Physical Land Suitability for Civet Arabica Coffee: Case Study of Bandung and West Bandung Regencies, Indonesia

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Abstract. Indonesia has been widely known as the best Arabica coffee (\textit{Coffea arabica}) producer, in terms of both aspects, quality and number of product. Currently, its production, however, declines to the 3\textsuperscript{rd} rank internationally. Issues emerged in the coffee cultivation are: land unsuitability, low quality of seeds, and poor management. Among Arabica coffee types, wild civet coffee is the most expensive one and harvested from the coffee beans which have been digested naturally. The study aims to determine the physical suitability of land as well as the constraints related to land for civet Arabica coffee in selected study cases, e.g., Bandung and Bandung Barat. The research methods employ multi-criteria analysis, and combined with weighted overlaying techniques for mapping. The criteria include temperature, rainfall, humidity, duration of dry season, slope, altitude, type of soil, soil texture, and erosion potential. Parameters of civet (\textit{Paradoxurus hermaphroditus}) are land use, altitude, and temperature. Local policy strongly supports the extensive management for land and the increase of coffee export. Processing data involved matching the comparison between guideline requirements for the land suitability classes, characteristics of Arabica coffee and civet habitat. The results covered the profile suitable land of the civet \textit{Arabica coffee} in the study areas.

Keywords: land suitability, civet arabica coffee, Bandung

1. Introduction

Coffee cultivation was introduced to Java in 1696. It spread to other Indonesian regions due to greater demand and geographically suitable for coffee [1, 2, 3]. The total area of coffee plantation is 1,230,495 ha. However, the Country dominance as the major coffee exporter continues to decline [2, 3, 4]. National productivity was only 761 kg/ha in 2015 compared to the 2\textsuperscript{nd} biggest Vietnam that reached 2000 kg/ha. The main challenges of national coffee are low productivity and poor quality. Classic obstacles include: largely (96.07\%) cultivated by smallholder farmers; and nearly 25\% of the existing area are not productive nor classified as suitable [5], [6]. Global Arabica consumption amounts to 70\%. Conversely, of the national coffee export, Arabica simply shares 15\% [4,5].

Coffee plantation occupies 12,000 ha in Bandung district [7]; and 1,406 ha in West Bandung [8]. The District governments implement policy to increase the export and expanding coffee farming. However, research on the suitable area for sustainably coffee farming is inadequate [9]. Belongs to
Rubiaceae family, Coffea arabica is considerably to have higher quality and therefore used for most premium coffee [10]. Key factors to have optimum coffee yield includes physical environment, practices of agricultural management, and genetic resources [11]. In Indonesia, optimum growing conditions are characterized by an altitude of 700-2,000 m a.s.l., annual rainfall 1,500-2,500 mm, temperature of 15-25°C, 3 months of dry season per year, and fine-textured soils as well [13].

Luxury (wild) civet Arabica coffee (kopi luwak) involves Asian palm civet (luwak pandan or luwak) digesting Arabica coffee cherries and mixing with enzymes passing through the digestive tract before its feces are collected. Digestive systems of civet give kopi luwak a uniquely rich aroma and smoothly rounded flavour. The quality of the coffee is better as the civet naturally selects the ripest cherries [14, 15, 16]. Luwak are native to tropical jungles and rainforests, mostly in southern China, northern Himalayas, southern India, south-east Asia [17]. Taxonomically, civet is in the Family Viverridae [18, 19]. Civets are highly active nocturnal animals, arboreal, mostly solitary and territorial by nature. Living in a variety of habitats as long as the food and areas they can rest in are available. A single civet needs an average of 17 km² territory and elevation range extend up to about 2,234 m a.s.l [17,20].

Figure 1. Administrative Region of Bandung Regency Source: Thematic Map of Spatial Plan 2007-2027

Figure 2. Administrative Region of West Bandung Regency Source: Thematic Map of Spatial Plan 2009-2029

There are various approaches to study land suitability. This research employs GIS approach on the basis of multi criteria rankings and weights assigned to variable that affect coffee growing and production [21, 22, 23, 24, 25]; and similar approach used to analyze civet habitat suitability. The multi-criteria analysis framework integrates nine physical land constraints for Arabica coffee including temperature, rainfall, humidity, dry season, slope, altitude, type of soil, soil texture, and erosion. As for luwak, the habitat characteristics consist of land use, altitude, and temperature. The study goals are: 1) to analyze land suitability of Arabica coffee; (2) to analyze habitat suitability of luwak; (3) to analyze suitability of civet Arabica coffee; (4) to provide maps of area expansion of civet Arabica coffee.
2. Study Area

Study area of the two districts can be seen in Figures 1-2. Figure 1 shows that Bandung Regency is located between latitudes of 6°41' and 7°19 South and longitudes of 107°22' and 108°5' East. Figure 2 shows Regency of West Bandung is located by latitude 6°53' South and longitude 107°25' East. The total area of districts Bandung and West Bandung covers 1,762,40 km\(^2\) and 1,305,77 km\(^2\). It is inhabited by 3,534,111 (2015); and 1,614,495 (2013). The main source of income in the study areas is industry and agriculture; and agriculture respectively [8, 9].

3. Data and Methodology

3.1. Data

The study uses datasets as summarized in the Table 1. Digitized and tabulated data were obtained from regional (district) spatial plan, including thematic maps of slope, elevation, soil type, temperature, rainfall, humidity, duration of dry month, slope, altitude, type of soil, soil texture, erosion, protected area and land use (scale 1:250,000). Data on micro climate were assembled from Meteorological, Climatological and Geophysical Agency (central and local stations). Data on existing coffee farms was acquired from survey and primary data/interview during field works. The expert opinion ratings were used for determining variable weighting for multi criteria modelling.

| Data set                          | Year             | Source                                                                 |
|----------------------------------|------------------|------------------------------------------------------------------------|
| Climate: rainfall, temperature,  | 2014-2015 (in excel) | Meteorological, Climatological and Geophysical Agency (Central and local stations) |
| relative humidity, duration of   |                  |                                                                        |
| dry months                       |                  |                                                                        |
| GIS thematic maps at a 1:250.000 | 2007-2027 (Bandung District) | 1. Bandung Regency Spatial Plan [25]                                   |
| scale of elevation, slope, soil  | 2009-2029 (W. Bandung District) | 2. West Bandung Regency Spatial Plan [26]                              |
| type and texture.                |                  |                                                                        |
| Land use/cover maps, protected    | 2007             | Indonesian base map                                                    |
| area                              |                  |                                                                        |
| Village maps                      | 2016             | Potensi Desa, BPS [27]                                                 |
| Erosion potential                 | 2015             | Calculated using the method of USLE [28]                               |
| Existing Arabica coffee cultivation | Survey, interview during field works 2016 | Survey, interview during field work                                     |

3.2. Methodology

The methodology used for this study integrates steps as follow:

- **Collecting thematic maps** of elevation, slope, soil type, soil texture that were obtained from geodata of regional spatial plan. Reclassification of classes with respect to Arabica coffee requirement using the spatial analyst tool in ArcGIS 10.3 (2013); **Generating maps of isohyet (climate parameters) using method of interpolating in the ArcGIS 10.3 (2013) software include rainfall, temperature, period of dry month, relative humidity [29]; **Generating map of erosion potential** by applying USLE methods [35] and raster calculation of weighted overlay; **Generating map of land use cover and protected area** was interpolated from Indonesian base map 2007.

- **Multi Criteria Analysis**: weighting is aimed to express the importance of each criteria relative to other criteria that influences the growth rate and coffee yield [29, 30] and civet habitat. The essential criteria were selected and weighted on the basis of expert opinions, scientific references, and
farmer’s experience. The classes of suitability for each criterion was defined and these classes were used as basis for constructing the individual criteria map. Referring to FAO 1976 Framework for land suitability classification, the classes consist of highly suitable (S1), moderate suitable (S2), marginally suitable (S3), not suitable (N) [13, 21, 22]. Table 2 shows criteria and weight for Arabica suitability and Table 3 presents criteria and weight for Asian palm civet suitability.

Table 2. Criteria and weight for Arabica coffee suitability

| Parameter             | Weight (%) | Highly suitable/S1 | Moderately suitable/S2 | Marginally suitable/S3 | Not suitable/N |
|-----------------------|------------|--------------------|------------------------|------------------------|---------------|
| Temperature (°C)      | 0.114      | 4,00-3,25          | 3,24-2,50              | 2,51-1,75              | 1,74-0        |
| Rainfall (mm/year)    | 0.114      | 1.200 - 1.800      | 1.000 - 1.200          | 2.000-3.000            | > 3.000; < 800|
| Dry season month      | 0.114      | 1 - 4              | < 1; 4 - 5             | 5-6                    | > 6           |
| Relative humidity %   | 0.114      |                    |                        |                        |               |
| Elevation (m.a.s.l.)  | 0.136      | 1.100 - 1.750      | 1.750 - 2.000          | 700 – 1.100            | >2,000; <100  |
| Slope (%)             | 0.114      | < 8                 | 8-16                   | 16-30;16-50            | > 30 ;> 50   |
| Erosion potential     | 0.091      | Very low           | Low-medium             | Heavy                  | Very heavy    |
| Soil type             | 0.091      | Andosol, Latosol   | Organosol, top soil    | Regosol                |               |
| Soil texture          | 0.114      | fine               | Moderately fine-medium | Medium-Moderately      | Coarse        |
|                       |            |                    |                        | coarse                 |               |

Source: Analysis, June 2017 and [13]

Table 3. Criteria and weight of civet habitat suitability

| Parameter             | Weight | Highly suitable/ S1 | Moderately suitable/ S2 | Marginally suitable/ S3 | Not suitable/ N |
|-----------------------|--------|---------------------|-------------------------|------------------------|-----------------|
| Land use cover        | 0.4    | Primary & protected forests | Secondary forest, agricultural cultivation, settlement area | fields, moor, shrubs | Paddys field, rivers, lakes |
| Elevation (m.a.s.l)   | 0.3    | 0-2500              |                         |                        | >2500           |
| Temperature (°C)      | 0.3    | 18-20; 30-36        |                         |                        | <18; > 36       |

Source: Analysis, June 2017

- Cross tabulation and overlay the maps of Arabica coffee and civet habitat suitability to create the maps of civet Arabica coffee as can be seen in Table 4.
Table 4. Cross tabulation for civet Arabica coffee suitability

|                | Asian Palm Civet Habitat | Arabica coffee |
|----------------|--------------------------|----------------|
|                | Not Suitable             | Marginally Suitable | Moderately Suitable | Highly suitable |
| Not Suitable   | Not Suitable             | Not Suitable       | Not Suitable       | Not Suitable    |
| Marginally Suitable | Not Suitable         | Marginally Suitable | Marginally Suitable | Marginally Suitable |
| Moderately Suitable | Not Suitable         | Marginally Suitable | Moderately Suitable | Moderately Suitable |
| Highly suitable | Not Suitable             | Marginally Suitable | Moderately Suitable | Highly suitable |

Source: Analysis, June 2017

- **Validation**: suitability maps for Arabica coffee is validated by overlaying them with the 3 (three) existing coffee farms in the field works in villages of Mekarmanik, Margamulya and Cikole areas.

4. Results and Discussion

The overall study results show that Arabica is more suited to be grown in Bandung as more than three fourth of the areas are in the class of highly and moderately suitable. In comparison to habitat suitability of civet, most of the areas (more than 90%) is classified as highly and moderately suitable; and none of the areas that are classified unsuitable.

4.1. Distribution of Arabica coffee land suitability

Based on the criteria selected and weighted scheme, equation to find the suitable class of farming area as follows:

\[
\text{Arabica Coffee Land Suitability (SKA)} = 0.114t + 0.114r + 0.114d + 0.114h + 0.136a + 0.114s + 0.091e + 0.091l + 0.114tx
\]

\[ (4.1) \]

\[ t = \text{temperature} \quad r = \text{Rainfall} \quad d = \text{Dry season} \]

\[ h = \text{Relative humidity} \quad a = \text{Elevation} \quad s = \text{Slope} \]

\[ l = \text{Soil type} \quad tx = \text{Soil texture} \quad e = \text{Erosion potential} \]

4.1.1 Arabica coffee suitability in Bandung Regency

The study site is located geographically in a mountainous region (500-1,800 m.a.s.l) part of the eastern and southern part of the rocky volcanic Bandung basin. Lying on the upper stream area of the Citarum watershed, the rivers of Citarak, Cikeruh, Cirasea, Cisangkyu, Ciwidey dan Cimahi bring a lot of benefits to local people as a source of clean water and agriculture. Annual rainfall in the area ranges from 1,500-4,000 mm/year and the relative humidity from 70 to 78%. During dry season (May-October) the rainfall average is under 2,000 mm. Land sloping towards south is steeper (more than 45%). This condition results in soil susceptible to erosion and avalanche. In addition, land use change and bad attitude of the society towards environment have placed the region as the fourth of disaster-prone in the Country [30].

The study results specify that the suitable zones (highly and moderately) for Arabica coffee growth and production in the region cover an area of 13,688.43 ha (7.73%) and 124,447.1 ha (70.25%) respectively. The remaining portion (38,998.35 ha or 22.01%; and 13.12 ha or 0.01%) is marginally suitable and not suitable respectively. Of the total sub districts (27), Pengalengan sub district provides the largest highly suitable area for the coffee farming (10,802.5 ha). On the contrary, very small area in sub districts of Cicalengka, Cileunyi and Rancaekek areas are classified unsuitable (3.37 ha, 1.75 ha, dan 8.01 ha, respectively). Map of land suitability for coffee growing in the area is shown in Figure 3.
4.1.2 *Arabica coffee suitability in West Bandung Regency*

The morphology of West Bandung area consists of plains, ramps, hills and mountains with altitude ranges of 500-2,000 m.a.s.l. Of the 1,305.77 ha area, 46.68% (59.614,15 ha) is located at an elevation of 500-1000 m.a.s.l; and the rest is at an elevation of 1500-2000 m.a.s.l. In terms of annual rainfall, the area is varying (1500-3,500 mm/year) with the highest amount is in Cikalong Wetan and Cipeundey. The majority of the area has slope more than 40%, and the steepest area can be found at Gununghalu sub district. Batujajar area slope, however, is only 0-8% (Figure 4).
The results revealed that 3.46% (4,296.83ha) of the region area was identified as the most suitable for Arabica coffee; 85,778.60 ha (55%) is moderately suitable area, the rest portion is 27.43% and 7.69 ha or 0.01% as marginally suitable and not suitable respectively. Four out of 13 sub districts in the area have few unsuitability lands for coffee, i.e., Cikalong Wetan (0.76 ha); Cipatat (0.02ha); Cipendeuy (20,39ha); and Gunung Halu (7,07ha). The total area should be deducted by nature reserve area (5,24 ha) and protected forest (21,152.9 ha) of which area prohibited for cultivating activities.

The overall result of land suitability analysis for Arabica coffee in the two regions is summarized and presented in Table 5.

| Table 5. Land suitability for Arabica coffee in study areas |
|-------------------------------------------------------------|
|                | Highly suitable/ | Moderately suitable/ | Marginally suitable/ | Not suitable/ | Total Area (ha) |
| Suitability Classification/ | S1               | S2               | S3               | N             |                     |
| **Bandung**    |                  |                  |                  |               |                     |
| Arabica coffee | 13,688           | 124,447          | 38,998           | 13            | 177,146            |
| %              | 7.73%            | 70.25%           | 22.01%           | 0.01%         | 100%               |
| Nature reserve | 1,761            | 12,929           | 683              | 0             | 15,373             |
| Protected forest| 4,080            | 31,881           | 1,730            | 0             | 37,691             |
| Wilderness area | 0               | 974              | 42               | 0             | 1,016              |
| **West Bandung**|                  |                  |                  |               |                     |
| Arabica coffee | 4,297            | 85,779           | 34,043           | 7             | 124,126            |
| %              | 3.46%            | 69.11%           | 27.43%           | 0.01%         | 100.00%            |
| Nature reserve | 0               | 5               | 0               | 0             | 5                  |
| Protected forest| 3,529            | 16,730           | 894              | 0             | 21,153             |

Source: Analysis, June 2017

Physical characteristics frequently used for Arabica suitability analysis and evaluation are topography, climate and soil [31]. In this study, it was expanded to be slope, altitude, type and texture of soil, temperature, humidity, the length of dry season, and potential erosion. Altitude is limiting barrier factor for the coffee to grow. The plants are vulnerable from pest and parasites at the elevation of lower than 800 m.a.s.l, and limit by frost which generally occurs at elevations of higher than 1500 m.a.s.l. [31].

On the other hand, coffee productivity is significantly attributable to climate factor [31]. Arabica relishes some altitude-influenced temperatures of 18-24°C. The role of temperature and duration of sun light can be seen from the formation of the primary branch until the coffee tree flowering. The more sun exposure, the faster the formation of flowers and fruits. Temperature does not directly affect the development of plants but rather its resistance to disease attacks. In practices, coffee farming is commonly combined with shade trees. The benefit of shade trees along with elevation factors, soil types and climates is to control pests and tree diseases because shade trees affect the temperature and humidity and moisture of micro soils [32, 33, 34]. In addition, shade tree plays the role in coffee growth, productivity and flavor [35].

Coffee plantation also requires rainfall between 2000-3000 mm/year for the development of Arabica beans, sensitive to humidity and demand fertile organic sufficiently soil that has good drainage [36, 37]. Most of the soil type and structure in the study areas support the Arabica requirements to grow, particularly in Pengalengan area. As explained above, productivity is more influenced by environment and cultivation techniques, while for bean quality is more influenced by climate factor, that is rainfall. In the rainy season, the size of coffee bean formed is greater [37, 38].
4.2. Distribution of Asian palm civet habitat suitability

Based on criteria selected and weighted scheme, the equation to find the suitable class of luwak habitat area as follows:

\[
\text{Asian palm civet habitat suitability (SHL) = 0.4 pl + 0.3 a + 0.3t } \]

\[ \text{………………… (4.2)} \]

\[ \text{pl = land use t = temperature a = elevation} \]

4.2.1 Asian palm civet habitat suitability in Bandung Regency

The study result clearly demonstrates the habitat suitability distribution for luwak in Bandung. As can be seen in Figure 6, the majority of the region are highly suitable/S1 and moderately suitable/S2 as civet habitat, covering an area of 49,337 ha (27.85%) and 118,356 ha (66.81%) respectively. The remaining 9453 ha (5.34%) is classified as marginally suitable/S3; and no area that is unsuitable for luwak. In the highly suitable class, the area includes nature reserve (1,761 ha) and protected forest (4,080 ha). Similarly, the area of moderately suitable involves protected area (31,881 ha) and wilderness area (974 ha); and 42 ha of suaka margasatwa should be included as marginally suitable. The map of suitability distribution for luwak habitat is shown in Figure 5.

![Habitat suitability map of Asian Palm Civet in Bandung Regency](image)

**Figure 5.** Habitat suitability map of Asian Palm Civet in Bandung Regency

Source: Analysis, June 2017

4.2.2. Asian palm civet habitat suitability in West Bandung Regency

In West Bandung, highly and moderately suitable cover the areas of 21.85 % (27,122 ha) and 96,945 ha (78.10%) as respectively. Of the total 124,126 ha, only 57 ha (0.05%) is categorized as marginally suitable. Contrasting to the other region, nature reserve provides only 5 ha that moderately suitable for luwak, while in protected forest has classes of highly suitable (3,529 ha), moderately suitable (16,730 ha) and marginally suitable (894 ha). Figure 6 illustrates the habitat suitability of civet in this area.
Figure 6. Habitat suitability map of Asian Palm Civet in West Bandung Regency  
Source: Analysis, June 2017

Table 6 presents the summary of the result for analysis for civet habitat suitability in the two regencies.

| Suitability Classification | Highly Suitable/ S1 | Moderately Suitable/ S2 | Marginally Suitable/ S3 | Not Suitable/ N | Total Area (ha) |
|---------------------------|---------------------|-------------------------|------------------------|-----------------|-----------------|
| **Bandung**               |                     |                         |                        |                 |                 |
| Civet habitat             | 49,337              | 118,356                 | 9,453                  | 0               | 177,146         |
| %                         | 27.85%              | 66.81%                  | 5.34%                  | 0               | 100%            |
| Nature reserve            | 1,761               | 12,929                  | 683                    | 0               | 15,373          |
| Protected forest          | 4,080               | 31,881                  | 1,730                  | 0               | 37,691          |
| Wilderness area           | 0                   | 974                     | 42                     | 0               | 1,016           |
| **West Bandung**          |                     |                         |                        |                 |                 |
| Civet habitat             | 27,122              | 96,945                  | 57                     | 2               | 124,126         |
| %                         | 21.85%              | 78.10%                  | 0.05%                  | 0.00%           | 100.00%         |
| Nature reserve            | 0                   | 5                       | 0                      | 0               | 5               |
| Protected forest          | 3,529               | 16,730                  | 894                    | 0               | 21,153          |

Source: Analysis, June 2017

Luwak (pandan) belong to the family of **Viverridae** are known as nocturnal, arboreal and mostly solitary animal. Being native to temperate and tropical forest within and around Asia, however, civet can survive in diverse terrestrial habitat (0-2,234 m.a.s.l), e.g., primary and secondary forests, shrubs, parks, settlement area, or plantations. Their activity is determined by the obtainable food and presence of the areas such as tree hollow and dense foliage where they can rest. Males need a larger territory than females with the range size is 5-20 km². In addition, it is recorded that daily range of males reach 17
km² whereas females up to 1.6 km² for females. To mark the territory, they have perineal scent gland \([14, 17, 20]\).

The research location is dominated by areas with altitudes less than 2000 m.a.s.l whose land-cover varies from agriculture, forests and settlements. The areas provide plenty of food to enable the surviving luwaks. The results of the habitat suitability analysis distinguished the study area in the class of S1, S2, and S3. It should, however, take into consideration that civets are extremely adaptable and opportunistic (omnivore, eating whatever is available).

4.3. Distribution of kopi luwak Arabica land suitability

The final cross-tabulating and overlaying of Arabica and civet suitability results in the map of civet Arabica coffee in the two areas.

4.3.1 Distribution of kopi luwak Arabica land suitability in Bandung Regency

The study area of Bandung is classified as being moderately suitable (71.62%, or 126,877 ha) for civet Arabica coffee. This finding is in agreement with the result of Arabica coffee and civet habitat suitability. The areas mapped as moderately suitable are having necessary requirements, e.g., elevation, temperature, rainfall, relative humidity, soil texture, and land cover with minor limitations. The map of the analysis result is presented in Figure 7.

![Figure 7. Civet Arabica coffee suitability map of Bandung](Source: Analysis, June 2017)

4.3.2 Civet Arabica coffee land suitability in West Bandung District

In West Bandung, result shows that an area of 4,296.83 ha (3.46%) is highly suitable for kopi luwak. The majority area (69.10% or 85,775.84 ha) is moderately suitable; and marginally suitable amounted to 34,043.46 ha (27.43%). The rest (9.77 ha or 0.01%) is classified as unsuitable due to of un-correctable criteria include slope and elevation (Figure 8).
To sum up the result of study, Table 7 presents the distribution kopi luwak suitability in both areas.

| Suitability classification | Highly suitable | Moderately suitable | Marginally suitable | Not suitable | Total area (ha) |
|----------------------------|-----------------|---------------------|---------------------|-------------|-----------------|
| Bandung District            |                 |                     |                     |             |                 |
| Civet Arabica coffee       | 6,408.10        | 126,877.30          | 43,848.45           | 13.12       | 177,147         |
| %                          | 3.62%           | 71.62%              | 24.75%              | 0.01%       | 100%            |
| Nature reserve             | 1,760.78        | 12,928.52           | 682.95              | 0.00        | 15,372.25       |
| Protected forest           | 4,080.43        | 31,880.86           | 1,729.66            | 0.00        | 37,690.94       |
| Wilderness area            | 0.00            | 974.28              | 42.02               | 0.00        | 1016.31         |
| West Bandung               |                 |                     |                     |             |                 |
| Civet Arabica coffee       | 4,296.826       | 85,775.84           | 34,043.46           | 9.77        | 124,125.90      |
| %                          | 3.46%           | 69.10%              | 27.43%              | 0.01%       | 100.00%         |
| Nature reserve             | 0.00            | 5.24                | 0.00                | 0.00        | 5.24            |
| Protected forest           | 3,529.15        | 16,729.82           | 893.93              | 0.00        | 2,1152.90       |

Source: Analysis, June 2017

4.4 Validation
Validation was conducted by overlaying suitability maps of civet habitat, Arabica coffee and the existing coffee farms as surveyed in the field works. The suitable areas are identified as suitable coincide with most Arabica coffee farming at Mekarmanik and Margamulya villages of Bandung District; and Cikole village in West Bandung. The result of validation is presented in Table 8.
Table 8. Validation of civet Arabica coffee suitability

|                      | Nature Preserve | Protected Forest | Non-Conservation | Total   | % hectares |
|----------------------|-----------------|------------------|------------------|---------|------------|
| **Margamulya**       |                 |                  |                  |         |            |
| Moderately Suitable/S2 | 111.10          | 252.76           | 415.06           | 778.93  | 68.04      |
| Highly Suitable/S1   | 0.00            | 329.45           | 36.37            | 365.82  | 31.96      |
| Total                | 111.10          | 582.21           | 451.44           | 1144.75 |            |
| %                    | 9.71            | 50.86            | 39.44            |         |            |
| **Mekarmanik**       |                 |                  |                  |         |            |
| Moderately Suitable/S2 | 507.13          | 793.53           | 0.32             | 1300.66 | 99.98      |
| Marginally suitable/S3 | 0.00            | 0.32             | 0.32             | 0.32    | 0.02       |
| Total                | 507.13          | 793.85           |                  | 1300.98 |            |
| %                    | 38.98           | 61.02            |                  |         |            |
| **Cikole**           |                 |                  |                  |         |            |
| Moderately Suitable  | 177.6344        | 177.6344         |                  | 355.27  | 100        |
| Highly Suitable      | 116.9468        | 116.9468         |                  | 233.89  |            |
| Total                | 294.58          | 294.58           |                  |         |            |
| %                    |                  |                  |                  | 100     |            |

Source: Analysis, June 2017

Figure 9 shows that 68.04% and 31.96% areas in Margamulya are categorized as moderately suitable and highly suitable respectively. However, only 39.44% of the Arabica suitable area is allowed to be cultivated (non-conservation). The rest is classified as nature preserve (9.71%) and protected forest (50.86%).

![Figure 9. Validation of civet Arabica coffee suitability maps in Margamulya coffee farming area](image)

Source: Analysis, June 2017
Similar to Mekarmanik area, the majority (99.98%) of the coffee farming is in moderately suitable class, and the rest (0.32 ha) is marginally suitable (Figure 10).

![Figure 10. Validation of civet Arabica coffee suitability maps in Mekarmanik coffee farming area](image)

Source: Analysis, June 2017

Whereas the whole area in Cikole village is suitable for Arabica farming, in which 60.3% is moderately suitable and 39.7% is highly suitable (Figure 11).

![Figure 11. Validation of civet Arabica coffee suitability maps in Cikole coffee farming area](image)

Source: Analysis, June 2017
5. Conclusions and Recommendation

This study was undertaken as a means of enhancing productivity of civet Arabica coffee in study area. Results show that the total suitable area for Civet Arabica coffee production West the Bandung is 69,808.46 ha, whereas in Bandung is amounted to 31,984.22 ha. Field works validated the Arabica civet coffee productivity of civet Arabica coffee (Kopi Luwak): a

References

[1] Wild A 2005 Coffee, a Dark History (New York: W.W. Norton & Company)

[2] Indarto P 2014 The Road to Java Coffee (Jakarta: Asosiasi Ekspor Kupi Indonesia)

[3] Hoffman J 2014 The World Atlas of Coffee: From Beans to Brewing-Coffees Explored, Explained and Enjoyed (Canada: Firefly Octopus Publishing Group Ltd. Ontario)

[4] International Coffee Organization (ICO) Coffee Statistic 2014

[5] Asosiasi Ekspor Kupi Indonesia (AEKI) 2016 Konsumsi Kopi di Pasar Domestik Naik Pesat. http://www.aeki-ace.org/news/1/laporan-bpp-aeki--2014/56.

[6] Direktorat Jenderal Perkebunan 2016 Produksi Kupi (Jakarta: DJK, Kementerian Pertanian)

[7] Kabupaten Bandung Dalam Angka 2014 http://bandungkab.bps.go.id/index.php/publikasi

[8] Kabupaten Bangli Dalam Angka 2014 http://banglikab.bps.go.id/v2/index/

[9] Jonasson, O 2017 Agricultural Geography. www.jstor.org/stable/10.2307.4996431.

[10] Integrated Taxonomy Information Report IT IS 2016

[11] Bosselman AS, Dons K, Oberthur T, Smith OC, Herman, U 2009 The influence of shade trees on coffee quality in small coffee agroforestry system in Southern Columbia Agriculture, Ecosystems & Environment 129(1-3) pp 253-260 Harvard.

[12] Ridley F V 2010 Department of Biological and Biomedical Sciences University of Durham. The past and future climatic suitability of arabica coffee (Coffea arabica L.) in East Africa Agriculture, Ecosystems & Environment 80(1-2).

[13] Djajunianto D, Marwan H, Subagio H, Hidayat A 2011 Petunjuk Teknis Evaluasi Lahan Untuk Komoditas Pertanian Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian Badan Penelitian dan Pengembangan Pertanian Bogor

[14] Jumhawan U, Putri S P, Yusianto, Marwani E, Bamba T, Fukusaki E 2013 Selection of discriminant markers for authentication of Asian palm civet coffee (Kopi Luwak): a metabolomics approach J Agric Food Chem 2013(33) pp 7994-8001.

[15] Marcone, F M 2004a Composition and properties of Indonesian palm civet coffee (Kopi Luwak) and Ethiopian civet coffee Food Research International 37 pp 901-912.

[16] Marcone, F M 2004b The science behind luwak coffee: an Analysis of the World’s Rarest and Most Expensive Coffee Annals of Improbable Research University of Guelph Ontario Canada 1-2.

[17] Duckworth, J 1997 Ranging Behaviour, Actity, Habitat Use and Morphology of the Malay Civet (Viverra tangalunga) on Peninsular Malaysia and Comparison with Studies on Borneo and Sulawesi Malamalian Biology pp 437-447.

[18] Nowak R M, Paradiso J L 1983 Walker’s Mammals of the World 4th Edition The John Hopkins University Press. Baltimore and London

[19] Grzimek B, Schlager D, Olendorf 2004 Grzimek’s Animal Life Encyclopedia Detroit: Gale.

[20] Duckworth J, Widmann P, Custodio J, Gonzalez A, Jennings G, Veron 2011 Paradoxurus hermaphroditus. The UN Red list of Threatened species http://www.uicnredlist.org/apps/redlist/details/416930.

[21] FAO 1976 Land evaluation towards a revised framework, Food and Agriculture Organization of the United Nations, Rome, Italy.

[22] FAO 2007 Land Evaluation Towards a Revised Framework (Rome, Italy: Food and Agriculture
Organization of the United Nation)
[23] Malczewski J 1999 *GIS and Multi Criteria decision Analysis USA and Canada* (USA: John Wiley & Sons)
[24] Karim Z 2012 Land Suitability Analysis for Coffee Cultivation Using Multi Criteria Evaluati Approach and GIS. *European Journal of Experimental Biology* 4(3) pp 639-648.
[25] Rencana Tata Ruang Kabupaten Bandung Tahun 2007-2027
[26] Rencana Tata Ruang Kabupaten Bandung Barat Tahun 2009-2029
[27] Potensi Desa Tahun 2016
[28] Wischmeier W H, Smith D D 1978 *Predicting Rainfall Erosion Losses—A Guide to Conservation Planning*. U.S. Department of Agriculture, Agriculture Handbook No. 537
[29] ArcGIS spatial analyst 2013 www.esri.com/software/arcgis/extensions/spatialanalyst/
[30] Pohlan H A J, Janssens M J 2010 Growth and production of coffee. Encyclopaedia of life support system (AOLSS) Vol III Oxford UK
[31] Castro L M 2010 *Shade Coffee Plantations A Sustainable Way to Protect Wildlife* US. Fish and Wildlife Service.
[32] Bote A D and Struijk P C 2011 Effects of Shade on Growth, Production and Quality of Coffe (*Coffea arabica*) in Ethiopia. *Journal of Horticulture and Forestry* 3(11) pp 336-341.
[33] Schroth G, Tscharntke T, Clough Y, Bhagwat S, Buchori D, Faust H 2000 Multifunctional shade-tree management in tropical agroforestry landscape. *Journal of Applied Ecology*.
[34] Bufo R, Diwew CC 2004 Flavor: an overview. *Journal Flavor and Fragnance* 1999-104. Manitoba.
[35] Asosiasi Eksportir Kopi Indonesia AEKI 2012 *Produksen Kopi Kesulitan Memenuhi Permintaan Kopi yang Meningkat* http://www.aeki-aice.org/link_aeki.html
[36] Erwiyono R, Yacob RY, Usmad 2012 Pengaruh pola curah hujan terhadap produksi kopi (Banyuwangi) *Pusat Penelitian Kopi dan Kakao Indonesia*.
[37] Pujiyanto 2007 Heading Toward Sustainable Coffee Production 23(1) *Warta Pusat Penelitian Kopi dan Kakao Indonesia* (23)1—10.