak	Ea Sup	M'Drak, Lak	Buon Ma Thuot, Buon Don, Ea Kar, Krong Bong	Ea H'leo, Krong Nang, Krong Buk , Cu M'gar, Krong Pak, Krong Ana, Cu Kuin, Buon Ho
	Dak Nong		Gia Nghia	Dak Glong, Cu Jut, Dak Song, Dak R'Lap, Tuy Duc	Dak Mil, Krong No
	Lam Dong	Da Lat, Bao Loc, Dam Rong, Lac Duong, Lam Ha, Don Duong, Duc Trong, Di Linh, Bao Lam, Da Huoai, Da Teh, Cat Tien			

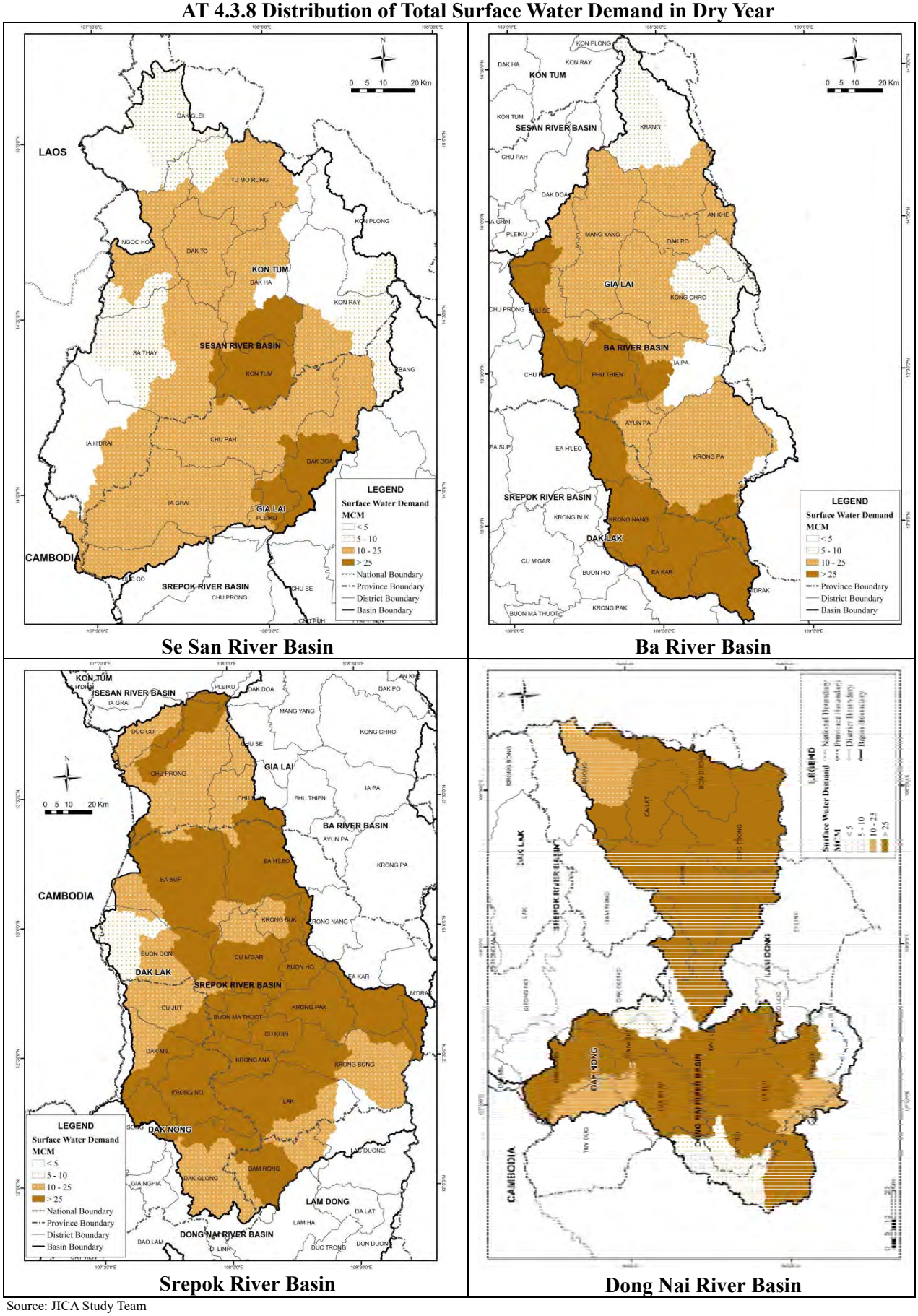
Source: JICA Study Team

AT 4.3.7 Annual Water Demand by District in Wet Year

Type	Province	< 5 MCM/ Year	5-10 MCM/ Year	10-25 MCM/ Year	>=25 MCM/ Year
Surface water	Kon Tum	Ia H'Drai		Dak Glei, Ngoc Hoi, Dak To, Kon Plong, Kon Ray, Sa Thay, Tu Mo Rong	Kon Tum, Dak Ha
	Gia Lai			An Khe, Ayun Pa, Dak Po, Chu PuH	Pleiku, KBang, Dak Doa, Chu Pah, Ia Grai, Mang Yang, Kong Chro, Duc Co, Chu Prong, Chu Se, Ia Pa, Krong Pa, Phu Thien
	Dak Lak				Buon Ma Thuot, Ea H'leo, Ea Sup, Krong Nang, Krong Buk, Buon Don, Cu M'gar, Ea Kar, M'Drak, Krong Pak, Krong Bong, Krong Ana, Lak, Cu Kuin, Buon Ho
	Dak Nong			Gia Nghia	Dak Glong, Cu Jut, Dak Mil, Krong No, Dak Song, Dak R'Lap, Tuy Duc
	Lam Dong			Lac Duong Da Huoai	Da Lat, Bao Loc, Dam Rong, Lam Ha, Don Duong, Duc Trong, Di Linh, Bao Lam, Da Teh, Cat Tien
Ground water	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Kon Plong, Kon Ray, Tu Mo Rong, Ia H'Drai	Sa Thay	Dak Ha	
	Gia Lai	An Khe, Ayun Pa, Kong Chro, Dak Po, Ia Pa, Krong Pa, Phu Thien	KBang, Chu PuH	Pleiku, Chu Pah, Mang Yang, Duc Co	Dak Doa, Ia Grai, Chu Prong, Chu Se
	Dak Lak	Ea Sup, M'Drak	Lak	Buon Ma Thuot, Krong Buk, Buon Don, Ea Kar, Krong Bong, Buon Ho	Ea H'leo, Krong Nang, Cu M'gar, Krong Pak, Krong Ana, Cu Kuin
	Dak Nong			Gia Nghia, Dak Glong, Cu Jut, Dak R'Lap, Tuy Duc	Dak Mil, Krong No, Dak Song
	Lam Dong	Da Lat, Bao Loc, Dam Rong, Lac Duong, Lam Ha, Don Duong, Duc Trong, Di Linh, Bao Lam, Da Huoai, Da The, Cat Tien			

Source: JICA Study Team

AT 4.3.8 Distribution of Total Surface Water Demand in Dry Year

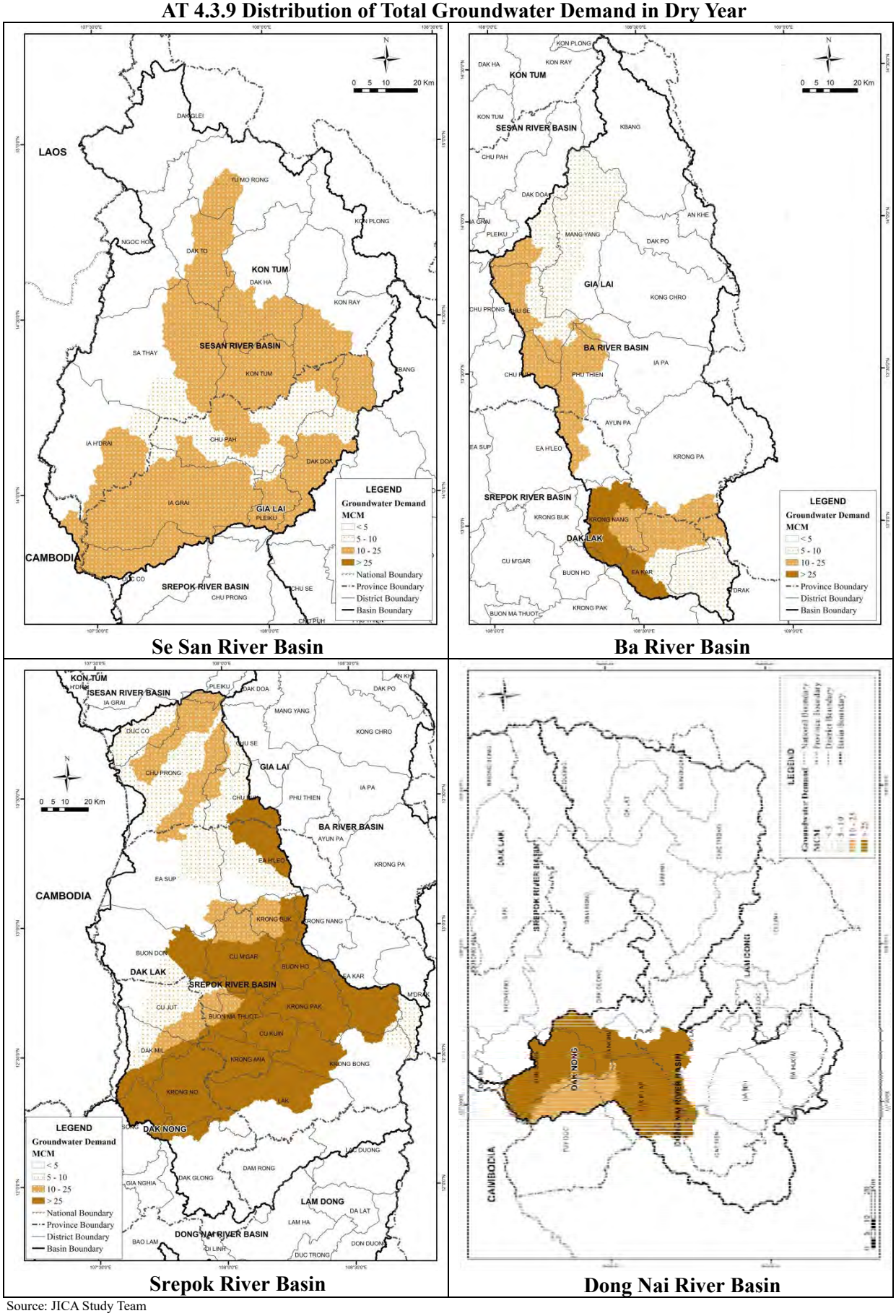


Se San River Basin | **Ba River Basin**

Srepok River Basin | **Dong Nai River Basin**

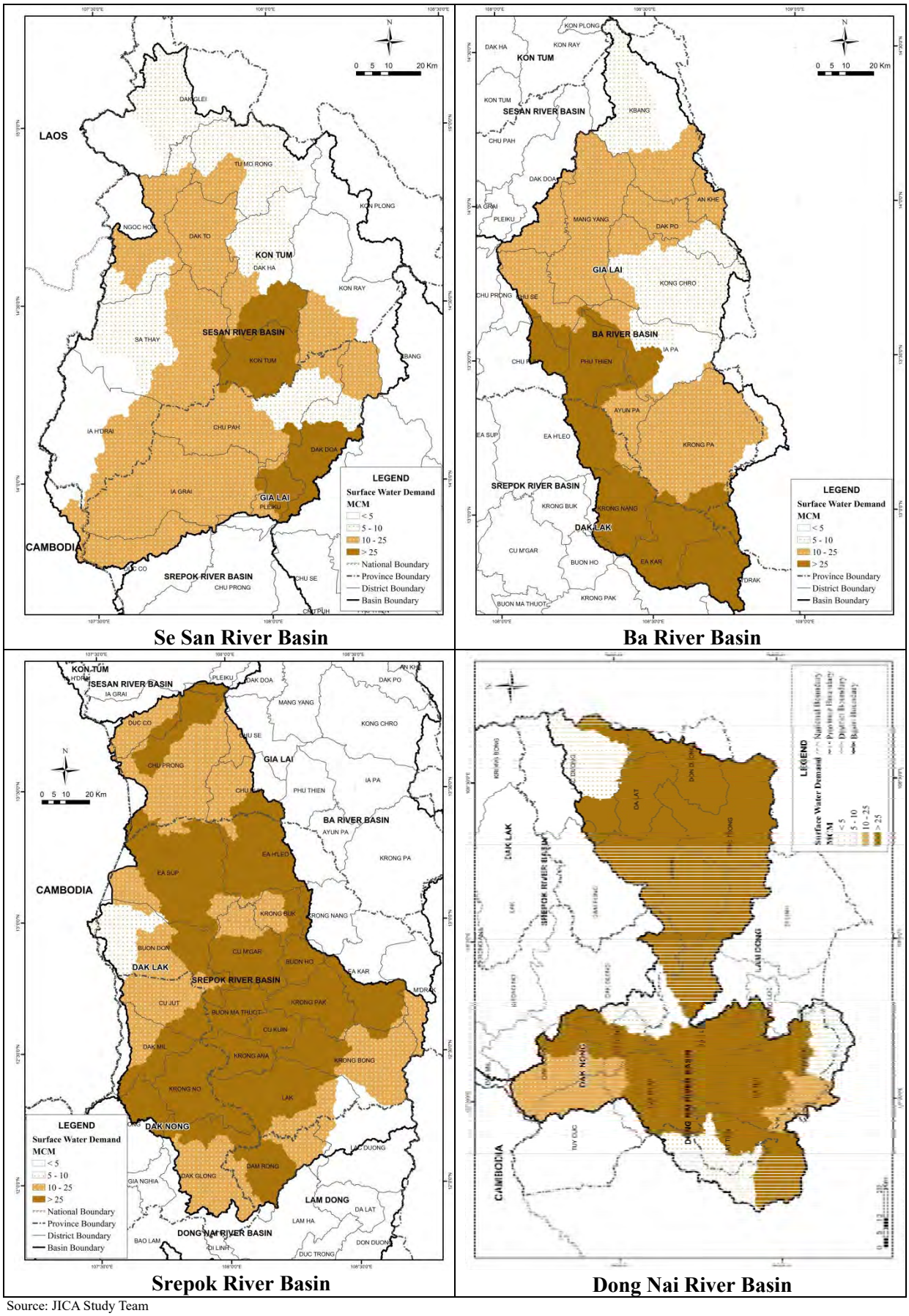
Source: JICA Study Team

AT 4.3.9 Distribution of Total Groundwater Demand in Dry Year



Source: JICA Study Team

AT 4.3.10 Distribution of Total Surface Water Demand in Wet Year



Se San River Basin

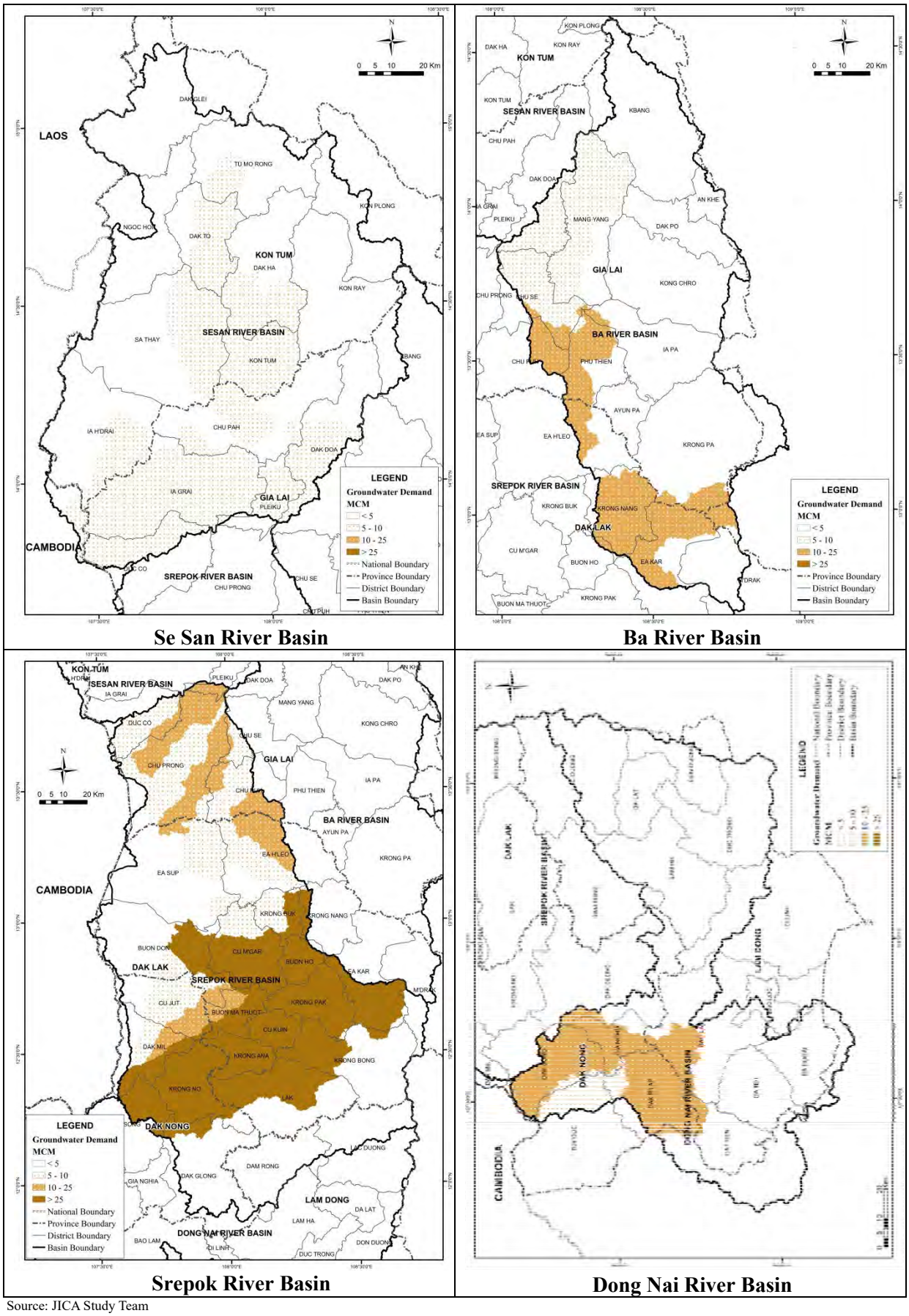
Ba River Basin

Srepok River Basin

Dong Nai River Basin

Source: JICA Study Team

AT 4.3.11 Distribution of Total Groundwater Demand in Wet Year



Se San River Basin

Ba River Basin

Srepok River Basin

Dong Nai River Basin

Source: JICA Study Team

AT 4.3.12 Estimated Water Demand in Central Highlands in Dry Year

(unit: MCM/year)

CODE	District	Province	Area	Domestict, Industrial, Live Stock, Fihery			Irrigation		
			(km^2)	Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
3901	Kon Tum	Kon Tum	432	9.63	1.35	10.98	23.57	2.01	25.58
3902	Dak Glei	Kon Tum	1,497	2.29	0.65	2.95	19.33	3.10	22.43
3903	Ngoc Hoi	Kon Tum	849	9.30	0.59	9.88	17.08	2.76	19.84
3904	Dak To	Kon Tum	508	4.04	0.52	4.56	14.80	3.88	18.67
3905	Kon Plong	Kon Tum	1,376	1.13	0.62	1.76	22.86	1.14	24.01
3906	Kon Ray	Kon Tum	919	1.91	0.40	2.30	22.05	11.67	33.72
3907	Dak Ha	Kon Tum	844	5.94	0.81	6.75	47.85	20.97	68.82
3908	Sa Thay	Kon Tum	1,399	3.98	0.63	4.62	16.75	3.49	20.24
3909	Tu Mo Rong	Kon Tum	860	1.02	0.58	1.61	11.80	1.75	13.54
3910	Ia H'Drai	Kon Tum	1,014	0.61	0.11	0.73	0.16	0.05	0.21
4001	Pleiku	Gia Lai	262	10.53	2.66	13.19	23.09	10.14	33.22
4002	An Khe	Gia Lai	200	4.94	1.08	6.02	17.18	0.00	17.18
4003	Ayun Pa	Gia Lai	289	2.28	0.61	2.89	38.10	0.00	38.10
4004	KBang	Gia Lai	1,843	2.08	0.88	2.96	44.05	6.90	50.95
4005	Dak Doa	Gia Lai	984	7.89	1.68	9.57	79.43	37.61	117.04
4006	Chu Pah	Gia Lai	981	1.98	1.03	3.02	46.33	23.78	70.11
4007	Ia Grai	Gia Lai	1,118	2.78	1.43	4.20	78.10	39.07	117.17
4008	Mang Yang	Gia Lai	1,129	8.11	1.76	9.87	58.00	15.49	73.49
4009	Kong Chro	Gia Lai	1,449	1.83	0.96	2.79	4.38	0.00	4.38
4010	Duc Co	Gia Lai	722	2.72	1.36	4.08	32.07	15.65	47.72
4011	Chu Prong	Gia Lai	1,699	13.68	1.82	15.49	60.46	38.98	99.44
4012	Chu Se	Gia Lai	646	10.75	1.72	12.47	81.70	34.42	116.12
4013	Dak Po	Gia Lai	503	1.65	0.89	2.54	26.92	0.00	26.92
4014	Ia Pa	Gia Lai	871	1.88	1.46	3.35	130.36	0.00	130.36
4015	Krong Pa	Gia Lai	1,629	13.12	1.51	14.63	83.79	0.00	83.79
4016	Phu Thien	Gia Lai	506	3.80	1.35	5.15	78.90	0.04	78.94
4017	Chu PuH	Gia Lai	719	2.75	1.40	4.15	22.31	10.87	33.19
4101	Buon Ma Thuot	Dak Lak	382	63.31	11.77	75.09	38.72	4.14	42.86
4102	Ea H'leo	Dak Lak	1,337	5.40	2.58	7.98	104.49	69.89	174.38
4103	Ea Sup	Dak Lak	1,769	54.88	2.81	57.69	116.91	0.13	117.04
4104	Krong Nang	Dak Lak	617	15.52	2.11	17.63	102.53	54.74	157.27
4105	Krong Buk	Dak Lak	356	13.18	1.55	14.73	56.00	39.28	95.28
4106	Buon Don	Dak Lak	1,410	25.54	1.86	27.40	36.26	10.34	46.60
4107	Cu M'gar	Dak Lak	826	5.27	2.77	8.04	124.44	78.46	202.90
4108	Ea Kar	Dak Lak	1,044	28.77	3.20	31.98	276.00	21.08	297.08
4109	M'Drak	Dak Lak	1,347	7.17	1.18	8.34	126.05	5.25	131.30
4110	Krong Pak	Dak Lak	630	8.99	3.49	12.49	165.57	38.93	204.49
4111	Krong Bong	Dak Lak	1,259	33.56	3.31	36.87	69.01	6.84	75.85
4112	Krong Ana	Dak Lak	354	14.34	2.39	16.73	125.99	26.69	152.68
4113	Lak	Dak Lak	1,252	16.51	1.51	18.02	88.77	6.27	95.04
4114	Cu Kuin	Dak Lak	292	22.46	1.60	24.06	73.21	30.46	103.68
4115	Buon Ho	Dak Lak	284	5.81	2.93	8.73	67.82	39.59	107.42
4201	Gia Nghia	Dak Nong	285	8.81	0.31	9.12	9.00	6.57	15.57
4202	Dak Glong	Dak Nong	1,450	9.72	0.85	10.57	19.94	13.28	33.22
4203	Cu Jut	Dak Nong	723	4.60	0.98	5.58	19.16	11.22	30.39
4204	Dak Mil	Dak Nong	684	13.99	1.40	15.38	57.75	43.09	100.84
4205	Krong No	Dak Nong	815	7.20	0.94	8.14	45.49	30.95	76.43
4206	Dak Song	Dak Nong	808	6.97	1.26	8.23	24.81	20.08	44.89
4207	Dak R'Lap	Dak Nong	637	6.07	0.96	7.03	20.27	14.13	34.40
4208	Tuy Duc	Dak Nong	1,121	3.36	0.64	4.00	21.26	15.43	36.69
4301	Da Lat	Lam Dong	395	50.80	2.91	53.71	27.87	0.00	27.87
4302	Bao Loc	Lam Dong	234	12.86	2.57	15.43	39.52	0.04	39.56
4303	Dam Rong	Lam Dong	865	9.23	1.08	10.31	47.07	0.03	47.09
4304	Lac Duong	Lam Dong	1,268	5.57	0.52	6.09	19.86	0.00	19.86
4305	Lam Ha	Lam Dong	984	10.11	1.69	11.81	191.85	0.47	192.32
4306	Don Duong	Lam Dong	613	9.32	1.39	10.70	85.58	0.02	85.60
4307	Duc Trong	Lam Dong	908	6.69	2.28	8.97	172.05	0.68	172.73
4308	Di Linh	Lam Dong	1,621	7.32	1.93	9.25	177.60	0.63	178.24
4309	Bao Lam	Lam Dong	1,467	5.47	1.93	7.40	117.85	0.30	118.15
4310	Da Huoai	Lam Dong	497	1.64	0.46	2.10	14.85	0.05	14.91
4311	Da Teh	Lam Dong	528	13.53	1.39	14.92	39.71	0.07	39.78
4312	Cat Tien	Lam Dong	427	3.93	0.55	4.47	51.84	0.07	51.91
Total			**54,737**	**650.54**	**100.96**	**751.50**	**3,876.51**	**872.97**	**4,749.49**

Source: JICA Study Team

AT 4.3.13 Estimated Water Demand in Central Highlands in Wet Year

(unit: MCM/year)

CODE	District	Province	Area (km^2)	Domestict, Industrial, Live Stock, Fihery			Irrigation		
				Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
3901	Kon Tum	Kon Tum	432	9.63	1.35	10.98	21.68	1.28	22.97
3902	Dak Glei	Kon Tum	1,497	2.29	0.65	2.95	9.64	1.77	11.42
3903	Ngoc Hoi	Kon Tum	849	9.30	0.59	9.88	14.23	1.81	16.05
3904	Dak To	Kon Tum	508	4.04	0.52	4.56	14.06	2.57	16.63
3905	Kon Plong	Kon Tum	1,376	1.13	0.62	1.76	19.09	0.82	19.92
3906	Kon Ray	Kon Tum	919	1.91	0.40	2.30	10.04	0.69	10.73
3907	Dak Ha	Kon Tum	844	5.94	0.81	6.75	42.34	17.23	59.57
3908	Sa Thay	Kon Tum	1,399	3.98	0.63	4.62	18.20	4.51	22.71
3909	Tu Mo Rong	Kon Tum	860	1.02	0.58	1.61	10.20	1.02	11.22
3910	Ia H'Drai	Kon Tum	1,014	0.61	0.11	0.73	0.18	0.06	0.23
4001	Pleiku	Gia Lai	262	10.53	2.66	13.19	25.47	8.95	34.42
4002	An Khe	Gia Lai	200	4.94	1.08	6.02	6.27	0.00	6.27
4003	Ayun Pa	Gia Lai	289	2.28	0.61	2.89	19.81	0.00	19.81
4004	KBang	Gia Lai	1,843	2.08	0.88	2.96	35.18	5.77	40.96
4005	Dak Doa	Gia Lai	984	7.89	1.68	9.57	62.77	25.94	88.70
4006	Chu Pah	Gia Lai	981	1.98	1.03	3.02	37.52	13.79	51.31
4007	Ia Grai	Gia Lai	1,118	2.78	1.43	4.20	57.16	27.28	84.43
4008	Mang Yang	Gia Lai	1,129	8.11	1.76	9.87	27.49	10.95	38.44
4009	Kong Chro	Gia Lai	1,449	1.83	0.96	2.79	28.90	0.00	28.90
4010	Duc Co	Gia Lai	722	2.72	1.36	4.08	33.33	17.60	50.93
4011	Chu Prong	Gia Lai	1,699	13.68	1.82	15.49	67.91	41.55	109.46
4012	Chu Se	Gia Lai	646	10.75	1.72	12.47	45.26	26.33	71.60
4013	Dak Po	Gia Lai	503	1.65	0.89	2.54	10.93	0.00	10.93
4014	Ia Pa	Gia Lai	871	1.88	1.46	3.35	65.09	0.00	65.09
4015	Krong Pa	Gia Lai	1,629	13.12	1.51	14.63	48.39	0.00	48.39
4016	Phu Thien	Gia Lai	506	3.80	1.35	5.15	81.59	0.03	81.62
4017	Chu PuH	Gia Lai	719	2.75	1.40	4.15	20.95	8.54	29.49
4101	Buon Ma Thuot	Dak Lak	382	63.31	11.77	75.09	35.96	3.78	39.75
4102	Ea H'leo	Dak Lak	1,337	5.40	2.58	7.98	100.12	33.77	133.89
4103	Ea Sup	Dak Lak	1,769	54.88	2.81	57.69	122.09	0.07	122.16
4104	Krong Nang	Dak Lak	617	15.52	2.11	17.63	83.56	53.08	136.64
4105	Krong Buk	Dak Lak	356	13.18	1.55	14.73	30.36	20.49	50.84
4106	Buon Don	Dak Lak	1,410	25.54	1.86	27.40	31.17	9.21	40.38
4107	Cu M'gar	Dak Lak	826	5.27	2.77	8.04	84.71	49.99	134.70
4108	Ea Kar	Dak Lak	1,044	28.77	3.20	31.98	133.41	18.19	151.60
4109	M'Drak	Dak Lak	1,347	7.17	1.18	8.34	47.37	3.13	50.49
4110	Krong Pak	Dak Lak	630	8.99	3.49	12.49	136.66	30.78	167.43
4111	Krong Bong	Dak Lak	1,259	33.56	3.31	36.87	61.49	7.02	68.51
4112	Krong Ana	Dak Lak	354	14.34	2.39	16.73	109.52	24.80	134.32
4113	Lak	Dak Lak	1,252	16.51	1.51	18.02	81.25	4.37	85.62
4114	Cu Kuin	Dak Lak	292	22.46	1.60	24.06	65.60	28.07	93.67
4115	Buon Ho	Dak Lak	284	5.81	2.93	8.73	34.81	17.41	52.21
4201	Gia Nghia	Dak Nong	285	8.81	0.31	9.12	14.58	10.25	24.83
4202	Dak Glong	Dak Nong	1,450	9.72	0.85	10.57	26.40	12.63	39.02
4203	Cu Jut	Dak Nong	723	4.60	0.98	5.58	35.11	10.43	45.54
4204	Dak Mil	Dak Nong	684	13.99	1.40	15.38	61.87	39.74	101.60
4205	Krong No	Dak Nong	815	7.20	0.94	8.14	66.29	24.21	90.51
4206	Dak Song	Dak Nong	808	6.97	1.26	8.23	56.79	35.68	92.47
4207	Dak R'Lap	Dak Nong	637	6.07	0.96	7.03	35.01	22.02	57.03
4208	Tuy Duc	Dak Nong	1,121	3.36	0.64	4.00	36.01	23.25	59.26
4301	Da Lat	Lam Dong	395	50.80	2.91	53.71	17.03	0.00	17.03
4302	Bao Loc	Lam Dong	234	12.86	2.57	15.43	42.51	0.04	42.55
4303	Dam Rong	Lam Dong	865	9.23	1.08	10.31	41.00	0.01	41.02
4304	Lac Duong	Lam Dong	1,268	5.57	0.52	6.09	12.58	0.00	12.58
4305	Lam Ha	Lam Dong	984	10.11	1.69	11.81	139.62	0.33	139.95
4306	Don Duong	Lam Dong	613	9.32	1.39	10.70	77.68	0.02	77.71
4307	Duc Trong	Lam Dong	908	6.69	2.28	8.97	162.20	0.57	162.78
4308	Di Linh	Lam Dong	1,621	7.32	1.93	9.25	134.85	0.47	135.33
4309	Bao Lam	Lam Dong	1,467	5.47	1.93	7.40	102.96	0.27	103.23
4310	Da Huoai	Lam Dong	497	1.64	0.46	2.10	20.63	0.07	20.70
4311	Da Teh	Lam Dong	528	13.53	1.39	14.92	42.93	0.07	43.00
4312	Cat Tien	Lam Dong	427	3.93	0.55	4.47	51.38	0.05	51.43
Total			**54,737**	**650.54**	**100.96**	**751.50**	**3,169.20**	**702.77**	**3,871.97**

Source: JICA Study Team

AT 4.3.14 Total Water Balance of River Basins in Central Highlands

Items	Dry Year				Wet Year			
	Se San	Ba	Srepok	Dong Nai	Se San	Ba	Srepok	Dong Nai
Catchment Area in Central Highlands (km^2)	11,377	10.779	17,887	9,236	11,377	10.779	17,887	9,236
Rainfall (mm)	1,509	1,323	1,880	2,175	2,081	1,432	1,901	2,190
Evapotranspiration (mm)	611	839	896	1012	650	866	878	889
Surface Runoff (mm)	78	85	124	151	205	120	99	173
Infiltration (mm)	607	317	759	855	927	327	809	888
Subsurface (inter) flow (mm)	193	105	112	195	279	111	140	208
Recharge to River (mm)	476	307	724	630	716	303	761	658
Seepage to Deep Aquifers (mm)	109	15.9	43.7	227	158	16.4	47.6	230
River Intake for Irrigation (mm)	20.5	50.8	44.2	35.7	17.2	34.0	37.3	52.5
River Intake for Domestic Water, etc. (mm)	11.5	14.1	5.73	6.9	11.5	14.1	5.73	6.9
Groundwater Demand for Domestic, etc. (mm)	0.7	1.12	1.16	1.36	0.7	1.12	1.16	1.36
Groundwater Demand for Irrigation (mm)	8.4	8.6	20.6	1.8	6.4	6.5	16.3	6.6
Groundwater Outflow to Downstream Basin (mm)	778	428	480	575	808	403	428	649

Source: JICA Study Team

AT 4.3.15 Annual Water Shortage by District in Dry Year

Type	Province	< 0.5 MCM/ Year	0.5-10 MCM/ Year	10-25 MCM/Year	>=25 MCM/ Year
Surface water	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Dak Ha, Sa Thay, Tu Mo Rong, Ia H'Drai	Kon Plong, Kon Ray		
	Gia Lai	An Khe, Ayun Pa, Chu Pah, Chu Prong, Chu Se, Phu Thien, Chu PuH	Pleiku, KBang, Dak Doa, Ia Grai, Mang Yang, Kong Chro, Duc Co, Dak Po, Ia Pa, Krong Pa		
	Dak Lak	Ea H'leo, Cu M'gar, Krong Bong, Krong Ana, Lak, Cu Kuin	Buon Ma Thuot, Ea Sup, Krong Buk, Buon Don, Buon Ho	M'Drak	Krong Nang, Ea Kar, Krong Pak
	Dak Nong	Gia Nghia, Dak Glong, Krong No, Dak R'Lap, Tuy Duc	Cu Jut, Dak Mil, Dak Song		
	Lam Dong	Da Teh, Cat Tien	Bao Loc, Dam Rong, Lac Duong, Bao Lam, Da Huoai	Da Lat, Don Duong, Di Linh	Lam Ha, Duc Trong
Ground water	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Kon Plong, Kon Ray, Sa Thay, Tu Mo Rong, Ia H'Drai	Dak Ha		
	Gia Lai	An Khe, Ayun Pa, KBang, Kong Chro, Chu Se, Dak Po, Ia Pa	Pleiku, Dak Doa, Chu Pah, Ia Grai, Mang Yang, Duc Co, Chu Prong, Krong Pa, Phu Thien, Chu PuH		
	Dak Lak	Buon Ma Thuot, Krong Ana, Lak	Ea H'leo, M'Drak, Krong Bong, Cu Kuin	Ea Sup, Krong Nang, Buon Don, Ea Kar, Krong Pak, Buon Ho	Krong Buk, Cu M'gar
	Dak Nong	Gia Nghia, Dak Glong, Cu Jut, Dak Mil, Krong No, Dak Song, Dak R'Lap, Tuy Duc			
	Lam Dong	Da Lat, Bao Loc, Dam Rong, Lac Duong, Lam Ha, Don Duong, Duc Trong, Di Linh, Bao Lam, Da Huoai, Da Teh	Cat Tien		
Total	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Sa Thay, Tu Mo Rong, Ia H'Drai	Kon Plong, Kon Ray, Dak Ha		
	Gia Lai	An Khe, Ayun Pa, Chu Se	Pleiku, KBang, Dak Doa, Chu Pah, Ia Grai, Mang Yang, Kong Chro, Duc Co, Chu Prong, Dak Po, Ia Pa, Krong Pa, Phu Thien, Chu PuH		
	Dak Lak	Krong Ana, Lak	Buon Ma Thuot, Ea Sup, Krong Bong, Cu Kuin	Ea Sup, Buon Don, Buon Ho	Krong Nang, Krong Buk, Cu M'gar, Ea Kar, M'Drak, Krong Pak
	Dak Nong	Gia Nghia, Dak Glong, Krong No, Dak R'Lap, Tuy Duc	Cu Jut, Dak Mil, Dak Song		
	Lam Dong	Da Teh	Bao Loc, Dam Rong, Lac Duong, Bao Lam, Da Huoai, Cat Tien	Da Lat, Don Duong, Di Linh	Lam Ha, Duc Trong

Source: JICA Study Team

AT 4.3.16 Annual Water Shortage by District in Wet Year

Type	Province	< 0.5 MCM/ Year	0.5-10 MCM/ Year	10-25 MCM/ Year	>=25 MCM/ Year
Surface water	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Kon Plong, Kon Ray, Dak Ha, Sa Thay, Tu Mo Rong, Ia H'Drai			
	Gia Lai	An Khe, Ayun Pa, Mang Yang, Duc Co, Chu Prong, Chu Se, Ia Pa, Phu Thien	Pleiku, KBang, Dak Doa, Chu Pah, Ia Grai, Kong Chro, Dak Po, Krong Pa, Chu PuH		
	Dak Lak	Buon Ma Thuot, Krong Buk, Buon Don, Cu M'gar, Krong Bong, Krong Ana, Lak, Cu Kuin, Buon Ho	Ea H'leo, Ea Sup, Krong Pak	Krong Nang, Ea Kar, M'Drak	
	Dak Nong	Gia Nghia, Dak Glong, Cu Jut, Dak Mil, Krong No, Dak Song, Dak R'Lap, Tuy Duc			
	Lam Dong	Bao Loc, Lac Duong, Don Duong, Bao Lam, Da Huoai, Da Teh, Cat Tien	Da Lat, Dam Rong, Lam Ha, Di Linh	Duc Trong	
Ground water	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Kon Plong, Kon Ray, Dak Ha, Sa Thay, Tu Mo Rong, Ia H'Drai			
	Gia Lai	An Khe, Ayun Pa, KBang, Kong Chro, Chu Se, Dak Po, Ia Pa, Krong Pa	Pleiku, Dak Doa, Chu Pah, Ia Grai, Mang Yang, Duc Co, Chu Prong, Chu Se, Phu Thien, Chu PuH		
	Dak Lak	Krong Ana, Lak	Buon Ma Thuot, Ea H'leo, Ea Sup, M'Drak, Krong Pak, Krong Bong, Cu Kuin	Krong Nang, Krong Buk, Buon Don, Ea Kar, Buon Ho	Cu M'gar
	Dak Nong	Gia Nghia, Dak Glong, Krong No, Dak Song, Dak R'Lap, Tuy Duc	Cu Jut, Dak Mil		
	Lam Dong	Da Lat, Bao Loc, Dam Rong, Lac Duong, Lam Ha, Don Duong, Duc Trong, Di Linh, Bao Lam, Da Huoai, Da Teh	Cat Tien		
Total	Kon Tum	Kon Tum, Dak Glei, Ngoc Hoi, Dak To, Kon Plong, Kon Ray, Dak Ha, Sa Thay, Tu Mo Rong, Ia H'Drai			
	Gia Lai	An Khe, Ayun Pa, Ia Pa	Pleiku, KBang, Dak Doa, Chu Pah, Ia Grai, Mang Yang, Kong Chro, Duc Co, Chu Prong, Chu Se, Dak Po, Krong Pa, Phu Thien, Chu PuH		
	Dak Lak	Krong Ana, Lak	Buon Ma Thuot, Ea H'leo, Ea Sup, Krong Bong, Cu Kuin	Krong Nang, Krong Buk, Buon Don, M'Drak, Krong Pak, Buon Ho	Cu M'gar, Ea Kar
	Dak Nong	Gia Nghia, Dak Glong, Krong No, Dak Song ,Dak R'Lap, Tuy Duc	Cu Jut, Dak Mil		
	Lam Dong	Bao Loc, Lac Duong, Don Duong, Bao Lam , Da Huoai, Da Teh	Da Lat, Dam Rong, Lam Ha, Di Linh, Cat Tien	Duc Trong	

Source: JICA Study Team

AT 4.3.17 Water Shortage by District in Central Highlands in Dry Year

			Dry Year		Unit: MCM	Dry Year		Unit: MCM	Dry Year		Unit: MCM
CODE	**Province**	**District**	**Total**	**SW**	**GW**	**Total**	**SW**	**GW**	**Total**	**SW**	**GW**
3901	Kon Tum	Kon Tum	0.00	0.00	0.00	36.6	33.2	3.4	0.0%	0.0%	0.0%
3902	Kon Tum	Dak Glei	0.00	0.00	0.00	25.4	21.6	3.8	0.0%	0.0%	0.0%
3903	Kon Tum	Ngoc Hoi	0.29	0.00	0.29	29.7	26.4	3.4	1.0%	0.0%	8.5%
3904	Kon Tum	Dak To	0.00	0.00	0.00	23.2	18.8	4.4	0.0%	0.0%	0.0%
3905	Kon Tum	Kon Plong	6.55	6.55	0.00	25.8	24.0	1.8	25.4%	27.3%	0.0%
3906	Kon Tum	Kon Ray	1.35	1.28	0.06	36.0	24.0	12.1	3.7%	5.4%	0.5%
3907	Kon Tum	Dak Ha	1.21	0.00	1.21	75.6	53.8	21.8	1.6%	0.0%	5.6%
3908	Kon Tum	Sa Thay	0.01	0.00	0.01	24.9	20.7	4.1	0.0%	0.0%	0.3%
3909	Kon Tum	Tu Mo Rong	0.34	0.24	0.10	15.1	12.8	2.3	2.3%	1.9%	4.5%
3910	Kon Tum	Ia H'Drai	0.03	0.03	0.00	0.9	0.8	0.2	3.5%	4.3%	0.0%
4001	Gia Lai	Pleiku	3.62	0.73	2.89	46.4	33.6	12.8	7.8%	2.2%	22.6%
4002	Gia Lai	An Khe	0.00	0.00	0.00	23.2	22.1	1.1	0.0%	0.0%	0.0%
4003	Gia Lai	AyunPa	0.49	0.00	0.49	41.0	40.4	0.6	1.2%	0.0%	80.9%
4004	Gia Lai	Kbang	1.08	1.06	0.01	53.9	46.1	7.8	2.0%	2.3%	0.1%
4005	Gia Lai	Dak Doa	9.52	1.45	8.07	126.6	87.3	39.3	7.5%	1.7%	20.5%
4006	Gia Lai	Chu Pah	1.37	0.39	0.99	73.1	48.3	24.8	1.9%	0.8%	4.0%
4007	Gia Lai	Ia Grai	7.48	1.94	5.54	121.4	80.9	40.5	6.2%	2.4%	13.7%
4008	Gia Lai	Mang Yang	6.93	3.06	3.87	83.4	66.1	17.2	8.3%	4.6%	22.4%
4009	Gia Lai	Kong Chro	1.56	1.45	0.11	7.2	6.2	1.0	21.7%	23.3%	11.4%
4010	Gia Lai	Duc Co	3.10	1.04	2.06	51.8	34.8	17.0	6.0%	3.0%	12.1%
4011	Gia Lai	Chu Prong	1.44	0.15	1.29	114.9	74.1	40.8	1.3%	0.2%	3.2%
4012	Gia Lai	Chu Se	0.09	0.00	0.09	128.6	92.5	36.1	0.1%	0.0%	0.3%
4013	Gia Lai	DaK Po	0.82	0.75	0.07	29.5	28.6	0.9	2.8%	2.6%	7.8%
4014	Gia Lai	Ia Pa	1.00	0.57	0.43	133.7	132.2	1.5	0.7%	0.4%	29.6%
4015	Gia Lai	Krong Pa	2.70	1.40	1.30	98.4	96.9	1.5	2.7%	1.4%	86.1%
4016	Gia Lai	Phu Thien	1.30	0.00	1.30	84.1	82.7	1.4	1.5%	0.0%	93.3%
4017	Gia Lai	Chu Puh	9.35	0.00	9.35	37.3	25.1	12.3	25.0%	0.0%	76.2%
4101	Dak Lak	Buon Ma Thuot	1.07	0.90	0.17	117.9	102.0	15.9	0.9%	0.9%	1.1%
4102	Dak Lak	Ea H'leo	1.49	0.27	1.22	182.4	109.9	72.5	0.8%	0.2%	1.7%
4103	Dak Lak	Ea Sup	22.82	2.66	20.15	174.7	171.8	2.9	13.1%	1.6%	685.1%
4104	Dak Lak	Krong Nang	65.01	47.57	17.43	174.9	118.1	56.9	37.2%	40.3%	30.7%
4105	Dak Lak	Krong Buk	28.78	2.98	25.80	110.0	69.2	40.8	26.2%	4.3%	63.2%
4106	Dak Lak	Buon Don	11.47	1.37	10.10	74.0	61.8	12.2	15.5%	2.2%	82.8%
4107	Dak Lak	Cu M'Gar	33.62	0.23	33.39	210.9	129.7	81.2	15.9%	0.2%	41.1%
4108	Dak Lak	Ea Kar	90.05	66.57	23.48	329.1	304.8	24.3	27.4%	21.8%	96.7%
4109	Dak Lak	M'Drak	28.44	22.53	5.91	139.6	133.2	6.4	20.4%	16.9%	91.9%
4110	Dak Lak	Krong Pak	48.88	32.79	16.09	217.0	174.6	42.4	22.5%	18.8%	37.9%
4111	Dak Lak	Krong Bong	5.05	0.00	5.05	112.7	102.6	10.2	4.5%	0.0%	49.8%
4112	Dak Lak	Krong Ana	0.00	0.00	0.00	169.4	140.3	29.1	0.0%	0.0%	0.0%
4113	Dak Lak	Lak	0.08	0.08	0.00	113.1	105.3	7.8	0.1%	0.1%	0.0%
4114	Dak Lak	Cu Kuin	1.38	0.00	1.38	127.7	95.7	32.1	1.1%	0.0%	4.3%
4115	Dak Lak	Buon Ho	23.54	1.94	21.59	116.2	73.6	42.5	20.3%	2.6%	50.8%
4201	Dak Nong	Gia Nghia	0.36	0.36	0.00	24.7	17.8	6.9	1.5%	2.0%	0.0%
4202	Dak Nong	Dak Glong	0.19	0.19	0.00	43.8	29.7	14.1	0.4%	0.6%	0.0%
4203	Dak Nong	Cu Jut	6.81	6.51	0.29	36.0	23.8	12.2	18.9%	27.4%	2.4%
4204	Dak Nong	Dak Mil	3.65	3.46	0.19	116.2	71.7	44.5	3.1%	4.8%	0.4%
4205	Dak Nong	Krong No	0.05	0.05	0.00	84.6	52.7	31.9	0.1%	0.1%	0.0%
4206	Dak Nong	Dak Song	3.33	3.33	0.00	53.1	31.8	21.3	6.3%	10.5%	0.0%
4207	Dak Nong	Dak R'lap	0.00	0.00	0.00	41.4	26.3	15.1	0.0%	0.0%	0.0%
4208	Dak Nong	Tuy Duc	0.00	0.00	0.00	40.7	24.6	16.1	0.0%	0.0%	0.0%
4301	Lam Dong	Da Lat	16.76	16.76	0.00	81.6	78.7	2.9	20.5%	21.3%	0.0%
4302	Lam Dong	Bao Loc	2.99	2.99	0.00	55.0	52.4	2.6	5.4%	5.7%	0.0%
4303	Lam Dong	Dam Rong	1.38	1.38	0.00	57.4	56.3	1.1	2.4%	2.5%	0.0%
4304	Lam Dong	Lac Duong	1.30	1.30	0.00	26.0	25.4	0.5	5.0%	5.1%	0.0%
4305	Lam Dong	Lam Ha	27.15	27.15	0.00	204.1	202.0	2.2	13.3%	13.4%	0.0%
4306	Lam Dong	Don Duong	14.67	14.67	0.00	96.3	94.9	1.4	15.2%	15.5%	0.0%
4307	Lam Dong	Duc Trong	37.67	37.67	0.00	181.7	178.7	3.0	20.7%	21.1%	0.0%
4308	Lam Dong	Di Linh	16.46	16.46	0.00	187.5	184.9	2.6	8.8%	8.9%	0.0%
4309	Lam Dong	Bao Lam	5.41	5.41	0.00	125.5	123.3	2.2	4.3%	4.4%	0.0%
4310	Lam Dong	Da Huoai	3.14	3.14	0.00	17.0	16.5	0.5	18.4%	19.0%	0.0%
4311	Lam Dong	Da Teh	0.00	0.00	0.00	54.7	53.2	1.5	0.0%	0.0%	0.0%
4312	Lam Dong	Cat Tien	0.61	0.00	0.61	56.4	55.8	0.6	1.1%	0.0%	98.1%
		TOTAL	565.24	342.84	222.40	5500.98	4527.05	973.93	10.3%	7.6%	22.8%
	Kon Tum		9.78	8.11	1.67	293.18	236.10	57.09	0.38	0.39	0.19
	Gia Lai		51.87	14.00	37.87	1,254.48	997.95	256.53	0.97	0.45	4.84
	Dak Lak		361.67	179.91	181.76	2,369.65	1,892.48	477.17	2.06	1.10	12.37
	Dak Nong		14.38	13.90	0.48	440.48	278.39	162.09	0.30	0.45	0.03
	Lam Dong		127.54	126.93	0.61	1,143.19	1,122.13	21.06	1.15	1.17	0.98
	Total		565.24	342.84	222.40	5,500.98	4,527.05	973.93	4.86	3.56	18.41

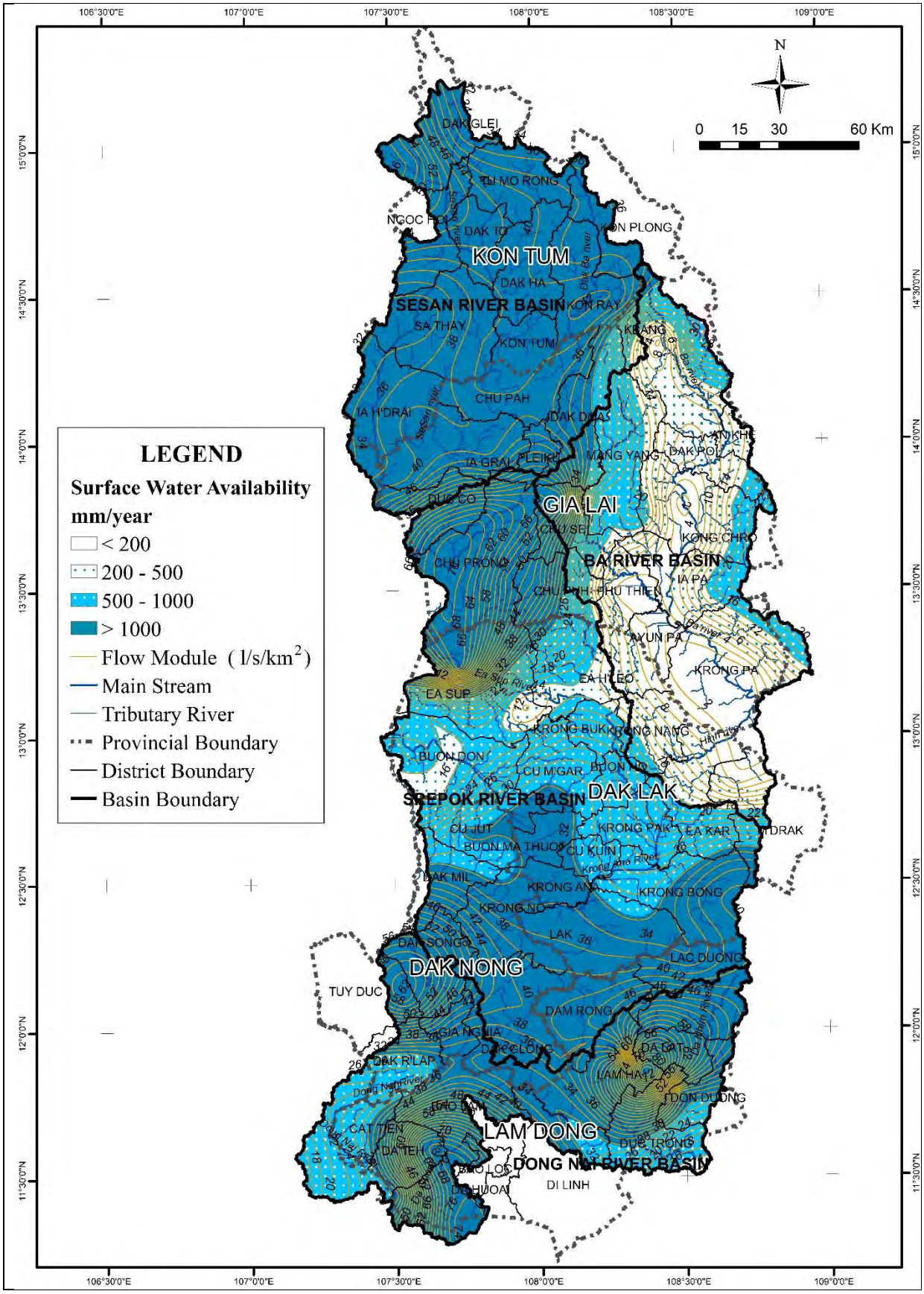
Source: JICA Study Team

AT 4.3.18 Water Shortage by District in Central Highlands in Wet Year

			Wet Year		Unit: MCM	Wet Year		Unit: MCM	Wet Year		Unit: MCM
CODE	**Province**	**District**	**Total**	**SW**	**GW**	**Total**	**SW**	**GW**	**Total**	**SW**	**GW**
3901	Kon Tum	Kon Tum	0.00	0.00	0.00	33.9	31.3	2.6	0.0%	0.0%	0.0%
3902	Kon Tum	Dak Glei	0.00	0.00	0.00	14.4	11.9	2.4	0.0%	0.0%	0.0%
3903	Kon Tum	Ngoc Hoi	0.29	0.00	0.29	25.9	23.5	2.4	1.1%	0.0%	11.9%
3904	Kon Tum	Dak To	0.00	0.00	0.00	21.2	18.1	3.1	0.0%	0.0%	0.0%
3905	Kon Tum	Kon Plong	0.00	0.00	0.00	21.7	20.2	1.4	0.0%	0.0%	0.0%
3906	Kon Tum	Kon Ray	0.00	0.00	0.00	13.0	11.9	1.1	0.0%	0.0%	0.0%
3907	Kon Tum	Dak Ha	0.43	0.00	0.43	66.3	48.3	18.0	0.6%	0.0%	2.4%
3908	Kon Tum	Sa Thay	0.01	0.00	0.01	27.3	22.2	5.1	0.0%	0.0%	0.2%
3909	Kon Tum	Tu Mo Rong	0.00	0.00	0.00	12.8	11.2	1.6	0.0%	0.0%	0.0%
3910	Kon Tum	Ia H'Drai	0.01	0.01	0.00	1.0	0.8	0.2	0.7%	0.9%	0.0%
4001	Gia Lai	Pleiku	2.31	0.77	1.54	47.6	36.0	11.6	4.8%	2.1%	13.3%
4002	Gia Lai	An Khe	0.01	0.01	0.00	12.3	11.2	1.1	0.1%	0.1%	0.0%
4003	Gia Lai	AyunPa	0.00	0.00	0.00	22.7	22.1	0.6	0.0%	0.0%	0.0%
4004	Gia Lai	Kbang	4.41	4.41	0.00	43.9	37.3	6.7	10.0%	11.8%	0.0%
4005	Gia Lai	Dak Doa	6.78	2.29	4.49	98.3	70.7	27.6	6.9%	3.2%	16.3%
4006	Gia Lai	Chu Pah	1.31	0.51	0.80	54.3	39.5	14.8	2.4%	1.3%	5.4%
4007	Gia Lai	Ia Grai	4.12	0.80	3.32	88.6	59.9	28.7	4.7%	1.3%	11.6%
4008	Gia Lai	Mang Yang	1.80	0.21	1.59	48.3	35.6	12.7	3.7%	0.6%	12.5%
4009	Gia Lai	Kong Chro	1.47	1.47	0.00	31.7	30.7	1.0	4.6%	4.8%	0.0%
4010	Gia Lai	Duc Co	1.38	0.47	0.91	55.0	36.1	19.0	2.5%	1.3%	4.8%
4011	Gia Lai	Chu Prong	1.69	0.41	1.29	125.0	81.6	43.4	1.4%	0.5%	3.0%
4012	Gia Lai	Chu Se	5.40	0.00	5.40	84.1	56.0	28.1	6.4%	0.0%	19.2%
4013	Gia Lai	DaK Po	0.65	0.65	0.00	13.5	12.6	0.9	4.8%	5.1%	0.0%
4014	Gia Lai	Ia Pa	0.32	0.32	0.00	68.4	67.0	1.5	0.5%	0.5%	0.0%
4015	Gia Lai	Krong Pa	1.16	0.67	0.49	63.0	61.5	1.5	1.8%	1.1%	32.5%
4016	Gia Lai	Phu Thien	1.09	0.00	1.09	86.8	85.4	1.4	1.3%	0.0%	78.8%
4017	Gia Lai	Chu Puh	9.69	3.83	5.86	33.6	23.7	9.9	28.8%	16.2%	58.9%
4101	Dak Lak	Buon Ma Thuot	0.67	0.00	0.67	114.8	99.3	15.6	0.6%	0.0%	4.3%
4102	Dak Lak	Ea H'leo	9.54	5.10	4.44	141.9	105.5	36.3	6.7%	4.8%	12.2%
4103	Dak Lak	Ea Sup	9.24	6.76	2.48	179.8	177.0	2.9	5.1%	3.8%	86.0%
4104	Dak Lak	Krong Nang	24.91	12.46	12.45	154.3	99.1	55.2	16.1%	12.6%	22.6%
4105	Dak Lak	Krong Buk	15.87	0.33	15.54	65.6	43.5	22.0	24.2%	0.8%	70.5%
4106	Dak Lak	Buon Don	10.04	0.00	10.04	67.8	56.7	11.1	14.8%	0.0%	90.6%
4107	Dak Lak	Cu M'Gar	42.52	0.21	42.31	142.7	90.0	52.8	29.8%	0.2%	80.2%
4108	Dak Lak	Ea Kar	34.31	19.65	14.66	183.6	162.2	21.4	18.7%	12.1%	68.5%
4109	Dak Lak	M'Drak	17.18	13.17	4.01	58.8	54.5	4.3	29.2%	24.1%	93.3%
4110	Dak Lak	Krong Pak	16.92	8.55	8.37	179.9	145.6	34.3	9.4%	5.9%	24.4%
4111	Dak Lak	Krong Bong	2.16	0.00	2.16	105.4	95.1	10.3	2.0%	0.0%	20.9%
4112	Dak Lak	Krong Ana	0.00	0.00	0.00	151.1	123.9	27.2	0.0%	0.0%	0.0%
4113	Dak Lak	Lak	0.16	0.16	0.00	103.6	97.8	5.9	0.2%	0.2%	0.0%
4114	Dak Lak	Cu Kuin	1.44	0.00	1.44	117.7	88.1	29.7	1.2%	0.0%	4.8%
4115	Dak Lak	Buon Ho	13.47	0.09	13.37	60.9	40.6	20.3	22.1%	0.2%	65.8%
4201	Dak Nong	Gia Nghia	0.00	0.00	0.00	33.9	23.4	10.6	0.0%	0.0%	0.0%
4202	Dak Nong	Dak Glong	0.38	0.38	0.00	49.6	36.1	13.5	0.8%	1.0%	0.0%
4203	Dak Nong	Cu Jut	2.96	0.00	2.96	51.1	39.7	11.4	5.8%	0.0%	25.9%
4204	Dak Nong	Dak Mil	1.93	0.00	1.93	117.0	75.9	41.1	1.7%	0.0%	4.7%
4205	Dak Nong	Krong No	0.09	0.09	0.00	98.6	73.5	25.2	0.1%	0.1%	0.0%
4206	Dak Nong	Dak Song	0.00	0.00	0.00	100.7	63.8	36.9	0.0%	0.0%	0.0%
4207	Dak Nong	Dak R'lap	0.00	0.00	0.00	64.1	41.1	23.0	0.0%	0.0%	0.0%
4208	Dak Nong	Tuy Duc	0.00	0.00	0.00	63.3	39.4	23.9	0.0%	0.0%	0.0%
4301	Lam Dong	Da Lat	2.34	2.34	0.00	70.7	67.8	2.9	3.3%	3.5%	0.0%
4302	Lam Dong	Bao Loc	0.01	0.00	0.01	58.0	55.4	2.6	0.0%	0.0%	0.2%
4303	Lam Dong	Dam Rong	0.71	0.71	0.00	51.3	50.2	1.1	1.4%	1.4%	0.0%
4304	Lam Dong	Lac Duong	0.00	0.00	0.00	18.7	18.2	0.5	0.0%	0.0%	0.0%
4305	Lam Dong	Lam Ha	5.23	5.23	0.00	151.8	149.7	2.0	3.4%	3.5%	0.0%
4306	Lam Dong	Don Duong	0.00	0.00	0.00	88.4	87.0	1.4	0.0%	0.0%	0.0%
4307	Lam Dong	Duc Trong	21.19	21.19	0.00	171.8	168.9	2.9	12.3%	12.5%	0.0%
4308	Lam Dong	Di Linh	4.09	4.08	0.00	144.6	142.2	2.4	2.8%	2.9%	0.2%
4309	Lam Dong	Bao Lam	0.00	0.00	0.00	110.6	108.4	2.2	0.0%	0.0%	0.1%
4310	Lam Dong	Da Huoai	0.00	0.00	0.00	22.8	22.3	0.5	0.0%	0.0%	0.0%
4311	Lam Dong	Da Teh	0.10	0.00	0.10	57.9	56.5	1.5	0.2%	0.0%	6.9%
4312	Lam Dong	Cat Tien	0.51	0.00	0.51	55.9	55.3	0.6	0.9%	0.0%	84.5%
		TOTAL	282.27	117.32	164.95	4623.47	3819.73	803.73	6.1%	3.1%	20.5%
	Kon Tum		0.73	0.01	0.73	237.57	199.53	38.04	0.03	0.01	0.14
	Gia Lai		43.59	16.80	26.79	977.11	766.79	210.32	0.85	0.50	2.56
	Dak Lak		198.42	66.49	131.93	1,828.00	1,478.78	349.22	1.80	0.65	6.44
	Dak Nong		5.36	0.47	4.89	578.31	392.78	185.53	0.08	0.01	0.31
	Lam Dong		34.18	33.56	0.62	1,002.48	981.86	20.62	0.24	0.24	0.92
	Total		282.27	117.32	164.95	4,623.47	3,819.73	803.73	3.00	1.41	10.37

Source: JICA Study Team

AT 4.4.1 Surface Water Availability Map in Wet Year



Source: JICA Survey Team

AT 5.2.1 Irrigated Agricultural Modernization

Sector	**Irrigation**		
Countermeasure	Irrigated Agricultural Modernization		
Target / Area	Water shortage area in the Central Highland provinces		
Implementation Agency	• Provincial DARD (Extension Center, Irrigation division) • District People Committee (Agricultural Extension Station, Irrigation Section)	Agencies Concerned	• Commune People Committee • Irrigation beneficiaries, etc.

Background

- The Central Highland provinces suffer from chronic water shortage due to rapid urbanization, population increase, and exploitation of water resources.
- The irrigation water is not well controlled and shares more than 80% of total demand.
- Agricultural products are of low quality and low sales prices.
- Overuse of irrigation water and no effective water sharing have worsened damages to crops in the events of droughts.
- There is no effective control in groundwater use, which has resulted in the decline of groundwater level, dry-up during drought, and crop damage.
- Advanced farmers apply sprinkler and drip tube irrigation for water saving.
- Majority of farmers cannot procure water saving facilities due to financial constraints.
- Although some districts and communes have succeeded in promoting private participation for better market access, the remote and drought vulnerable areas have less opportunities to attract private sectors.

Narrative Summary

Overall Goal Increase and stabilize farmers' income Purpose Improve agricultural productivity and products' values with suitable crop variety and proper farming practices using limited irrigation water	Outputs 1. Capacity of staff of agricultural extension and irrigation in the target districts is enhanced. 2. Private investments by traders, local enterprises, organic promotion companies, etc. for improving farming technology and marketing activities are promoted. 3. Rehabilitation/Improvement of irrigation system and develop access road are next of implemented. 4. Quality of products and farming technology is improved. 5. Water demand in peak dry season is decreased and risk of water shortage is mitigated.

Activities

1-1. Implement the Training of Trainer (TOT) for DARD and district staff on irrigated agricultural modernization in regards to the following issues:
  1) Appropriate O&M of irrigation facilities.
  2) Guidance for disseminating O&M of irrigation facilities to districts and farmers.
  3) Introduction of water saving irrigation facilities.

2-1. Promote collaboration between farmer and private sector through contract farming for investment, technical transfer and improving marketing activities, especially for high value products.

3-1. Prepare guidelines for introducing water saving facilities and O&M of pipeline system.

3-2. Repair and rehabilitate canal linings, pipeline, etc.

3-3. Increase available for irrigation water resources.

3-4. Develop or rehabilitate small scale reservoirs and ponds to store surface water during wet season for irrigation in dry season.

3-5. Develop access road to reduce transportation cost.

4-1. Extend appropriate varieties (short growing period, drought tolerant) and cropping pattern for water saving irrigation.

5-1. Conduct water balance analyses and share the results with district, communes and famers to minimize peak irrigation water demand.

Recommended Infrastructure, Facility and Private Participation
1. Encourage the private cooperation in providing water saving facility and its assistance in O&M activities.
• Purpose: Improve the irrigation efficiency and crop production under the cooperation with private sector.
• Facility:
- Irrigation system: reservoir, pond, concrete lined canal, piping, etc.
- Water saving irrigation system: sprinklers, drip tube, etc.
- Access road.
• Present Private Activities:
- Thang Loi Coffee JSC is a trader of purchasing raw coffee in Dak Lak. This company support the farmer by giving a loan for buying farm inputs with the interest as same as the banks provide. The company has totally 2,141 ha agricultural land, of which 1,782 ha is coffee farm. Through the verbally contract, they warrant the farmers to buy their product and export to Japan. They also cooperate with local authority and farmer unions to train famers to improve their farming practice. The company do not invest any infrastructure and agricultural facility.
- Lam Dong Food and Agriculture Joint Stock Company is a trader of purchasing vegetable in Da Lat city. This company has 100 ha of vegetable and about 200 employees. By the contract agreement with farmers through Farmer Union or individual farmers, they promise farmers' product will be bought with a stable prize and can be exported to Japan. The company has their own technical staffs to guide the farmers and to monitor the process of using fertilize, pesticide and the harvesting on the farm site.

Source: JICA Study Team

Irrigated Agricultural Modernization					**Province: Gia Lai**
District	Commun	Area	Population	Households	Major Crops
Chu Puh	Ia Blu	193.2	7,324	1,750	Annual: Paddy; Perennial: Coffee, Pepper
	Ia Phang	126.6	10,001	2,400	ditto

I. Chu Puh District

Item	Ia Blu commune	Ia Phang commune
Background	- Paddy: (322 ha including 200 ha irrigated, 122 ha rainfed); pepper (520,7 ha); coffee (280 ha). - Pepper is the main perennial crop, but tend gradually to be replaced by coffee due to drought risk. - Paddy is the main annual crop, mostly for home consumption of local people, not for selling (only sell when the production over local demand). - Irrigation facilities have been built for a long time, destroyed and not functional. - Canal length: 8.7 km, including: 1 weir and 2 drainage gates. - The system provides water for 200ha of paddy. The system can only supply only in wet season; in dry season providing for 50 ha of 200 ha. The 100 ha of paddy field at minority hamlet (Kuai) can irrigate in wet crop season, but low productivity. - Perennial crops use ground water from sallow wells and deep wells which farmers construct by themselves. A few cultivated areas are irrigated by water saving system (sprinklers).	- Paddy (310 ha); pepper (577 ha); coffee (180 ha). - Pepper is the main perennial crop, but tend gradually to be replaced by coffee due to drought risk. - Paddy is the main annual crop, mostly for home consumption of local people, not for selling (only sell when the production over local demand). - Annual crops use surface water resources from irrigation system and rain, 5/12 hamlets take the advantages of irrigation system, others cultivate one rainy crop season. - Perennial crops use ground water from sallow wells (mainly) and deep wells which farmers construct by themselves. The 35% of perennial area is irrigated by saving system (sprinklers), covering 95% pepper area. - Currently, ethnic minority receives support from the DPC and CPC of finance, seed and fertilizer, new technique and training (from Agriculture and Land Management Divisions, DPC).
Specific issues	➢ **Situation of drought in 2015/2016:** Some deep wells dried up (85m depth). As the area of coffee and pepper increase recently, the water level in shallow well has lowered. ➢ **Water usage:** There is canal system in the commune, but it is hard to access the irrigation facilities in wet season because of bad road condition. Though some farmer introduce water saving irrigation system (sprinkler), a lot of farmers can't procure due to the fund shortage. ➢ **Regulation of irrigation facilities:** The irrigation management board (IMB) at commune level is not functioned. IMB only monitors in case of conflict among surface water use. The farmers clean the irrigation system by themselves. The annual maintenance of irrigation system is implemented twice/year by IMC, provided by irrigation subsidy. ➢ **Desire of commune people:** The local farmers cannot access any market to sell sweet corn and banana. More weirs are necessary to provide water for paddy under rainfed.	➢ **Situation of drought in 2015/2016:** The water volume in natural streams was reduced. Since there is no reservoir, they can't receive enough water for crops. ➢ **Water usage:** Because of insufficient capacity of irrigation system, farmers can irrigate only 30% area for paddy in dry season. Low groundwater level due to uncontrolled and over use of water from deep wells (100-120m depth). There are temporary weirs in addition to above weirs in dry season. ➢ **Regulation of irrigation facilities:** The IMB is active in supporting farmers in scheduled irrigation. The eight weirs in Ia Phang commune are under control of IMB (total 8 unit, each unit has 5 persons). The operators do not receipt monthly salary. ➢ **Desire of commune people:** Additional irrigation canal needs to be constructed. Detail schedule for irrigation O&M is prepared. Up to now the IMB members use only for their experience.
Recommended Infrastructure/ Activities	For perennial crops, water saving irrigation should be introduced. When it comes to annual crops growing in dry season, small scale reservoir or pond may be necessary. *Remarks:* To introduce water saving facilities, private enterprises (traders or promotion organic farming enterprises) may sponsor for investigation.	Guide farmers to change cropping pattern to mitigate climate change impacts.

Photos

Fig 1. Sprinkler irrigation by ground water, irrigated in dry season (Ia Blu)

Fig 2. Deep well (80m), invested by farmers (Ia Blu)

Fig 3. Shallow well (30m), invested by farmers (Ia Blu)

Fig 4. Weir in Chu Bo 2 hamlet operated by IMC, supporting water for 25-30 ha of paddy (2 cropping season, this weir can irrigate 60% in dry season.

Fig 5. Canal system from the weir. Total 1.5 km comprising 0.5 km concreted canal and 1 km earth canal (Ia Phang)

Fig 6. Pumping machine, use in dry season to pump up water to canal (Ia Phang)

Source: JICA Study Team

Irrigated Agricultural Modernization					**Province: Dak Lak**
District	Commune	Area (km^2)	Population	Households	Major Crops
Ea Kar	Ea Sar	56.4	8,975	2,081	Annual: Paddy; Perennial: Coffee, Pepper
Ea Sup	Ya To Mot	90.28	5,571	1,614	Cassava, Rubber, Cashew, Sugar Cane

I. Ea Kar District

Item	Ea Sar commune
Background	- Paddy: (620 ha), coffee (892 ha), pepper (270 ha). - Total 4,800 ha of cultivated area; only 400 ha is irrigated by natural streams and one reservoir. The rest is rainfed. - The one reservoir supplies water for 100 ha of paddy and 50 ha of other annual crops; 1.8 km canal (1 km concreted, 0.8 km temporary) - Perennial crop use ground water both from sallow and deep wells and private ponds to store surface water that farmers constructed by themselves. A few households cultivated pepper with water saving irrigation system (sprinklers). - All water supply (from reservoir, streams, ground water) can irrigate only 40% of the area. The rest of the area is rainfed.
Specific issues	➢ **Situation of drought in 2015/2016:** The lowering of ground water level resulted in water shortage both for domestic and irrigation. Drought in the first six months in 2016 decreased the productivity of both annual crops (paddy, maize) and perennial (coffee, pepper) from 30% to 70%. ➢ **Water usage:** Most depends on surface water from streams. At some hamlets cannot take the water from streams. The farmers dig shallow and deep wells and small tanks for irrigation without CPC's support. ➢ **Regulation of irrigation facilities:** One Limited Company (belong to PPC) operate one reservoir. The schedule was based on water demand from farmers. The farmers use pump machine to take the water from streams individually. ➢ **Desire of commune people:** Planting litchi increase farmers' income. Technical and financial support are necessary. A weir and pump station at the hill of hamlet 9, in Krong No river are necessary to irrigate in dry season.
Recommended Infrastructure/ Activities	Construct the small and medium irrigation system with pipe network. Encourage farmers to construct tank to mitigate water loss for water saving. *Remarks:* To introduce water saving facilities, private enterprises (traders or promotion organic farming enterprises) shall participate.

Photos

Fig 1. Bang Lang reservoir supply water for 100 ha of paddy and 50 ha of other annual crops

Fig 2. The operation activity of Bang lang reservoir is in charge of Limited Company (PPC)

Fig 3. 1.8 km of canal after reservoir (1 km concrete)

Fig 4. The control gate from reservoir to canal

Fig 5. Deep well (62 m depth), for irrigation

Fig 6. Shallow well (9-10 m depth) for drinking, have no water in dry season.

II. Ea Sup District	
Item	Ya To Mot commune
Background	Ya To Mot is one of the poorest communes in Dak Lak and has the high percentage of minority (4/15 hamlets). Farmers cultivate by using their own experience due to low benefit, high cost of transportation and the low sale price. Irrigation system covers paddy area only. - Main perennial crops: Rubber, Cashew - Cashew and mango are gradually replaced rubber area due to the low production of rubber. -Annual crop: Cassava (6,631 ha), sugar cane (4,037 ha).
Specific issues	➢ **Situation of disaster:** Rice fields of the village are flooded every year due to low land. Floods from Dak Pet stream affect the field with no drainage canal. ➢ **Product distribution:** Market access is limited, especially for annual crops. Coffee farmers sell products to enterprises individually. Because the road condition is very poor, transportation cost become high and the farmers' sales become lower. Some farmers can't transport products to the market in wet season. ➢ **Irrigation system:** Canal system (8 km) provides water for paddy. The 600 ha out of 900 ha are irrigated (300 ha by gravity and 300 ha by pump). The level of tertiary canal is lower than paddy field (40cm lower). The water cannot flow into paddy field so that farmers have to use pump. ➢ **Saving water facility:** Water-saving facility: drip tube (using pumping machine), mainly for fruit trees such as citrus, mango and jack fruit. Only rich farmers can afford to pay for the machine. ➢ **Contract to Enterprise and Farmer Union:** Farmers sell products through enterprises/private traders. Because of low sales price and high cost of transportation, farmer's income become low. - Big enterprises order their demands and deposit money to farmers (Dak Nong Sugarcane company, rubber private company). Other traders collect annual crops products from farmers without support. -Outside farmers from other provinces come to rent local farmer's land and cultivate water melon, etc and sell production by themselves. - Farmers' Union support: In collaboration with other company: fertilizer (late payment) and seed are provided. Vocational training is provided to set up pilot model for ethnic minority and poor households. ➢ **Desire of commune people:** They are willing to change cropping pattern and arrange available agricultural lands to be supported from investors/enterprises.
Recommended Infrastructure/ Activities	Water saving irrigation (pipeline, sprinklers and drip irrigation) needs to be introduced for perennial crops

Photos

Fig 1. Earth road in Ya To Mot commune

Fig 2. Sugarcane factory (under construction)

Fig 3. Apartment house of Labor of Sugarcane Factory (under construction)

Fig 4. In some canal location, farmers dig the hole illegally to take water to the paddy field

Fig 5. Canal system for paddy field

Fig 6. Traders collect paddy (collecting rice by truck)

Irrigated Agricultural Modernization					**Province: Dak Nong**
District	Commune	Area (km^2)	Population	Household	Major Crops
Krong No	Tan Thanh	88.07	3,561		Annual: Cassava; Perennial: Coffee, Rubber

Krong No District

Item	Tan Thanh commune
Background	Total agricultural land: 7,583 ha, of which: - Annual crops: 1,827 ha (cassava: 1250 ha; paddy rice: 30 ha only in rainy season) - Perennial crops: 5,756 ha (coffee 4261 ha) mainly irrigated by surface water Irrigation system: There is one reservoir in Dak Ri Hamlet, irrigating 300 ha of coffee. Farmers take water from the reservoir individually by pumping machine due to no canals.
Specific issues	➢ **Situation of drought in 2015/2016:** The reservoir didn't dry up but water level lowered by two or three meters. PPC distributed the guidelines for farmers to change paddy to maize and vegetable for water saving irrigation (dry season) ➢ DPC support the damaged household from 2015-2016 drought: VND 2 million/ha for paddy; VND 4 million/ ha for perennial crop ➢ **Water usage:** The streams and ponds irrigate coffee, fruit and paddy. When farmers use the water, they have to use pumping machine. In normal year, water from streams/ponds provide sufficient water for 3 times irrigation. In drought year, there is enough water for 2 times. The rest would take water from deep well or no irrigation. ➢ **Irrigation system:** Tan Thanh commune does not have IMB for O&M ➢ **Support from the local authority (PPC, DPC):** The project funded by IFAD, implemented from 2011: technical training, fertilize guideline, conduct pilot study for drip irrigation system in small scale (one ha pepper field) support 30- 50% cost for pilot farmers). ➢ **Activities of commune people:** Drip tube irrigation system has been introduced by farmers at pilot area through IFAD. They also cultivate beans to cover surface of land and prevent evapotranspiration. However, the other farmers don't introduce these approaches. ➢ Coffee farmers sell their product to traders or enterprises.
Recommended Infrastructure/ Activities	Water saving facilities shall be introduced for perennial crops. In Dak Luu hamlet, irrigation system is necessary for dry season. The geological study to identify the potential area of ground water is necessary. In some area, farmers cannot take the ground water.

Photos

Fig 1. Tube Irrigation System, apply for pepper in a small scale.

Fig 2. Trader collect coffee

Fig 3. Trader measure the water content of coffee

Source: JICA Study Team

AT 5.2.2 Strengthening Farmers' Organizations for Sustainable Irrigation Management

Sector	**Irrigation**		
Countermeasure	Strengthening Farmers' Organizations for Sustainable Irrigation Management.		
Target / Area	Water shortage irrigation areas in the Central Highland provinces		
Implementation Agency	• Provincial DARD (Irrigation unit, Extension unit) • DPC (Agricultural Extension Centers, etc.)	Agencies Concerned	IMC

Background

- The Central Highland provinces suffers from chronic water shortage due to rapid urbanization, population increase, and exploitation of available water resources.
- The irrigation water is not well controlled and shares more than 80% of total demand.
- Since water resources planning and management is not well considered, water is inefficiently used, which worsens water availability especially in the event of droughts.
- The O&M of irrigation system does not work properly due to the limit of IMC and PPC's financial and human resources.
- The irrigation facilities in the cultivated fields such as canals and gates are mainly operated by individual farmers without the participation of Famers' Organization.
- There is no effective control in utilization of groundwater, which lead to the decline of groundwater level, dry-up in the events of droughts, and crops damages.
- There is no clear delegation in term of responsibility between IMC and Farmers' Organization.

Narrative Summary

Overall Goal Irrigation water demand is optimized, and water shortage risk is mitigated Purpose 1. O&M of water use is strengthened through organizational approach. 2. Irrigation efficiency is improved through proper and organized O&M of irrigation facilities.	Outputs 1. Demarcation of O&M of irrigation systems in target province is defined. 2. Capacity of DARD and district staff is enhanced 3. Farmers' participation in water management and O&M of irrigation facilities are promoted. 4. Appropriate irrigated farming is executed under cooperation with private sectors.

Activities

1-1. Prepare provincial policy to direct all the relevant sector for sustainable O&M of irrigation systems.
1-2. Prepare guidelines to clarify the responsibility of O&M of irrigation systems.
2-1. Implement O&M trainnings for DARD and district staff.
3-1. Organize farmers' water user groups (WUGs).
3-2. Prepare guidelines for famers to reduce overuse of surface water and ground water and monitor groundwater utilization.
3-3. Guiding practical O&M activities through PIM of irrigation system, execution and monitoring.
3-4. Strengthen roles and functions of farmers' groups at village level for efficient management in water use, through the following contents:
  1) Explanation for roles of farmers' groups,
  2) Selection of representative from each farmers' group at village level,
  3) Clarification of legitimate irrigation area of each farmer by drawing cadastal borders in-between for fair water distribution,
  4) Imposement of punishment on those who do not comply with rules of O&M of irrigation facilities,
  5) Umbrella organizations of farmers' groups.
4-1. Provide guidance on irrigation scheduling and O&M of irrigation facilities.
4-2. Promote utilization of water saving facilities and improve farming technologies with cooperation of private sectors.

Recommended Infrastructure, Facilities and Private Participation
2. Encourage the private cooperation in providing irrigated farming. • Purpose: Improve farming technologies and crop products under the coorperation with private sectors. • Facility: - Farming guidebooks. - Technical farming training courses. • Present Private Activities: - Thang Loi Coffee JSC (Refer AT 5.2.1). - Hung Thinh Manufacture Trading Fertilizer Co.Ltd is a trader of purchasing raw coffee bean as well as a fertilizer seller. The company finances to the farmers for buying their fertilizer with a small interest. Through the verball agreement, the company promises to buy farmers' product with a stable prize. The company has many respresentative agencies in Central Highland provinces that can support farmers in transportation of product. - Lam Dong Food and Agriculture Joint Stock Company (Refer AT 5.2.1).

Source: JICA Study Team

Strengthening Farmer's Organizations for Sustainable Irrigation Management					**Province: Dak Lak**
District	Commune	Area	Population	Households	Major Crops
Ea Sup	Ya To	90.2	5,571	1,614	Cassava, Rubber, Cashew, Sugar Cane

Ea Sup District

Item	Ya To Mot commune
Background	Ya To Mot is one of the poorest communes in Dak Lak province and has a higher percentage of minority (4/15 hamlets), 637 poor households of the total 1614 households. Farmers cultivated by using their own knowledge, high cost of transportation and the low sale price. Only paddy is irrigated. - Main perennial crops: Rubber, cashew. - Cashew and mango have gradually replaced rubber due to the low production of rubber. - Annual crop: Cassava (6,631ha), sugar cane (4,037ha).
Specific issues	➢ **Situation of disaster in 2015/16**: Paddy fields of the village are flooded every year due to the low land. Floods from Dak Pet stream affect the field where no drainage canal was constructed. ➢ **Water source**: There is no reservoir in the commune. Free intake from streams and rivers is common. The field far from main or secondary canal do not have enough water for irrigation. The farmers using ground water from shallow and deep wells are limited. ➢ **Irrigation facilities**: The canal system (8 km length) irrigate paddy. The 600 ha out of 900 ha are irrigated (300 ha by gravity and 300 ha by pump). In some location, the level of tertiary canal is lower than paddy field (40cm lower). The water cannot flow into paddy field so that farmer has to use pump. Sugar cane and water melon are cultivated at rainfed area. ➢ **O&M of irrigation facilities**: The main gates located at the head of main canal are operated by IMC following cropping schedule of annual crop prepared by Agriculture Division, DPC. The secondary, tertiary canals and the gates at fields are operated by farmers by themselves. CPC assigns some farmer representatives who investigate water distribution and condition of irrigation facilities. ➢ **Farmers' Union support**: In collaboration with the companies to sale fertilizer (late payment) and seeds. Vocational trainings are provided to set up pilot model for ethnic minority and poor households.
Recommended Activities	- The irrigation management board shall be strengthened to operate irrigation facilities and monitor the situation of taking water illegally, including the farmers cultivating perennial crops. - The water user groups shall be organized to strengthen the situation of poor agriculture. They are also recommended to have responsibility to coordinate CPC, traders and farmers.

Photos

Fig 1. Main canal operated by IMC

Fig 2. A hole bored by farmers to take water

Fig 3. The hole is closed when the farmer does not need water

Fig 4. Intake gates in a paddy field. These gates are operated by farmers by themselves

Fig 5. The O&M activities are not active. The gate was stolen and the canal got stuck

Fig 6. Watermelon field, belonging to outside province farmers who rent the field from local farmers and cultivate by themselves

Source: JICA Study Team

Strengthening Farmer's Organizations for Sustainable Irrigation					**Province: Dak Nong**
District	Commune	Area	Population	Households	Major Crops
Krong No	Nam Nung	104.82	6,431		Maize, Coffee, Rubber

Krong No District

Item	Nam Nung commune
Background	Nam Nung commune has 5,929 ha of farming area, comprising two main perennial crops: rubber (2,568 ha) and coffee (1,484 ha). The annual crops: maize (770 ha), cassava (555 ha), and paddy (77 ha) are planted mainly in rainy season to take the advantage of surface water resources from 3 reservoirs, comprising 2 reservoirs have the canal systems. The three reservoirs support 40% of water demand for irrigation (mainly of coffee and paddy). The farmers who cannot take water from reservoirs and streams construct the shallow and deep wells for irrigation.
Specific issues	➢ **Situation of drought damage in 2015/16**: There are 3 reservoirs and one of them dried up. Water shortage has occurred especially for perennial crop (coffee). The total damaged area is 631 ha, comprising 627 ha coffee and 4 ha paddy. ➢ **Water source**: Most of farmers including coffee farmers use surface water from streams, reservoirs and rain; some coffee farmers use ground water. The three reservoirs support 40% of water demand for irrigation. The ground water from shallow and deep wells provide water for 20% of farming area. ➢ **Irrigation facilities**: Because there are 3 reservoirs in the commune, many crops including perennial crops (mainly coffee) are irrigated. Few farmers introduce water saving irrigation (sprinkler for coffee). Few households use the drip irrigation system for pepper. However, this system can only work effectively for two years because the drip tube got stuck. ➢ **O&M of irrigation facilities:** The gates in the reservoirs are operated by IMC following cropping schedule of the annual crops. The fields near the gates and canal are irrigated by pump from the canals without control of water uses. ➢ **Farmers' Union support:** The 40% farmers of the commune are members of Farmer Union. The Farmer Union organizes quarterly meeting to provide training course, introduce new farming model and share experience among farmers. They also work with fertilizer company so that farmers can buy the fertilizer with lower price. Farmer Union is going to set a cooperative to provide essential material and help farmers sale with higher price. The member farmers are guaranteed by Farmer Union for lending money from Social Policy Bank.
Recommended Activities	The water user groups shall be organized to support effectively the operation of irrigation facilities, including cultivation of perennial crops. They are also recommended to control and monitor irrigation water utilization, O&M of facilities, etc with CPC and IMC.

Photos

Fig 1. Dak M'Hang reservoir

Fig 2. The main gates from the reservoir are under the operation of IMC

Fig 3. A gate downstream canal is locked

Fig 4. Ditches next to canal to prevent the sediment and soil inflow to the canal

Fig 5. Farmers plant coffee next to canal to take water easily

Fig 6. Drip Irrigation System for pepper

Source: JICA Study Team

Strengthening Farmer's Organizations for Sustainable Irrigation Management					**Province: Lam Dong**
District	Commune	Area (km^2)	Population	Households	Major Crops
Duc Trong	Ninh Gia	144.48	13,666	3,528	Vegetable, maize, coffee, pepper
Di Linh	Tam Bo	277.2	6,656	1,620	Paddy, coffee

I. Duc Trong District

Item	Ninh Gia commune
Background	The farmers in Ninh Gia commune cultivate the crop without irrigation system. The main perennial crop is coffee (4,217 ha), vegetable (100 ha in dry season) and paddy (80 ha in rainy season). The farmers take natural stream water to irrigate. The ponds are made to store water from stream and rain water to irrigate in dry season. Pumps are used to take water from these ponds. The farmers who utilize shallow and deep wells for irrigation are limited. The drought occurs frequently and affects mainly the coffee area. The flood only occurs as a result of water release from hydro power dam. There is one hydropower plant and its dam (Dai Ninh) near the commune. Three out of nine hamlets are affected by the water released from the dam that cause flood to the coffee areas.
Specific issues	➢ **Situation of drought damage in 2015/16**: Many deep wells dried up (over 80m depth) but some wells near the stream did not dry up (30m depth). The farmers near the stream constructed ponds to use water in dry season. The 700 ha of coffee and 3 ha of paddy were seriously affected by 2016 drought. ➢ **Water source**: They use surface water mainly for irrigation because of the poor quality of ground water in this area. However, since the amount of surface water is not enough, the farmers dig deep wells and construct small ponds individually for irrigation. ➢ **Activities of commune people**: Since there is no canal system, farmers use surface water from natural streams. A limited percentage of farmers who use shallow and deep wells. Almost all paddy fields take water from stream and rain water. ➢ **Farmers' Union support**: Farmer Union has responsibility to promote improved farming. Agricultural Extension Station under DPC supports farmers with farming technical trainings and new crop recommendations. Some farmers are introduced to water saving irrigation (sprinklers, drip) through the training by Farmer Union (95 ha of vegetable is under drip irrigation system). Farmer Union support farmers to reach Viet GAP standards.
Recommended Infrastructure/ Activities	Hiep Thanh reservoir and the irrigation facilities shall be constructed to provide water for irrigation in combination of storing the water released from Dai Ninh dam. The Farmer Union is also recommended to strengthen their responsibility to coordinate traders and farmers. Farmers are recommended to follow the technical requirements and ensure the quality of vegetable under Viet Gap standard.

Photos

Fig 1. Natural stream through the coffee field

Fig 2. Pond constructed near the stream to store the water for irrigation

Fig 3. Elastic tube line farmer used to pump up from stream/pond to fields

Fig 4. A well did not dry up in 2015/16 (30m depth). Water from the well is used to fill ponds for irrigation

Fig 5. Pump machine that farmers use to pump up water from streams/ponds to coffee field

Fig 6. Farmers grow coffee and with curry

II. Di Linh District	
Item	Tam Bo commune
Background	Tam Bo Commune has 3,700 ha of perennial crops of which 3,000 ha is coffee irrigated by surface water from two streams, two weirs and canal system. The two weirs and canal system irrigate 2,000 ha of coffee and 52 ha of paddy. Other farmers use pump to take water directly from streams. Due to poor quality of ground water (high arsenic level), farmers construct ponds to store the surface water from streams and rain water for irrigation.
Specific issues	➢ **Situation of drought damage in 2014/15**: Two main streams in this commune were dried up. 90 ha of paddy field was damaged. ➢ **Situation of flood damage in Dec 2016**: Floods occur frequently. 60 ha of coffee near the stream was affected in the 2016 flood. ➢ **Water source**: Tam Bo commune has no reservoir. Paddy and coffee take the water from canals that is connected to weirs (natural streams). Farmers also construct the ponds to store rain water for irrigation. Once the natural streams become dried up, the farmers who don't have their pond and wells cannot take the water for irrigation. Water shortage is serious, especially in dry season. ➢ **Irrigation facilities**: No irrigation management board in commune level. The 1.1 km canal and temporary canal follow Dah Le weir is under the management of farmers. Farmers use the water for both paddy and coffee fields (use pump machine to pump water to coffee fields). In Cau Xanh stream, farmers construct the temporary canal (earth) by themselves to drive water from stream to cropping fields. ➢ **O&M of irrigation facilities**: The O&M activities is not functional. A gate at Dah Le weir is broken (always open) and is not fixed yet.
Recommended Activities	The irrigation management board shall be strengthened to operate irrigation facilities. The Farmer Union is also recommended to strengthen their responsibility to coordinate enterprises/traders and farmers, especially for the marketing activity.

Photos

Fig 1. Dah Le weir in Dah Le stream dried up in 2014/15 drought

Fig 2. The gate of Dah Le weir is broken. This canal system has only one gate

Fig 3. Farmers take water from the streams to irrigate coffee field.

Fig 4. DPC supports the minority farmers to construct ponds to irrigate

Fig 5. The ponds are used to irrigate for both paddy and coffee

Fig 6. The road condition is very bad in wet season

Source: JICA Study Team

AT 5.2.3 Community-based Rural Livelihood Improvement in Flood-prone Area

Sector	**Flood**		
Countermeasure	Community-based Rural Livelihood Improvement in Flood-prone Area		
Target / Area	Flood-prone area in the Central Highland provinces		
Implementation Agency	• Provincial Steering Committee for Natural Disaster Prevention and Control, • DONRE, • District People's Committee, • National Center for Hydro-Meteorological Forecasting (HMF) under MONRE.	Agencies Concerned	• Commune People's Committee, • Mass organizations, • Local communities, etc.

Background

- Deforestation leads more & rapid surface runoff and less groundwater recharge.
- Increasing extreme rainfall due to climate change resulted in flash flood and erosion of river bank.
- People (immigrants) live in flood-vulnerable area and high risk of flood damage.
- Lack of real-time meteorological / hydrological (MH) observation.
- Lack of flood forecasting and warning system.
- Lack of flood control facility and flood evacuation preparation.
- Unstable livelihood in the flood-prone areas.

Narrative Summary

Overall Goal Livelihood improvement by mitigation of flood damages and victims Purpose 1. Establish real-time meteorological hydrological (MH) monitoring system 2. Develop early warning system for flood and evacuation 3. Improve local livelihoods in the flood-prone areas	Outputs 1. MH are monitored and assessed, and warning and evacuation systems including shelters for emergency are introduced. 2. Flood forecasts and analyses are conducted, and the results are shared with districts, communes and villagers. 3. Participation of private sectors, local government authorities and communities in real-time MH monitoring system, its O&M, early warning system for flood and evacuation are made. 4. Local people's living in the flood-prone area are stabilized and improved.

Activities

1-1. Prepare guideline with participatory approach on prevention of flood damages.
1-2. Prepare and implement the Training of Trainer (TOT) for district staff, village people, community groups and Steering Committee for Natural Disaster Prevention and Control (SCNDPC) on the following issues:
  1) Appropriate O&M of MH monitoring systems.
  2) Communication skills for dissemination to commune staff, villagers and farmers in charge of development and O&M of monitoring systems.
1-3. Conduct trainings of (SCNDPC) to be capable as a main responsible organization for O&M of MH monitoring system.
1-4. Linkage with MH monitoring at sub-basin level.
2-1. Integrate MH monitoring data.
2-2. Increase technical capacity of DONRE and National Center for Hydro-Meteorological Forecasting (HMF) for flood forecasting and analysis.
2-3. Upgrade tools and sources for communication and sharing information up to village level.
3-1. Promote private investment and cooperation between private sectors and villagers for establishing MH monitoring system and information dissemination.
4-1. Assess exitsing landuse plan and make necessary revision, and relocate residents in flood-prone areas.
4-2. Introduce livelihood improvement program in the flood-prone areas.

Recommended Infrastructure, Facility and Private Participation

1. Telemetric real-time automatic MH monitoring systems
   - Purpose: flood early warning,
   - Facilities:
     - Telemetric automatic rainfall gauges,
     - Telemetric automatic river water level gauges,
     - MH data/information real-time monitoring device,
     - X band radar rainfall monitoring device,
     - Loudspeakers and Communication device, etc.
   - O&M: MH monitoring O&M by CPC/DPC, Expense burden of O&M: NCHHE DONRE, DPC.

2. River dike with rural road and flood protection facilities
   - Purpose: flood protection
   - Facilities
     - River dike with rural road,
     - Flood protection facilities such as gabion, concrete block masonry, etc.
   - O&M: O&M by CPC/DPC, Expense burden of O&M: DARD, DPC, CPC
3. Evacuation shelters in flooded area as necessary
   - Purpose: flood evacuation
   - Facilities
     - Evacuation shelters in flooded area
   - O&M: O&M by DPC, Expense burden of O&M: DARD, DPC
4. Private participation
   - Fertilizer, seed company
   - Software company to provide information to residents,
   - Private broadcasting company such as TV or radio company,
   - Website operating company and mobile phone company.
   - Dam Operation Company
   - Present private activities

   1) AGRIMEDIA Vietnam JSC

   Not only sell the facilities but also provide some services and solutions related to agriculture and disaster management. Their main products include:
   - Automatic Climate Station (ACS) can provide about 80 parameters: temperature, wind, soil moisture, air moisture, precipitation, solar, wind direction, etc. This station can monitor for a sub-region with about 20km radius. There are 60 own stations have been setup in Vietnam, in which, 8 stations are located in Dak Lak province (1 in city Buon Ma Thuot and 7 in Cư M'gar, Ea H'leo, Ea Súp, Krông Năng, Krông Pắk, Lắk, M'Đrắk districts),
   - Automatic Weather Station: include several ACSs and the management system to analyze data from ACS and National Center for Hydro-Meteorological Forecasting to forecast the sub-region weather and broadcast for flood early warning. The users have to pay about VND 5 million/month for the daily weather forecast.
   - This company also have a good solution for effective dam operation. Based on the management system (predict rainfall data, reservoir water level, income discharge, etc.), they can help the dam operation to make a decision (keeping or releasing water). Besides, based on the water reservoir availability, they can assess the water shortage in the region.

   2) Watec SJC Company manages VRAIN system including about 300 own automatic rainfall gauges. These rain gauges are installed in 22 districts and cites in Vietnam and in about 60 irrigation dams. The assess information could be provided through smart phone. The users can download and update real time the information of rainfall together with flood warning. The users have to pay about VND 3 million/month for using the service.

   3) VINARAIN automatic rainfall gauges: 10 own gauges was set up in Dak Nong in 2016, 10 own gauges are in Lao Cai province in 2017, 9 own rainfall gauges are in Thai Nguyen province in 2017. The users can update the rainfall information through a website by free of charge.

   4) Telecommunication companies such as Viettel and Vinaphone provide weather forecast service through message. People can get it by free of charge.

Source: JICA Study Team

Community-based Rural Livelihood Improvement in Flood-prone Area					**Province: Kon Tum**
District	Commune	Area (km^2)	Population	Households	Major Crops
Dak Ha	Dak La	50.131	9,000	1,900	Coffee, Rubber, Paddy and Cashew
	Dak Long	58.00	3,300	710	Coffee, Rubber, Paddy

I. Dak Ha District

Item	Dak La commune	Dak Long commune
Background	The Dak La suffers from flood as the commune is located in low land area (15% of paddy field is affected by flood every year). Deforestation has weakened the commune's resilience to natural disasters. Ethnic minorities share over half of the total population, among whom local ones such as Xa Dang and Ro Ngao, and Northern ones like Tay and Muong are living.	About 400 households in commune were flooded by the water-rise of the Dak Pxi River in 2009. There are three inflow hydraulic power plants (Dak Pxi No. 1, 2 and 5) in the commune's upstream area. In August 2017, the International University of Ho Chi Minh installed two telemeter water level gauges on the Dak Pxi River (Fig. 7). Information on river water level is reported wirelessly to DPC. But at this stage it is not utilized for residents' evacuation.
Specific issues	➢ **Site situation**: In the flood in 2009, all paddy fields (170 ha) and 200 households were flooded (no human injury) (Fig 1). Currently there is no early warning system in the commune but in Dak Long commune. There is no flood evacuation plan. ➢ **Result of interview with farmers**: Flood occurs every year due to limited capacity of drainage channel and culvert (Fig 2). ➢ **Possibility to apply technologies**: The steering committee comprised of CPC, army, public security and mass organizations develops the Natural Disaster Prevention Plan and evacuation drills are also done accordingly. ➢ **Introduce practices mentioned above**: The SCNDPC of commune shall be the main responsible organization for O&M of MH	➢ **Site situation**: In the upstream area of the commune, there are three hydraulic power plants (HPP). When the flood occurs due to HPP, there is not enough time for evacuation ➢ **Result of interview with farmers**: About 400 households were flooded in the commune by the Dak Pxi River in the flood in 2009. ➢ **Possibility to apply technologies**: SCNDPC comprised of CPC staff, police, army, mass organizations (such as Women's Union and Youth Union), has a "flood evacuation plan" and SCNDPC notifies flood warning, helps villagers to evacuate and work on the post-flood operation. ➢ **Introduce practices mentioned above**: The SCNDPC of commune will be the main responsible organization for O&M of MH.
Recommended Infrastructure and Activates	➢ Setting up an early warning system (automatic rainfall gauges and automatic river water level gauges) ➢ Construction of river dike with rural road and flood protection facilities ➢ Prepare the inundation map ➢ Channel lining ➢ Widening the old culvert (Fig 2) and lining the downstream canal in order to drain the larger discharge in rainy season.	➢ Install rain gauge to measure the inflow discharge from upstream of the reservoirs ➢ Setting up an early warning system ➢ Construction of river dike with rural road and flood protection facilities ➢ Local people authorize CPC to use their facilities for evacuation and rescue purpose

II. Photos

2.1 Dak La Commune

Fig 1. Flood-prone area in Dak La Commune. About 170ha of paddy field and 200HHs were inundated in the 2009 flood (no human death).

Fig 2. Old culvert in Dak La commune can not drainage flood discharge.

Fig 3. Water level of the Dak La Stream rose up to 5m high in the 2009 flood

 Fig 4. Downstream of Dak La Stream (no river dike) and flood prone area	 Fig 5. Downstream view of the Dak Trit Reservoir (upstream of the inundated area)	 Fig 6. Control gate of Dak Trit Reservoir (upstream of the inundated area)
2.2 Dak Long Commune		
 Fig 7. Dak Pxi river telemetric river water level gauge installed place (light bank)	 Fig 8. Telemetric river water level gauge installed by International University of Ho Chi Minh at Dak Pxi river in Aug. 2017.	 Fig 9. Destroyed bridge due to flooding

Source: JICA Study Team

Community-based Rural Livelihood Improvement in Flood-prone Area					**Province: Dak Lak**
District	Commune	Area (km^2)	Population	Household	Major Crops
Ea Sup	Ya To Mot	90.28	5,517	1,614	Sugarcane, Vegetables, Rubber

1. Ea Sup District

Item	Ya To Mot commune
Background	Ya To Mot Commune is weak in resilience to natural disasters. It dries up if sunny weather lasts for 5 to 6 days, and consecutive rainfalls for a couple of days causes floods (Fig 1). Of 15 hamlets, hamlet No. 4, 7, 8 and 12 suffer from floods at least 2 times/year. Flood are caused by rainfalls, reservoir water release and water from upstream. If it rains heavily, it takes only 2 hours to get flooded in the household living near stream (flood level 50-100cm). There is no flash flood. There are three evacuation places in the commune. There is no emergency drill implemented. When water is discharged from reservoir, announcement is supposed to be done 1 day in advance (DPC sends correspondence to CPC; CPC informs hamlet/local people via speaker/letter).
Specific issues	➢ **Site situation**: In flood 2013, the total 1,000 ha paddy was flooded. There is a real-time telemetric meteorological and hydrological monitoring system under IMC in Ea Sup District that was installed by MARD as a pilot project in 2010 (Fig 2, 3). ➢ **Result of interview with farmers**: In Ya To Mot Commune, floods occurring in 2011, 2012, and 2013 were among the severest. About 30% of the houses were damaged and about 30 animals were killed in the 2013 flood. The flood damage has become worse year by year, and the flood in 2016 is the maximum. ➢ **Possibility to apply technologies**: Commune SCNDPC comprised of CPC staff, police, army, mass organizations (such as Women's Union and Youth Union), has a "flood evacuation plan" and SCNDPC notifies flood warning, helps villagers to evacuate and work on the post-flood operation. ➢ **Introduce practices mentioned above**: The SCNDPC of commune will be the main responsible organization for O&M of meteorological / hydrological monitoring system.
Recommended Infrastructure and Activities	➢ Enhance the communication system from dam operation to SCNDPC province level to SCNDPC DPC level to SCNDPC in CPC level and to local people (example through message) ➢ Prepare the inundation map ➢ Construction of river dike with rural road and flood protection facilities ➢ Local people authorize CPC to use their facilities for evacuation and rescue purpose

2. Photos

Fig 1. Flood prone area of Dak Pet stream, Ya To Mot Commune, Ea Sup District

Fig 2. Real time telemetric meteo-hydrological monitoring system in IMC of Ea Sup District installed by MARD pilot project in 2010

Fig 3. Telemetric rainfall and reservoir water level monitoring and gate operating system at Ea Sup Thuong Reservoir in Ea Sup District

Source: JICA Study Team

Community-based Rural Livelihood Improvement in Flood-prone Area					**Province: Lam Dong**
District	Commune	Area (km^2)	Population	Households	Major Crops
Duc Trong	Ninh Gia	143.0	13,824	3,550	Coffee, Cassava, Vegetable, Rubber
Di Linh	Tam Bo	277.2	6,656	1,724	Coffee and Paddy

I. Duc Trong District	
Item	Ninh Gia commune
Background	There is a hydropower plant (Fig 1) and its dam (Dai Ninh) in the commune, from which massive amount of water is discharged. According to the GOVN's regulation on the procedure of water release, the hydropower plant informs CPC, and CPC announces local people via loudspeakers (Fig 2). Three of nine hamlets are affected by the water released which irrigates and cause flood to the coffee area. Paddy rice area is too far to be affected. There is no irrigation facility in the commune.
Specific issues	➢ **Site situation**: In Dec 2016, total crop area of 23.82ha was affected by flood of the Dai Ninh River (Fig. 3) ➢ **Result of interview with farmers**: About 900 m^3/s discharge was released from Dai Ninh hydropower dam in Dec 2016 flood. There was no human or household damage. There was only economic damage (mostly coffee). ➢ **Possibility to apply technologies**: Commune SCNDPC comprised of CPC staff, police, army, mass organizations (such as Women's Union and Youth Union), has a "flood evacuation plan" and SCNDPC notifies flood warning, helps villagers' evacuation and works on the post-flood operation. ➢ **Introduce practices mentioned above**: The SCNDPC of commune will be the main responsible organization for O&M of meteorological / hydrological monitoring system.
Recommended Infrastructure and Activities	➢ Establish more louder speakers ➢ Lining the downstream canal in order to drain the larger discharge in rainy season and restrict illegal cultivation in flood area. ➢ Increase dam flood control capacity in rainy season. ➢ Local people authorize CPC to use their facilities for evacuation and rescue purpose

II. Di Linh District	
Item	Tam Bo commune
Background	Tam Bo Commune has the biggest land area among all communes in Di Linh District, of which 70 % is the production forest (23,000 ha) managed by the State Forest Company Ltd. The 10 % of the total population live below poverty line and 41 % are ethnic minorities such as Co Ho and Ra Glai. People often suffer from flash floods in the commune. The steep slopes in its mountainous area make them happen abruptly and cause the crop damages severer. People living near the rivers and in the low land are often flooded above floor level and their houses are damaged.
Specific issues	➢ **Site situation**: In Dec 2016, 2 houses were affected by the flush flood occurred in the upstream of the Cau Xanh River in the area of upstream of national road bridge (Fig 4) ➢ **Result of interview with farmers**: The flood water level rose as high as 160cm from the floor level of their houses nearby the river (Fig 5). Approximately 3 tons of coffee and two houses were totally washed away. There are louder speakers (Fig 6) for warning but no planed evacuation place for the people. ➢ **Possibility to apply technologies**: Commune SCNDPC comprised of CPC staff, police, army, mass organizations (such as Women's Union and Youth Union), has a "flood evacuation plan" and SCNDPC notifies flood warning, helps villagers' evacuation and works on the post-flood operation. ➢ **Introduce practices mentioned above**: The SCNDPC of commune will be a main responsible organization for O&M of meteorological / hydrological monitoring system.
Recommended Infrastructure and Activities	➢ Setting up an early warning system (automatic rainfall gauges and automatic river water level gauges) ➢ Dredging river in the location near national road bridge to increase drainage capacity. ➢ Preparation of relocation plan and its execution. ➢ Construct louder speakers in the rural area. ➢ Construction of river dike with rural road and flood protection facilities ➢ Local people authorize CPC to use their facilities for evacuation and rescue purpose

III. Photos

3.1 Ninh Gia commune

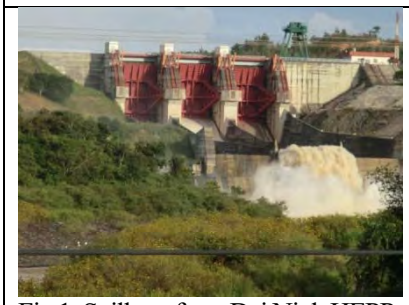


Fig 1. Spill out from Dai Ninh HEPP dam, (10th Nov. 2017, Q=350m^3/s)

Fig 2. Bulletin board of release warning siren from Dai Ninh Dam

Fig 3. Flood damaged area of Dai Ninh River, Ninh Gia Commune, Duc Trong District

3.2 Tam Bo commune

Fig 4. The naional road bridge in the upstream of the Cau Xanh River

Fig 5. A victim who shows the flood water level at his house in Dec 2016 (approximately 160cm-high)

Fig 6. Loudspeaker used for flood warning

Source: JICA Study Team

AT 5.2.4 Community-based Monitoring for Effective Utilization of Local Water Resources

Sector	**Water Resources**		
Countermeasure	Community-based Monitoring for Effective Utilization of Local Water Resources		
Target / Area	Drought-prone areas in the Central Highland provinces		
Implementation Agency	• Province People Committee, • District People Committee, • DONRE, • National Center for Hydro-Meteorological Forecasting (HMF) under MONRE	Agencies Concerned	• Private dam/reservoir operators, • Rural community groups, etc.

Background

- The Central Highlands provinces suffer from chronic water shortage due to urbanization, rapid population increase, and exploitation of available water resources.
- Water demand has been increased in all sectors: agriculture, domestic, industrial uses, etc.
- The irrigation water shares more than 80% of total demand. The amount of water demand for agriculture is not controlled and efforts for reduction is not effectively done yet.
- There is no effective control in groundwater use, which has resulted in the decline of groundwater level, dry-up in the events of droughts, and crop damages. Unplanned overuse of groundwater has resulted in severe water shortage in peak dry season.
- Majority of farmers are faced with constraints in knowledge on water requirement, technical skills for effective crop production, especially perennial crops.
- Collection of meteorological / hydrological (MH) data and information, observation of groundwater level (GWL), and records on dam/reservoir operation are insufficient, which does not allow proper assessment and effective management of water resources.
- There has been no water resource monitoring activities that enables to figure out water availability and estimate water shortage in the catchment area.

Narrative Summary

Overall Goal Damages by drought to the rural livelihood are mitigated Purpose 1. Mechanism of MH data monitoring, GWL observation and dam/reservoir operation are functional. 2. Weather and GWL forecast system for drought is operated.	Outputs 1. Water resources are well monitored and assessed locally for valid water resources utilization. 2. Drought forecasts and analyses are conducted, and the results are shared with districts, communes and villager for reduction of drought damages. 3. Capacity of district and commune staff is enhanced. 4. Private participation in early warning system for droughts is established.

Activities

1-1. Assess the existing MH, GW and locally monitored information on water resources
1-2. Assess water balance and share the results with district, communes, WUGs and farmers to promote effective irrigation water use.
1-3. Prepare the guidelines and systems for water resources monitoring and assessment activities (sub-basin and community levels)
1-4. Develop a system for MH and GW monitoring activities at community level and linkage with wider area water resources assessment information and water balance assessment.
2-1. Drought forecast and analysis (NCHMF and DONRE) and share the results with districts, communes, farmer groups (FGs) and villagers.
2-2. Develop early warning system for droughts.
2-3. Prepare guidelines for introducing O&M of monitoring systems
2-4. Introduce tools and sources for communication and sharing information.
3-1. Prepare and implement training program for establishing monitoring and assessment systems (O&M of MH, GWL and dam/reservoir operation) from district level to local communities in drought-affected area.
4-1. Promote business matching activities between private firms and districts/FGs
4-2. Enhance collaboration between villagers and private sectors, and encourage private investments for introducing MH and GWL monitoring systems

Recommended Infrastructure, Facilities and Private Participation

1. Telemetric real-time automatic MH and GWL monitoring systems
   - Purpose: Early warning for GW exploitation and monitoring of ground water balance
   - Facilities:
     - Telemetric automatic climate gauging stations
     - Telemetric automatic GWL gauges
     - MH data/information real-time monitoring system
     - Communication equipment, etc.
   - O&M: MH and GWL monitoring O&M by CPC/DPC
   - Expense burden of O&M: NCHHE DONRE, DPC, Private Sector
2. Private participations:
   - Hydropower operated companies, Fertilizer or Seed company
   - Software company planning to provide information to residents
   - Private broadcasting company such as TV or radio company
   - Website operating company and mobile company
   - Present private activities
     1. AGRIMEDIA Vietnam JSC (Refer AT 5.3.3)
     2. Nestle Vietnam company (NVC) invest the fund of USD 2 million in some projects to help coffee famers through reduction of the effect of drought damage. NVC define the water shortage area, create weather forecasting system and also train the farmer how to effectively irrigate coffee. As the results, the water demand for coffee reduce significantly about 30%, but the productivity is still warranted. They also provide new coffee seed that could improve the productivity. And finally NVC guides the famer to follow the GAP (Good agriculture practice) to ensure the clean product.

Source: JICA Study Team

Community-based Monitoring for Effective Utilization of Local Water Resources					**Province: Kon Tum**
District	Commune	Area (km^2)	Population	Households	Major Crops
Dak Ha	Dak La	50.16	9,000	1,900	Coffee, Rubber, Paddy and Cashew

I. Dak Ha District

Item	Dak La commune
Background	The Dak La Commune suffers from not only floods but droughts due to the facts that streams often become dried up and the commune is located at the end of the canal system. Deforestation has weakened the commune's resilience to natural disasters and made it difficult to recharge sufficient groundwater. Approximately 100 ha of paddy rice cannot be irrigated during the dry season mainly due to the inappropriate layout and design of irrigation facilities.
Specific issues	➢ **Site situation**: Currently irrigation is possible only once a year for paddy due to water shortage by deforestation. Groundwater is used for domestic water only (Fig 1). People has no water treatment method when using for domestic purpose. They use surface water for coffee production and paddy cultivation but it is not enough in dry season. People use small artificial private pond to save water in rainy season (Fig 2). ➢ **Result of interview with farmers**: Every year, the shallow wells are dried up. There are three deep wells (Fig 3) for water supply, but the GWL keeps descending every year. Moreover, the domestic water supply system (Fig 4) can only provide to a limited part of commune. Village No. 10 which is settled by ethnic minority people in a higher altitude. Thus, there is no ground water in dry season (Fig. 5). Even the water system was available in this village, the ethnic people also has no money for using it. There is no MH and GWL observation station in the district. There are 5 reservoirs for irrigation purpose in commune and Dak Trit reservoir with capacity of about 3 MCM is the biggest (Fig 6). ➢ **Possibility to apply technologies**: CPC and DPC are aware of the necessity of meteorological / hydrological (MH) and groundwater level (GWL) observation and willing to cooperate. ➢ **Introduce practices mentioned above**: The CPC and farmers groups or WUGs in the commune will be the main responsible organizations for O&M of MH and GWL monitoring system.
Recommended Infrastructure and Activities	➢ Setup the telemetric automatic GWL gauges and GW potential map ➢ Extend the tap water system to the local area where ethnic minority settle. Reduce water tariff ➢ Install MH monitoring system in order to estimate the water potential in the area ➢ Establish ground water exploitation regulation

Photos

Fig 1. Shallow well using for domestic purpose. It dries up every year in dry season

Fig 2. Artificial small pond for saving water in rainy season

Fig 3. Deep well No 2 for water supply system in Dak La commune

Fig 4. Dak La Commune domestic water supply system, constructed in 2012 by the Province, use 3 deep wells (70~100 m depth, D=63~90 mm). Water tariff=4,000 VND/m^3.

Fig 5. Around 100 HHs of the Village No.10, where domestic water cannot be supplied by the shallow wells (Depth=10 m, D=90 cm) that dries up in dry season every year

Fig 6. Dak Trit Reservoir (earth fill dam, dam crest width=220 m, H=30 m, 3 spill way gates) constructed in 2008 by Dak Ha District

Community-based Monitoring for Effective Utilization of Local Water Resources					**Province: Gia Lai**
District	Commune	Area (km^2)	Population	Households	Major Crops
Chu Puh	Ia Blu	191.145	7,786	1,744	Coffee, Pepper and Paddy
	Ia Phang	126.604	12,102	2,285	Pepper, Coffee, Rubber and Paddy

II. Chu Puh District

Item	Ia Blu commune	Ia Phang commune
Background	The groundwater level in the commune is low as a result of uncontrolled use of water from deep wells for along years. They lack domestic water supply. There is an irrigation system Ia Hlop under the management of Chu Se IMC. It is supposed to provide water for 200 ha of paddy field, but it actually provides for only 50 ha in wet season due to its deterioration. O&M activities of the irrigation system are made twice a year due to lack of budget. The rest area uses rain water and stream water.	There are eight (8) in among 12 villages in Ia Phang commune are habituated by ethnic minorities. Groundwater is used for perennial crops production. 65% of water for perennial crop is from wells (mostly shallow wells with 10 to 30 m depth. But shallow wells cannot provide sufficient water in dry season). The rest (35%) of water for perennial crop is from nature (stream, etc). Domestic water is also taken from wells (shallow and deep wells).
Specific issues	➢ **Site situation**: There is no reservoir in this commune. GWL has descended by about 10 m over the past 10 years. Main perennial crops (coffee and pepper) are irrigated by groundwater. ➢ **Result of interview with farmers**: Tap water is limited, thus people has to use GW for domestic use. There is a deep well constructed by DPC for ethnic minority (Fig 1). However it was broken in 2017. Some households use saving water irrigation system (Fig 2). During the drought in 2015/16, many shallow wells (about 30 m depth) and many deep wells (about 100~120 m depth) were dried up (Fig 3). There is no MH and GWL observation station in this district. ➢ **Possibility to apply technologies**: CPC and DPC are aware of the necessity of MH and GWL observation and willing to cooperate. ➢ **Introduce practices mentioned above**: The CPC and farmers group of the Commune will be the main responsible organizations for O&M of MH and GWL monitoring system.	➢ **Site situation**: CPC supports VND 5 million/well subsidies for cost of drilling deep well. There are 8 weirs and 9.83 km of irrigation canal. Most families have either deep or shallow wells. GWL of wells is descending. There are two deep wells (Depth = 100 ~ 120 m, D = 200 mm) supplying domestic water to 3 villages (285HHs) from 2011 (by NGO). There is a plan to develop a new reservoir (about 2 MCM). Water availability at the shallow wells is scarce in dry season. Although there is a regulation to restrict groundwater use, farmers do not stop using them. There is Ia Ke irrigation weir (Fig 3) supplying for 25 ha paddy. In 2015/16 drought, it was mostly dried up. ➢ **Result of interview with farmers**: In the 1980s, GWL ranged between 25-40 m depth. Recently, it declined to about 100 m depth, due to deforestation, steep slope, no reservoir, less precipitation and increase in groundwater use (Fig 5, 6). Drought damage in 2015/16 was the most significant. Approximately 30% of pepper production area dried up. There is no MH and GWL observation station in the district. ➢ **Possibility to apply technologies**: CPC and DPC are aware of the necessity of MH and GWL observation and are willing to cooperate. ➢ **Introduce practices mentioned above**: The CPC and farmers group of the Commune will be the main responsible organizations for O&M of MH and GWL monitoring system.
Recommended Infrastructure and Activities	➢ Setup the telemetric automatic MH and GWL gauges ➢ Prepare the ground water potential map ➢ Promote saving water irrigation. ➢ Establish ground water exploitation regulation	➢ Setup telemetric MH and GWL gauges ➢ Prepare the ground water potential map ➢ Establish ground water exploitation regulation ➢ Training WUGs to efficiently operate irrigation system to reduce water loss.

Photos

1. Ia Blu Commune

Fig 1. Old domestic water supply for Ia Blu Commune using a deep well (Depth=80 m, D=145 mm) was built by DPC in 1992. The strainer of the well is clogged in 2017 and it no longer can be used.

Fig 2. Irrigate pepper fields with sprinkler using GW

Fig 3. Deep well (Depth=82 m, D=95 mm) for pepper field irrigation.

2. Ia Phang Commune

Fig 4. Ia Ke irrigation weir (W=20 m, H=2.65 m, Q=about 1.0 m^3/s) supply water for 25 ha of paddy field constructed by DPC in 2007. In the 2015/16 drought, the river water was mostly dried up. There is no regulation and operation record.

Fig 5. Dried up deep well (D=150 mm). In 2004 it was drilled by 95 m depth but water did not come out.

Fig 6. Dried up shallow well (36 m depth)

Source: JICA Study Team

Community-based Monitoring for Effective Utilization of Local Water Resources					**Province: Dak Lak**
District	Commune	Area (km^2)	Population	Households	Major Crops
Ea Sup	Yo To Mot	90.18	5,517	1,614	Sugarcane, Vegetable and Rubber

I. Ea Sup District

Item	Ya To Mot commune
Background	Ya To Mot Commune is weak in resilience to natural disasters. It dries up if sunny weather lasts for 5 to 6 days, and consecutive rainfalls for a couple of days causes floods (Fig 1). People from northern part of the country migrated in 1990s to the places without basic infrastructure. There is no reservoir/pond for irrigation in this commune. People mostly used surface water that is released from upstream reservoir Ea Sup Thuong/Ha for irrigation (Fig 2).
Specific issues	➢ **Site situation**: There is the real-time telemetric meteorological and hydrological (MH) monitoring system (2 reservoirs and 4 rainfall gauges) under IMC in Ea Sup District that was installed by MARD as a pilot project in 2010 (Fig 3, 4). However, there is no weather forecasting system at present. ➢ **Result of interview with farmers**: At the time of drought in 2015/16, about 3,000 cattle and 1/3 irrigation areas were damaged in the District. About 1,000 ha of crop area was damaged by the flood in 2012/13. In every dry season, the shallow wells were dried up. There is no linkage between famers in downstream area and dam operator for irrigation purpose. About 10% deep wells were dried up in the dry season. In Ya To Mot Commune, floods were occurred in 2011, 2012, 2013 and 2016. The flood damage has become worse year by year, and the flood in 2016 is the maximum. The food warning facility is old and not effective for flood early warning (Fig 5). There are some louder speakers, but its number is limited and some of them could not work properly (Fig 6). ➢ **Possibility to apply technologies**: CPC and DPC are aware of the necessity of MH and GWL observation and willing to cooperate. ➢ **Introduce practices mentioned above**: The IMC, CPC and farmers groups of the Commune will be a main responsible organization for O&M of MH and GWL monitoring system.
Recommended Infrastructure and Activities	➢ Install more MH data/information real-time monitoring system ➢ Improve number and quality of communication equipment ➢ Improve the dam operation in order to guarantee the benefit of the famer ➢ Set up telemetric automatic GWL gauges

Photos

Fig 1. Flood prone are in rainy season and also drought prone in dry season

Fig 2. Downstream channel of Ea Sup Thuong Reservoir goes through Ya To Mot commune

Fig 3. Real time telemetric meteo-hydrological monitoring system

Fig 4. Telemetric rainfall and reservoir water level monitoring.

Fig 5. Water level gauge

Fig 6. Loudspeaker notifying flood warning

Source: JICA Study Team

Community-based Monitoring for Effective Utilization of Local Water Resources					**Province: Dak Nong**
District	Commune	Area (km^2)	Population	Households	Major Crops
Krong No	Nam Nung	104.82	6,900	1,600	Coffee, Pepper, Rubber and Fruit
	Tan Thanh	88.07	3,420	819	Coffee, Pepper, Maize and Cassava

I. Krong No

Item	Nam Nung commune	Tan Thanh commune
Background	CPC provides warning to farmers at the beginning of dry season based on the results of Agriculture Division's analysis and IMC's water assessment, and farmers store water (in lake, pond, etc.) accordingly. If the water source is not sufficient, CPC asks farmers to transfer paddy rice to maize (requiring less water). IMC also has a plan of releasing water so that farmers know which day they can take water. Some farmers try applying drip irrigation in coffee field but majority of them could not install the system due to its high costs (around VND 100 mil/ha). Famers also need to maintain the system frequently and to be careful in case the facilities are stolen. The commune has 2 projects: IFAD project and VnSAT (Vietnam Sustainable Agriculture Transformation) project under MARD in 2018. IFAD project technical transfer in coffee plantation and also introduce water saving model in coffee production. VnSAT start in 2018 will support coffee production through investment in clean coffee model, infrastructure and equipment.	Total agriculture land area is 7,583 ha. Annual crop area is 577 ha (paddy rice: 30 ha), and perennial crop area is 5,756 ha (coffee, pepper and fruit). Production value is VND 68 million/ ha on average. There is one reservoir Dak Ri providing water for 300 ha of coffee. It is managed by an Operation Group (DPC assign CPC, and the CPC assign hamlet). No support is provided to this group, but they can raise fish for their individual use (not for selling). Farmers around reservoir use pump to take water without any charge. There are 4 main streams without canal system. There is no flood damage in the commune, but mainly droughts.
Specific issues	➢ **Site situation**: Climate change and deforestation have caused water shortages in the district. Agricultural land area was approximately 3,000 ha in 1987, which has now expanded to 43,000 ha. During the drought in 2015/16, 5 reservoirs out of 12 reservoirs were dried up. The length of irrigation channel is still limited and some parts were broken. ➢ **Result of interview with farmers**: There are two reservoirs (Dak Mhang reservoir 0.657 MCM (Fig 1) and RCap reservoir 0.396 MCM) and 2 irrigation systems in the Commune (Fig 2). They were dried up in 2015/16 drought. There is no MH and GWL observation station in the district. People also used GW for irrigation through shallow and deep wells. However, it is not enough water, especially in dry season (Fig 3) ➢ **Possibility to apply technologies**: CPC and DPC are aware of the necessity of MH and GWL	➢ **Site situation**: There is one reservoir (Dak Ri Reservoir, operation by farmers, irrigation area of 30 ha) (Fig 4) in the commune. There is no irrigation canal system. In the 2014/15 drought, 74.2 ha was damaged affecting 50 households. In the drought of 2015/16, 814.25 ha of farmland was damaged affecting 1,235 households. Compensation about VND 1.7 billion to the all affected people. The 2015/16 drought damaged 100 ha of coffee, and the productivity of coffee is still low in 2017. There are four (4) water supply systems, of which three (3) are broken due to the pump damage and cannot supply water. The 30 households living near the commune center use tap water from the remaining domestic water supply system, but the rest of households use deep well for domestic demand. ➢ **Result of interview with farmers**: For crops such as pepper and coffee, surface water is only enough to irrigate 3 times (periods) per year. For the last irrigation time (period) famers must be used groundwater. Approximately 70% of families have own deep wells. There are about 200 shallow wells (Fig 5). These wells were mostly dried up in dry season. Some of them have enough water only for domestic use. Last time, the domestic water was

	observation and willing to cooperate. ➢ **Introduce practices mentioned above**: The IMC, CPC and farmers group of the Commune will be the main responsible organizations for O&M of MH and GWL monitoring system.	from deep well with 50 m depth, however these day, in some cases, the 100 m depth still cannot reach ground water. ➢ **Possibility to apply technologies**: CPC and DPC are aware of the necessity of MH and GWL observation and willing to cooperate. ➢ **Introduce practices mentioned above**: The IMC, CPC and farmers group of the Commune will be the main responsible organizations for O&M of MH and GWL monitoring system.
Recommended Infrastructure and Activities	➢ Prepare the GW potential map. ➢ Install the telemetric automatic GWL gauges ➢ Install the telemetric automatic climate gauging stations	➢ Setup telemetric automatic GWL gauges ➢ Prepare GW potential map ➢ Establish regulation of exploitation of groundwater ➢ Support famer (financial and technical) to increase the number of household applying irrigation water saving ➢ Setup MH real-time monitoring system.

Photos

1. Nam Nung Commune

Fig 1. Dak Mhang reservoir (earth fill dam, capacity=0.657 MCM) operated by IMC and constructed in 1984. In 2015/16 drought, this reservoir was dried up.

Fig 2. Irrigation canal from Dak Mhang reservoir (Q=0.37 m^3/s) operated by IMC.

Fig 3. Deep well for irrigation of coffee and pepper (Depth=80 m, D=90 mm).

2. Tân Thanh Commune

Fig 4. Dak Ri Reservoir (erthfill dam, capacity=0.375MCM, dam crest length=88 m) constructed by DPC and operation by farmers. In the 2015/16 drought, the reservoir was mostly dried up.

Fig 5. This shallow well (Depth=22m, D=85cm) dried up in the 2015/16 drought.

Fig 6. Deep well for domestic water (Depth=90 m, D=100 smm). It took 2 months to recover the GWL after the drought in 2015/16.

Source: JICA Study Team

Community-based Monitoring for Effective Utilization of Local Water Resources					**Province: Lam Dong**
District	Commune	Area (km^2)	Population	Households	Major Crops
Duc Trong	Ninh Gia	143.0	13,824	3,550	Coffee, Cassava, Vegetable, Rubber
Di Linh	Tam Bo	277.2	6,656	1,724	Coffee, Maize/Vegetable and Paddy

III. Duc Trong District

Item	Ninh Gia commune
Background	There is a hydropower plant Dai Ninh (Fig 1) in the Commune, from which massive amount of water is discharged. Three of nine hamlets are affected by the water released to cause flood to the coffee area. Before releasing water, hydropower plant informs CPC, and CPC announces local people via loudspeakers (Fig 2). There is no irrigation facility in the commune. The 97 % of area is irrigated by surface water. The people mostly use water released from the reservoir. They used private pump to take water from Dai Ninh river
Specific issues	➢ **Site situation**: The severest flood damage was in Dec 2016. The damaged crop area (mostly coffee) was 23.82 ha that locate near the downstream of Dai Ninh reservoir (Fig. 3). ➢ **Result of interview with farmers**: The flood occurs every year in rainy season. There was no human or household damage. There was only economic damage (harvested coffee and pump) ➢ **Possibility to apply technologies**: Steering Committee for Natural Disaster Prevention and Control (SCNDPC) including CPC staff, police, army, mass organizations such as Women's Union and Youth Union, has a "flood evacuation plan" and SCNDPC notifies flood warning, helps villagers' evacuation and works on the post-flood operation. ➢ **Introduce practices mentioned above**: The SCNDPC of commune will be the main responsible organization for O&M of meteorological / hydrological (MH) monitoring system.
Recommended Infrastructure and Activities	➢ Establish MH monitoring system. ➢ Lining the downstream channel in order to drain the larger discharge in rainy season and restrict illegal cultivation in flood area. ➢ Install the telemetric automatic GWL gauges ➢ Improve the dam operation in order to guarantee the benefit of the famer.

IV.Di Linh District

Item	Tam Bo commune
Background	Tam Bo Commune has the biggest land area among all communes in Di Linh District, of which 70 % is the production forest (23,000 ha) managed by the State Forest Company Ltd. The 10 % of the total population live below poverty line and 41 % are ethnic minorities such as Co Ho and Ra Glai. In rainy season people living near the rivers and in the low land are often flooded above floor level and their houses are damaged. On the other hand, in the dry season this commune has to face with drought problem. There is not enough water for irrigation and even domestic use.
Specific issues	➢ **Site situation**: In Dec 2016, 4 houses were affected by the flush flood occurring in the upstream of the Cau Xanh River in the area of upstream of national road bridge (Fig 4). There is no reservoir for irrigation purpose in Tam Bo commune. They plan to make 2 reservoirs, but the possibility is very low due to limited budget. The severest drought in this decade occurred in 2014/15. The total damage was around VND 17 billion (mostly vegetable, coffee and pepper). GW quality is very low due to the high arsenic. There is a water supply plant (funded by French NGO), however the water source is not adequate and the location is far from residential area. ➢ **Result of interview with farmers**: There is a shallow well (4 m in depth and diameter 1160 mm) constructed in 1986. It is dried up every year in dry season (Fig 5). There is also a deep well (110 m in depth) (Fig 6, 7), but there is no water. Local people often use artificial pond to store water and use in dry season. However, due to big effect of drought in 2014/15 they have to make deep well for irrigation (Fig 8). Every year, from Nov to Dec when water sources is very scare, people bring cans to take water from the stream in mountain for domestic use. They also made rain water storage system to store the rain water in rainy season (Fig 9). ➢ **Possibility to apply technologies**: Commune Steering Committee for Natural Disaster Prevention and Control (SCNDPC) comprised of CPC staff, police, army, mass organizations (such as Women's Union and Youth Union), has a "flood evacuation plan" and SCNDPC notifies flood warning, helps villagers to evacuate and work on the post-flood operation. ➢ **Introduce practices mentioned above**: The SCNDPC of commune will be the main responsible organizations for O&M of meteorological / hydrological monitoring system.

Recommended Infrastructure and Activities	➢ Set up MH monitoring system ➢ Set up GWL monitoring system ➢ Prepare GW potential map ➢ Help people (technical and financial) to increase the number of household using rain water storage system.

Photos

1. Ninh Gia commune

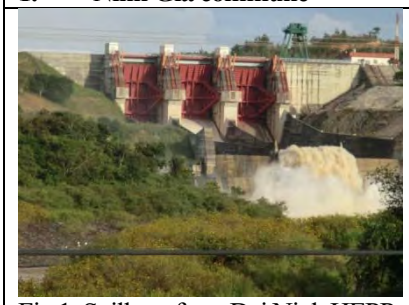


Fig 1. Spill out from Dai Ninh HEPP dam, (10th Nov. 2017, Q=350m^3/s)

Fig 2. Bulletin board of release warning siren from Dai Ninh Dam

Fig 3. Flood damaged area of Dai Ninh River, Ninh Gia Commune, Duc Trong District

2. Tam Bo commune

Fig 4. National road bridge near the flood prone area.

Fig 5 A shallow well was constructed in 1986. It is always dried up in dry season.

Fig 6. A deep well at 110 m in depth that was dried up.

Fig 7. Sample of borehole

Fig 8. Deep well for irrigation (coffee and pepper).

Fig 9. Rain water storage system in domestic house

Source: JICA Study Team

AT 5.2.5 Annual Maximum Daily Rainfall in Central Highlands

Name of Station		Kon Tum		An Khe		Krong Bong		Dak Mil		Da Lat	
Province		Kon Tum		Gia Lai		Dak Lak		Dak Nong		Lam Dong	
No.	Year	Annual Rainfall (mm/yr)	Return Period (Year)	Annual Rainfall (mm/yr)	Return Period (Year)	Annual Rainfall (mm/yr)	Return Period (Year)	Annual Rainfall (mm/yr)	Return Period (Year)	Annual Rainfall (mm/yr)	Return Period (Year)
1	1977	66.6	1.10	109.2	1.63						
2	1978	55.6	1.01	134.1	2.16			68.3	1.10		
3	1979	155.0	26.00	133.2	2.05			69.4	1.13	101.4	10.86
4	1980	113.6	2.69	169.6	3.48	88.0	1.51			80.1	3.04
5	1981	83.3	1.28	113.1	1.70	151.5	5.23	81.2	1.49	60.0	1.07
6	1982	110.8	2.52	46.4	1.01	95.4	1.74	101.0	4.00	67.9	1.29
7	1983	136.5	5.20	78.3	1.10	106.6	2.19	101.0	4.00	72.5	1.69
8	1984	106.0	1.90	118.7	1.78	97.9	1.84	128.0	10.86	74.1	1.77
9	1985	81.6	1.24	159.9	2.96	190.0	6.18	93.3	2.30	77.8	2.30
10	1986	139.4	6.00	172.4	3.81	148.3	4.00	73.3	1.25	86.5	4.00
11	1987	65.4	1.07	240.8	26.67	76.5	1.08	63.8	1.04	68.2	1.33
12	1988	108.6	2.23	128.0	1.95			83.6	1.55	89.0	4.47
13	1989	128.6	4.59	97.5	1.40	82.6	1.24	83.7	1.62	74.3	1.85
14	1990	94.6	1.59	214.2	11.43	148.9	4.53	91.0	2.05	71.3	1.55
15	1991	55.9	1.04	80.1	1.13			74.8	1.29	97.7	8.44
16	1992	85.1	1.32	178.4	4.21	190.6	7.56	95.8	2.62	92.8	5.07
17	1993	72.0	1.16	187.4	5.33	281.1	22.67	113.1	6.91	76.7	2.17
18	1994	139.8	7.09	136.0	2.29	80.6	1.15	91.7	2.17	78.8	2.62
19	1995	91.2	1.53	100.2	1.45	114.2	2.52	85.2	1.85	66.9	1.21
20	1996	141.0	8.67	151.4	2.58	90.2	1.58	104.5	4.47	61.4	1.10
21	1997	71.9	1.13	94.4	1.36	109.4	2.34	96.6	3.04	112.0	25.33
22	1998	73.7	1.20	187.7	6.15	228.9	13.60	99.5	3.30	59.6	1.04
23	1999	109.4	2.36	108.2	1.57	142.0	3.24	96.0	2.81	76.0	1.95
24	2000	114.4	2.89	86.0	1.23	213.6	9.71	112.7	5.07	113.9	76.00
25	2001	88.1	1.47	84.2	1.19	138.9	2.96	135.2	25.33	72.5	1.69
26	2002	87.2	1.42	89.4	1.31	83.6	1.28	76.4	1.33	64.6	1.17
27	2003	95.7	1.66	105.1	1.51	121.5	2.72	137.9	76.00	95.0	6.91
28	2004	107.8	2.00	57.2	1.04	86.4	1.39	62.8	1.01	67.9	1.29
29	2005	108.4	2.11	193.9	7.27	95.2	1.66	70.9	1.17	93.2	5.85
30	2006	96.8	1.81	87.5	1.27	85.4	1.33	72.9	1.21	59.0	1.01
31	2007	119.6	3.71	157.7	2.76	147.0	3.58	84.2	1.69	77.9	2.45
32	2008	119.6	3.71	137.7	2.42	104.4	2.06	66.2	1.07	76.4	2.05
33	2009	152.4	15.60	187.3	4.71	71.5	1.01	80.2	1.43	63.3	1.13
34	2010	96.5	1.73	162.0	3.20			88.0	1.95	81.0	3.30
35	2011	157.9	78.00	65.5	1.07	87.9	1.45	84.3	1.77	68.7	1.43
36	2012	115.7	3.12	225.7	16.00	104.0	1.94	118.2	8.44	68.3	1.38
37	2013	144.8	11.14	258.2	80.00	74.6	1.05	94.6	2.45	86.2	3.62
38	2014			119.9	1.86	81.3	1.19	133.9	15.20	79.1	2.81
39	2015	85.5	1.37	83.3	1.16	77.0	1.11	113.0	5.85	70.4	1.49
40	2016	124.7	4.11	212.6	8.89	291.5	68.00	78.4	1.38	102.5	15.20
Max.		157.9		258.2		291.5		137.9		113.9	
Average		105.1		136.3		126.1		92.2		78.6	
Min.		55.6		46.4		71.5		62.8		59.0	

Hazen Plot : P=(2i-1)/(2n) ; P: Non-Excess Probability, i: Rank, n: Number of data.

Return Period = 1/(1-P)

Source: JICA Study Team, based on rainfall data by MONRE

AT 5.2.6 Damaged Crop Area by Drought in Central Highlands (2010-2016)

(Unit: ha)

CODE	Province	District	2010	2011	2012	2013	2014	2015	2016
3901	Kon Tum	Kon Tum city		758					1,233
3902	Kon Tum	Dak Glei		99				54	284
3903	Kon Tum	Ngoc Hoi		280				94	804
3904	Kon Tum	Dak To		211					762
3905	Kon Tum	Kon Plong	274						
3906	Kon Tum	Kon Ray	21	168				13	161
3907	Kon Tum	Dak Ha		720				90	290
3908	Kon Tum	Sa Thay	2,382	256					483
3909	Kon Tum	Tu Mo Rong		10				3	38
3910	Kon Tum	Ia H'Drai							66
4001	Gia Lai	Pleiku		1,758					880
4002	Gia Lai	An Khe							562
4003	Gia Lai	Ayun Pa		39					253
4004	Gia Lai	KBang		30					661
4005	Gia Lai	Dak Doa		700					809
4006	Gia Lai	Chu Pah		2,700					1,697
4007	Gia Lai	Ia Grai		1,202					1,925
4008	Gia Lai	Mang Yang		179					590
4009	Gia Lai	Kong Chro							2,724
4010	Gia Lai	Duc Co		2,732					1,446
4011	Gia Lai	Chu Prong		3,013					4,361
4012	Gia Lai	Chu Se		2,960					4,703
4013	Gia Lai	Dak Po							1,289
4014	Gia Lai	Ia Pa		109					3,322
4015	Gia Lai	Krong Pa							948
4016	Gia Lai	Phu Thien							1,044
4017	Gia Lai	Chu PuH		1,987					3,343
4101	Dak Lak	Buon Ma Thuot				567		46	307
4102	Dak Lak	Ea H'leo	1,732	4,430		1,304		1,741	1,146
4103	Dak Lak	Ea Sup	6	50		320	85	14,768	11,411
4104	Dak Lak	Krong Nang	358	1,629	1,984	7,699		13,178	7,357
4105	Dak Lak	Krong Buk	1,882	3,717		5,044	4,030	9,944	10,760
4106	Dak Lak	Buon Don	115	315		647	17	4,155	6,400
4107	Dak Lak	Cu M'gar		276	50	4,790	25	10,267	16,972
4108	Dak Lak	Ea Kar	2,589		7,136	3,531	600	7,102	4,360
4109	Dak Lak	M'Drak	483		5,688	235	1,257	5,917	3,700
4110	Dak Lak	Krong Pak	147	143	7,542	3,634	336	1,861	3,999
4111	Dak Lak	Krong Bong	1,262	1,113	9,232	908	645	691	632
4112	Dak Lak	Krong Ana	137	1,075		2,879	1,577	4,365	7,497
4113	Dak Lak	Lak	394	559	51	1,751	1,035	1,147	2,209
4114	Dak Lak	Cu Kuin	27	20		756	444	2,651	1,252
4115	Dak Lak	Buon Ho	748	46	1,784	3,078	93	5,718	8,560
4201	Dak Nong	Gia Nghia							923
4202	Dak Nong	Dak Glong							3,289
4203	Dak Nong	Cu Jut							1,337
4204	Dak Nong	Dak Mil							2,425
4205	Dak Nong	Krong No							6,374
4206	Dak Nong	Dak Song							1,816
4207	Dak Nong	Dak R'Lap							2,238
4208	Dak Nong	Tuy Duc							123
4301	Lam Dong	Da Lat							905
4302	Lam Dong	Bao Loc							1,732
4303	Lam Dong	Dam Rong							652
4304	Lam Dong	Lac Duong							
4305	Lam Dong	Lam Ha							5
4306	Lam Dong	Don Duong							107
4307	Lam Dong	Duc Trong							4,108
4308	Lam Dong	Di Linh							13,074
4309	Lam Dong	Bao Lam							9,664
4310	Lam Dong	Da Huoai							355
4311	Lam Dong	Da Teh							848
4312	Lam Dong	Cat Tien							754

Source: Statistical Book of Provinces

AT 5.2.7 Damaged Crop Area by Flood in Central Highlands in 2010-2016

(Unit: ha)

CODE	Province	District	2010	2011	2012	2013	2014	2015	2016
3901	Kon Tum	Kon Tum city	28.5	132.7	8.5	216.7	27.5	2.0	0.0
3902	Kon Tum	Dak Glei	0.0	51.0	0.0	4.0	2.4	2.0	0.0
3903	Kon Tum	Ngoc Hoi	0.0	153.0	0.0	161.2	1.6	212.7	0.0
3904	Kon Tum	Dak To	0.0	101.9	0.0	147.1	29.8	19.6	0.0
3905	Kon Tum	Kon Plong	55.0	145.0	77.4	573.7	0.0	0.0	0.0
3906	Kon Tum	Kon Ray	0.0	72.4	14.9	68.5	10.8	0.0	0.0
3907	Kon Tum	Dak Ha	0.0	176.2	132.2	413.1	121.9	0.0	0.0
3908	Kon Tum	Sa Thay	51.3	335.8	0.0	624.7	3.8	0.0	0.0
3909	Kon Tum	Tu Mo Rong	0.0	0.0	0.3	31.2	0.0	0.0	0.0
3910	Kon Tum	Ia H'Drai	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4001	Gia Lai	Pleiku	0.0	99.7	0.0	0.0	0.0	0.0	0.0
4002	Gia Lai	An Khe	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4003	Gia Lai	Ayun Pa	0.0	21.6	0.0	0.0	0.0	0.0	0.0
4004	Gia Lai	KBang	465.0	42.9	0.0	0.0	0.0	0.0	0.0
4005	Gia Lai	Dak Doa	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4006	Gia Lai	Chu Pah	0.0	570.0	0.0	0.0	0.0	0.0	0.0
4007	Gia Lai	Ia Grai	0.0	92.1	0.0	0.0	0.0	0.0	0.0
4008	Gia Lai	Mang Yang	40.0	244.5	0.0	0.0	0.0	0.0	0.0
4009	Gia Lai	Kong Chro	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4010	Gia Lai	Duc Co	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4011	Gia Lai	Chu Prong	0.0	130.0	0.0	0.0	0.0	0.0	0.0
4012	Gia Lai	Chu Se	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4013	Gia Lai	Dak Po	173.0	0.0	0.0	0.0	0.0	0.0	0.0
4014	Gia Lai	Ia Pa	233.0	16.0	0.0	0.0	0.0	0.0	0.0
4015	Gia Lai	Krong Pa	170.0	12.0	0.0	0.0	0.0	0.0	0.0
4016	Gia Lai	Phu Thien	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4017	Gia Lai	Chu PuH	0.0	25.0	0.0	0.0	0.0	0.0	0.0
4101	Dak Lak	Buon Ma Thuot	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4102	Dak Lak	Ea H'leo	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4103	Dak Lak	Ea Sup	0.0	1,204.3	3,429.3	0.0	3,205.0	0.0	0.0
4104	Dak Lak	Krong Nang	0.0	55.4	0.0	0.0	0.0	0.0	0.0
4105	Dak Lak	Krong Buk	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4106	Dak Lak	Buon Don	0.0	218.5	0.0	413.0	0.0	0.0	0.0
4107	Dak Lak	Cu M'gar	0.0	0.0	0.0	131.0	0.0	0.0	0.0
4108	Dak Lak	Ea Kar	362.3	0.0	475.8	0.0	0.0	0.0	0.0
4109	Dak Lak	M'Drak	2,487.2	0.0	0.0	0.0	0.0	0.0	0.0
4110	Dak Lak	Krong Pak	1,211.4	0.0	161.2	0.0	216.0	0.0	0.0
4111	Dak Lak	Krong Bong	1,735.5	521.2	64.7	61.0	353.7	0.0	0.0
4112	Dak Lak	Krong Ana	518.1	135.0	557.6	350.0	1,032.0	0.0	0.0
4113	Dak Lak	Lak	906.0	2,079.2	1,563.3	0.0	1,743.0	0.0	0.0
4114	Dak Lak	Cu Kuin	0.0	0.0	100.0	0.0	53.2	0.0	0.0
4115	Dak Lak	Buon Ho	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4201	Dak Nong	Gia Nghia	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4202	Dak Nong	Dak Glong	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4203	Dak Nong	Cu Jut	2.1	17.4	0.3	0.0	0.0	0.0	0.0
4204	Dak Nong	Dak Mil	0.0	2.0	0.0	0.0	0.0	0.0	0.0
4205	Dak Nong	Krong No	545.2	105.6	55.0	0.0	153.7	0.0	0.0
4206	Dak Nong	Dak Song	0.0	0.0	0.0	17.0	0.0	0.0	0.0
4207	Dak Nong	Dak R'Lap	81.3	0.1	25.9	1.5	77.0	0.0	0.0
4208	Dak Nong	Tuy Duc	33.3	0.1	18.0	0.3	22.5	0.0	0.0
4301	Lam Dong	Da Lat	0.0	66.4	0.0	2.0	170.2	250.8	904.9
4302	Lam Dong	Bao Loc	0.0	0.0	54.4	0.0	0.0	0.0	1,581.8
4303	Lam Dong	Dam Rong	0.0	0.0	0.0	0.0	4.0	0.0	601.7
4304	Lam Dong	Lac Duong	0.0	8.4	588.9	24.1	86.4	620.0	0.0
4305	Lam Dong	Lam Ha	0.0	0.0	158.7	514.4	27.9	531.1	4.9
4306	Lam Dong	Don Duong	468.8	0.0	0.0	119.0	0.0	136.8	102.3
4307	Lam Dong	Duc Trong	351.0	0.0	451.1	0.0	114.7	0.4	4,216.0
4308	Lam Dong	Di Linh	0.0	0.0	32.0	0.0	363.8	60.3	13,074.0
4309	Lam Dong	Bao Lam	0.0	0.0	0.0	0.0	184.3	0.0	9,634.0
4310	Lam Dong	Da Huoai	0.0	0.0	43.7	19.6	11.8	14.3	355.2
4311	Lam Dong	Da Teh	0.0	653.1	70.0	1,105.0	180.0	0.0	278.0
4312	Lam Dong	Cat Tien	0.0	270.5	0.0	26.0	145.5	0.0	633.9

Source: Statistical Book of Provinces.

AT 5.2.8 Average Cost per Effective Volume of Irrigation Purpose Dam

No.	River Basin	Name of Reservoir	Province	Commune	Storage Volume (10^6 m³)				Purpose of Dam			Total Project Cost (US$ million)	Cost per Effective Volume (US$ million/ MCM)
					Normal Storage Volume	Surcharge Storage Volume	Dead Storage Volume	Effective Storage Volume	Hydro-power	Irrigation/ Domestic	Flood Control		
1	Se San	Thuong Kon Tum	Kon Tum	Dak Tang	145.52	158.45	42.46	103.10	x	x	x	338.00	3.28
2	Se San	Dak Yen	Kon Tum	Hoa Binh	6.12	6.57	0.22	5.95		x			
3	Se San	Dak Loh	Kon Tum	Ngoc Wang	13.63	15.94	1.28	2.65		x			
4	Se San	Dak Uy	Kon Tum	Dak Ngok	29.72	33.00	3.83	25.84		x			
5	Se San	Dak Kal	Kon Tum		3.20		0.71	2.49		x			
6	Se San	Tan Son	Gia Lai	Tan Son	4.19	5.28	0.31	4.09		x			
7	Se San	Yaly	Gia Lai	Ialy	1,065	1,307	528	779	x	x	x	365.17	0.47
8	Se San	Pley Krong	Kon Tum	Sa Binh	1,048.69	1,244.87	100.65	948.00	x	x	x	127.59	0.13
9	Se San	Se San 4	Kon Tum	IaO	893.34	1,079.13	629.14	264.20	x	x	x	250.00	0.95
10	Se San	Se San 4a	Kon Tum	IaO	13.13	13.13	5.74	7.60					
11	Se San	Bien Ho	Gia Lai	Pleiku	12.40	41.50	1.50	10.90		x			
12	Se San	Se San 3	Kon Tum	Ia Kren	86.70	102.00	82.90	3.80	x	x	x	175.99	46.31
13	Se San	Se San 3a	Kon Tum		80.60	80.60		80.60	x			80.95	1.00
14	Ba	Ka Nak	Gia Lai	LoKu - Dong	313.74	319.54	28.25	313.70	x	x	x	164.55	0.50
15	Ba	An Khe	Gia Lai	An Khe	15.85	19.51	10.25	15.90	x	x			
16	Ba	Ayun Ha	Gia Lai	AyunPa	253.00	528.80	52.00	201.00	x	x	x		
17	Ba	La Glai	Gia Lai	Ia Glai	3.60		0.80	2.80		x			
18	Ba	La'Mla	Gia Lai	M'la	54.15	58.76	4.95	48.64		x			
19	Ba	Krong Buk Ha	Dak Lak	Ea Phe	109.34	120.92	13.60	95.74		x	x		
20	Ba	Krong Hnang	Dak Lak	Ea So	171.56	185.30	59.28	108.50	x	x		64.98	0.60
21	Ba	Vu Bon	Dak Lak	Vu Bon	5.07	6.11	1.15	5.00		x			
22	Ba	Ia Dreh	Gia Lai	Ia Dreh	5.35	7.54	0.46	4.85	x				
23	Ba	Dak Srong 2	Gia Lai	Ko Ninh	85.80		80.60	85.80	x			19.01	0.22
24	Ba	Ayun Thuong	Gia Lai	H'nol	4.54	4.54	4.02	4.54	x			12.76	2.81
25	Srepok	Buon Tua Srah	Dak Nong	Nam Ka	786.87	798.72	264.29	522.60	x	x	x	100	0.19
26	Srepok	Buon Kuop	Dak Nong	Dray Sap	63.24	87.10	48.55	14.70	x	x	x	203	13.82
27	Srepok	Srepok 3	Dak Nong	Ea Po	218.99	276.75	156.13	62.82	x	x	x	214	3.40
28	Srepok	Srepok 4	Dak Nong	Ea Wer	25.94	38.60	17.50	8.44	x	x	x		
29	Srepok	Dak N'teng	Dak Nong	Quang Son	25.49	34.35	5.02	25.49	x				
30	Srepok	Krong No 2	Lam Dong	Dung K'No	8.79	9.03	7.43	8.79	x			61.95	7.05
31	Srepok	Krong No 3	Dak Lak	Da Tong	18.64	28.05	17.76	0.87	x			26.79	30.80
32	Srepok	Chu Prong	Gia Lai	Chu Prong	4.13	4.35	0.32	3.74		x			
33	Srepok	Hoang An	Gia Lai	Ia Phin	6.80		0.80	5.20		x			
34	Srepok	Ia Rinh	Gia Lai	Ia Tiem	10.76		0.58	10.18		x			
35	Srepok	Pleipai	Gia Lai	Chu Prong	20.91	30.53	3.68	9.58		x			
36	Srepok	Yang Reh	Dak Lak	Yang Reh	6.30		0.90	4.50		x			
37	Srepok	Ea Uy	Dak Lak	Ea Uy	6.30	6.75	1.80	6.30		x			
38	Srepok	Ea Kuang	Dak Lak	Ea Yong	3.70	4.58	3.03	4.60		x			
39	Srepok	Srepok 4A	Dak Lak	Krong Na				0.78	x			87.99	112.81
40	Srepok	Ea Bong	Dak Lak	Ea Bong	8.76	17.58	0.60	2.66		x			
41	Srepok	Drao II	Dak Lak	Cu Dlie M'nor	3.30		0.50	3.30		x			
42	Srepok	Tay	Dak Nong	Dak Mil	7.77		3.57	3.33		x			
43	Srepok	Buon Tria	Dak Lak	Buon Tría	3.98	6.74	0.50	4.00		x			
44	Srepok	Ea Suop Ha	Dak Lak	Ea Sup	9.28	11.80	3.21	7.00		x			
45	Srepok	Ea Nhai I	Dak Lak	Krong Pak	10.98		8.03	11.03		x			
46	Srepok	Ea Kar	Dak Lak	C Ni	10.95		5.81	11.00		x			
47	Srepok	Ea Kao	Dak Lak	Ea Kao	17.76	22.40	4.00	13.76	x				
48	Srepok	Buon Triet	Dak Lak	Buon Triet	21.30		3.00	22.00		x			
49	Srepok	Ea Soup Thuong	Dak Lak	Cu Mgar	143.00	162.00	10.65	135.94		x		45.00	0.33
50	Srepok	Ea Rot	Dak Lak	Cu Ea Lang	18.43	18.43	1.73	16.80		x		131.99	7.86
51	Srepok	Ea Chur Kap	Dak Lak	Buon Me Thu	11.20	20.50	5.10	11.20	x				
52	Srepok	Buon Yong	Dak Lak	Cu Mgar	15.24		5.00	15.24		x			
53	Srepok	Dak Lo	Lam Dong	Gia Vien	12.12	15.94	1.28	12.35		x			
54	Srepok	Dak Dier	Dak Nong	Cu Knia	5.92	8.57	0.42	5.50		x			
55	Srepok	Tay	Dak Nong	Dak Mil	3.33		0.50	3.33		x			
56	Srepok	Vu Bon	Dak Lak	Vu Bon	5.07	6.11	1.45	5.00		x			
57	Srepok	Dak Sak	Dak Nong	Duc Minh	6.70		1.50	6.50		x			
58	Srepok	Krong Buk ha	Dak Lak	Ea Phe	109.34	120.92	13.60	95.74		x	x	109.99	1.15
59	Dong Nai	Tuyen Lam	Lam Dong	Phuong 3	27.85	31.50	1.51	15.20		x			
60	Dong Nai	Proh	Lam Dong	P'Róh	3.22	4.02	0.21	3.01		x			
61	Dong Nai	Dak Lo	Lam Dong	Gia Vien	13.63	15.94	1.28	12.35		x			
62	Dong Nai	Phuoc Trung	Lam Dong	Phuoc Cat 2	3.19	3.72	0.06	3.12		x			
63	Dong Nai	Thon 5 Quoc Oai	Lam Dong	Quoc Oai	3.94	4.72	0.49	3.46		x			
64	Dong Nai	Da Teh	Lam Dong	My Duc	22.11	52.82	3.11	19.19		x			
65	Dong Nai	Da Ron	Lam Dong	Da Ron	5.55	7.29	1.90	3.62		x			
66	Dong Nai	Dan Kia	Lam Dong	Xa Lat	10.70	15.93	0.34	11.31	x	x	x		
67	Dong Nai	Dak R'Tih	Lam Dong	Nhan Co	137.12		38.91	101.80	x	x	x		
68	Dong Nai	Dai Ninh	Lam Dong	Phu Hoi	319.77		68.04	143.40	x	x	x	440.00	3.07
69	Dong Nai	Da Nhim	Lam Dong	Dran	165.00	172.54	9.86	165.00	x	x	x	45.45	0.28
70	Dong Nai	Dong Nai 2	Lam Dong	Tan Thanh	280.80	302.08	137.40	143.40	x	x	x	153.99	1.07
71	Dong Nai	Dong Nai 3	Lam Dong	Loc Lam	1,690.06	1,878.22	798.58	891.50	x	x	x	224.38	0.25
72	Dong Nai	Dong Nai 4	Lam Dong	Loc Bao	332.05	359.93	315.69	16.40	x	x	x	171.59	10.46
73	Dong Nai	Dong Nai 5	Lam Dong	Dak Nia	0.11		0.10	8.35	x	x	x	182.59	21.87
74	Dong Nai	Da Ham	Lam Dong	An Nhon	6.40	7.66	1.24	2.90		x			

Average Cost per Effective Volume (million USD/MCM)=	10.83
Average Cost per Effective Volume included Irrigation Purpose (million USD/MCM)=	6.10
Average of Irrigation Purpose Dam Only (million USD/MCM)=	3.11
Average Cost per Effective Volume of Including Irrigation Purpose Dam by Life Cycle of 50 years (million USD/MCM)=	0.122
Average Cost per Effective Volume of Irrigation Purpose Dam Only by Life Cycle of 50 years (million USD/MCM)=	0.062

Source: MARD and MOIT. Cost data is based on data published on the Internet.