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Landscape Ecology Analysis to Assist Water Requirement Mapping on Upland Area of Electric Micro-Hydro Instalation (Ciambulawung Watershed), Lebak Picung, Banten Province

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ABSTRACT

Sustainability in food and energy supply has been one of important agenda to Indonesia. There have been abundant efforts to obtain such accomplishments. However, many Indonesian rural regions have confronted considerable food and energy sustainability. In many cases, comprehending sustainability is difficult due to lacking of data. This include Lebak Picung site although the site is fairly close to many prominent in West Java and Banten.

During several field trips, substantial datasets were obtained, including rainfall, discharge and land use. These primary data, along with secondary information, delivered a first endeavor to study food and energy sustainability in Lebak Picung site. Due to inadequate data, assessment of rainfall was made possible using Bayah meteorological station, assuming there was no significant partiality between two sites. Analysis of Bayah data showed that there was divergent rainfall during dry and rainy seasons. This finding was also concluded in dry season field survey (July 2011). These variable rainfall records were also aligned with discharge measured in both seasons. We found that Lebak Picung people wisely became accustomed to this circumstance by implementing once rice planting season per annum. They also attempt to conserve neighboring forested landscape. These prudent practices would save enough water from extensive irrigation needs.

By developing a simple arithmetic rule, this research endeavored to account water availability in the watershed. Following variables were utilized: rainfall, domestic uses, vegetal water requirements and microhydro water supply. It was inferred that Lebak Picung had a very limited amount of water availability, which may lead to constrained food and energy in dry season. In contrary, there would be no noteworthy problems in wet season or in situation where local inhabitants sustain once-only rice planting every year. Nonetheless, it was concluded that hydropower seemed exhibit such problems since discharge in dry season was fairly low.

I. INTRODUCTION

1.1 Background

Sustainability in food and energy has been one of emerging issues in developing countries including Indonesia. Previously, many efforts have been made to achieve food sustainability across the nation. These included expansion of rice fields and intensification through various ways, such as the SRI (Systems of Rice Intensification) (Dobermann, 2004). However, recent date

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shows that problems in energy in Indonesia have become apparent.

Lacking of energy supply from PLN (national state enterprise of electricity) has driven some endeavors to look after alternative energy sources. This includes bio-energy, thermal and solar cells. Bio-energy has been a promising energy source, despite shortage of advance research and industrial challenge. Geothermal energy has been exploited as well, such as of Wayang Windu (Bogie et al. 2008) and Karaha-Telaga Bodas (Nemcok et al., 2007), nonetheless, the capacity has been very small (Lund and Freeston, 2000). Although solar cells could be potential, it requires good energy saving devices and should be optimally operated during daylight.

Another prospective option is water. Some small-scale power generators were established under the Corporate Social Responsibility programs, including the one in Lebak Picung kampung in Lebak, Banten Province. Nonetheless, the installation should be backed by thorough observations on climatic, hydrologic and land use data to ensure continuous, reliable supply of electricity. In addition, there is a need to observe water requirement on various landscape to assist better water management, since there is competing water use between hydropower, domestic use and rice field irrigation. Therefore, a research to address this problem should be performed.

1.2 Purpose

The aims of the research are to assess potentials of stream flow to support various water uses and study strategies of maintaining sustainability of small watershed.

II. METHODOLOGY

2.1 Datasets

To achieve the goal, several data that were acquired and compiled, includes:

1. Maps: basemaps (topography) and thematic maps (geology, soil, land system, land use and forest management)
2. Satellite imageries: Shuttle Radar Topography Mission (SRTM) C-band and ALOS AVNIR-2
3. Climate: rainfall
4. Hydrology: tributaries and discharge.

2.2 Field Surveys

Three field surveys were managed during the research. The first was a pre-survey and was designed to set up 5 rainfall gauges across the watershed. A thorough field survey to collect soil and hydrological data was conducted in second week of February 2011. About 90 soil samples were collected at two levels of soil depth throughout lower basin, which was the primary target. Additional thorough field visit was conducted in July 2011 to observe and collect data in upper basin. Figure 1 show the location of study.

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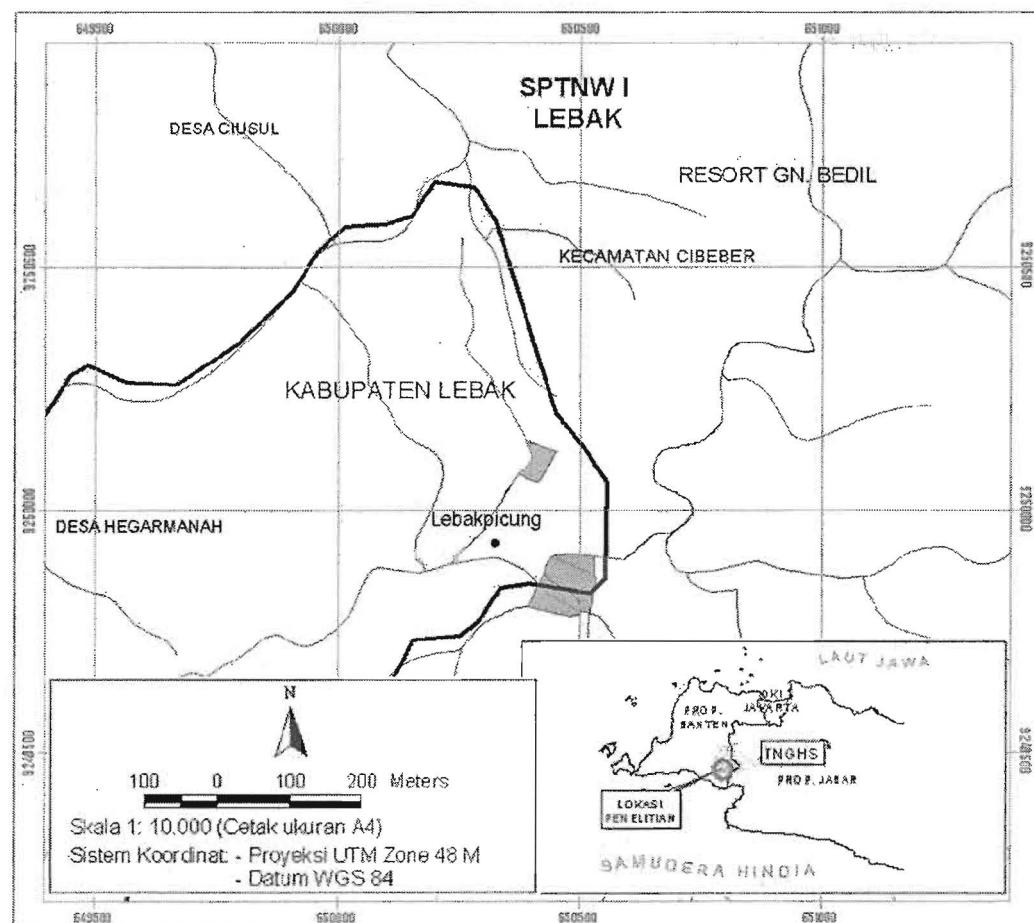


Figure 1. Location of Study

2.3 Data Analysis

Updated land use information is one of primary data required in this research. The data were mainly constructed through visual image interpretation of ALOS AVNIR-2 imagery acquired in 2009. In order to fill gaps due to cloud cover, the research also exploited Google Earth dataset, again using visual interpretation. Primary interpretation keys to discriminate various land covers were tone, texture, association, and shape.

Prior visual interpretation, remotely sensed data were pre-processed using national base maps (BAKOSURTANAL's Rupa Bumi Indonesia). Geometric correction of remote sensing data requires a set of tie points which were visually identifiable both in the field and in visual appearance. To align the image according to the base map, bilinear interpolation was used. This interpolation technique is a compromise between positional accuracy while subsequently maintains image properties, such as tone and texture.

To assist spatial analysis, additional thematic datasets such as forest management and thematic maps were also collected. Some information, including slope, were extracted from digital elevation model. There are some

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sources of digital elevation model: (a) topographic maps at scale of 1:25,000; (b) SRTM; and (c) ASTER GDEM. To avoid misjudgment in proper DEM selection, a preliminary observation was constructed. The result was presented in a seminar (Proceedings-GeoSARNas, 2011).

Rainfall data were problematic since there is no meteorological station nearby the research area. To obtain the data, 5 conventional rainfall gauges were established in the Ciambulawung watershed (Figure 2). The gauges were visited daily to obtain daily-basis rainfall data on the test site.

Discharge data were obtained during 2 field surveys, i.e. in wet and dry seasons, using current meter. To obtain minimum discharge related to rainfall intensity and land use, this research employed water balance equation as follows:

$$\text{Water Storage/Supply} = R - WR_{ref} - DU - HP$$

where:

R = Rainfall

WR_{ref} = Water requirement of rice and forest

DU = Domestic water used

HP = Hydropower requirement.

III. RESULT AND DISCUSSION

3.1 Rainfall Data

Rainfall data are one of important datasets in this research. Five conventional rain gauges were settled to assist the research. However, the data are insufficient to conclude general rainfall pattern. To comprehend the pattern, we first employed meteorological data recorded by Bayah Station, one of the nearby meteorological stations. Figure 2 presents fluctuating rainfall records between 2008 and early 2011.

Rainfall (mm)

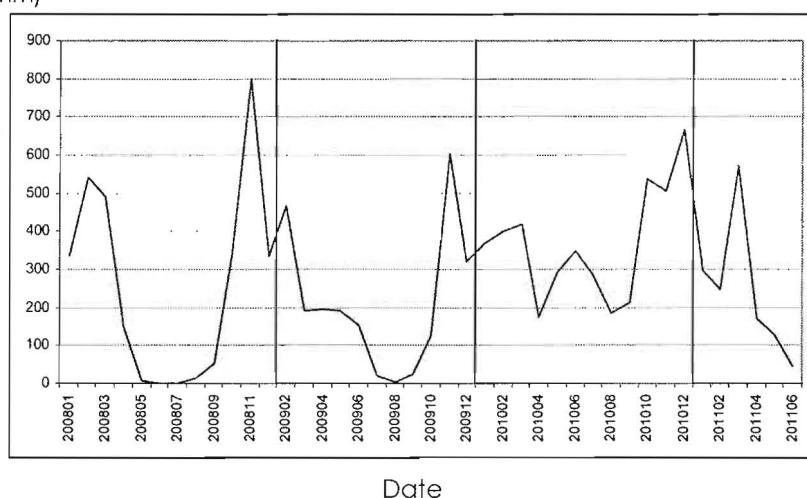


Figure 2. Rainfall data (Bayah Station)

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It appears that Southern Banten region has about 4-5 months of dry season with monthly rainfall records nearly zero. In the 2010, effects of La Nina as reported by Australian Government Bureau of Meteorology (BOM, 2011) are clearly seen in the figure. First semester of 2011 seems following original condition of 2008. Based on Bayah the data, 2008-2010 yearly average could be computed easily. We obtained **3,253 mm** of yearly average rainfall.

3.2 Discharge

In order to observe actual flows of Ciambulawung river, two direct measurements were conducted during wet season (February 2011) and dry season (July 2011) field surveys (Table 1).

Table 1. Discharges at rainy and dry seasons observed during field surveys

Point	X	Y	Wet (L/s)	Dry (L/s)	Deficit (L/s)
A	650432	9249889	242.71	47.60	195.11
B	650705	9249927	153.60	28.54	125.06
C	650679	9249908	39.45	16.20	23.25
D	650707	9249882	66.15	15.96	50.19
E	650718	9249857	26.03	4.55	21.48
F	650718	9249864	39.30	13.05	26.25
G	650685	9249945	118.23	51.38	66.85
H	650671	9250043	206.10	35.21	170.89
I	650671	9250045	112.38	49.25	63.13

Point A (outlet, hydropower site) is located within the main course of the Ciambulawung river. It has highest discharge during rainy seasons. Nonetheless, the table also indicates that substantial deficit was seen in the outlet. Field survey on July 2011 pointed out that water deficit on the turbine was fairly severe, and local inhabitants experienced many blackouts during the dry season.

3.3 Land Use

ALOS AVNIR-2 and Google Earth images were employed for land use mapping (Figure 3). Field visit to verify satellite-derived land use information was taken in February 2011 and successfully acquired 50 point observations. Acreage of each land use class is presented in Table 2.

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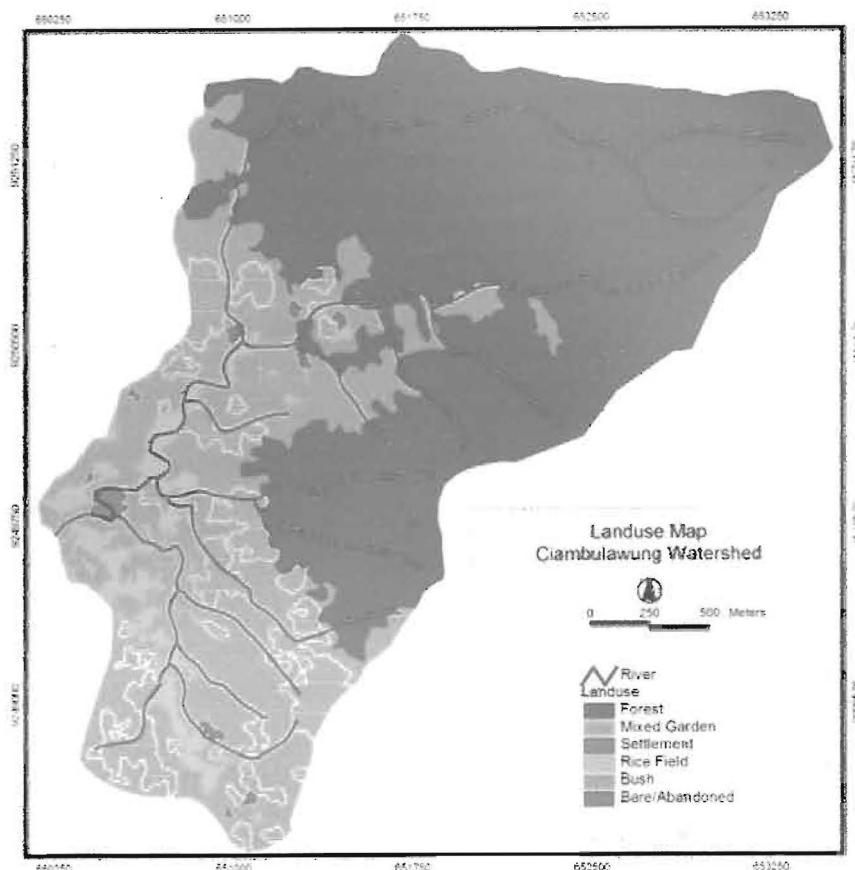


Figure 3. Land use map.

Table 2. Land use classes in Ciambulawung sub watershed

Land use class	Total (ha)
Forest	326.57
Mixed Garden	155.67
Settlement	1.65
Rice Field	26.52
Bush	42.62
Bare/Abandoned	2.02
Total	555.05

3.4 Water Availability

In this research, water availability was computed using following arithmetic operation:

$$\text{Water Storage/Supply} = R - WR_{ref} - DU - HP$$

where:

R = Rainfall

WR_{ref} = Water requirement of rice and forest

DU = Domestic water used

HP = Hydropower requirement.

Yearly average rainfall data was computed in Section 3.1., that is **3,253 mm**.

Water loss by means of evapotranspiration was accounted by only considering two major land use types: forest and rice fields. Specifically for rice fields, we used Arsyad's findings, i.e. 4.09 mm/day (for dry season) and 5.08 mm/day (for wet season). These values were then extrapolated into yearly basis using following assumptions: 4 months (once rice planting season per annum).

$$\text{Water_loss_rice} = (5.08 \text{ mm/day} \times 30 \text{ days} \times 4 \text{ months}) = \underline{609.6 \text{ mm.}}$$

Water loss by forest was estimated using Ciwulan watershed (Onrizal, 2005) mentioning the fact that Ciambulawung watershed is also dominated by forest.

$$\text{Water_loss_forest} = 109.0 \text{ mm/month} \times 12 \text{ months} = \underline{1308 \text{ mm.}}$$

Therefore, estimated water loss by evapotranspiration is **1917.6 mm**.

To compute domestic water use, this research employed general water requirement by a household as described in Triatmojo (2008) i.e. 82.5 L/person/day. Assuming Lebak Picung population was still 54 households and each household had 4 members, estimated water required by all population is 17,820 L/day or about 6,504,300 L p.a or $65043 \times 10^8 \text{ mm}^3 \text{ p.a}$. Again assuming these value was required by solely settlement areas (1.65 ha), it was estimated that domestic requirement of water is :

$$\frac{65043 \times 10^8}{165 \times 10^8}$$

which leads to **394.2 mm**. Compared to estimated rainfall, domestic use water requirement is fairly small (about 12%).

In this research, we used an approximation from previous work by Sudargana et al. (2005) which estimated suitable discharge for Lebak Picung microhydro turbine (10 KVA) at 0.1274 m³/sec or 4017686.4 m³/year. Water requirement for microhydro turbine was then computed using division by watershed acreage (555.05 ha) and resulted **723.8 mm**.

Considering above variables, overall water availability on annual basis was

$$\text{Water Availability} = 3,253.9 \text{ mm} - 1917.6 \text{ mm} - 394.2 \text{ mm} - 723.8 \text{ mm}$$

$$= 217.3 \text{ mm}$$

This suggests that availability of water to support daily living and continuous supply of energy through hydropower has been sufficient, except during dry season when the river discharge is very small and it is not sufficient at all for the hydro-electric generation. However, the research also found that variability between dry and wet seasons has been high. Therefore, future research should account computation based on each season as an aid to identify critical months in dry season.

IV. CONCLUSION

Securities in food and energy have been substantial to many nations policy, including Indonesia. Numerous efforts were or being implemented to assist such achievements. However, in many remote parts of Indonesia, food and energy sustainability is a real challenge. In some cases, assessing food and energy sustainability is problematic due to unavailable or insufficient data. Lebak Picung site has been experiencing similar problem as well.

Through numerous field visits, important datasets have been captured. This included rainfall, discharge and land use. These primary data, along with secondary information, provided a first attempt to study food and energy sustainability in Lebak Picung site. Due to insufficient rainfall data, assessment of rainfall was made possible using Bayah meteorological station, assuming there was no significant biases between two sites. It was expected that there was contrasting rainfall during dry and rainy seasons. This was confirmed by field survey in dry season (July 2011). These fluctuating rainfall were also reflected in comparison of discharge measured in both seasons. Lebak Picung inhabitants wisely adapt to this situation through once rice planting season per annum and attempt to preserve forested landscape. This would save enough water from extensive irrigation needs.

Employing simple arithmetic rule, this research attempted to account water availability in the site. Following variables were exploited: rainfall, domestic uses, vegetal water requirements and microhydro water supply. It was concluded that Lebak Picung had a small amount of water availability, which may lead to restricted sustainability for both food and energy. There would be no significant problems in wet season or if local inhabitants maintain once rice season every year. A greater problem lies in hydropower sustainability since discharge in dry season seemed fairly low.

Above suggestions should be backed by thorough observation and data collection. It is therefore strongly recommended to continue data collection in selected location in the watershed, especially rainfall and discharge.

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