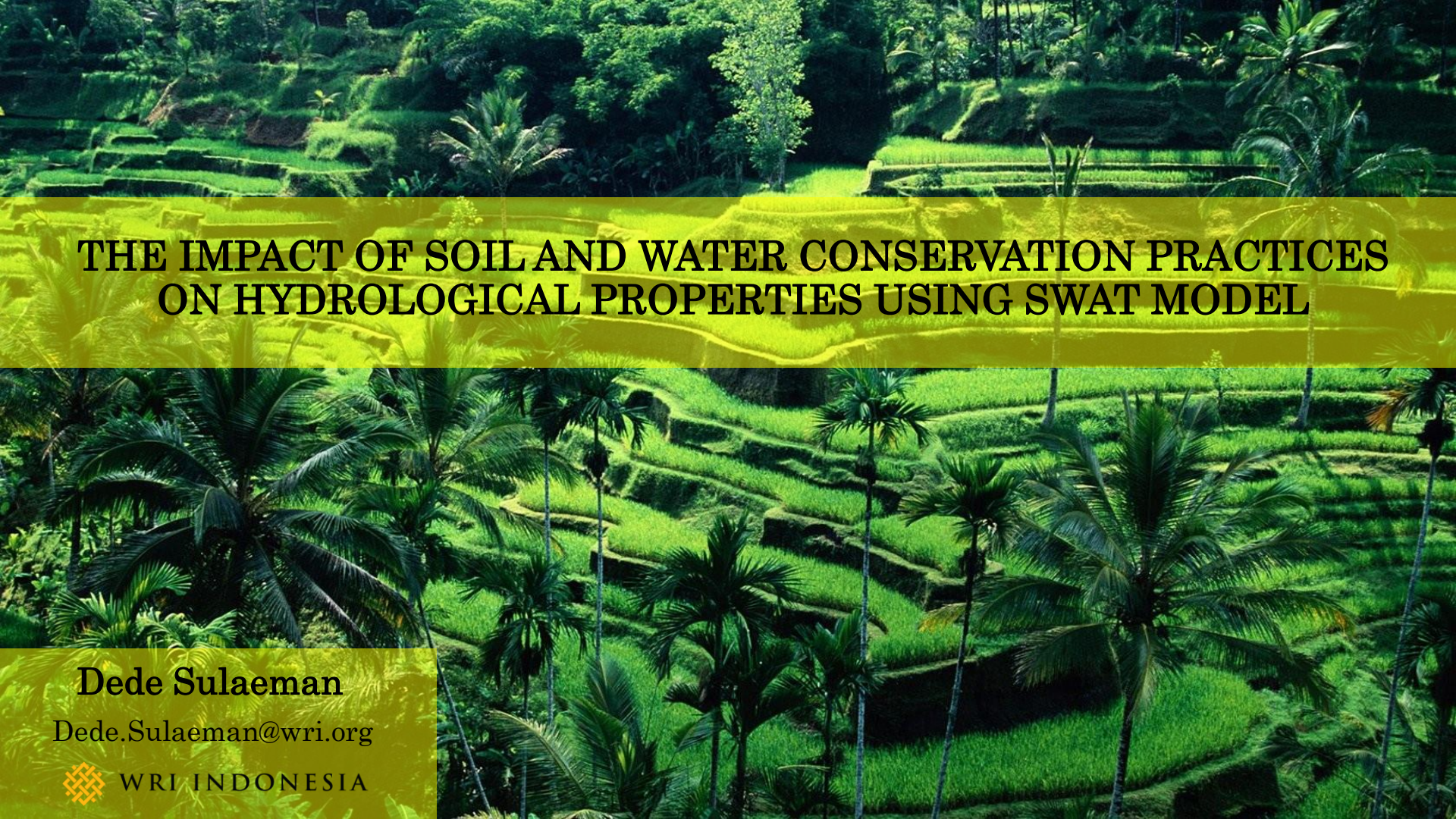

THE IMPACT OF SOIL AND WATER CONSERVATION PRACTICES ON HYDROLOGICAL PROPERTIES USING SWAT MODEL

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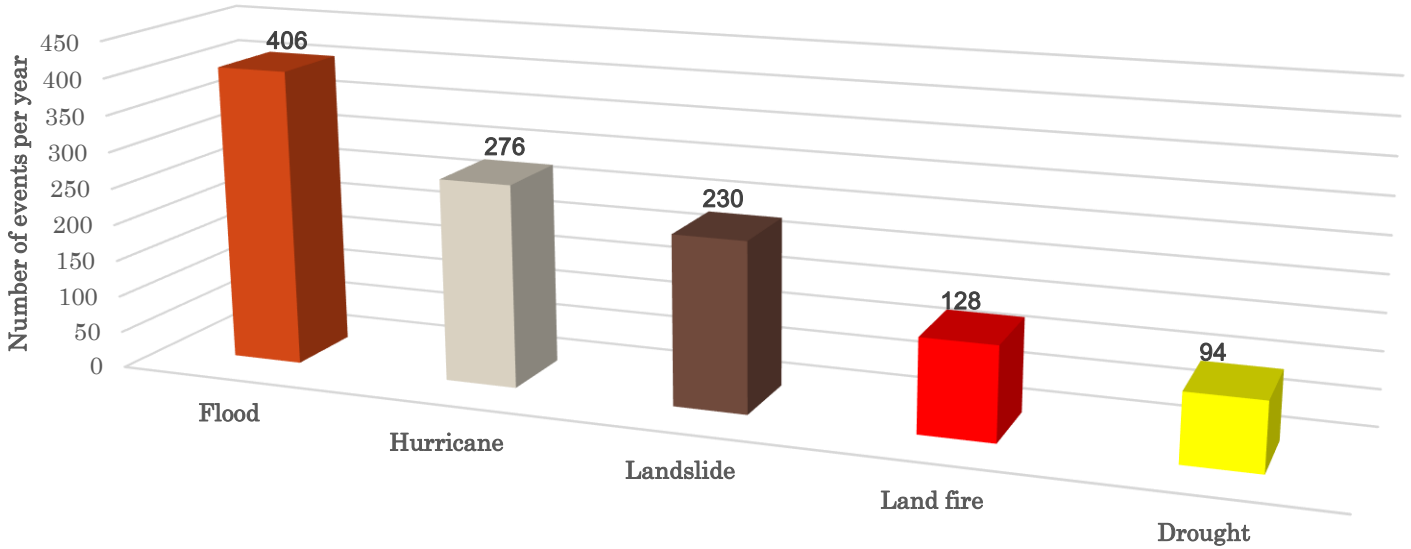
WRI INDONESIA

THE PRESENTATION CONSIST OF :

- INTRODUCTION
- METHODOLOGY
- DATA REQUIREMENTS & TOOLS
- BIOPHYSICAL INFORMATION
- RESULT
- CONCLUSION

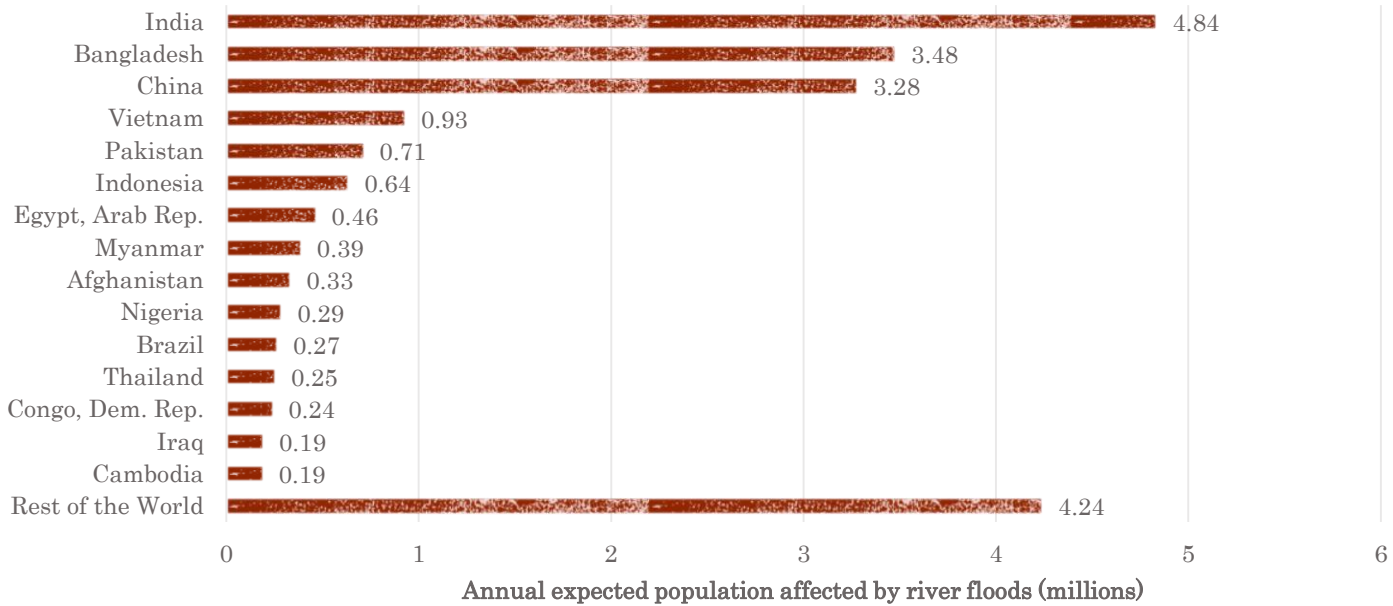
INTRODUCTION



Source : **Indonesian National Board for Disaster Management**

The most often disaster occurred in Indonesia (1999-2018)

INTRODUCTION



Source: The Aqueduct Global Flood Analyzer, a new online tool, quantifies and visualizes the reality of global flood risk. World Resources Institute co-developed the tool with four Dutch research organizations: Deltares, the Institute for Environmental Studies of the VU University Amsterdam, Utrecht University and PBL Netherlands Environmental Assessment Agency, supported by the Netherlands' Ministry of Infrastructure and the Environment

INTRODUCTION

Ciujung Watershed :

- Forest area < 30%
- Landuse change
- Agricultural Practices
- Degraded Watershed
- Flooding : Annually occured

SWAT Model

The study aims to:

(1) Assess the impact of soil and water conservation practices on hydrological properties

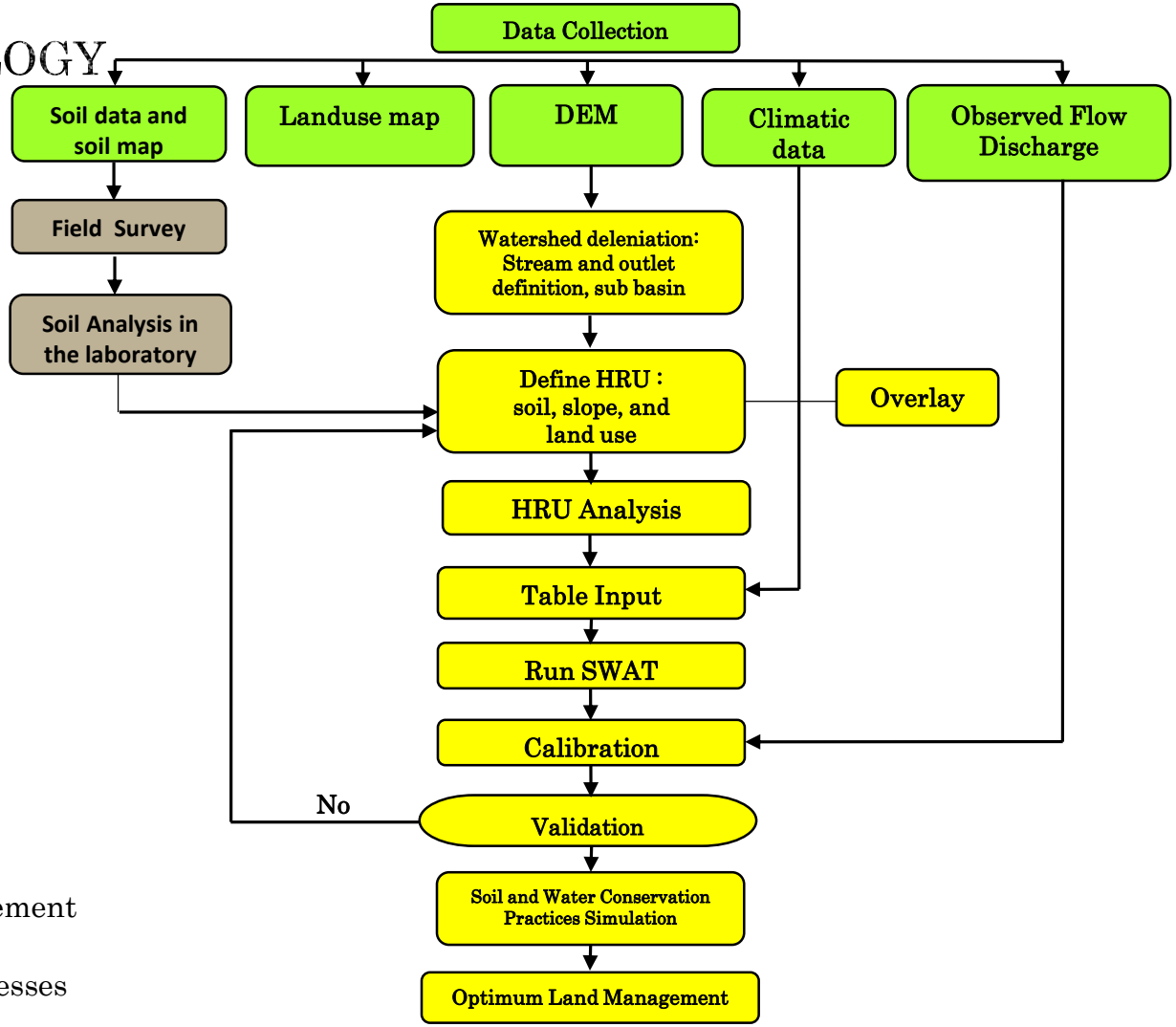
(2) Determine the best management practice to maintain watershed condition

DATA REQUIREMENTS & TOOLS

Dat Set	Source	Scale	Data Description
Terrain	USGS (https://earthexplorer.usgs.gov/)	30 m	Digital Elevation Model
Soil	Indonesian Center for Agricultural Land Resources Research and Development (BBSDLP)	1 : 250,000	Soil map
Landuse	Directorate General of Forestry Planning and Environmental Management, MoEF	1 : 250,000	Landuse map (extracted from Landsat 8)
Weather	Meteorological, Climatological, and Geophysical Agency (BMKG)	Daily	precipitation, temperature, humidity, wind, and solar radiation (2002-2017, 21 stations)
Streamflow	a. Center for River Region of Cidanau-Ciujung-Cidurian (BBWS)	Daily	Observed flow discharge (2002-2017)
	b. Water Resources Management Agency of Ciujung-Cidanau (PSDA)		

Tools : ArcGIS 10.1, ArcSWAT 2012 (10.1.14) as an interface, pcpSTAT, SWAT BFlow, and SWAT CUP, SWAT Plot

METHODOLOGY



Data Collection

Soil Data Measurement

SWAT Model Processes

CALIBRATION AND VALIDATION

- **Coefficient determination (R^2)**

$$r^2 = \left(\frac{\sum_{i=1}^{n} (O_i - \bar{O})(P_i - \bar{P})}{\sqrt{\sum_{i=1}^{n} (O_i - \bar{O})^2} \sqrt{\sum_{i=1}^{n} (P_i - \bar{P})^2}} \right)^2$$

$R^2 \geq 0.5$ the acceptable value of R-squared in predicting river flow discharge (Moriasi *et al.* 2007)

- **Nash-Sutcliffe Efficiency (NSE)**

$$NSE = 1 - \left[\frac{\sum_{i=1}^{n} (Y_i^{obs} - Y_i^{sim})^2}{\sum_{i=1}^{n} (Y_i^{obs} - Y^{mean})^2} \right]$$

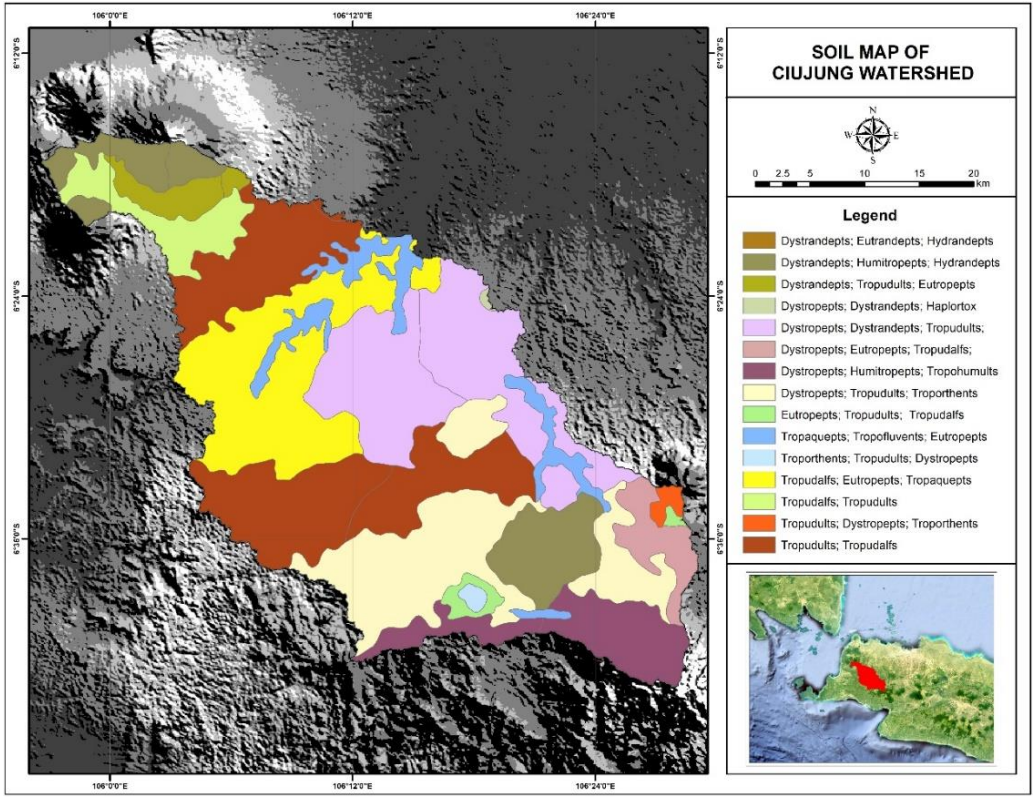
Performance	NSE
Very Good	$0.75 \leq NSE \leq 1.00$
Good	$0.65 \leq NSE \leq 0.75$
Satisfactory	$0.50 \leq NSE \leq 0.65$
Unsatisfactory	$NSE \leq 0.50$

METHODOLOGY

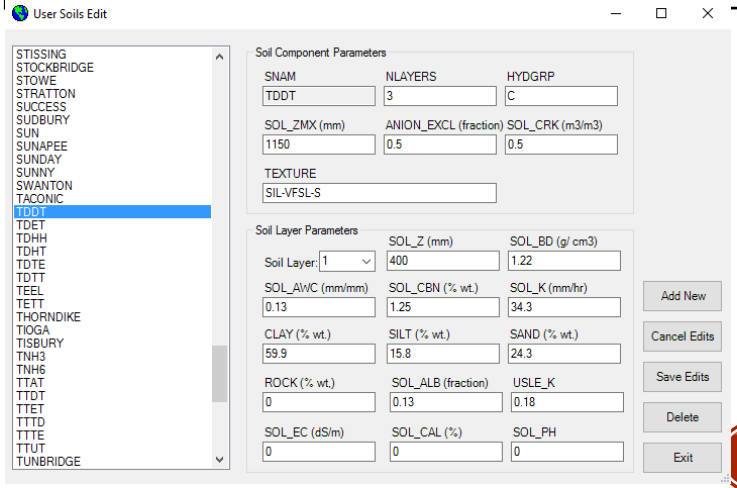
SIMULATION

Scenario	Land Management	Soil and Water Conservation Practices Implementation	Parameters Simulation	Simulation Location (Sub Basin)	Area	
					hectare	%
1	Forest implementation based on forest function map	Reforestation	CN2, SOL_K, SOL_C , dan SOL_BD	4, 7, 9, 10, 11, 20	17,333	12
2	Degraded land rehabilitation	Reforestation	CN2, SOL_K, SOL_C, SOL_BD, dan SOL_AWC	4, 5, 7, 10, 11, 12, 15, 17, 18, 20, 21	42,946	30
		Agroforestry	CN2, SOL_K, SOL_C, SOL_BD, dan SOL_AWC	1, 2, 4-7, 9-21		
3	Soil and wáter conservation practices (vegetative method)	Reforestation	CN2, SOL_K, SOL_C, SOL_BD, dan SOL_AWC	1, 2, 4-7, 9-21	40,202	28
		Agroforestry	CN2, SOL_K, SOL_C, SOL_BD, dan SOL_AWC	1, 2, 4-7, 9-21		
		Stripcropping	STRIP_CN, STRIP_P, STRIP_C, dan STRIP_N	1, 2, 4-7, 9-21		
4	Soil and wáter conservation practices (mechanical method)	Dam	RES_VOL, RES_EVOL, dan RES_PVOL	15	47,954	34
		Contouring	CONT_P dan CONT_CN	1, 2, 4-7, 9-21		
		Biopore Infiltration hole	SOL_BD dan SOL_K	1, 2, 4-7, 9-15, 17-21		

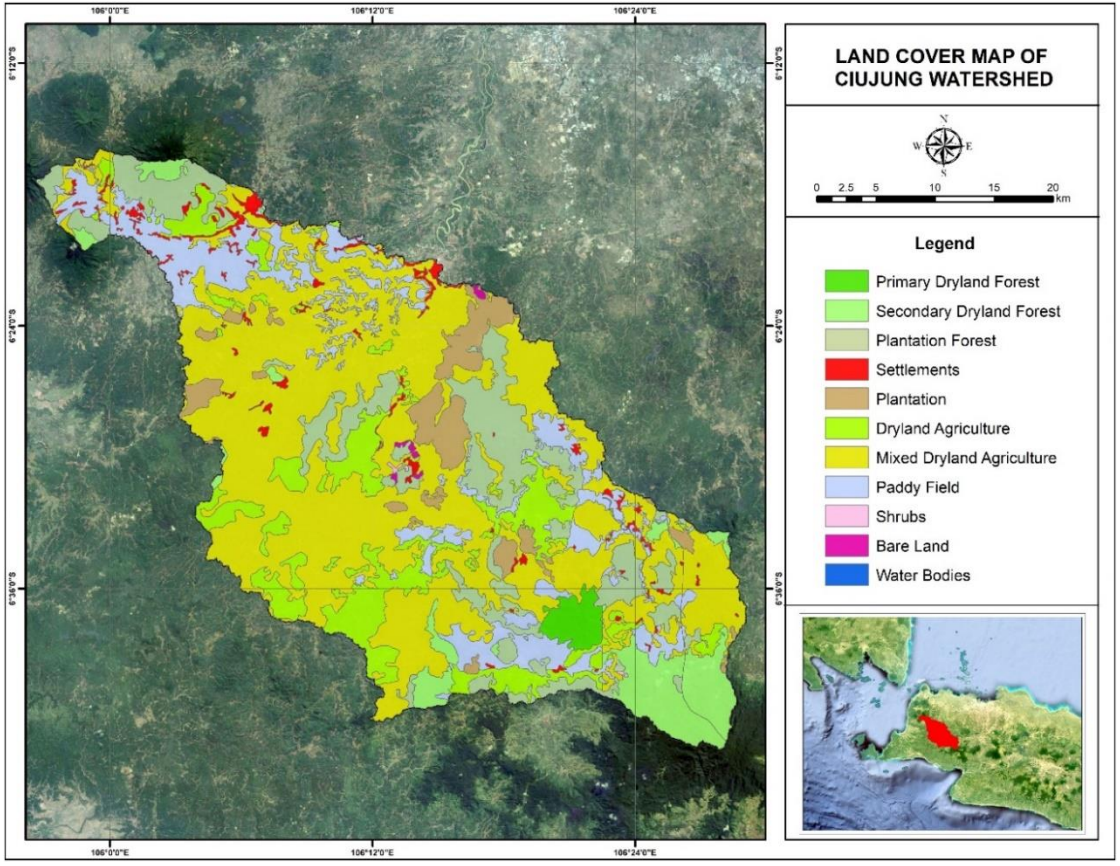
BIOPHYSICAL INFORMATION



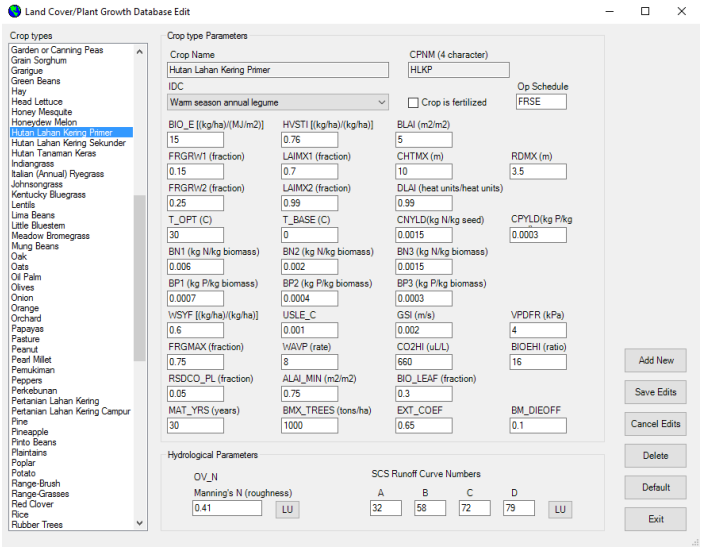
Soil Association	SWAT Code	Area	
		ha	%
Troporthents; Tropudults; Dystropepts	TTTD	454.48	0.32
Dystrandepts; Humitropepts; Hydrandepts	TDHH	11,804.95	8.31
Dystrandepts; Tropudults; Eutropepts	TDTE	3,273.23	2.30
Dystropepts; Dystrandepts; Tropudults	TDDT	25,480.33	**17.94**
Dystropepts; Eutropepts; Tropudalfs;	TDET	4,230.03	2.98
Dystropepts; Humitropepts; Tropohumults	TDHT	9,335.69	6.57
Dystropepts; Tropudults; Troporthents	TDTT	22,513.40	**15.85**
Eutropepts; Tropudults; Tropudalfs	TETT	1,337.16	0.94
Tropaquepts; Tropofluvents; Eutropepts	TTTE	6,287.11	4.43
Tropudalfs; Eutropepts; Tropaquepts	TTET	20,230.12	14.24
Tropudalfs; Tropudults	TTAT	5,843.41	4.11
Tropudults; Tropudalfs	TTUT	30,711.14	**21.62**
Tropodults, Dystropepts, Troporthents	TTDT	554.93	0.39
Total		**142,055.96**	**100**



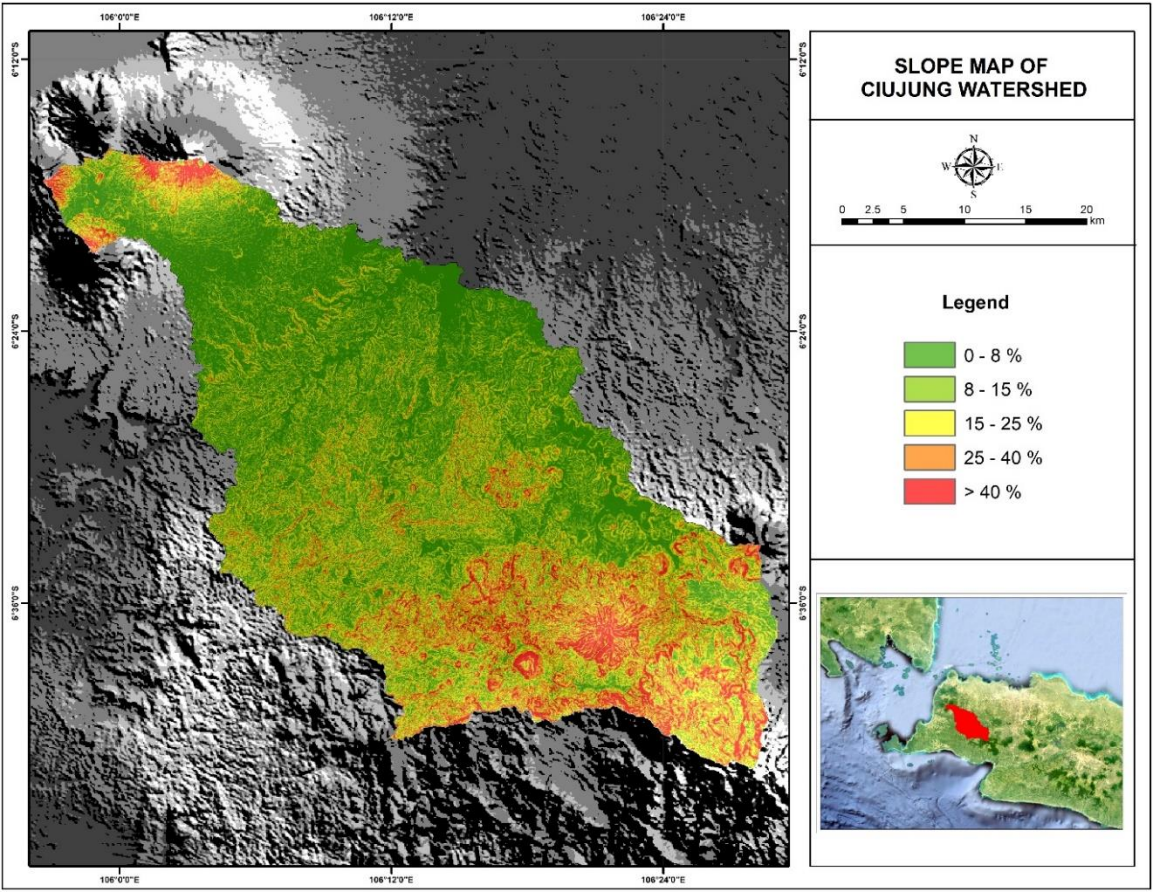
BIOPHYSICAL INFORMATION



Land cover	SWAT Code	Area	
		hectare	%
Mixed dryland agriculture	**PLKC**	**60,168.80**	**42.36**
Settlements	PMKN	1,238.10	0.87
Plantation forest	HTTN	18,302.02	12.88
Shrub	SMBK	7,299.67	5.14
Paddy field	**PADI**	**27,993.10**	**19.71**
Dryoland Agriculture	PTLK	8,347.54	5.88
Secondary dryland forest	HLKS	8,235.93	5.80
Plantation	PKBN	8,925.43	6.28
Primary dryland forest	HLKP	1,544.46	1.09
Total		142,055.96	100

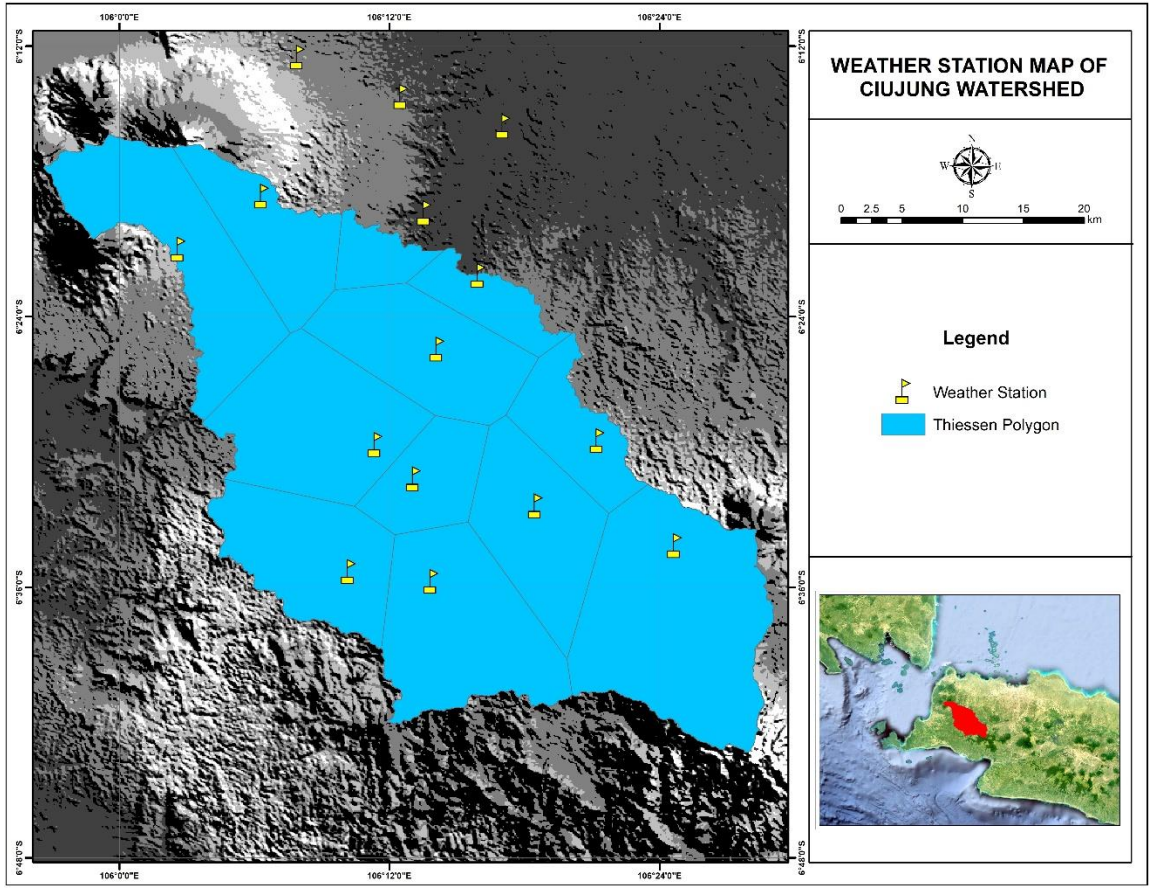


BIOPHYSICAL INFORMATION



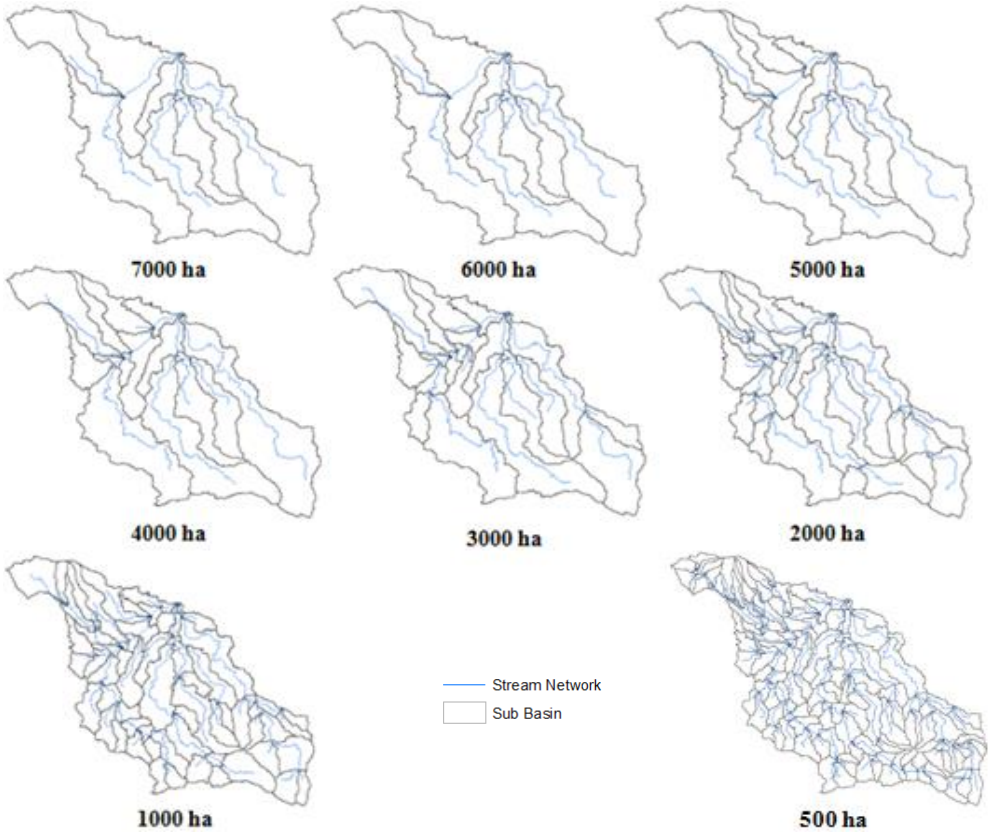
Slope (%)	Classification	Area	
		ha	%
0-8	Flat	34,719.13	24.44
8-15	**Sloping**	**40,826.65**	**28.74**
15-25	Rather steep	34,610.46	24.36
25-40	steep	20,609.62	14.51
>40	Very steep	11,290.11	7.95
Total		142,055.96	100

BIOPHYSICAL INFORMATION



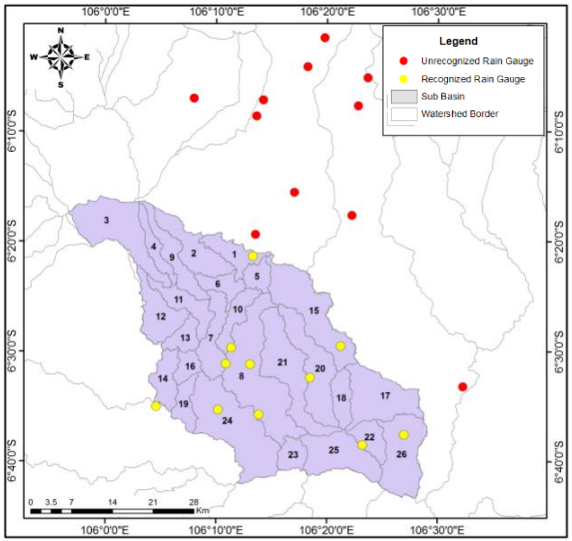
Precipitation (mm)	2000-3000
Max. Temperature (oC)	31.81
Min. Temperature (oC)	23.22
Wind Speed (km/hour)	0.68
Relative Humidity (%)	87

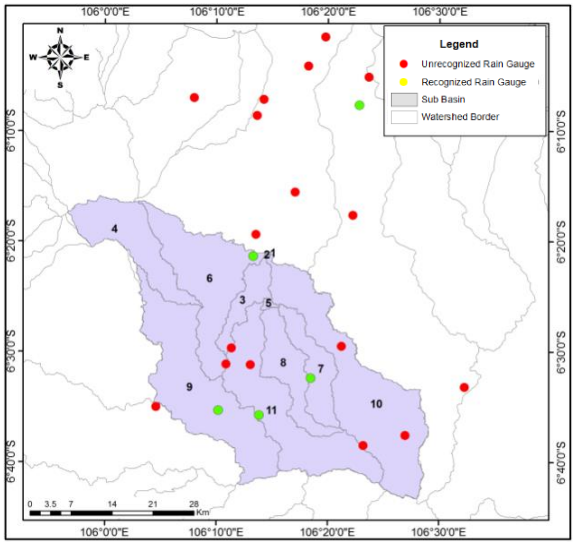
RESULT : WATERSHED DELINEATION



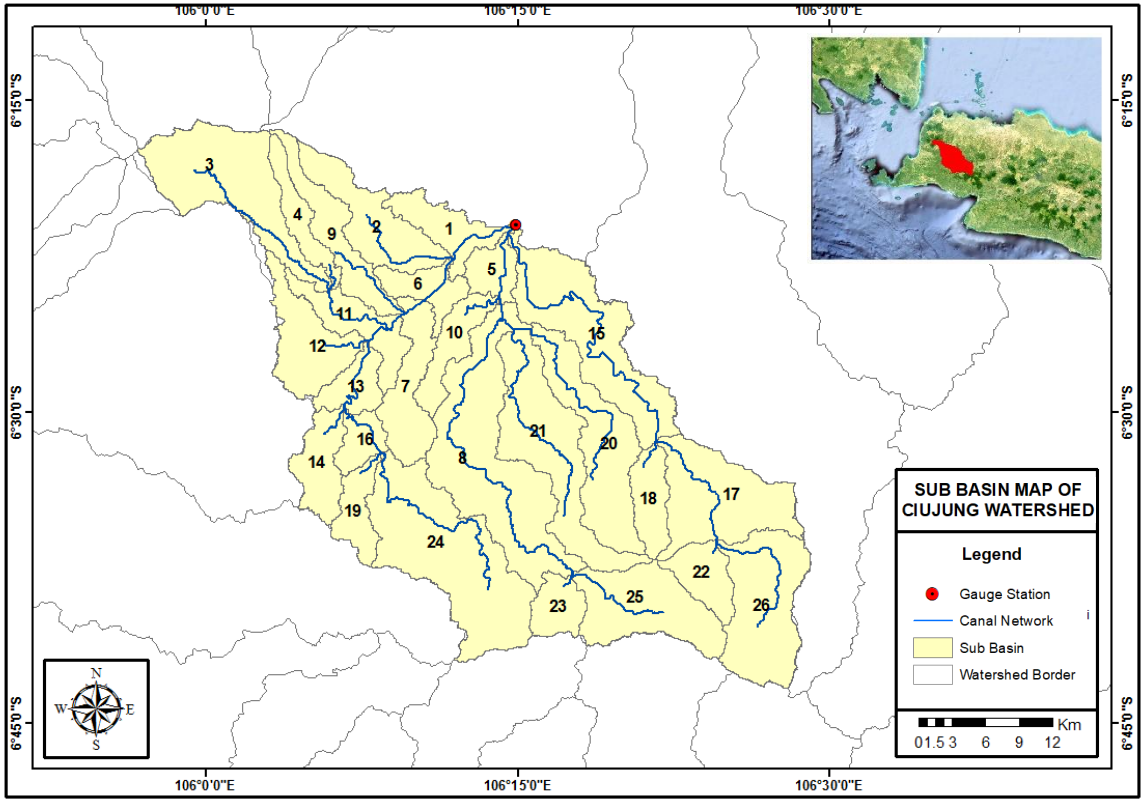
RESULT : WATERSHED DELINEATION

Treshold (ha)	Number of Sub Basin	Rain Gauge	PCP (mm)	SURQ (mm)	LATQ (mm)	GWQ (mm)	Q (m^3/s)	R^2	NSE
7000	11	5	1724.43	496.77	233.99	158.24	40.22	0.395	-0.208
6000	11	5	1724.42	496.77	234.00	158.25	40.21	0.403	-0.120
5000	15	6	1804.35	519.07	238.04	197.47	43.26	0.449	0.054
4000	17	6	1792.61	516.31	236.96	190.26	42.71	0.442	0.029
3000	23	8	1860.02	548.47	242.76	202.81	45.02	0.526	0.144
2000	35	11	1945.71	579.27	259.01	210.54	47.49	0.547	0.177
1000	71	12	1899.66	548.31	255.04	198.94	45.37	0.553	0.234
500	155	12	1882.64	542.13	247.38	195.32	44.56	0.558	0.233





RESULT : WATERSHED DELINEATION



Sub Basin	Area	
	hectare	%
1	3,256.49	2.29
2	5,540.90	3.90
3	9,595.00	6.75
4	2,353.97	1.66
5	1,963.24	1.38
6	2,369.27	1.67
7	4,481.32	3.15
8	14,479.40	10.19
9	4,152.16	2.92
10	2,853.31	2.01
11	3,651.49	2.57
12	5,018.47	3.53
13	2,264.08	1.59
14	3,318.63	2.34
15	10,286.57	7.24
16	1,764.55	1.24
17	8,210.54	5.78
18	2,702.99	1.90
19	2,390.56	1.68
20	8,201.70	5.77
21	9,452.18	6.65
22	2,716.67	1.91
23	2,208.68	1.55
24	13,495.83	9.50
25	7,071.42	4.98
26	8,256.53	5.81
Total	142,055.96	100

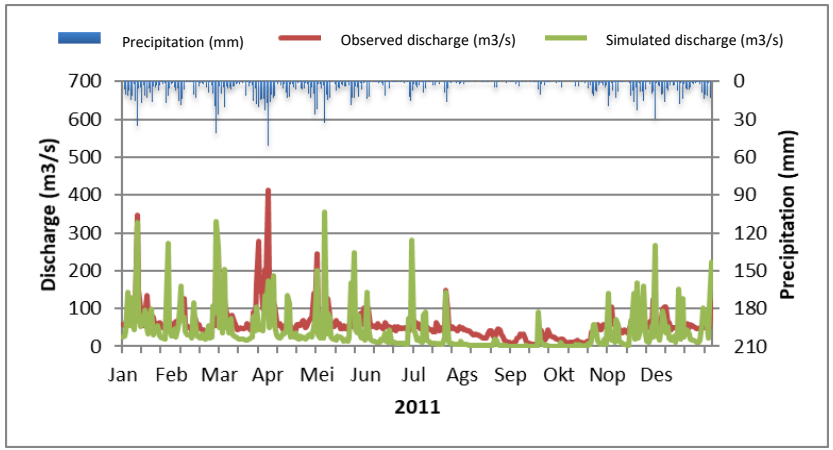
RESULT : SENSITIVITY ANALYSIS

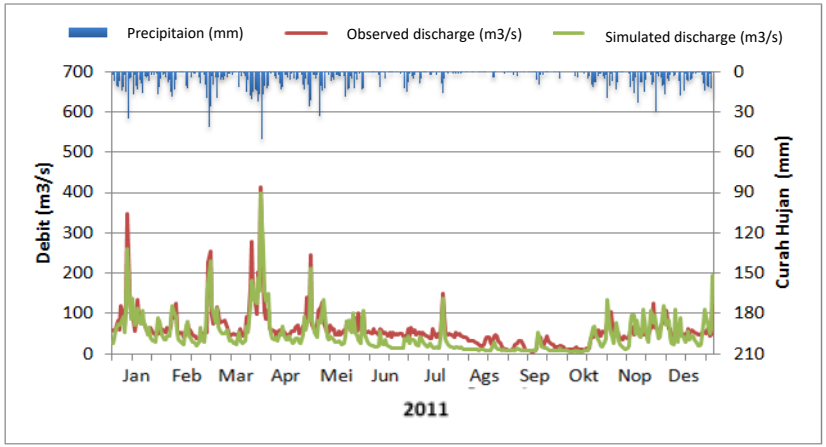
Parameters	t-Stat	P-Value	Sensitivity Rank
r_CN2,mgt	-55.145	0.0000	1
v_SHALLST,gw	6.4028	0.0000	2
v_SURLAG,bsn	-6.0224	0.0000	3
r_SOL_BD,sol	3.9222	0.0001	4
v_GWQMN,gw	-3.4268	0.0007	5
v_ESCO,bsn	-2.5448	0.0128	6
r_SOL_K,sol	-1.6157	0.1073	7
v_RCHRG_DP,gw	1.5256	0.1282	8
v_ALPHA_BNK,rte	1.4028	0.1618	9
v_GW_REVAP,gw	-1.4003	0.1625	10
v_EPCO,bsn	1.3830	0.1678	11
r_CH_N2,rte	-0.9405	0.3478	12
r_CH_K2,rte	0.9061	0.3676	13
v_ALPHA_BF,gw	0.8654	0.3875	14
r_OV_N,hru	0.8201	0.4146	15
r_SOL_AWC,sol	0.7987	0.4252	16
v_GW_DELAY,gw	0.5736	0.5667	17
v_REVAPMN,gw	0.0879	0.9300	18

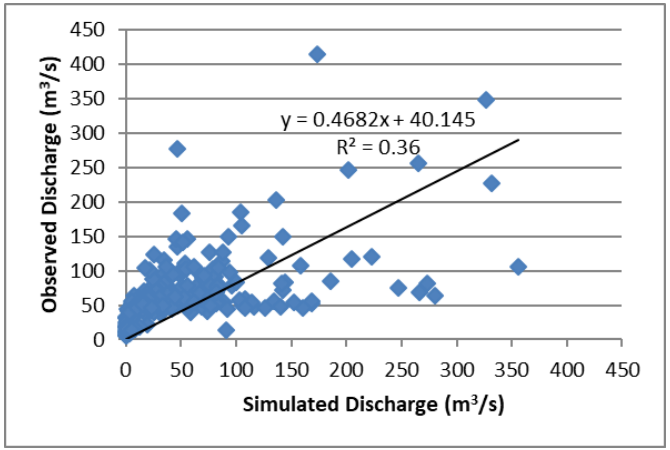
RESULT : MODEL CALIBRATION

No	Parameters	Definition	Minimum Value	Maximum Value	Used Value
1	CN2	Initial SCS Curve Number for moisture condition 2	35	92	35-94**
2	SHALLST	Initial depth of water in the shallow aquifer (mmH2O)	1000	5000	4000
3	SURLAG	Surface Runoff Lag Coefficient	1	4	2
4	GWQMN	Treshold Depth of wáter in the shallow aquifer required for return flow to occur (mmH2O)	1000	4000	3500
5	ESCO	Soil evaporation compensation factor	0.6	0.98	0.85
6	RCHRG_DP	Deep aquifer percolation fraction	0.05	0.25	0.1
7	ALPHA_BNK	Baseflow alpha factor for bank storage (days)	0.2	0.9	0.55
8	GW_REVAP	Groundwater “revap” coefficient	0.02	0.2	0.02-0.1**
9	EPCO	Plant uptake compensation factor	0.5	0.8	0.56
10	CH_N(2)	Manning’s N value for the main channel	0.02	0.1	0.04-0.1*
11	CH_K(2)	Effective hydraulic conductivity in main channel alluvium (mm/hr)	0.001	0.025	0.004-0.025*
12	ALPHA_BF	Baseflow alpha factor (1/days)	0.1	1	0.52
13	OV_N	Manning’s N value for overland flow	0.01	0.48	0.011-0.41**
14	GW_DELAY	Groundwater delay time (days)	15	80	65
15	REVAPMN	Treshold depth of wáter in the shallow aquifer for “revap” or percolation to the deep aquifer to occur	350	1000	500

RESULT : MODEL CALIBRATION





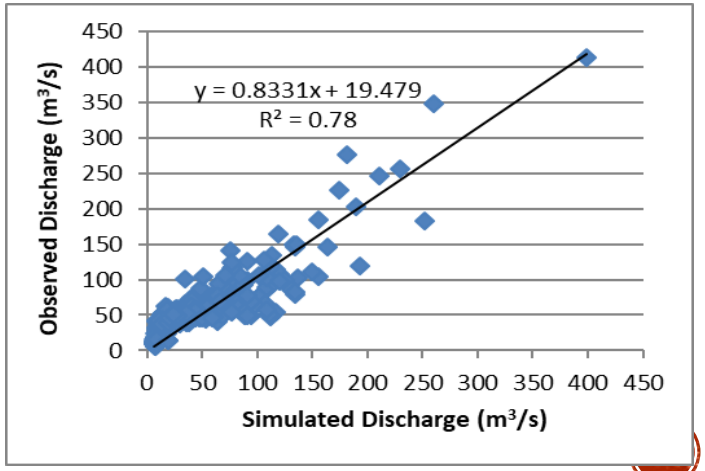


Uncalibrated

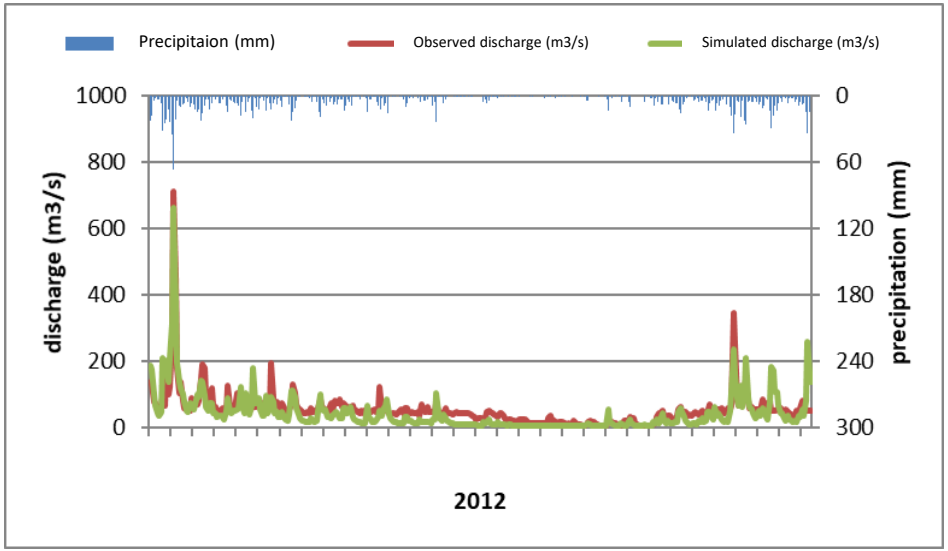
$R^2 = 0.36$
NSE = 0.17

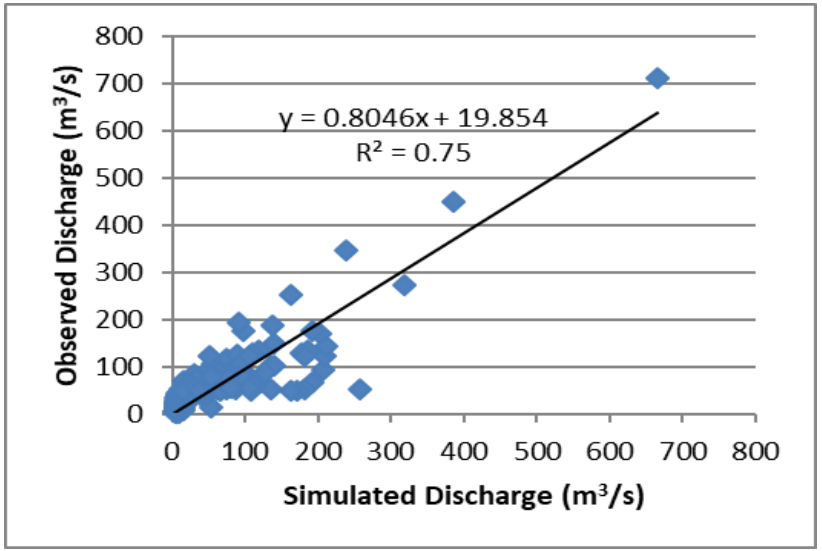
Calibrated

$R^2 = 0.78$
NSE = 0.67



RESULT : MODEL VALIDATION



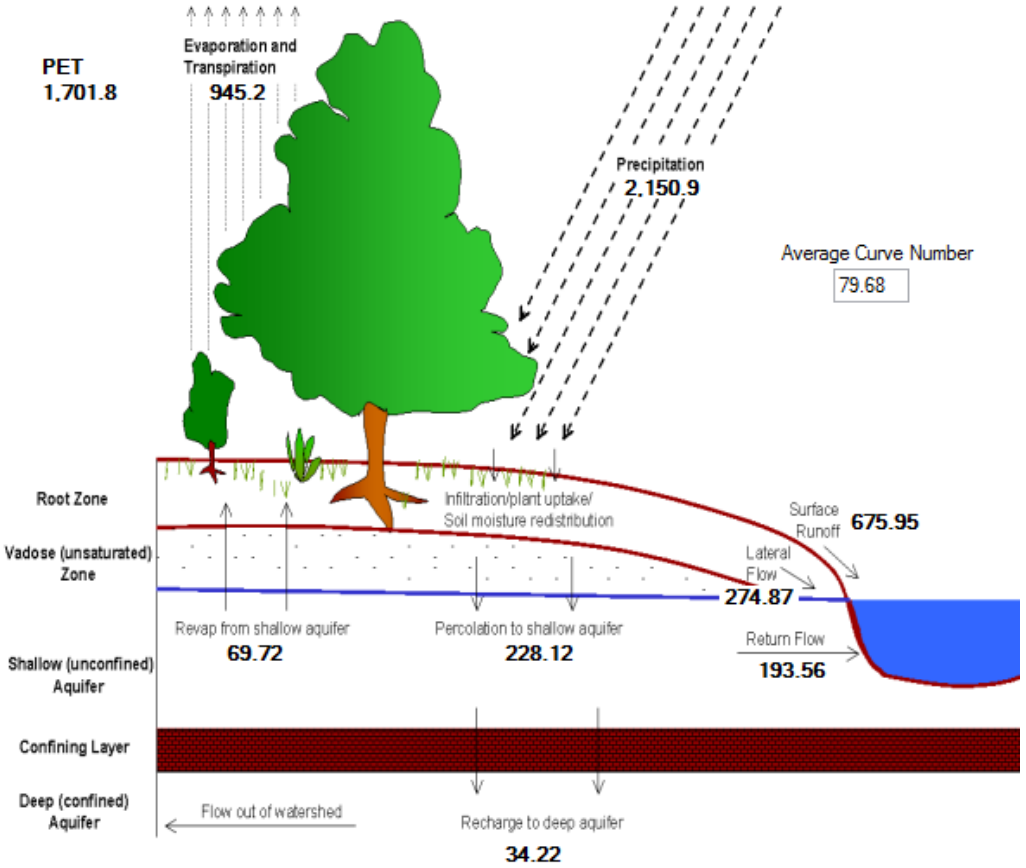


Validated

$R^2 = 0.75$

NSE = 0.67

RESULT : WATER BALANCE



RESULT : MODEL SIMULATION

	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Qmax	511.8	493.1	480.0	510.3	**457.0**
Qmin	2.6	3.3	4.4	3.3	**5.0**
Qmax/Qmin	198	148	109	155	**91**

Scenarios	PCP	SURQ	Δ SURQ		LATQ	Δ LATQ		GWQ	Δ GWQ	
	mm	mm	mm	%	mm	mm	%	mm	mm	%
Baseline	1873	575	-	-	236	-	-	211	-	-
1	1873	487	-87	-15	276	39	19	218	7	3
2	1873	400	-175	-30	286	50	23	279	68	**32**
3	1873	515	-60	-10	262	26	12	204	7	3
4	1873	393	-182	**-32**	288	52	22	240	29	1

1. Floods is the most common natural disaster in Indonesia
2. SWAT model can be used to predict flow discharge in ciujung Watershed
3. SWC practices with mechanical method is the best management practices to reduce surface runoff
4. Degraded land rehabilitation (reforestation and agroforestry) is the best management practices to increase ground water storage

CONCLUSION


THANK YOU
TERIMA
KASIH

DATA TEKNIS BENDUNGAN KARIAN

Scheme	Description
Catchments area	288 km^2
DAM type	CCRD
DAM crest elevation	72.5 EL.m
Flood high water level	70.85 EL.m
Normal high water level	67.5 EL.m
Low water level	46.0 EL.m
Maximum DAM height	60.5 EL.m
Reservoir area	1,740 Ha
Effective storage volume	207.48 million
Embankment volume of main DAM	1.23 million
Design flow discharge	
a. Inflow	3,672 (lt/s) atau 3.672 (m^3/s)
b. Outflow	3,190 (lt/s) atau 3.190 (m^3/s)
Spillway gate	
a. Type	Radial gate
b. Dimension	2 nos x width 12.5m x height 14.2 m
Side overflow spillway weir	50.0 m
Flood control volume	60.8 million

Scheme	Description
Length	36.5 km
Type of conveyance	Pressured by pump
Maximum flow capacities	12.4 cm/s atau 0.124 m/s
Type of waterway	Steel pipeline
Dimension	Dia 2.0 x 2 (20 km) Dia 1.4 x 2 (16 km)
Related Structures	
a. Booster pump station	1 nos
b. Railway crossing	1 nos
c. Control valves	280 nos
d. Flow meters	5 nos