

Land Use for Keeping Water Balance Case Study in Cidanau Watershed, Indonesia

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1. INTRODUCTION

In Indonesia, the population of many cities has been increasing, and the watershed faces problems of maintaining water. The Cidanau watershed, located in the Serang Regency and Pandeglang Regency in the Banten Province of Western Java (Fig. 1), has experienced a drought in the dry season and flood during the rainy season¹. Many researchers have predicted that the Cidanau watershed cannot meet the water demand for all activities. The Serang Regency consists of the sub-districts of Padarincang, Ciomas, Mancak, Gunungsari, and Cinangka while the Pandeglang Regency consists of only the sub-district of Mandalawangi. The Cidanau watershed serves as a water resource to fulfill the need of people living in the Serang Regency and Pandeglang Regency as well as the industrial activities in the Cilegon Municipality, which is in the neighborhood of those regencies².

This paper aims to analyze land use in the Cidanau watershed area and prescribe the watershed condition through spatial planning and water resource management of the Cidanau watershed.



Figure 1. Cidanau Watershed

2. LAND USE AND WATER BALANCE

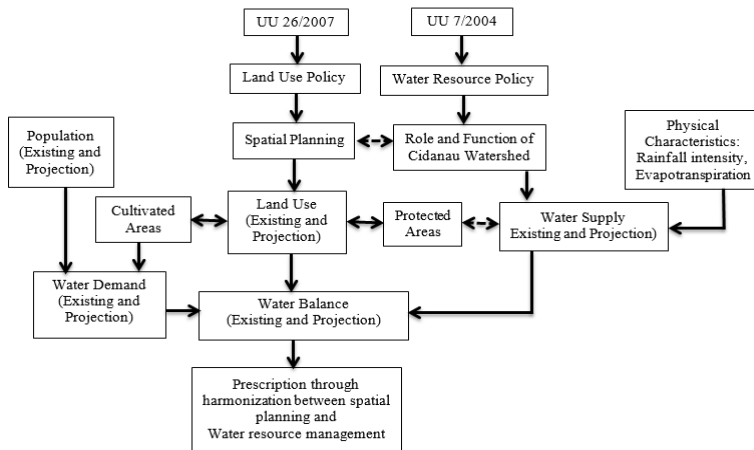


Figure 2. Research framework

Law Regulation Number 26 Year 2007³ stated that spatial planning includes spatial structures and patterns. In spatial patterns, land is classified into protected areas and cultivated areas. Kodoatie and Syarif (2010)⁴ explained that protected areas serve as a recharge area or the venue for groundwater replenishment whereas cultivated areas function as a discharge area where groundwater is used.

Figure 2 shows the framework of this research, indicating that land use has a relationship with water supply and water demand affected by the population and activities of the land. Land use conditions affect the movement of water.

Figure 3 shows the framework and flow of this research. The analysis process is based on the water balance analysis, which is viewed from the aspect of the amount of water availability (supply: Q_s) and water utilization (demand: Q_d).

Water supply in relation to land use can be calculated by using an empirical approach-namely, by using the following modified rational formula:

$$Q_s = 1 - C \times (P - ET) \times A \dots \dots (1)$$

Where: Q_s : Water supply debit ($m^3/year$), C :

Run off coefficient

P : Precipitation ($mm/year$) $\rightarrow 2355 \text{ mm/year}^5$

ET : Evapotranspiration ($mm/year$) $\rightarrow 1023 \text{ mm/year}^5$

A : Area (m^2)^{6&7}

Meanwhile, water demand (Q_d) is related to the cultivated type of land use. This includes several activities: settlement area, plantation area, farming area, and so on. Water demand (Q_d) depends on the number of people or the area of each land use. Q_d and the standard coefficient (K) for demand are estimated using the following formula:

$$Q_d = K \times N \dots \dots (2)$$

Where: Q_d : Water demand debit ($m^3/year$)

K : Standard Coefficient using coefficient from SNI 19 19-6728.1-2002⁸; K for Settlement area (K_s): 120 L/Day/People; K for Plantation (K_p): 0.25L/Second/Ha; K for Farming area (K_f): 1L/Second/Ha; N : Number of people or Area of land use (m^2)

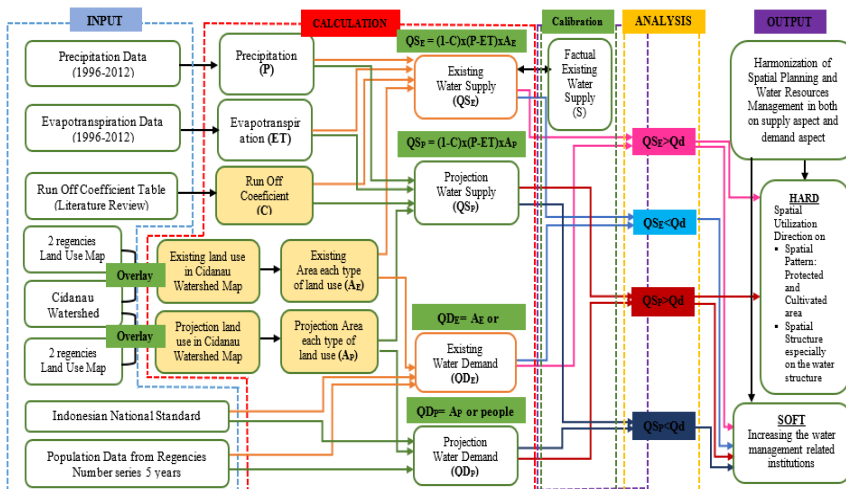


Figure 3. Research framework and analysis flow

3. DATA ANALYSIS AND DISCUSSION

Figure 4 shows the present condition of Cidanau watershed. It is clearly seen that the percentage of cultivated area which dominated with plantation and Farming area is 67% while the protected area is 33%. Compared with **Figure 5**, it informs the percentage of cultivated area and protected area in the planning condition which are 75% and 25% respectively.

Moreover, **Tabel 1** and **Tabel 2** show land use area of each type, water supply and water demand. It can be seen in **Tabel 1** that present water supply is 116,246,585 m³/year and water demand is 125,407,667 m³/year. While in **Tabel 2**, water supply and water demand in 2031 are estimated as 110,448,746 m³/year and 141,105,894 m³/year respectively. In general, those tables show that the water demand is outweigh the water supply in both conditions. In particular, there is slightly different of the water supply today in comparing with the plan condition which decrease about 5%. However, it gives significant change in water demand. It is also predicted that the water demand will increase and will outweigh the water supply up to 30,657,148 m³/year.

The percentages of CA and PA for balance the water demand with water supply can be estimated at 47% and 53%, respectively. Although, in the Spatial Plan, rehabilitation and stabilization functions of water catchment areas and river banks area, control the spatial utilization, and restrict cultivation activities in water catchment and riparian areas, water conservation measures are list up as water conservation measures, there is no concrete program for the balancing. Another solution may be to change about 4% of CA to reservoir. It is not easy to find feasible programs for this. But it is required for the local government to improve the land use plan by considering the water balance.

4. SUMMARY

- (1) The results of the analysis at present (2008) and in the planned condition (2031) showed that the water demand outweighs the water supply in certain conditions.
- (2) These results indicate that the local government should manage land use to maintain the balance in the water supply and demand.

References

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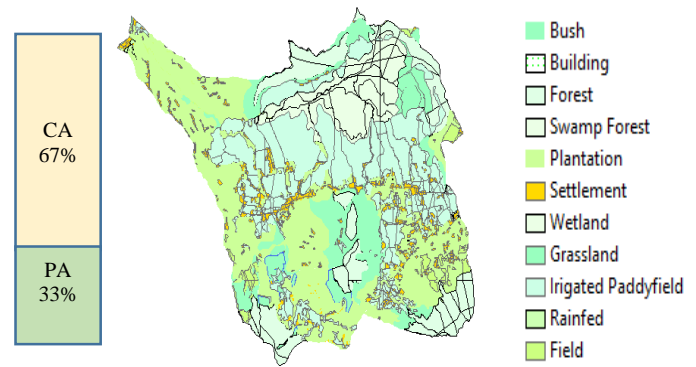


Figure 4. Existing land use Cidanau watershed

Table 1. Existing land use, water supply and water demand

Land Use	Synchronized Land Use	Area	C	ET	I	Q Supply	Q Demand
		m2		mm	mm/year	(I-C)*(I-ET)*A	K*N
						m³/year	m³/year
Cultivated Area							
Settlement	Settlement Area	9,953,655	0.8	1332	2355	2,036,518	17,438,803
Building	Other Used Area	5,245	0.9	1332	2355	537	765,776
Plantation	Plantation Area	71,041,397	0.6	1332	2355	29,070,140	56,009,038
Field		4,207,695	0.6	1332	2355	1,721,789	3,317,346
Irrigated Paddyfield	Farming Area	60,526,120	0.5	1332	2355	30,959,110	47,718,793
Rainfed		200,293	0.5	1332	2355	102,450	157,911
Cultivated Area		145,934,405	67%				125,407,667
Protected Area							
Grassland	Local Protected Area	3,219,237	0.4	1332	2355	1,975,968	
Bush	Green Open Space	25,011,512	0.4	1332	2355	15,352,066	
Forest	Area that provides	26,462,369	0.3	1332	2355	18,949,703	
Swamp Forest	protection against	9,962,603	0.2	1332	2355	8,153,394	
Wetland	subordinates region	8,607,485	0.1	1332	2355	7,924,912	
Protected Area		73,263,207	33%				
Total Area		219,197,612				116,246,586	125,407,667

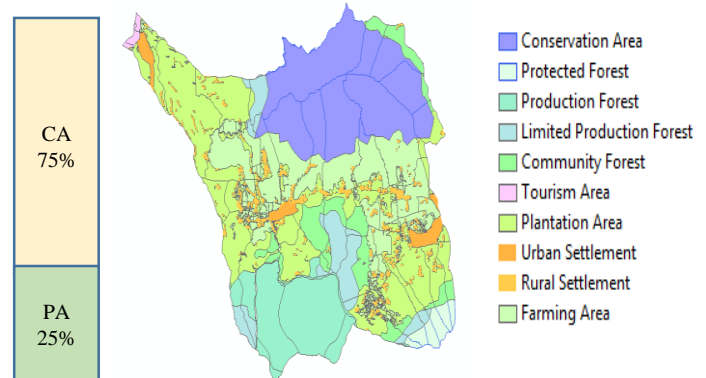


Figure 5. Land use plan of Cidanau watershed in 2031

Table 2. Land use plan, water supply and water demand in 2031

Land Use Plan	Synchronized Land Use Plan	Area	C	ET	I	Q Supply	Q Demand	
		m2		mm	mm/year	(I-C)*(I-ET)*A	K*N	
						m³/year	m³/year	
Cultivated Area								
Rural Settlement	Settlement Area	8,372,422	0.8	1332	2355	1,712,998	14,668,484	
Urban Settlement		4,458,371	0.9	1332	2355	456,091	7,811,066	
Plantation	Plantation Area	61,026,991	0.6	1332	2355	24,972,245	48,113,680	
Farming Area	Farming Area	38,856,387	0.5	1332	2355	19,875,042	30,634,376	
Limited Production Forest	Production Forest	12,930,604	0.4	1332	2355	7,936,805	10,194,488	
Production Forest		22,793,701	0.6	1332	2355	9,327,183	17,970,554	
Community Forest		14,507,863	0.6	1332	2355	5,936,617	11,437,999	
Tourism	Tourism	754,103	0.9	1332	2355	77,145	275,247	
		163,700,443	75%				141,105,895	
Protected Area								
Conservation Area	Conservation Area	51,459,063	0.3	1332	2355	36,849,835		
Protected Forest	Protected Forest	4,038,106	0.2	1332	2355	3,304,786		
		55,497,169	25%					
		219,197,612					110,448,746	141,105,895