ANNEX I

HYDROLOGY

The Feasibility Study
on
Integrated Agricultural and Rural Development
in
Highland Area In the Republic of Indonesia

ANNEX I HYDROLOGY

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CHAPTER 1 DEPENDABLE FLOW IN THE MODEL AREAS

Water availability for the proposed water source is estimated for the Study on the basis of; i) rainfall, ii) catchment area at the intake, iii) runoff coefficient to rainfall, and iv) lowest flow estimated from field observation. In order to assume the runoff coefficient, correlation between rainfall and river discharge is examined.

DI Cijanngel is a technical irrigation scheme, which includes Tugumukti model area. Provincial Irrigation Services of West Java observed the river discharge of the Kali Cimahi river at the intake weir[1] for eight (8) years from 1988 until 1995. According to the records, discharges of 80 % probability are estimated and listed as "Debit Andalan" by PU (dependable flow) as shown below:

Dependable Flow of Kali Cimahi River at the Intake of DI Cijanggel

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Discharge (m^3/s)	0.94	1.16	1.04	1.10	1.00	0.93	0.71	0.49	0.47	0.26	0.41	0.59
Depth (mm)	128	142	142	145	135	122	96	67	62	35	54	81

The correlation between the above dependable flow and average monthly rainfall at Lembang (1989-1998) is examined. Taking into account the time lag between the rainfall and the runoff, correlations between rainfall(variable "x") and discharge of one-month later, and two-months later (variable "y") are examined as follows:

Variable (y)	Variable (x)	Slope (a)	Intercept (b)	Correlation coefficient R
Dependable flo of month (n)	Rainfall of month (n)	0.16	0.57	0.36
Dependable flo of month (n+1)	Rainfall of month (n)	0.33	0.36	0.75
Dependable flo of month (n+2)	**Rainfall of month (n)**	**0.40**	**0.27**	**0.92**
Dependable flo of month (n+3)	Rainfall of month (n)	0.36	0.32	0.82

Judging from the above results, certain correlation between the rainfall in $(n)^{th}$

[1] Catchment area is 19.7 km^2.

month and the dependable flow of $(n+2)^{th}$ is confirmed. It is assumed that the long-term runoff coefficient to the rainfall is 0.40 or 40 % and the base flow which is constant through the year, is 0.27 m^3/s. Annual runoff (total volume) to the annual rainfall is 62 % for the Kali Cimahi river. Even no rainfall is observed for several months, the lowest discharge would not become lower than the base flow. In Lembang or the catchment of Kali Cimahi river, it rains for 5 or 6 days on the average even in the driest month, and the lowest flows would be larger than 0.27 m^3/s (the base flow).

On the basis of the results of the above correlation analysis, the following assumption is made for the relation between the catchment rainfall[2] and dependable flow:

- The long-term runoff coefficient is between 40 % to 60 %.
- The time lag between the rainfall and the runoff should be bigger for larger catchment.
- Total runoff to the annual rainfall should not exceed 60 %.
- The base flow is smaller than the lowest flow observed during the dry season.

According to the above assumptions, dependable flows of the proposed water sources in the model areas are estimated. The base flows are estimated from the results of discharge measurement at the water sources, and the runoff coefficients are adjusted between 40 % and 60 % taking into account the estimated lowest flows and total runoff volume (not more than 60 %) to the annual rainfall.

The results are given in Table I-1 to I-8.

[2] Records of five rainfall stations are used, namely, Lembang (for Langensari, Tugumukti), Bandung (for Mekarjaya, Cisurupan, Tanjungkarya), Pacet (for Gekbrong), Jatiwangi (for Mekarmukti), and .Kuningan (for Cisantana)

Tables

Table I-1 Estimated Monthly Dependable Flow, Mekarjaya

Citiis River CA= 4.6 km2 Rcoff= 50 % BaseF 0.030 m3/s

Month (n+2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.289	0.282	0.232	0.243	0.294	0.257	0.167	0.102	0.078	0.094	0.105	0.143		
Depth (mm)	168	148	135	137	171	145	97	59	44	55	59	83	1302	59%
Month (n)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct		
Rainfall (mm)	301	265	236	240	307	256	159	84	54	75	84	132	2192	

Cikuya Spring CA= 0.8 km2 Rcoff= 50 % BaseF 0.005 m3/s

Month (n+1)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.045	0.044	0.041	0.053	0.043	0.030	0.018	0.013	0.017	0.018	0.026	0.050		
Depth (mm)	150	134	137	170	145	96	59	44	54	60	83	168	1302	59%
Month (n)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		
Rainfall (mm)	265	236	240	307	256	159	84	54	75	84	132	301	2192	

Ciremes Spring CA= 0.4 km2 Rcoff= 50 % BaseF 0.003 m3/s

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	
1 month (m3/s)	0.022	0.022	0.020	0.026	0.022	0.015	0.009	0.007	0.008	0.009	0.013	0.025		
(mm)	150	134	137	170	145	96	59	44	54	60	83	168	1302	59%
Month (n)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		
Rainfall (mm)	265	236	240	307	256	159	84	54	75	84	132	301	2192	

Table I-2 Estimated Monthly Dependable Flow, Langensari

Cikukang CA= 6.1 km2 Rcoff= 50 % BaseF 0.034 m3/s

Month (n+1)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.317	0.352	0.247	0.401	0.277	0.173	0.118	0.094	0.092	0.111	0.157	0.319		
Depth (mm)	139	140	108	170	122	73	52	41	39	49	67	140	1140	59%
Month (n)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		
Rainfall (mm)	248	252	186	312	213	118	73	52	49	68	104	250	1927	

Cipogo CA= 1.0 km2 Rcoff= 50 % BaseF 0.006 m3/s

Month (n+1)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.052	0.058	0.040	0.066	0.045	0.028	0.019	0.015	0.015	0.018	0.026	0.052		
Depth (mm)	139	140	108	170	122	73	52	41	39	49	67	140	1140	59%
Month (n)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		
Rainfall (mm)	248	252	186	312	213	118	73	52	49	68	104	250	1927	

Table I-3 Estimated Monthly Dependable Flow, Tugumukti

Kali Cimahi Rive CA= 19.7 km2 Rcoff= 40 % BaseF 0.270 m3/s

Month (n+1)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	1.007	1.079	1.011	0.837	1.187	0.919	0.616	0.486	0.429	0.415	0.476	0.577		
Depth (mm)	137	133	138	110	161	121	84	66	56	56	63	78	1203	62%
Month (n)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		
Rainfall (mm)	248	252	186	312	213	118	73	52	49	68	104	250	1927	

Note: CA= catchment area, Rcoff = runoff coefficient (slope "a"), BaseF = base flow (y axis intercept "b"),
Rcoff_v = Annual runoff to rainfall (%)

Table I-4 Estimated Monthly Dependable Flow, Gekbrong

Cibeleng River CA= 3.1 km2 Rcoff 50 % BaseF 0.025 m3/s

Month (n+1)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.239	0.256	0.174	0.193	0.201	0.142	0.088	0.068	0.079	0.096	0.173	0.259		
Depth (mm)	206	200	150	161	173	119	76	59	66	83	144	224	1661	59%
Month (n)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		
Rainfall (mm)	370	360	257	280	304	196	109	75	90	122	247	404	2814	

Table I-5 Estimated Monthly Dependable Flow, Cisurupan

Cihaleumas, etc. CA= 4.5 km2 Rcoff 50 % BaseF 0.030 m3/s

Month (n+1)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.253	0.249	0.231	0.297	0.245	0.168	0.100	0.075	0.095	0.101	0.144	0.283		
Depth (mm)	150	134	138	171	146	97	60	45	55	60	83	168	1306	60%
Month (n)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		
Rainfall (mm)	265	236	240	307	256	159	84	54	75	84	132	301	2192	

Table I-6 Estimated Monthly Dependable Flow, Tanjungkarya

Cisaat River CA= 5.5 km2 Rcoff 50 % BaseF 0.039 m3/s

Month (n+1)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.312	0.307	0.285	0.365	0.302	0.208	0.125	0.095	0.119	0.126	0.179	0.349		
Depth (mm)	152	135	139	172	147	98	61	46	56	61	84	170	1322	60%
Month (n)	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		
Rainfall (mm)	265	236	240	307	256	159	84	54	75	84	132	301	2192	

Cidadalilebak Sp CA= 0.95 km2 Rcoff= 30 % BaseF 0.020 m3/s

Month (n+2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.052	0.051	0.045	0.046	0.053	0.048	0.037	0.029	0.026	0.028	0.029	0.034		
Depth (mm)	147	130	127	126	149	131	104	82	71	79	80	96	1322	60%
Month (n)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct		
Rainfall (mm)	301	265	236	240	307	256	159	84	54	75	84	132	2192	

Tanjungpura Spr CA= 0.45 km2 Rcoff= 30 % BaseF 0.010 m3/s

Month (n+2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.025	0.024	0.021	0.022	0.025	0.023	0.018	0.014	0.012	0.013	0.014	0.016		
Depth (mm)	147	131	127	127	149	131	104	82	71	79	80	96	1323	60%
Month (n)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct		
Rainfall (mm)	301	265	236	240	307	256	159	84	54	75	84	132	2192	

Cilatung Spring CA= 11.0 km2 Rcoff= 30 % BaseF 0.232 m3/s

Month (n+2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.603	0.594	0.522	0.537	0.610	0.557	0.428	0.335	0.301	0.324	0.339	0.394		
Depth (mm)	147	131	127	127	149	131	104	82	71	79	80	96	1323	60%
Month (n)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct		
Rainfall (mm)	301	265	236	240	307	256	159	84	54	75	84	132	2192	

Note: CA= catchment area, Rcoff = runoff coefficient (slope "a"), BaseF = base flow (y axis intercept "b"),
Rcoff_v = Annual runoff to rainfall (%)

Table I-7 Estimated Monthly Dependable Flow, Mekarmukti

Ciliang CA= 3 km2 Rcoff 15 % BaseF 0.121 m3/s

Month (n+2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.175	0.203	0.206	0.196	0.192	0.176	0.140	0.134	0.126	0.128	0.128	0.140		
Depth (mm)	157	164	184	170	171	152	125	120	109	114	111	125	1701	60%
Month (n)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct		
Rainfall (mm)	324	443	504	435	421	316	112	77	31	41	40	114	2857	

Table I-8 Estimated Monthly Dependable Flow, Cisantana

Cipager CA= 14.6 km2 Rcoff 40 % BaseF 0.164 m3/s

Month (n+2)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual(mm)	Rcoff_v
Discharge (m3/s)	0.479	0.886	0.646	0.792	0.734	0.544	0.527	0.295	0.298	0.242	0.211	0.277		
Depth (mm)	88	147	119	141	135	97	97	54	53	44	38	51	1062	60%
Month (n)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct		
Rainfall (mm)	144	299	221	279	261	169	167	60	60	36	21	52	1768	

Note: CA= catchment area, Rcoff = runoff coefficient (slope "a"), BaseF = base flow (y axis intercept "b"),
Rcoff_v = Annual runoff to rainfall (%)