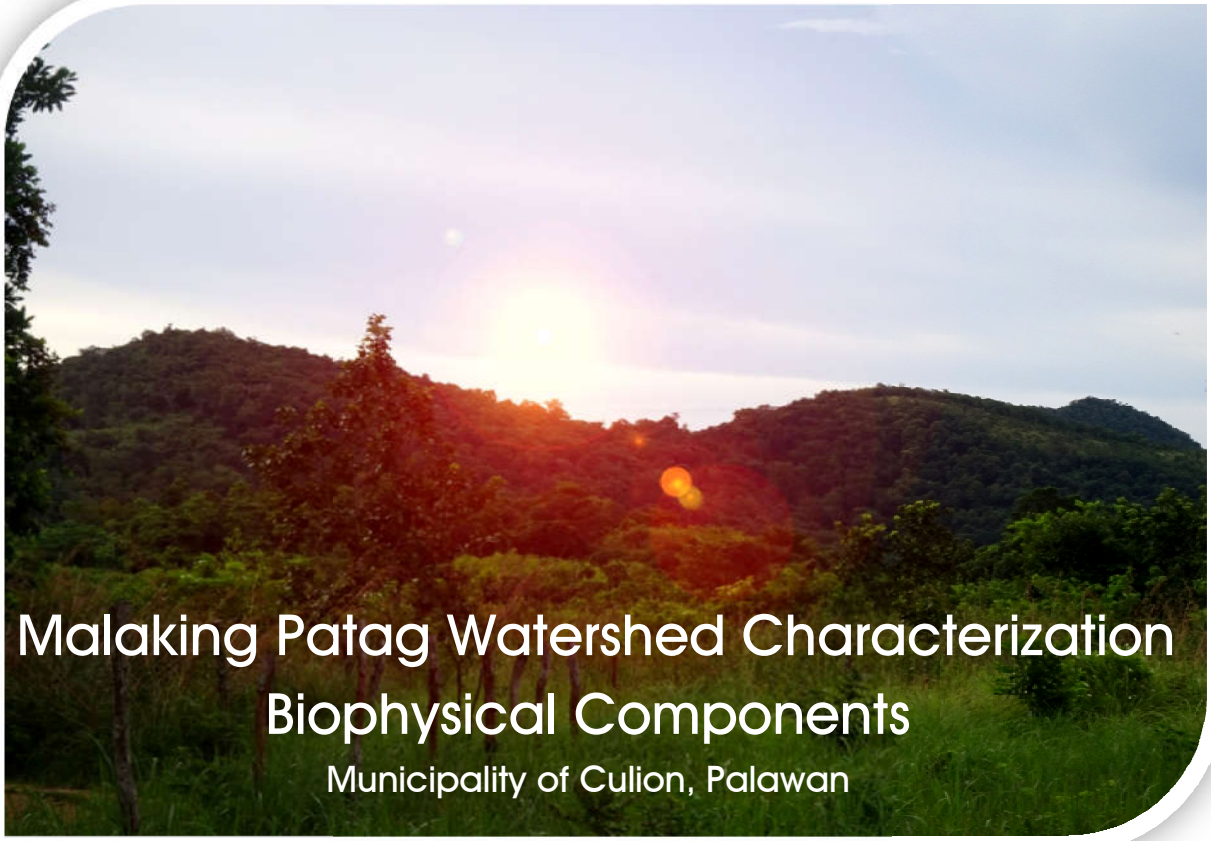
I-C-RESILIENCE PROJECT IN CALAMIANES



Malaking Patag Watershed Characterization Biophysical Components

Municipality of Culion, Palawan

Forest Foundation Philippines

Cordaid

Increasing Resilience through Watershed Mapping and Management Planning (I-C Resilience)

FINAL REPORT

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Cover Photo: Mt. Chinankan, Malaking Patag, Culion, Palawan, by Marvin Jay P. Sarmiento

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1. BACKGROUND

In March 2020, Cordaid together with the Calamianes Resilience Network (CRN) was awarded a project intended for the four [4] municipalities in the Calamianes Group of Islands (CGI) by Forest Foundation Philippines (FFP). The project seeks to come up with plans that will contribute to making CGI resilient, anchored on sustainable development and conservation, and deliver improved environmental services. Scopes of the project are as follows:

1.1. Watershed characterization and vulnerability assessment of four (4) major watershed areas in CGI to include the following:

- Conduct bio-physical assessment of four (4) watershed areas;
- Perform recharge, retention and reuse (3R) and risk assessment (climate and disaster) in the four (4) watersheds;
- Conduct socio-economic assessment in four (4) communities within watershed areas; and,
- Generate technical reports and maps on watershed characterization and vulnerability.

1.2. Enhance community, Civil Society Organizations (CSOs) and Local Government Unit (LGU) partnerships for resilience through capacity building and improved forest governance.

- Increase the capacity of communities and LGU on the forest, wildlife, 3R, Disaster Risk Reduction (DRR) and climate change.

1.3. Multi-stakeholder advocacy strategy on forest and watershed protection, management and conservation support integration of resilience priorities in LGU plans, policies, budgets, and project proposals, to wit:

- Facilitate the promotion, publication, and dissemination of research results;
- Develop programs and strategies to increase investment for forest and watershed protection and management; and,
- Advocate for programs and strategies among LGUs and other stakeholders for climate change adaptation and mitigation and risk reduction initiatives.

Due to the COVID-19 pandemic that inevitably limited the movement of the team for field works due to quarantine requirements and other health and safety protocols, the team implemented modified strategies through digital processing and modeling, data archive collection, virtual data analysis and consultation sessions.

2. SCOPE OF WORK

Watershed characterization was conducted in accordance with the DENR Memorandum Circular 2008-05 wherein the 10 components under the physical environment including flora and fauna were identified and described.

Detailed methodologies were adapted from the manual on Watershed Characterization and Vulnerability Assessment Using Geographic Information System and Remote Sensing developed by the Forest Management Bureau of the Department of Environment and Natural Resources (DENR-FMB). Limitations on field works and other primary data collection due to nationwide quarantine, health and safety protocols were considered in data processing.

3. OUTPUTS AND DELIVERABLES

3.1. Comprehensive technical report for the bio-physical components on four (4) study sites identified in item no. 4.
3.2. Scope of Work under DENR Memorandum Circular 2008-05.

4. APPROACHES AND METHODOLOGY

A pool of consultant had closely coordinated with CRN and Cordaid for the provision of technical and scientific support for the characterization of watershed in Dita Water Source, Malaking Patag, Culion, Palawan.

4.1. Physical Components

4.1.1. Geophysical Characterization

Physical features of the watershed were generated using hydrology plug-ins of open source GIS program following the watershed characterization manual of FMB-DENR (2015). General steps are as follows: 1) filling of imperfections in the Digital Elevation Model (DEM); 2) burning of stream network (when applicable); 3) assigning flow direction in each cell; 4) calculating flow into each cell; 5) creation of pour points; 6) generation of watershed boundaries; and 7) generation of stream order.

Once watershed boundaries and streams are defined, morphometric information can be extracted with the use of GIS processing tools. These are as follows: shape parameters (area, gravel form factor, bifurcation ratio, elongation ratio, circulatory ratio, basin length), relief features (relief ratio, relative relief, elevation, slope,), channel

morphology (stream order, stream length), and drainage texture (drainage density, stream density and length of overland flow).

4.1.2. Topography / Geo-morphological features

Parameters	Data Requirements
A. Watershed-shape	
1. Area: Discuss the effects of peak flow and time for flood flow to reach a given station.	Area – DEM
2. Gravelius form factor = $Gf = \frac{\text{Average width}}{\text{Axial length of basin}}$ Discuss the relationship of the basin form factor with intense rainfall.	Width – DEM Axial Length basin -DEM
3. Bifurcation ratio: Discuss the ratio of the number of streams (in the watershed) of any given order to the number of the streams in the next lower order and its influence on flood discharges. $R_b = N_u/N_{u+1}$ Nu = Total number of stream segments of order 'u' Nu+1 = Number of stream segments of the next higher order	River network– (DEM)
4. Elongation ratio: Discuss the ratio between the diameter of a circle with the same area as the watershed and the maximum length of the watershed (which is the distance from the outlet to the farthest point in the watershed) $R_e = (2/L_b)[(A/\pi)^{0.5}]$ A = Area of watershed Lb = Basin length	Topo – (DEM)
5. Circulatory ratio (compactness coefficient): Discuss the ratio of the circumference of a circle of the same area, as the basin to the basin perimeter $R_c = (4\pi A)/P^2$ A = Area of watershed P = Perimeter	Topo – (DEM)
6. Basin length. Discuss the measure from the outlet of the basin to its drainage divide.	Topo – (DEM)

<table>
<tr><th>Parameters</th><th>Data Requirements</th></tr>
<tr><td>Basin length (L_b)</td><td></td></tr>
<tr><td>B. Watershed-Relief Features</td><td></td></tr>
<tr><td>1. Relief ratio =
$\text{Relief ratio} = \frac{\text{highest point} - \text{lowest point}}{\text{Maximum basin length}}$
Discuss the relief ratio together with climatic factors of erosion in relation to sediment yield.</td><td>Topo – (DEM)</td></tr>
<tr><td>2. $\text{Relative relief} = \frac{\text{highest elevation}}{\text{Perimeter of the basin}}$</td><td>Topo – (DEM)</td></tr>
<tr><td>3. Elevation: Discuss the variation in elevation, median elevation, and mean elevation of a watershed in relation to temperature and precipitation.</td><td>Topo – (DEM)</td></tr>
<tr><td>4. Slope: Discuss the mean slope, slope maps, and maximum valley slope
<table>
<tr><th>Sub-watershed</th><th>Slope</th><th>Area (ha.)</th></tr>
<tr><td></td><td>Level to gently sloping (0-8%)
Moderate (8-18%)
Steep (18-30%)
Very Steep (30-50%)</td><td></td></tr>
</table></td><td>DEM
Slope map</td></tr>
<tr><td>C. Channel Morphology.
Describe the drainage net of a watershed and correlate the hydrologic and sediment characteristics within the watershed using
Cross-section and profile;
Stream ordering;
Stream length.</td><td>Cross-section – on site
Stream order – GIS
Stream length – GIS</td></tr>
<tr><td>D. Discuss the drainage texture of the watershed using the following:
1. Drainage density
$Dd = \frac{L}{A} = \frac{\text{Total length of stream}}{\text{area of watershed}}$
Describe the efficiency with which a stream collects and discharges available water.</td><td>GIS</td></tr>
<tr><td>2. Discuss the stream density.
$DS = \frac{N}{A} = \frac{\text{number of streams}}{\text{area of watershed}}$</td><td>GIS</td></tr>
<tr><td>3. Length of overland flow</td><td>GIS</td></tr>
</table>

Parameters	Data Requirements
Discuss the distance over which runoff will flow before concentrating on permanent channels. $Fl = \frac{1}{2\ Dd}$ Dd – drainage density	
SOIL	
Indicate and discuss major soil type conditions and characteristics, and erosion susceptibility based on soil map. Include the influence of soil characteristics and infiltration capacity of watersheds and subsequent surface runoff, groundwater recharge, and related processes. Assess soil characteristics relative to the suitability of an area for crop production. Essential features to be included are: a. Soil texture = relative proportions of various size groups. Clay = less than 0.002 mm in diameter. Silt = greater than 0.002 mm but less than 0.05 mm.) Sand = greater than 0.05 but less than 200 mm) b) Soil structure: Discuss the aggregation of primary soil particles into compound particles or clusters, in terms of grade structure less, weak, moderate, strong); size (very fine, fine, medium, coarse and very coarse); and shape (platy, prismatic, columnar, blocky, sub-angular, granular or crumb). c) Bulk Density and Permeability: Discuss the quality of soil that enables it to transmit water or air (very slow, slow, moderately slow, moderate, moderately rapid, rapid, and very rapid). d) Erosion Condition: Describe the area affected by various types of soil erosion prevailing in the watershed area such as: • Non-slighterosion	Reports, SEMP LMU Maps CLWUP

Parameters	Data Requirements
• Moderate erosion • Severe erosion • Very Severe erosion Each degree or type of soil erosion should be presented by areas (in hectares) and supported with maps. e) Soil fertility: Discuss pH, plant nutrient and organic matter content, and origin of parent material (e.g. limestone, volcanic, alluvial, etc.) f) Soil Depth: Discuss the conduct of soil survey and analysis. Soil samples will be collected for laboratory analysis from the upper, middle, and lower elevations. Secondary data will suffice if this available in other concerned agencies. Indicate major soil type conditions and characteristics and erosion susceptibility based on the soil map. Include a discussion on the morphological characteristics and chemical properties of the soil in the watersheds.	

4.1.3. Hydrology

Hydrological parameters(stream flow rate, peak and minimum flow, streamflow quantity and sediment run-off) were calculated with Soil and Water Assessment Tool (SWAT v.12)(Arnold *et al.*, 2012; Neitsch, Arnold, Kiniry, & Williams, 2011; Winchell, Srinivasan, Di Luzio, & Arnold, 2013). SWAT is a river basin scale, continuous-time and a spatially distributed model developed by the USDA Agricultural Research Service (ARS) and Texas A&M AgriLife Research to model land management practices on sediment, water and agri-chemical yields for large and complex watersheds over long periods (Neitsch *et al.* 2011). The study areas were divided into sub-basin/sub-watershed. Each sub-basin/sub-watershed may be further divided into hydrologic response units (HRUs) which are a unique combination of soil, land use, and slope. Important input includes; rainfall, temperature, digital elevation model, land use, and soil maps (Neitsch *et al.* 2011).

Operational computation was based on land and routing phases of the hydrologic cycle. The land phase of the hydrologic cycle controls the amount of water, sediment, nutrient, and pesticide loadings to the main channel in each sub-basin. Water stored in the soil profile, shallow and deep aquifer. Surface run-off from daily rainfall can be estimated using the SCS curve number method. Peak run-off will be predicted based on modified Rational Formula. In order to estimate the watershed concentration-time, Manning's formula was used. Routing phase of the hydrologic cycle can be defined as the movement of water, sediments, etc., through the channel network of the watershed to the outlet which was simulated using the variable storage or Muskingum method.

The hydrologic cycle as simulated by SWAT will be based on the water balance equation (Eq. 1) and primarily controlled by the prevailing climate.

$$SW_t = SW_0 + \sum_{i=1}^{t}(R_{day} - Q_{surf} - E_a - w_{seep} - Q_{gw}) \quad \text{(eq. 1)}$$

Where: SW_t and SW_0 are the final soil water content and initial soil water content; t is time (days); R_{day}, Q_{surf}, E_a, w_{seep}, Q_{gw} are the amount of precipitation, surface runoff, evapotranspiration, water entering the vadose zone from the soil profile, and return flow respectively. All parameters have units in mm and *I* represent the parameter value for a day.

The spatial and point data, sources, and descriptions needed in SWAT modeling are summarized in Table 1.

Table 1. Input data for SWAT

Data Type	Description	Sources
Digital elevation model	SRTM 5m by 5m resolution	National Mapping and Resource Information Authority (NAMRIA)
Land Use Vector	2015 Digitized Landsat 8 (30mx30m)	NAMRIA
Soil Vector	Digital Soil Map of the World v. 3.6 (1: 5000000)	Food and Agriculture Organization (FAO)
Climate data (year to year)	Daily rainfall, relative humidity, max, and min temperature (station point)	Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA)
Weather Generator	Weather generator generated from the PAGASA observations	Alibuyog *et al.* 2015

Data on surface run-off, stream flow or discharge, soil erosion, and sediment load were included in relation to the description in the drainage map. The following are the required data:

- Drainage pattern
- Streamflow rate (daily/annual)
- Peak flow and minimum flow
- Stream water flow quantity/quality (dissolved chemical constituents such as Ca, nitrate, phosphate, etc. and microorganisms (fecal and total coliform) and physical and chemical properties of water (temperature, conductivity, pH, salinity, COD).
- Location of springs including discharge
- Water Uses (irrigation, hydropower, domestic, industrial use, etc.) with an indication of the water yield in terms of quality (potability pollution level) and quantity (volume and flow regime).

Discussion on the streamflow rate and quality were based on a wide variety of methods and instrumentations that can be generated through various means, such as rainfall-streamflow relationship and modeling.

4.1.4. Climate

Daily rainfall, relative humidity, and temperature (minimum and maximum) was obtained from the Philippine Atmospheric Geophysical and Astronomical Services Administration-Coron Synoptic Station (PAGASA-CSS) from 1986-2016. These parameters are the moisture and energy inputs that control the water balance in the watershed as well in the SWAT simulation. The discussions were based on the indicative influence of climate on the different biophysical and socio-economic features and processes within a watershed.

4.1.5. Land use and classification

Land cover and classification analysis of the target watershed was undertaken with the use of GIS processing tools. An official map of periods 2010 and 2015 was obtained from the DENR. Surveys of land use were taken using the satellite imageries. Most land uses, especially those that involve human interventions, affect soil properties of a watershed. Discussion on the prevailing and actual manner in the utilization of land, its allocation, development, and management were taken into consideration. Its existing land –use type per municipality and extent (in ha.) was also supported by tables. Obtain land-based maps from BSWM-DA and forest cover maps for the country from NAMRIA resources can be sufficient with the support of past and recent satellite imageries from various concerned sources.

Land use categories were discussed based on existing land use, tenurial arrangements, and existing/proposed foreign- assisted and locally funded projects in the watershed. This can be supported by the Municipal/Provincial land use map. Data categories are as follows:

- Built-up areas
- Barren Land
- Inland Water
- Inland Water pond
- Aqua-agriculture areas
- Forest
- Production
- Protection
- Other Uses/Special Uses

The land classification/legal status was determined on the extent of Alienable and Disposable Lands (A&D) and forestlands in terms of area coverage within the watershed. The extent of the area was presented in tables and land classification maps. In order to determine the capacity of the land to support the production and allocation of different sub-watersheds to the best uses, the Watershed Management Planning Team may use the available system of land capability classification developed by the USDA Soil Conservation Service, or adopt the Land Management Unit (LMU) approach being employed by BSWM.

4.2. Biological Components

Sampling stations were set-up in three different elevations (upstream, midstream, and downstream) perpendicular in each identified river system, except in coastal marine areas. Transect walks and transect swims were employed in terrestrial and coastal areas, respectively.

4.2.1. Terrestrial Fauna and Flora

A 500 meters transect was set in each three (upstream and midstream) different elevations, which served as survey stations. Transect walks following the methods of Bibby, *et al.* (1992) was conducted by three observers. The trail for transect lines was observed at most 10 meters belt width for sampling and captures. For those wildlife species outside transect, an opportunistic sampling was employed for species listing. Wildlife Gratuitous permit (WGP) was granted by the office of Palawan Council for Sustainable Development (PCSD) for collection of wildlife species samples (See Annex B for details of WGP).

4.2.1.1. Avian Community

Avian surveys were conducted by traversing the transect lines from 600H to1000H and 1500-1800H. Direct observation of species encountered on transect lines were listed including identification, number of individuals, type of observation (visual and/or acoustics), habitat type, and important notes. Acoustic surveys were also be done to complement the methods, focally for cryptic species. Species encountered on areas not covered by the transect line was added to the species list and noted as general observation especially for lowland areas.

4.2.1.2. Herpetofauna

The survey followed the same transect lines to be established for other taxa in three stations. Diverse habitats including fossorial (humus deposits, under rotting logs and rocks), ground-level (forest floor and leaf litter), waterlogged areas (ponds and running water) and arboreal habitats (tree, ferns, vines, axillae of *Pandanaceae* and holes in trees)were sampled from 0900-1100 and 1900 hrs. Captured specimens were subjected to morphometrics and photo documentation.

4.2.1.3. Mammals

A combination of snap traps and live traps for small non-volant mammals were conditionally deployed in higher elevation. Traps were set on ground, possible runways, and hole in trees, above ground in trees or vines. Traps were maintained for three consecutive days before moving to a different location within or to the next elevation. Checking and re-baiting of traps were done at 0500-0600 and 1500-1600 hrs. Captured individuals were checked for gender, age, and morphometric characters. Captured animals were released within the site of capture except when voucher specimens that required further identification.

4.2.1.4. Flora

The Variable Transect Method for Rapid Assessment was used in the conduct of the assessment of flora assemblages. Surveyors walked down the middle of a habitat to be surveyed and quickly register and identify a pre-determined number (e.g. 50) of individuals of plants of any class. Transect was used to describe the composition and diversity of the different habitats within elevations.

The sampling areas were defined by the extent by which no less than 50 individuals of trees measuring 30 cm or above in diameter be accommodated for lowland areas and high elevation areas. In areas where predominantly diameter of trees is considerably smaller, the minimum diameter class can be set to a lower value or

decreased. The inventory included all major growth forms of vascular plant groups (including trees, lianas, herbs, etc.). Identification was done up at most at the genus level but whenever possible, it can be done up to the species level. In ensuring the breadth of representation, sample sites were chosen in a stratified-random manner within each general habitat type.

4.2.2. Mangrove community

Due to insufficient time allotted for fieldworks, a secondary data was acquired from the Palawan Council for Sustainable Development In-Depth Coastal/Marine Resources Survey Report in 2003-2004 for the Municipality of Culion. The data collection follows the 20m x 20m plot size standard plot size of the PCSDS Coastal Resource Assessment methods applied in its mangrove monitoring surveys in Palawan to allow for future comparison of survey data (English *et al.* 1997).Transect stations were laid on site with 20m x 20m plots at a 100m plot interval perpendicular to the mangrove forest. The geographic position of transect was determined using a Garmin Montana 680 - Global Positioning System (GPS) navigator with a minimum of 3.64-meter standard navigation error.

5. SURVEY OUTCOME

5.1. Physical Components

5.1.1. General Features –Malaking Patag Watershed

Malaking Patag Watershed, where Carigmalan River is located, is being proposed as a watershed of the municipality because it is where the existing water source of Bgy. Malaking Patag is located. Surface water is abundant only during the rainy season, from June to December, hence, Culion has only short, intermittent creeks and gulleys (PCSD, 2006). While reliable surface water sources are being sought, the current water system in the municipality relies heavily on aquifers, springs, and creeks (FLUP, 2019).

It is located in the municipality of Culion, in the Calamianes Island Group (CIG), geographically located at 110 30'-120 00' N. latitude and 1190 45'-120 15' E. longitude, bounded by Linapacan Islands on the South, Busuanga Islands on the north, and Municipality of Coron on the east (Figure 1). The watershed covers a total are of 49.66 km^2.

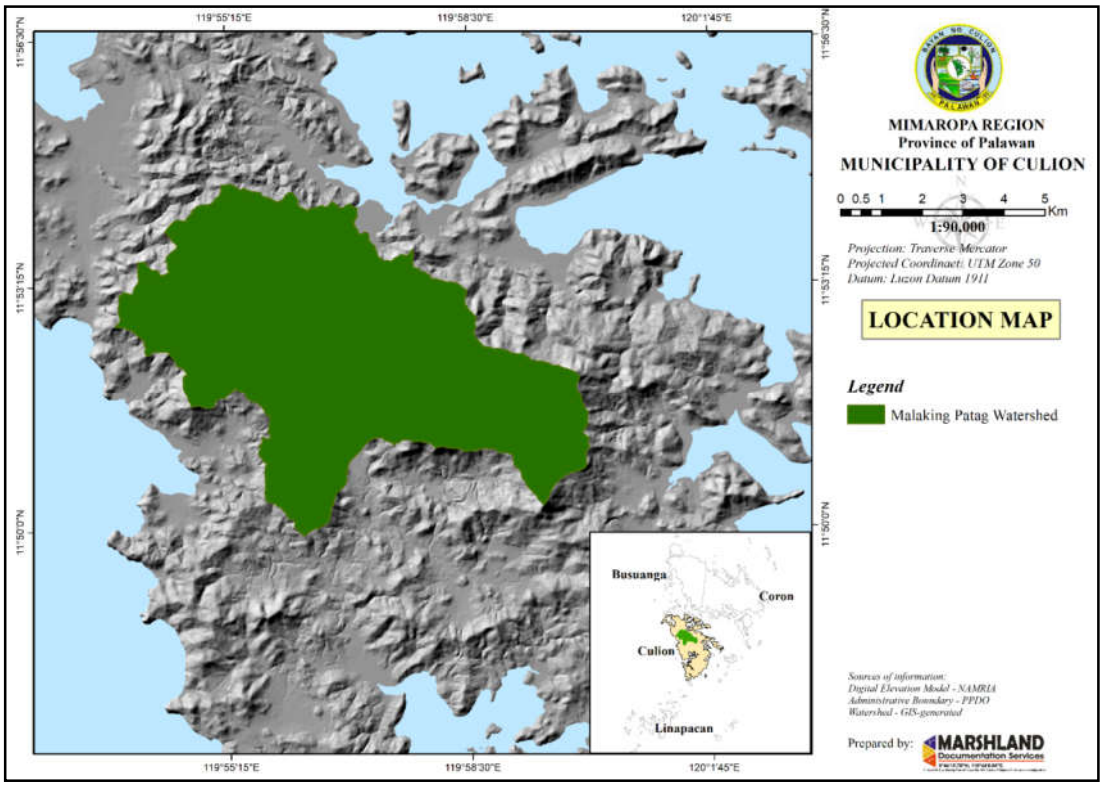

Figure 1. Location map of Malaking Patag Watershed within the Calamianes Group of Island, Province of Palawan.

Multiple water sources (deep-well, spring, and surface water) are being tapped by the municipal water district to supply domestic water 2142 households (FLUP 2019-2029). Survey team visited the site within the watershed that is currently being used as water source of Bgy. Malaking Patag. A discharge simulation was carried out for this site and is reported at the hydrology portion of this paper. It is reported by the local to be a perennial river which can be an additional potential source of surface water for the municipality.

5.1.2. Geophysical Location

Malaking Patag watershed encompasses four (4) barangays (Figure 2). Table 2 shows the area and percent share of each barangay within the watershed. Barangay Luach as the largest share with 47.2%. It is followed by Bgy. Malaking Patag with 43%. The least among them is Bgy. Osmena with only 0.1% share of the watershed.

Table 2. Administrative area of Malaking Patag Watershed

Barangay	Area		% Share
	Ha	Km2	
Baldat	485.16	4.85	9.8%
Osmeña	5.44	0.05	0.1%
Luac	2342.34	23.42	47.2%
Malaking Patag	2133.06	21.33	43.0%

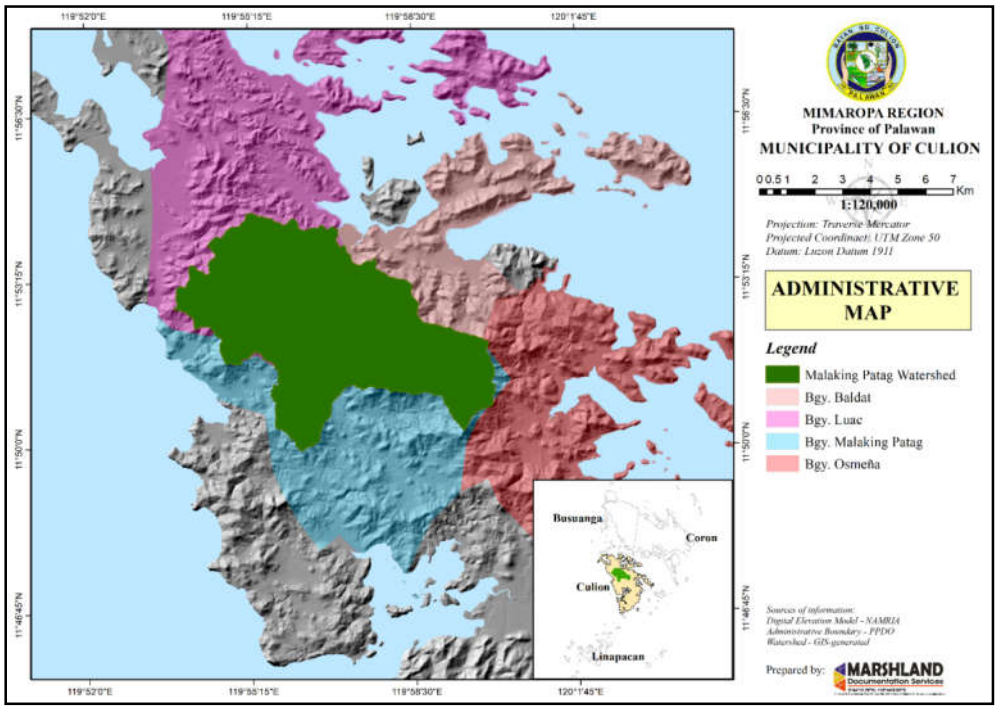

Figure 2. Malaking Patag Watershed Administrative Map

5.1.3. Topography/Geo-Morphological Features

Generally, the municipality has mountainous topography with slopes vary from rolling to steep. Mountainous portion of Malaking Patag watershed is located at Bgy. Luac, while flat to undulating lands are located at Bgy. Malaking Patag (Figure 3). Elevation ranges from 0 meters at the river outflow at Bgy. Luac peaking at 412 meters above sea level at Bgy. Osmena.

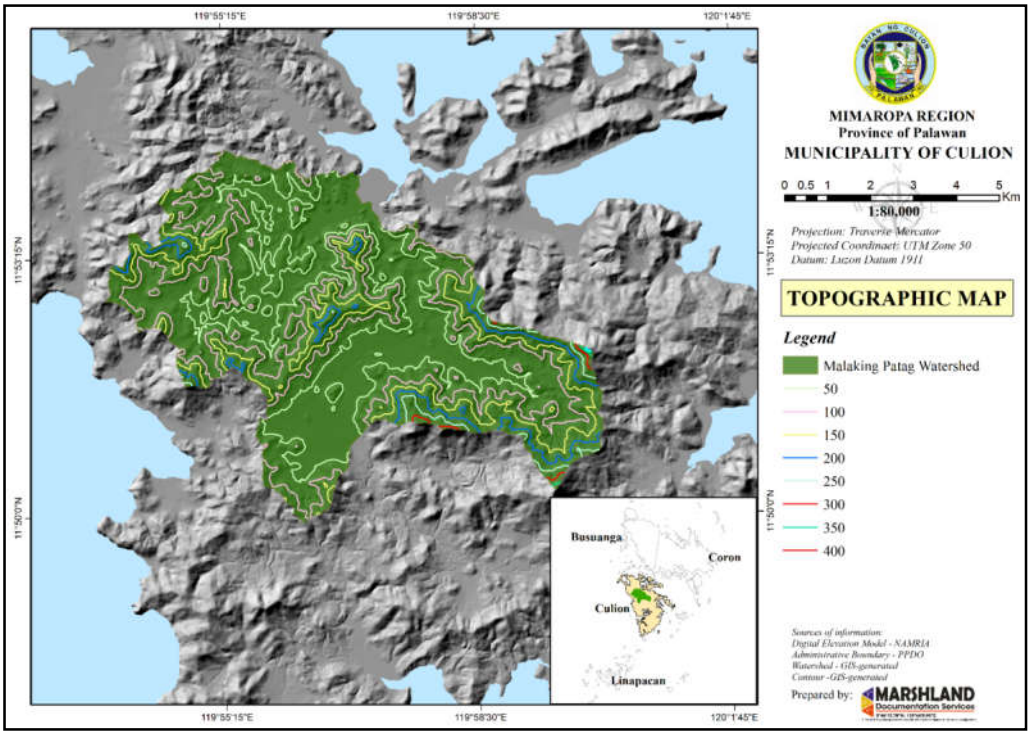

Figure 3. Topographic Map of Malaking Patag Watershed.

5.1.3.1. Watershed-Shape Parameters

Several shape parameters had been developed to reflect watershed shape. In this report, we include gravelius form factor, elongation ratio, and circularity ratio.

5.1.3.2. Area

Malaking Patag watershed has a total area of 49.66km2 (4966ha) with an approximate basin length of 13km and average width of 7.19km. It has an approximate perimeter length of 43km encompassing ridges and tributaries draining to Bgy. Luac. Since the watershed is too small, it was not subdivided into subwatersheds[1].

Table 3. Watershed shape parameters

Area		Perimeter		Basin length		Average width	
(ha)	(km^2)	(m)	(km)	(m)	(km)	(m)	(km)
4966	49.66	52,210	52.2	13,39	13.4	7,190	7.19

[1]Per DENR Memorandum Circular 2008-05, small watersheds are areas with scale of ≤10,000 ha (<100km^2), medium scale watersheds are with area of more >10,000 ha (>100km^2) and <50,000 ha (<500km^2), and large scale watersheds are with area above 50,000 ha (>500km^2).

5.1.3.3. Gravelius Form Factor (G_f)

Gravelius form factor (Gf) is mathematically expresses in equation 1 and is always smaller than 1. The smaller the Gf, the more elongated/elliptical the watershed. Malaking Patag watershed has a Gf of 0.54, its shape is less elongated. When intense rainfall occurs, runoff tends to spread out over time, thus producing a smaller flood peak compared to that of a circular watershed.

eq. 1 $$\mathrm{Gf} = \frac{\text{Average width}}{\text{Axial length of the basin}}$$

$$= \frac{7.19}{13.4}$$

$$= 0.54$$

5.1.3.4. Bifurcation Ratio (R_b)

Bifurcation ratio (Rb) is the ratio between the number of stream segments in one order and the next and is mathematically expressed in equation 2, where N_u as the total number of segments of order u and N_{u+1} as the number of stream segments of the next higher order.

eq. 2 $$R_b = \frac{N_u}{N_{u+1}}$$

Stream order is depicted in Map 5. The R_b of Malaking Patag watershed is 3.33. Values lower than 5 suggest that the drainage pattern is not affected by the geologic structures. Further, lower R_b values suggests a delayed hydrograph peak.Higher stream order is associated with greater discharge and higher velocity. This enhances erosion rates that may contribute to higher sediment loading. Malaking Patag watershed is within the moderate value. In addition, total number of stream segments decrease with stream order (this is referred to as Horton's law of stream numbers). It indicates that the whole area has uniform underlying lithology, and geologically, no probable uplift in the watershed. Deviation from Horton's Law suggests otherwise.

Table 4. Stream order of Malaking Patag Watershed, Culion, Palawan

Stream Order	**# of streams**	**Bifurcation ratio**
1	109	109/24 = 4.54
2	24	24/7 = 3.428
3	7	7/3 = 2.333
4	3	3/1 = 3
5	1	
Average		3.33

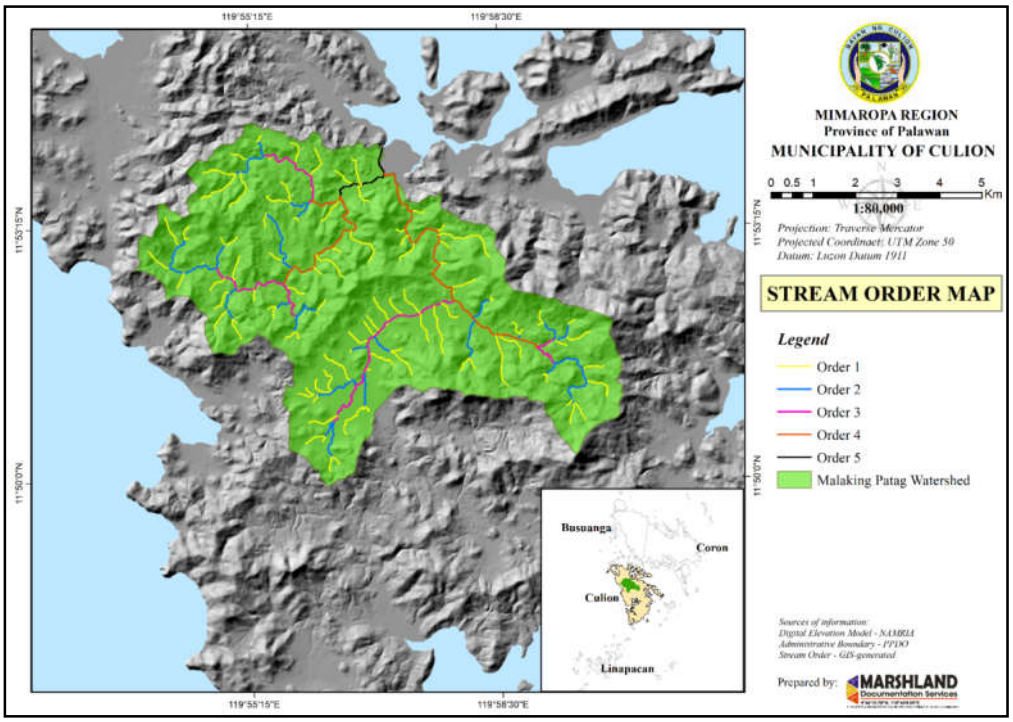

Figure 4. Stream order map generated though GIS by STRAHLER method

5.1.3.5. Elongation Ratio (R_e)

Elongation ratio (Re) is ratio of the diameter of a circle of the same area as the basin to the maximum basin length, a dimension-less property, mathematically expressed in equation 3.L_b is the maximum basin length (which is the distance from the outlet to the farthest point in the watershed) and A the area of watershed. Generally, Re value is classified into two classes, the low value (<1) which means elongated watershed, and high value (>1) which means circular watershed. Malaking Patag watershed has a Re of 0.59, that is it, the watershed is less elongated and is associated with moderate relief and steep slope. Moderate relief watershed has a moderate susceptibility to erosion. However, it must be noted that there are other factors affecting erosion potential of an area, as such, vegetative cover, and soil type.

$$\text{eq. 3} \quad R_e = \left(\frac{2}{L_b}\right)\left[\left(\frac{A}{\pi}\right)^{0.5}\right]$$

$$= \left(\frac{2}{13.4km}\right)\left[\left(\frac{49.66km}{\pi}\right)^{0.5}\right]$$

$$= 0.59$$

5.1.3.6. Circularity Ratio (R_c)

Circularity ratio (Rc), also a dimension-less property, is the ratio of basin area (A) to the area of circle having the same circumference as the perimeter (P) as basin and is mathematically expressed in equation 4. The Rc of Malaking Patag watershed is 0.23 signifying the watershed is elongated, hence, run-off is more spread-out overtime. Thus, smaller peak in hydrograph.

eq.4 $$R_c = \frac{(4\times\pi\times A)}{P^2}$$

$$= \frac{4\times\pi\times 49.66km^2}{(52.2km)^2}$$

$$= 0.23$$

5.1.3.7. Basin Length

Basin length is defined as the distance measured along the main channel from the watershed outlet to the basin divide. Malaking Patag watershed's length was measured along the main channel from the outlet draining to the sea extended up to the divide at Bgy. Malaking Patag which measures 13.4km.

5.1.4. Watershed-Relief Features

5.1.4.1. Relief Ratio (R_r) and Relative Relief

It is the measurement of the overall steepness of a basin/ watershed and is mathematically expressed in equation 5, also a dimension-less property. It also suggests the intensity of erosion processes operating in the watershed. Higher value of R_r suggests of high intensity erosion processes are taking place. Literatures did not mention about the value range of relief ratio. The subject watershed has only R_r of 0.03.Relative relief value is 0.008 and computed with equation 6.

eq. 5 $$R_r = \frac{highestpoint - lowestpoint}{Maximumbasinlength}$$

$$= \frac{0.412km - 0}{13.4km}$$

$$= 0.02$$

eq. 6 $$RelativeRelief = \frac{highestelevation}{permiterofthebasin}$$

$$= \frac{0.412km}{52.2km}$$

$$= 0.008$$

5.1.4.2. Elevation

The highest elevation is 0.412km, at Mt. Chinankan at Bgy. Osmena, while the lowest is zero km at the outflow at Bgy. Luac draining to the sea. Its mean elevation is 0.9km.

5.1.4.3. Slope

Slope of the watershed is depicted in Figure 5. Flat to undulating terrain (slope of 0-8 %) is 18.5%of the watershed area and falls within the flat lands of Barangay Malaking Patag, Baldat and Luac. Adjacent to these are slope of 8-18% or areas with undulating to rolling terrain, about 18% of the watershed, which are also present in these three barangays. The areas with rolling to hilly, hilly to mountainous and mountainous terrain comprises 26.09%, 31.11%, and 5.97% of the watershed and are distributed among the four barangays, equivalent to 69% of the watershed area (Table 5). In addition, vulnerability to erosion and flooding were measured using critical factor analyses stipulated in the FMB Technical Bulletin No. 16-A, Annex K. The same measurement scale was gathered for soil and land cover.

Table 5. Slope class of Malaking Patag Watershed

Slope Class	Area		%	Erosion vulnerability	Flood Vulnerability
	Ha	Km^2			
Level to undulating (0-8%)	918.94	9.19	18.5	Very low	Very High
Undulating to Rolling (8-18%)	910.07	9.10	18.33	Low	High
Rolling to Hilly (18-30%)	1295.46	12.95	26.09	Moderate	Moderate
Hilly to mountainous (30-50%)	1544.99	15.45	31.11	High	Low
Mountainous (above 50%)	296.54	2.97	5.97	Very high	Very Low

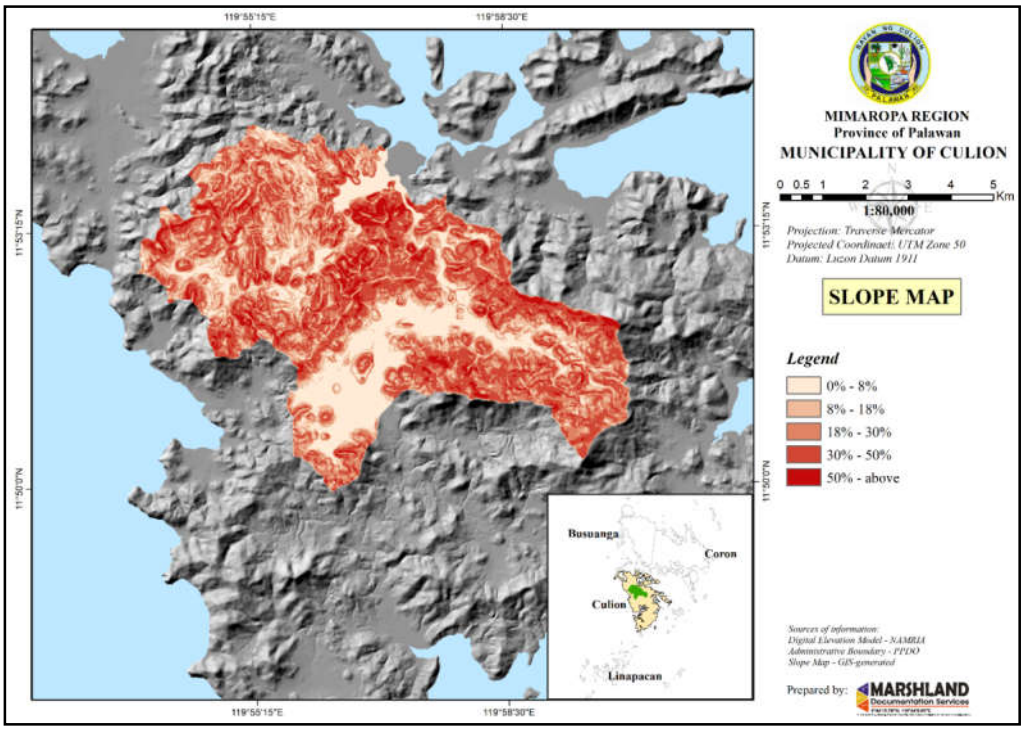

Figure 5. Malaking Patag watershed slope map

5.1.4.4. Channel Morphology

The watershed exhibits a dendritic drainage pattern. The river channels, both called Carigmalan Rivers, traverse all of the four barangays. Its confluence at Bgy. Luac, and finally drains to the sea (Figure 6). Cross-section of the creek at simulation point is 0.15 m^2 (refer to figure 12).

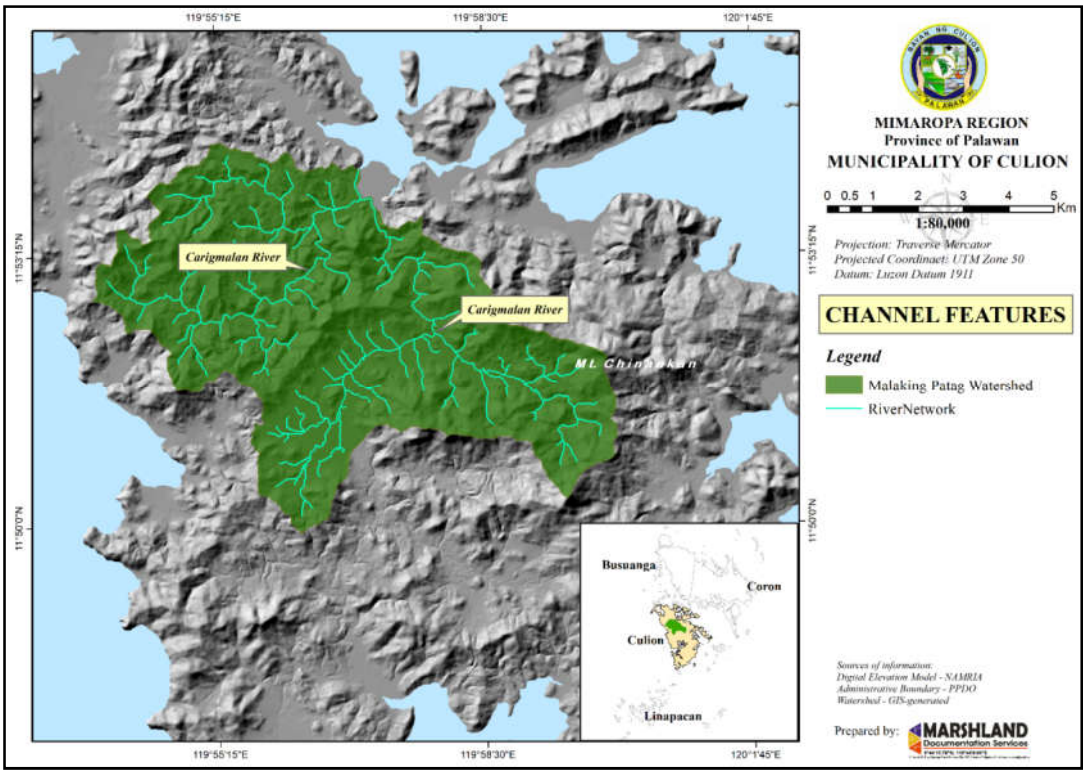

Figure 6. Channel features of Malaking Patag Watershed.

5.1.4.5. Drainage Texture

5.1.4.5.1. Drainage Density (D_d)

Drainage Density (D_d) is the measure of the length of stream channel per unit area of drainage basin, mathematically expressed in equation 6. Generally, it can be classified as low (or coarse class, <5) and high (or fine class, >5). The watershed has low D_d at 1.91km·km^{-2}. This suggests that the watershed has a permeable subsoil material and dense vegetation. It further suggests that surface runoff is not rapidly removed from the watershed making it highly susceptible to flooding, gully erosion.

eq. 6
$$D_d = \frac{L}{A}$$
$$= \frac{94.84}{49.66}$$
$$= 1.91\text{km·km}^{-2}$$

5.1.4.5.2. Stream Density/Stream Frequency (F_s)

Stream frequency (F_s) is the total number of channel segments of all stream orders per unit area, mathematically expressed in equation 7.There can be high and low classification which is relative to the watershed being investigated. In

the case of Malaking Patag watershed, no other watersheds within the municipality have morphometric analysis to generate comparison. Generally, low F_s value may have good cover of vegetation, and has good infiltration capacity. Hence, discharge takes longer time to peak.

eq.7 $$F_s = \frac{N}{A}$$
$$= \frac{144}{49.66}$$
$$= 2.9\text{km}^{-2}$$

5.1.4.5.3. Length of overland flow (L_g)

Length of overland flow (L_g) is the length of water over the ground before it gets concentrated into certain stream channels, mathematically expressed in equation 8. Several studies classify L_g into three classes, low (0.2), medium (0.2-0.3), and high (>0.3). Malaking Patag watershed has medium *Lg* and suggests that moderate relief, medium flow paths, moderate infiltration, and moderate runoff which leads to moderate vulnerability to the flash flooding.

eq. 8 $$L_g = \frac{1}{2\,Dd}$$
$$= \frac{1}{2 \times 1.91}$$
$$= 0.26\text{km}$$

The shape morphology suggests a low vulnerability to flooding while channel morphology suggests a moderate vulnerability to flooding. Mountainous portion may exhibit high erosion potential and may be reduced with a good vegetative cover.

5.1.5. Soil

Soil characteristics of the Malaking Patagwatershed (Figure 7) is derived from the Land Resources Evaluation Project (LREP) of DA-BSWM and PIADP in 1988.This study provided the most modern and detailed of whole-island surveys in the province and most useful for broad scale planning.It generateda physiographic unit called land management unit (LMU) for the whole province (see table for detialed description for each LMU). For the purpose of this study, we will focus on soil texture in its relation to hydrological responses. Metamorphic hill high and low relief (77.27% of the watershed) with soil texture of sandy clay loam to clay loam, is well drained and has a medium water holding capacity.Infilled valley, enclosed vallery and residual terrace (21.47% of the watershed area) with sandy clay loam to clay soil texture, is well to moderately well drained, has low permeability, and has low water holding capacity. Mangrove/nipa

with soil texture loamy sand to clay (1.26% of the area), very poorly drained. Other properties of each LMU are summarized in Table 6.

Table 6. Description of land management unit of Malaking Patag Watershed

Land Management Unit	Soils	Soil Chemistry	Soil Texture	Area (Ha)	Erosion vulnerability	Flood Vulnerability	Soil depth
Enclosed valley	Deep collu-alluvium. Light gray to gray grayish brown with strong brown mottles, light clay to clay texture	pH 4.2 to 4.7;organic matter (OM) and nitrogen is medium to high; available phosphorous low to medium; K is medium to high; Ca & Mg is high; basic soil productivity(BSP) is medium; salinity is favorable and moderate fertility	Sandy clay loam to clay	625.93	Low to moderate	High	Deep
Infilled valley	Collu-alluvium, dark gray to gray, light gray to gray, dark grayish brown and strong brown mottles; silty clay loam to clay	pH 4.1 to 6.8; OM and nitrogen content is medium to low; available phosphorous is low; exchangeable potassium medium; Ca and Mg	Sandy clay loam to clay	17.34	Low to moderate	High	Deep

Land Management Unit	Soils	Soil Chemistry	Soil Texture	Area (Ha)	Erosion vulnerability	Flood Vulnerability	Soil depth
		is high; BSP is medium; salinity is favorable and inherent fertility					
Mangrove/ nipa	moderately deep to very deep, fluvio marine deposit,dark gray dark brown, dark grayish brown, grayish brown, yellowish brown, nudulain by partly decomposed or decomposed plant residues	pH 3.4 extremely acid; high OM content; medium phosphorus; trace potassium; high Ca and Mg, low fertility	Loamy sand to clay	62.55	Low to moderate	Low	Deep
Metamorphic hill high relief	Shallow soils, dark grayish dark brown very dark brown, brown to dark brown sandy clay loam to clay loam underlain by rock fragment	pH 4.1 to 4.9; OM nitrogen content is medium to low; phosphorous medium to low; potassium, Ca, Mg is medium; BSP is medium, fertility level is low	Sandy clay loam to clay loam	1835.18	Low to moderate	High	Shallow

Land Management Unit	Soils	Soil Chemistry	Soil Texture	Area (Ha)	Erosion vulnerability	Flood Vulnerability	Soil depth
Metamorphic hill low relief	Shallow soils, dark grayish dark brown very dark brown, brown to dark brown sandy clay loam to clay loam underlain by rock fragment	pH 4.1 to 4.9; OM and nitrogen content is medium to low; phosphorous medium to low; potassium, Ca, Mg is medium; BSP is medium; fertility level is low	Sandy clay loam to clay loam	1998.58	Low to moderate	High	Shallow
Residual terrace	Derived from sedimentary, volcanic, metamorphic and ultrabasic rock or from the weathering of unconsolidated complex rock, sandy clay loam to clay, dark brown with strong brown and yellowish brown	pH 5.0 to 5.4; OM and nitrogen content is medium; available phosphorous is high; exchangeable potassium is low; Ca and Mg is high; BSP is high; salinity is favorable, general fertility is low	Sandy clay loam to clay	422.23	Low to moderate	High	Moderately Deep

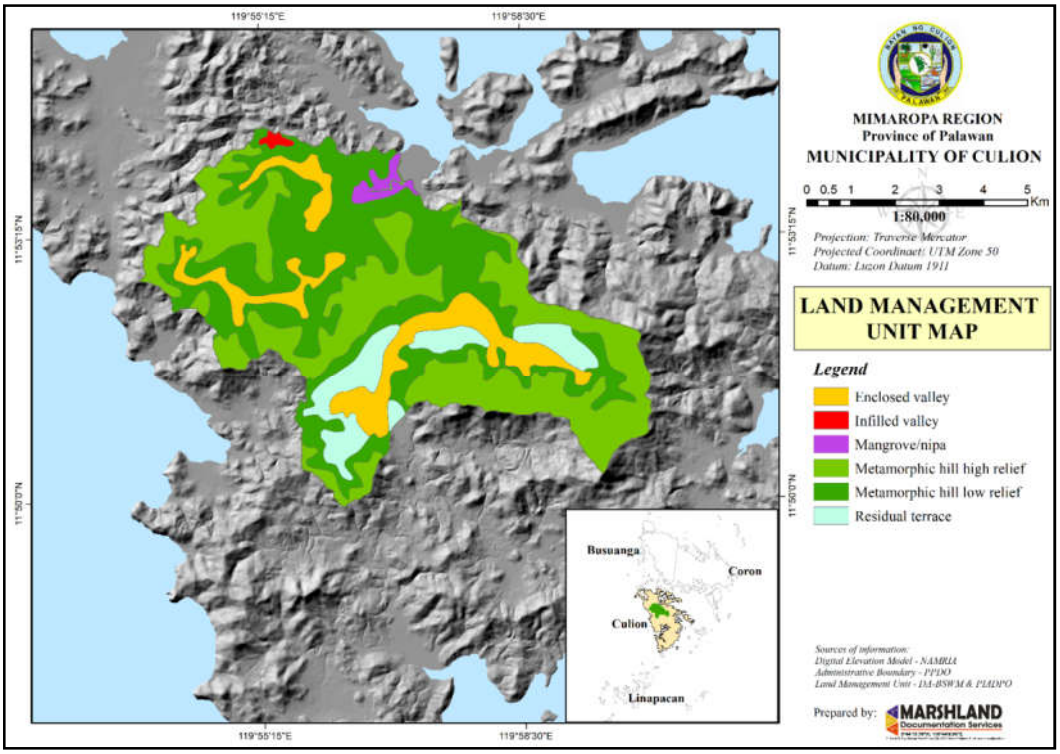

Figure 7. Land Management Unit Map of Malaking Patag watershed.

5.1.6. Land Classification

Forestlands comprise 64.4% of the watershed area. These are mostly found at the mountainous portions of the four barangays. On the other hand,35.6% are classified as alienable and disposable land (Figure 8) located at Bgy. Luac, Malaking Patag and Baldat.

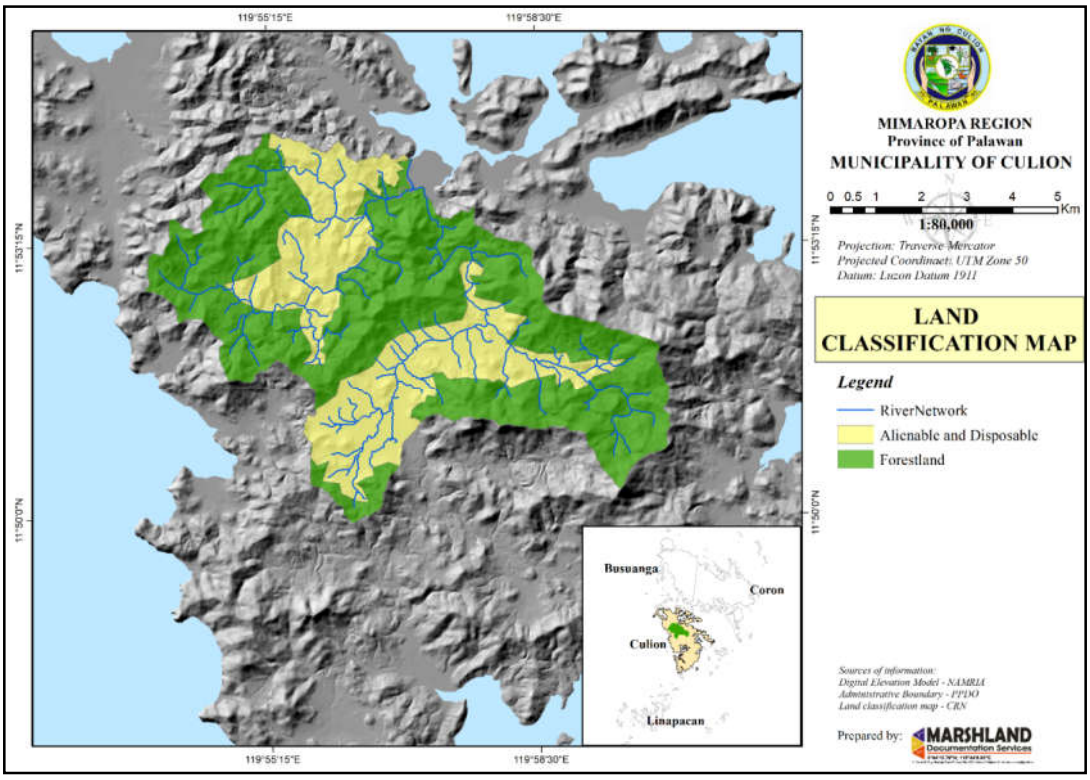

Figure 8. Land Classification of MalakingPatag Watershed

5.1.7. Land Cover / use

In 2015 land cover, the watershed is dominantly covered by brush/shrubs (56%) and followed by open forest (26.6.38%), followed by grassland (9.4%) (see Figure 9 and Table 7). The least is inland water at about 0.3%.

Open forest and annual crop area as decreased cover by2.56 km^2 and 4.41 $km^2$from 2010 to 2015, respectively (see Table 8). On the other hand, brushlands, grasslands, and mangroves increased by 25.68 km^2,1.67 km^2, and 0.04km^2, respectively.

Table 7. 2015 Land Cover

Cover Type	Area		% Area	Erosion Vulnerability	Flood Vulnerability
	Ha	Km^2			
Annual Crop	279	2.79	5.6%	High	High
Brush/Shrubs	2783	27.83	56.0%	Moderate	Moderate
Built-up	44	0.44	0.9%	High	High
Grassland	467	4.67	9.4%	Moderate	Moderate
Inland Water	13	0.13	0.3%	Very low	Very low
Mangrove Forest	61	0.61	1.2%	Low	Low
Open Forest	1320	13.2	26.6%	Low	Low

Source: NAMRIA 2015, FMB TB No. 16-A

Table 8. Comparison of 2015 and 2010 land cover

Cover Type	2015		2010		Area (+/-)		% Change
	(Ha)	(Km^2)	(Ha)	(Km^2)	(Ha)	(Km^2)	
Annual Crop	279	2.79	720	7.2	-441.00	-4.41	-61.3%
Brush/Shrubs	2783	27.83	215	2.15	2568.00	25.68	1194.4%
Grassland	467	4.67	300	3	167.00	1.67	55.7%
Inland Water	13	0.13	11	0.11	2.00	0.02	18.2%
Mangrove Forest	61	0.61	57	0.57	4.00	0.04	7.0%
Open Forest	1320	13.2	1582	15.82	-262.00	-2.62	-16.6%
Wooded grassland*	-	-	2081	20.81	-	-	-
Built-up*	44	0.44	-	-	-	-	-

** No similar cover type between 2010 and 2015*
Sources: NAMRIA 2010 and 2015

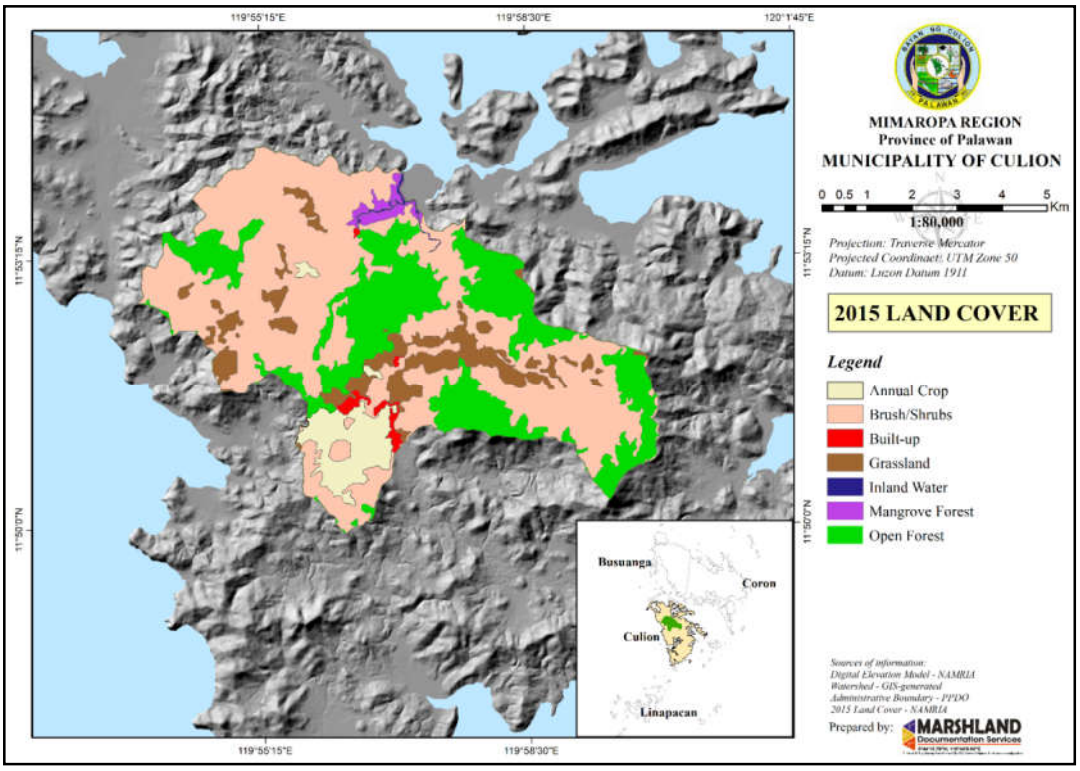

Figure 9. Land Cover of Malaking Patag Watershed.

5.2. Climate

Rainfall, Temperature, and Relative Humidity - The Calamian Group of Island belongs to Type I of Corona's Climate Category. There is a distinct dry and a wet season, that is, wet from June to November and dry the rest of the year. This holds true based on thirty-seven-year (37) daily precipitation records of PAG-ASA Coron synoptic station (CY 1980-2016). Records showed that there can be little to no precipitation in the months of November-May (see Table 9). It receives a mean annual precipitation of 2,458.1mm. The highest rainfall of 3163.6mmwas recorded in year 1982 and the lowest of 1663.5mm during the year 1986. During wet months, precipitation ranges from 47.8mm to 1,051.7mm per month. Wet months also have greater number of days with recorded rainfall on the same period (Figure 10). It must be noted that there are months of missing values, denoted with *-2*. One of which is during the month of November 2013 where Super Typhoon Yolanda left widespread damage in the Calamines Island Group due strong wind and heavy rainfall.

Table 9. Monthly rainfall record from year 1980 to 2016 (Source: PAG-ASA Coron Synoptic Station (1980-2016) located at 12° 00' 13.20N, 120° 11' 59.40"E, 59.938 masl)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1980	9.7	0.0	10.0	0.0	146.3	368.8	509.6	344.3	259.0	131.6	67.5	150.5	**1,997.3**
1981	14.0	8.8	2.0	0.0	18.2	602.2	358.0	650.5	250.7	208.2	22.4	48.0	**2,183.0**
1982	23.0	4.2	60.2	0.0	110.2	498.2	700.6	893.6	604.4	185.2	39.6	44.4	**3,163.6**
1983	8.4	0.0	0.0	-2	-2	-2	441.8	264.6	452.7	372.6	153.4	8.3	**1,701.8**
1984	21.6	0.0	13.8	3.2	138.5	824.1	230.3	647.1	519.6	454.8	132.7	7.2	**2,992.9**
1985	6.6	1.2	0.0	169.0	61.0	-2	457.9	127.4	456.2	250.4	129.1	42.2	**1,701.0**
1986	79.6	34.0	0.0	2.7	123.8	242.7	365.2	344.0	188.2	120.9	162.4	-2	**1,663.5**
1987	1.0	0.0	0.0	2.3	27.1	412.6	606.0	544.8	921.0	259.1	131.4	139.4	**3,044.7**
1988	6.8	0.0	0.0	68.6	164.9	403.4	438.5	200.0	332.2	712.6	166.4	38.2	**2,531.6**
1989	0.0	0.0	19.7	37.0	394.8	563.4	526.1	752.5	418.3	159.4	2.0	0.0	**2,873.2**
1990	7.6	0.0	0.0	0.0	197.5	573.9	574.7	485.2	221.0	141.1	289.7	7.2	**2,497.9**
1991	12.6	1.8	32.9	82.7	81.8	240.7	504.5	544.1	449.4	56.6	4.7	20.8	**2,032.6**
1992	70.3	11.0	0.0	5.4	130.2	396.4	409.3	324.3	270.0	368.7	37.1	4.4	**2,027.1**
1993	20.0	5.3	11.0	0.0	1.4	132.5	404.9	648.4	384.9	318.4	103.7	408.1	**2,438.6**
1994	15.0	1.4	0.0	33.6	248.1	295.7	1051.7	296.5	711.0	289.0	1.5	194.5	**3,138.0**
1995	4.0	0.0	0.0	0.0	147.0	217.0	370.4	432.0	761.3	316.1	121.7	49.9	**2,419.4**
1996	7.0	9.7	37.9	95.7	284.2	143.6	256.4	256.4	418.6	197.7	248.4	5.8	**1,961.4**
1997	19.2	35.0	1.8	11.8	430.0	181.6	500.2	597.8	516.1	47.8	16.1	4.0	**2,361.4**
1998	0.0	2.6	1.0	0.2	347.0	205.9	111.7	211.5	572.2	460.4	241.5	236.7	**2,390.7**
1999	13.7	6.1	97.9	118.1	199.4	551.2	731.7	403.9	289.5	93.8	146.0	36.4	**2,687.7**
2000	18.8	63.6	23.6	46.2	449.2	276.6	811.2	325.2	245.6	265.8	87.6	130.6	**2,744.0**
2001	2.7	161.5	47.3	19.7	355.3	435.4	506.7	727.3	162.7	182.1	211.8	163.7	**2,976.2**
2002	11.6	0.6	7.6	3.4	179.3	364.1	654.5	732.8	653.7	156.1	22.1	2.6	**2,788.4**
2003	8.6	0.0	1.6	7.4	469.1	272.8	358.2	408.2	427.7	-2	176.7	4.8	**2,135.1**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	23.7	16.4	0.0	39.8	99.5	672.6	261.5	580.0	88.2	151.8	197.2	28.8	**2,159.5**
2005	4.2	0.0	59.7	48.1	112.5	244.0	469.8	638.8	-2	270.6	48.0	104.8	**2,000.5**
2006	49.3	0.3	-2	-2	131.6	245.9	672.9	647.8	468.1	156.4	65.4	213.7	**2,651.4**
2007	7.8	2.7	0.0	0.0	112.4	113.8	304.0	337.5	805.5	347.3	230.9	10.7	**2,272.6**
2008	38.7	24.4	14.2	141.7	360.0	321.9	285.5	246.0	522.8	159.1	72.6	52.6	**2,239.5**
2009	42.9	30.5	0.0	130.1	340.5	528.4	820.8	368.4	657.4	210.2	25.7	1.4	**3,156.3**
2010	16.6	0.0	0.0	2.6	31.4	140.7	210.9	417.6	197.5	366.8	269.7	63.5	**1,717.3**
2011	39.1	33.9	4.7	16.4	216.7	344.6	403.9	592.0	625.4	302.1	45.7	144.5	**2,769.0**
2012	48.8	27.9	97.1	92.4	297.6	680.2	696.0	421.9	436.2	196.5	2.0	42.8	**3,039.4**
2013	14.1	3.7	0.0	30.4	134.7	525.0	368.8	328.8	745.7	337.1	-2	140.0	**2,628.3**
2014	4.2	50.4	1.0	69.8	23.9	389.5	130.3	1013.9	916.4	284.1	26.8	39.0	**2,949.3**
2015	4.0	0.4	8.2	0.2	20.3	263.1	480.8	530.2	460.2	191.2	1.6	33.0	**1,993.2**
2016	1.4	171.2	0.0	4.6	94.8	171.0	335.4	904.4	514.0	396.2	253.2	77.0	**2,923.2**
Mean	**18.3**	**19.2**	**15.4**	**36.7**	**185.6**	**367.0**	**468.1**	**491.6**	**470.1**	**253.3**	**109.8**	**75.0**	**2,458.1**
Minimum	**0.0**	**0.0**	**0.0**	**0.0**	**1.4**	**113.8**	**111.7**	**127.4**	**88.2**	**47.8**	**1.5**	**0.0**	**1663.5**
Maximum	**79.6**	**171.2**	**97.9**	**169.0**	**469.1**	**824.1**	**1051.7**	**1013.9**	**921.0**	**712.6**	**289.7**	**408.1**	**3163.6**

-2 indicates missing values

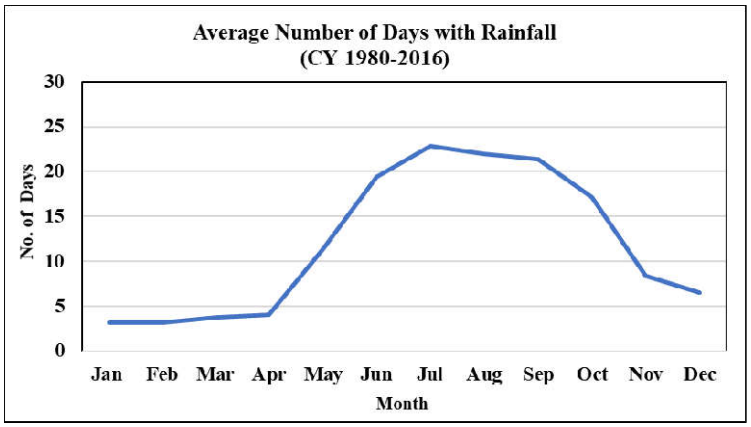

Figure 10. Average number of days per month with recorded rainfall (CY 1980-2016)

Mean minimum temperature ranges from 20.25°C to 26.18.26°C (See Table A1)while mean maximum temperature ranges from 29.16°C to 35.23°C (See Table A1). Mean monthly relative humidity ranges from 66.1% to 93.0% (Table A3).

Mean monthly trend of precipitation, temperature, and relative humidity for the past 37 years (CY 1985 to 2016) is shown in Figure 11. Month of March has the least precipitation while the month of August recorded the highest, with 14.95mm and 491.61mm, respectively. Month of July recorded the lowest temperature while month of April is the warmest, with 23.16°C and 33.99°C, respectively. Relative humidity is low during months of

March and April recorded peaks at the month of September, with 77.8%, 77.8% and 88.58% respectively.

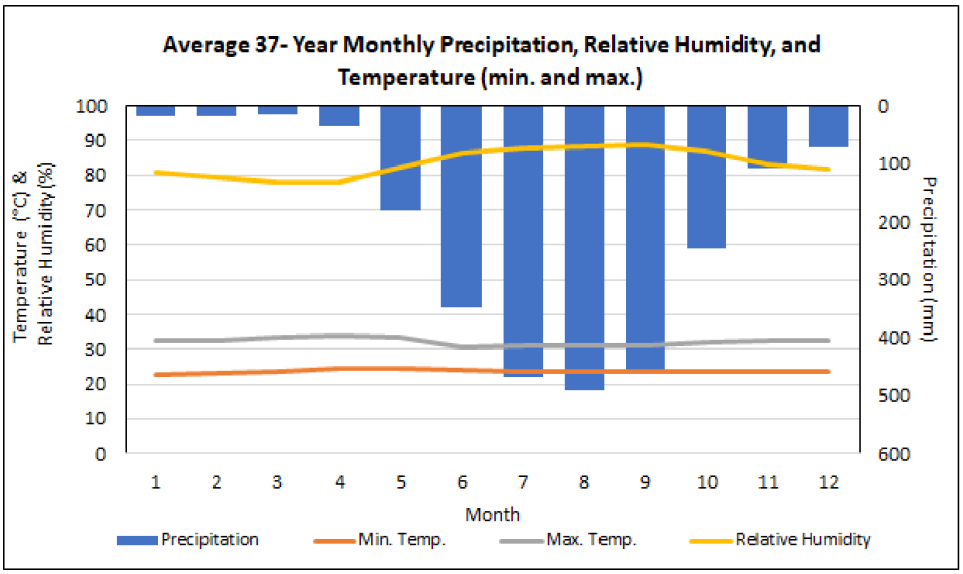

Figure 11. Average monthly values of 37-year precipitation, minimum and maximum temperature, and relative humidity (Source: PAG-ASA Coron Synoptic Station (1980-2016) located at 12° 00' 13.20N, 120° 11' 59.40"E, 59.938 masl)

5.3. Hydrology

Surface water yield at the discharge monitoring point (Figure 12), was simulated with Soil and Water Assessment Tool (SWAT v12). The site was selected for it is the source of water of Bgy. Malaking Patag and is reported to be a perennial river. SWAT was selected for it has the capability to calculate the response of a watershed to prevailing climate combining the properties of land cover, slope and soil (Arnold *et al.*, 2012; Neitsch, Arnold, Kiniry, & Williams, 2011; Winchell, Srinivasan, Di Luzio, & Arnold, 2013). It has a sub-catchment area of 0.28 km^2 or roughly 0.6% of the entire watershed.

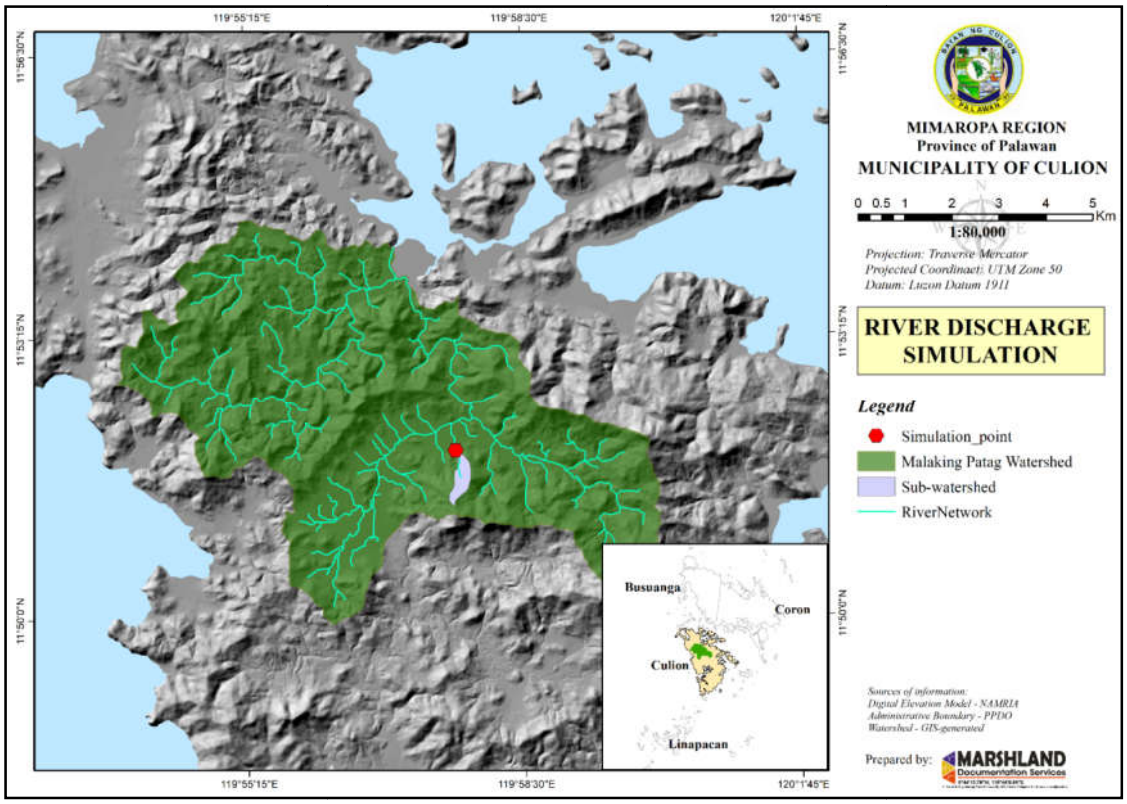

Figure 12. Simulation River discharge point.

Probability of exceedance at 80% during the simulation period (Figure 13), the river discharge is estimated at 0.03 m^3 s^{-1} or equivalent to 0.08 Million m^3 $month^{-1}$of water yield. Thus, the creek assures a dependable yield of 0.03 m^3 s^{-1} or 30.53L s^{-1} 80% of the time.

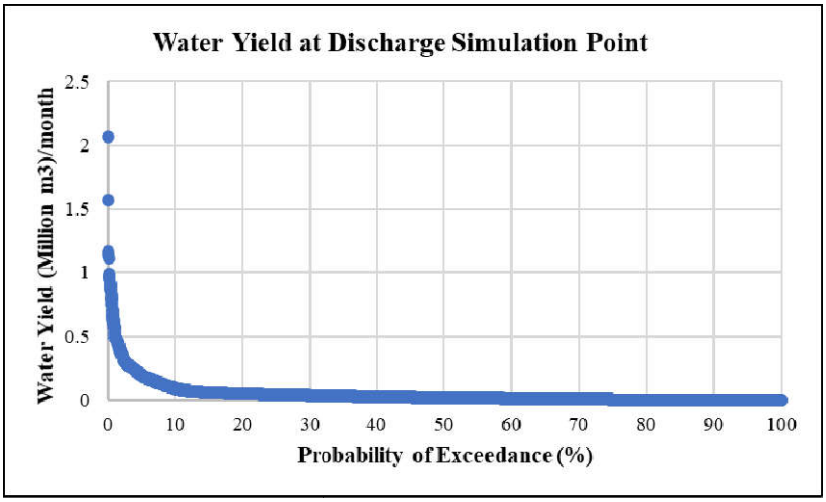

Figure 13. Water Yield at Simulation Point vis-à-vis Probability of Exceedance

5.4. Biological Components

The island municipality of Culion and its surrounding smaller islands are included in the Palawan Pleistocene Aggregate Island Complex (Palawan PAIC) which possesses unique fauna and flora endemic only within the region. A two-day transect survey was conducted in the upstream and midstream of the proposed watershed to document diurnal and nocturnal fauna, as well as terrestrial trees. A total of 112 species of terrestrial flora and fauna were documented during the survey. Moreover, the presence of some threatened species in the watershed would provide additional support in the need for protecting the habitat and establishing it as a watershed.

5.4.1. Avian Community

A total 58 bird species were documented in the proposed watershed, 11 of which are Palawan endemic, with two globally threatened and 19 regionally protected under PCSD 15-521(Table 10), and eight migratory species. There were several avian species present in the watershed that are under a threatened category and are Key Biodiversity Area (KBA) trigger species.

- **Crested Goshawk** (*Accipiter trivirgatus*) is classified as Endangered species under PCSD 15-521. Race *palawanus* of this species is endemic to Calamian Islands and mainland Palawan. It is primarily a lowland bird, and an all-year resident. As a predator in its habitat, it controls population of its prey item which includes other, birds, mammals, and reptiles. This species was not observed during the actual survey in the watershed area but past records and ethnobiological interviews with local residents and key informants confirmed the presence of this bird in the site.

- **White-bellied Sea Eagle** (*Haliaeetus leucogaster*) is classified as Endangered species under PCSD 15-521. It usually inhabits terrestrial habitats near oceans, but they usually can live in forests around 900 masl. They are sedentary birds, and birds and will only leave an area once all resources are depleted. Another bird of prey, this species often feeds on fish in aquatic habitats, but also prey on small terrestrial mammals and reptiles, playing an important role in the exchange of energy and nutrients between aquatic and terrestrial habitats. This bird was not observed during the actual survey in the watershed area but past records and ethnobiological interviews with local residents and key informants confirmed the presence of this bird in the site.

- **Crested Serpent Eagle** (*Spilornis cheela*) is classified as Endangered species under PCSD 15-521. Race *palawanensis* of this species is endemic to Calamian Islands and the rest of Palawan. Due to their large size, this species primarily inhabits forest edges occasionally entering forest interiors.

They are known to reach elevations of 1900 masl. An apex predator, this species often preys on reptiles like snakes and lizards, as well as small mammals (Del Hoyo et al. 1994), controlling the populations of these animals. This species was observed doing thermal flights while calling a loud shrill during mid-day within the upstream of the watershed area.

- **Chinese Sparrowhawk** (*Accipiter soloensis*) is a migratory raptor in the Philippines and is classified as Endangered species under PCSD 15-521. During winter migration, it prefers to dwell in forests and wooded areas, including plantations, often near paddy fields or wetlands, where most of its prey can be found (Orta & Kirwan2018).It also acts as a top predator in its habitat controlling populations of its prey items. A large flock (kettle) of this species was observed doing thermal flights during mid-day in the upstream portion of the watershed area.

- **Palawan Hornbill** (*Anthracoceros marchei*) is a Palawan endemic and is classified as Endangered species under PCSD 15-521 and Vulnerable species under IUCN and DENR AO 2019-09. It is also a KBA trigger species and CITES-listed species. It acts as a bio-indicator due to its sensitivity to environmental changes. It mainly feeds on fruits, and with its large home range, it is an important seed disperser of large-seeded trees (Hamann & Curio 1999). A few individuals of this species were observed calling a raucous "caaaww" notes from a far in the midstream during the afternoon survey.

- **Yellow-throated Leafbird** (*Chloropsis palawanensis*) is a Palawan endemic and is classified as Vulnerable species under PCSD 15-521. It is also a KBA trigger species. It prefers to thrive in canopy and edge of lowland evergreen forest, as well as secondary growth. It was one of the most commonly observed birds in the midstream of watershed, feeding on flowers and small fruits which indicates its important role in the pollination of the forest flowers (Wells 2018).

- **Black-chinned Fruit-Dove** (*Ramphiculus leclancheri*) is classified as Vulnerable species under PCSD 15-521. Race *gironieri* of this species is endemic to Calamian Islands and the rest of Palawan. It inhabits forest and dense secondary growth in the lowlands up to at least 700 m. It is known to feed on fruits, figs and berries making it a very good natural agent of seed dispersal in the forest (Baptista *et al.* 2018). This species was not observed during the actual survey in the watershed area but past records and ethnobiological interviews with local residents and key informants confirmed the presence of this bird in the site.

- **Palawan Flowerpecker** (*Prionochilus plateni*) is a Palawan endemic and is classified as Vulnerable species under PCSD 15-521. It is also a KBA trigger species. Race *culionensis* of this species is restricted to Calamian Islands. It can be found on primary forest, secondary growth, scrub, and gardens, particularly around fruiting and flowering trees. It is one of the most commonly observed birds in the watershed area. It also plays an important role in pollination inside the forest as it primarily feeds on fruits, nectar, and pollen of mistletoes (Cheke & Mann 2018).

- **Palawan Fairy-bluebird** (*Irena tweeddalii*) is a Palawan endemic and is classified as Near Threatened species under IUCN. It is naturally occurring in evergreen and semi-evergreen forest and forest edge from lowlands up to 700 masl, typically in forest canopy. It is primarily frugivorous feeding on wild figs and berries making it also an important seed disperser in the forest (del Hoyo *et al.* 2018).This species was not observed during the actual survey in the watershed area but past records and ethnobiological interviews with local residents and key informants confirmed the presence of this bird in the site.

- **Long-tailed Shrike** (*Lanius schach*) is classified as Vulnerable species under PCSD 15-521. In Palawan faunal region, it is only occurring in Calamian Islands. It usually thrives in open country with scrub, light woodland, cultivated areas and grasslands with scattered bushes. It is very opportunistic predator acting like a small raptor which helps in regulating the population of its prey items. It largely feeds on insects and other vertebrates such as small mammals, lizards, frogs, crabs, and small birds (Yosef 2018). This species was observed in open grasslands in the midstream portion of the watershed.

- **Blue Paradise-flycatcher** (*Terpsiphone cyanescens*) is a Palawan endemic and is classified as Vulnerable species under PCSD 15-521. It is also a KBA trigger species. It inhabits the understorey of primary forest and secondary growth, but not in isolated tracts of secondary vegetation. It is strictly insectivorous which may help in reducing the presence of insect pest species in the watershed area (Moeliker 2018).This species was not observed during the actual survey in the watershed area but past records and ethnobiological interviews with local residents and key informants confirmed the presence of this bird in the site.

- **Palawan Blue Flycatcher** (*Cyornis lemprieri*) is a Palawan endemic and is classified as Near Threatened species under IUCN and Vulnerable species under PCSD 15-521. It is also a KBA trigger species. It inhabits lowland and

submontane dry primary and secondary forest up to 1000 masl. It mainly feeds on insects and other small invertebrates, which may help in regulating the populations of these organisms (Clement 2018). It was observed to be fairly common in both upstream and midstream portions, particularly in the shaded thickets near riparian habitat.

- **White-vented Shama** (*Kitacincla nigra*) is a Palawan endemic and is classified as Vulnerable species under PCSD 15-521. It is also a KBA trigger species. It naturally occurs in lowland forest and forest edge, second growth and scrub. It is a good indicator of detecting presence of other species in the area as it can mimic various bird calls. Its dietary habits also help in controlling insect populations (Collar 2018). This species was quite common in the watershed area, in both midstream and upstream portions, often observed vocalizing a loud, varied, and melodious song.

- **Lovely Sunbird** *(Aethopyga shelleyi)* is a Palawan endemic and is classified as Vulnerable species under PCSD 15-521. It generally thrives on forest, forest edge, and cultivation, often around flowering and fruiting trees of lowlands up to 2000 masl. This feeding habits is helpful in facilitating pollination in the forest (Cheke & Mann 2018). This species was encountered feeding on nectar of flowering trees in the upstream portion of the watershed.

- **White-bellied Woodpecker** *(Dryocopus javensis)*is a resident woodpecker in the Philippines and is classified as Vulnerable species under PCSD 15-521. Race *hargitti* of this species is endemic to Palawan. It inhabits various types of evergreen and deciduous forest, also pine forest, mixed bamboo stands, light secondary forest with large trees. Like other woodpecker species, it plays an important ecological role in its habitat by providing cavities in trees as nesting and roosting habitat for a broad range of fauna like arboreal mammals, reptiles, and amphibians, as well as insects and other birds (Winkler *et al.* 2018). This species was not observed during the actual survey but past records and ethnobiological interviews with local residents and key informants confirmed the presence of this bird in the watershed area.

- **Spot-throated Flameback** *(Dinopium everetti)* is a Palawan endemic and is classified as Near-threatened species under IUCN, Other Threatened Species under DENR AO 2019-09, and Vulnerable under PCSD 15-521. It thrives well in open forest and woodlands, also in coconut plantations indicating some tolerance of habitat modified by humans. Aside from providing nesting and roosting habitat for other cavity-dwelling fauna, the two aforementioned woodpecker species may also provide an important role in controlling insect outbreaks as they feed mainly on ants, beetle larvae, termites, and the like

(del Hoyo *et al.* 2018). This species was not observed during the actual survey but past records and ethnobiological interviews with local residents and key informants confirmed the presence of this bird in the watershed area.

- **Blue-headed Racquet-tail** *(Prioniturus platenae)* is a Palawan endemic and is classified as Vulnerable species under IUCN and DENR AO 2019-19, and Endangered species under PCSD 15-521. It is also a KBA trigger species and CITES-listed species. In the past decade, it has been threatened by deforestation and the illegal exotic pet trade. It inhabits lowland forests and adjacent agricultural lands of up to 300 masl (Birdlife International 2012). This is the most common and regularly observed bird species in the watershed area, frequently foraging in small to large groups on fruiting trees. Through its feeding habits, it can exert cascading effects on fruiting trees' life cycles and shape the structure and functioning of ecosystems in the watershed (Collar & Boesman 2018).

- **Blue-naped Parrot** (*Tanygnathus lucionensis*) is a Philippine near-endemic and is classified as Near Threatened species under IUCN and Critically Endangered species under DENR DAO 2019-09 and PCSD 15-521. It is also a CITES-listed species. It is widespread throughout the country and is found in secondary forests and plantations of up to 1000 masl, nesting in tree holes (Birdlife International 2012). It primarily feeds on seeds and some fruits acting as seed disperser for these plants (Collar *et al.* 2018). This species was not observed during the actual survey but past records and ethnobiological interviews with local residents and key informants confirmed the presence of this bird in the watershed area.

- **Spotted Wood Owl** (*Strix seloputo*) is a resident species in Palawan and is classified as Endangered species under PCSD 15-521. Race *wiepkeni* of this species is endemic to Calamian Islands and the rest of Palawan. It naturally occurs in lowland open forest and forest edge, stands of trees near habitation, orchards, plantations, secondary growth, and mangrove forest. It also acts as a top predator feeding mostly on small rodents such as rats and mice, small birds, and large insects (Holt *et al.* 2018). This species was heard callinga deep and forceful "hoo-hoo-hoo-hooo" during night survey in the upstream.

- **Common Hill Myna** (*Gracula religiosa*) is classified as Vulnerable species under DENR AO 2019-09 and Critically Endangered under PCSD 15-521. It is also a CITES-listed species. Race *palawanensis* of this species is endemic to Palawan. It is widespread in the oriental region and is commonly found in

hills between 300 masl to 2000 masl. They prefer areas with high rainfall and humidity (Feare & Craig 1999). It feeds on fruits and insects but has been threatened by the exotic pet trade with its ability to mimic sound. It primarily feeds on wild figs, berries and fruits making it also a highly dependable seed disperser in the forest (Craig & Feare 2018). This species was not observed during the actual survey but past records and ethnobiological interviews with local residents and key informants confirmed the presence of this bird in the watershed area.

Table 10. Avian species recorded in recorded in Malaking Patag, Culion, Palawan.

NO.	SCIENTIFIC NAME	COMMON NAME	CRN 2020	Rico & Oliver 2009	SEMP-NP	CONSERVATION STATUS		
						IUCN	DAO 2019-09	PCSD 15-521
1	*Accipiter soloensis*	Chinese Sparrowhawk	+			LC		EN
2	*Accipiter trivirgatus*	Crested Goshawk	+			LC		EN
3	*Aethopygashelleyi*	Lovely Sunbird (a)	+		+	LC		VU
4	*Amaurornisphoenicurus*	White-breasted Waterhen	+			LC		
5	*Anthracocerosmarchei*	Palawan Hornbill (a,b,c)	+	+	+	VU	VU	EN
6	*Anthusrufulus*	Paddyfield Pipit	+			LC		
7	*Aplonispanayensis*	Asian Glossy Starling	+			LC		
8	*Bubulcus ibis*	Cattle Egret	+			LC		
9	*Cacomantismerulinus*	Plaintive Cuckoo	+			LC		
10	*Caprimulgus macrurus*	Large-tailed Nightjar	+			LC		
11	*Centropus bengalensis*	Lesser Coucal	+			LC		
12	*Ceyxerithaca*	Oriental Dwarf-Kingfisher	+			LC		
13	*Chalcophaps indica*	Grey-capped Emerald Dove	+		+	LC		
14	*Charadrius leschenaultii*	Greater Sandplover	+			LC		
15	*Chlidoniashybrida*	Whiskered Tern	+			LC		
16	*Chloropsispalawanensis*	Yellow-throated leafbird (a,b)	+			LC		VU
17	*Cinnyris jugularis*	Olive-backed Sunbird	+			LC		
18	*Collocalia esculenta*	Glossy Swiftlet	+			LC		
19	*Corvus enca*	Slender-billed Crow	+			LC		
20	*Cyornislempreiri*	Palawan Blue Flycatcher (a,b)	+		+	NT		VU
21	*Dicaeumpygmaeum*	Pygmy Flowerpecker	+			LC		
22	*Dicrurushottentottus*	Hair-crested Drongo	+		+	LC		
23	*Dicrurusleucophaeus*	Ashy Drongo	+			LC		
24	*DinopiumEveretti*	Spot-throated Flameback (a)	+			NT	OTS	VU
25	*Dryocopusjavensis*	White-bellied Woodpecker	+			LC		VU
26	*Eurystomusorientalis*	Oriental Dollarbird	+			LC		
27	*Gallus gallus*	Red Junglefowl	+		+	LC		
28	*Gracula religiosa*	Common Hill Myna (c)	+	+	+	LC	VU	CR
29	*Haliaeetus leucogaster*	White-bellied Sea Eagle	+	+		LC		EN
30	*Hirundojavanica*	House Swallow	+			LC		
31	*Hypothymisazurea*	Black-naped Monarch	+			LC		
32	*Irena tweeddalii*	Palawan Fairy-bluebird (a)	+			NT		VU
33	*Kitacincla nigra*	White-vented Shama (a,b)	+		+	LC		VU
34	*Laniuscristatus*	Brown Shrike	+			LC		
35	*Laniusschach*	Long-tailed shrike	+			LC		VU
36	*Merops americanus*	Rufous-crowned Bee-eater*	+			LC		
37	*Meropsphilippinus*	Blue-tailed Bee-eater	+			LC		

38	*Motacilla cinerea*	Gray Wagtail	+			LC		
39	*Muscicapagriseisticta*	Gray-streaked Flycatcher	+			LC		
40	*Onychoprionanaethetus*	Bridled Tern	+			LC	OTS	
41	*Oriolus chinensis*	Black-naped Oriole	+			LC		
42	*Orthotomussericeus*	Rufous-tailed Tailorbird	+			LC		
43	*Phaenicophaeuscurvirostris*	Chestnut-breasted Malkoha	+			LC		
44	*Pitta sordida*	Hooded Pitta	+			LC		
45	*Prioniturusplatenae*	Blue-headed Racquet-tail (a,b,c)	+	+	+	VU	VU	EN
46	*Prionochilusplateni*	Palawan Flowerpecker (a,b)	+			LC		VU
47	*Pycnonotuscinereifrons*	Ashy-fronted Bulbul (a)	+			LC		
48	*Rallinafasciata*	Red-legged Crake	+			LC		
49	*Ramphiculusleclancheri*	Black-Chinned Fruit-Dove	+			LC		VU
50	*Spilopelia chinensis*	Eastern Spotted Dove	+	+		LC		
51	*Spilornischeela*	Crested Serpent Eagle	+	+		LC		EN
52	*Sterna dougallii*	Roseate Tern	+			LC		
53	*Strixseloputo*	Spotted Wood Owl	+			LC		EN
54	*Tanygnathuslucionensis*	Blue-naped Parrot (c)	+	+	+	NT	CR	CR
55	*Terpsiphonecyanescens*	Blue Paradise-Flycatcher (a,b)	+		+	LC		VU
56	*Todiramphuschloris*	Collared Kingfisher	+			LC		
57	*Treronvernans*	Pink-necked Green-Pigeon	+	+		LC		
58	*Turnixsuscitator*	Barred Buttonquail	+			LC		

a – Endemic
b - KBA trigger species
c - CITES listed species

5.4.2. Herpetofauna

A total of 16 species of amphibians and reptiles were documented in the proposed watershed, five of which are Philippine endemic, with six regionally protected species under PCSD 15-521(Table 11).There were several notable amphibian and reptile species that served as bio-indicators, which provides information on the limnological characteristics of each proposed watershed.

- **Culion Frog** (*Pulchrana moellendorffii*) inhabits moderately disturbed permanent rivers. It is also a Palawan endemic and is classified as Vulnerable (PCSD 15-521). This species was encountered in the upstream and midstream areas of the proposed watershed and was the most abundant frog species.

- **Asian Leaf Turtle** (*Cyclemys dentata*) is a widespread species encountered in the forests of Palawan and Sulu Archipelago in the Philippines. It usually inhabits clear streams and small rivers in lowland forests and is a highly elusive species. It is classified as Near Threatened (IUCN) and Vulnerable (DENR DAO 2019-09). One individual of this species was encountered in the upstream areas of the water collection area of the watershed, indicating that the stream water is clean in this area.

- **Palawan Water Monitor** (*Varanus palawanensis*) is a Palawan endemic and is widespread throughout its range occurring from coastal areas and surrounding mangrove forests to inland rainforests and riparian habitats of up to 700 masl. This monitor lizard and is considered as a key predator in its habitat, controlling population of its prey. They are generalist carnivores but are also scavengers. It is classified as Endangered under PCSD 15-521. One dead individual was encountered near the midstream transect.

Table 11. Herpetofauna species recorded in Malaking Patag, Culion, Palawan.

NO.	SCIENTIFIC NAME	COMMON NAME	CRN 2020	Rico & Oliver 2009	CONSERVATION STATUS		
					IUCN	DAO 2019-09	PCSD 15-521
1	*Ahaetulaprasina*	Oriental Whipsnake	+		LC		
2	*Bronchocelacristatella*	Green Crested Lizard	+		DD	OTS	
3	*Cyclemys dentata*	Asian Leaf Turtle (c)	+		NT	VU	
4	*Eutropismultifasciata*	Common Mabuya	+		LC		
5	*Fejervaryavittigera*	Luzon Wart Frog (a)	+		LC		
6	*Gekko gecko*	Tokay Gecko (c)	+		LC	OTS	VU
7	*Gekkomonarchus*	Twin-spotted Gecko	+		DD		
8	*Hemidactylus frenatus*	Common House Gecko	+		LC		
9	*Ingerophrynusphilippinicus*	Philippine Toad (a)	+	+	LC		VU
10	*Limnonectes acanthi*	Busuanga Wart Frog (a)	+		NT	OTS	VU
11	*Malayopython reticulatus*	Reticulated Python (c)	+	+	LC	OTS	EN
12	*Occidozygalaevis*	Common Puddle Frog	+		LC		
13	*Ophiophagus hannah*	King Cobra	+				
14	*Polypedatesleucomystax*	Common Tree Frog	+				
15	*Pulchranamoellendorffi*	Culion Frog (a)	+		LC		VU
16	*Varanus palawanensis*	Palawan Water Monitor (a,c)	+		DD	OTS	EN

a – Endemic
b - KBA trigger species
c - CITES listed species

5.4.3. Mammals

A total of 16 mammal species were recorded in the proposed watershed, four of which are Philippine endemic, with two globally threatened species and 10 regionally protected under PCSD 15-521(Table 12). There were several notable mammal species encountered during the assessment classified under a threatened category which would provide additional support in the need for protecting the habitat and establishing it as a watershed.

- **Philippine Long-tailed Macaque** (*Macaca fascicularis philippensis*) is Endangered under PCSD 15-521.This endemic subspecies is widespread throughout forested areas and disturbed habitats in the country. It is ecologically important, as it is a main seed disperser in forests with its

omnivorous diet and high mobility. It is also an important predator in its ecosystem and may have impact on its prey species. This species has been reported within the forest of the proposed watershed.

- **Philippine Pangolin** (*Manis culionensis*) is a Palawan endemic and is classified Critically Endangered under IUCN and PCSD 15-521 and Endangered under DENR DAO 2019-09. It inhabits lowland forests, grasslands, and agricultural areas (Batin & Widmann 2008). Ants and termites are among the most important insect groups in tropical forests ecosystems. Playing an important role in the nutrient and carbon cycle. Philippine pangolins prey on these ants and termites, controlling the population of these insects. This species has been reported to occur within the forest of the proposed watershed.

- **Palawan Bearded Pig** (*Sus ahoenobarbus*) is a Palawan endemic and is classified as Vulnerable under DENR DAO 2019-09 and Endangered under PCSD 15-521. It is a habitat generalist, inhabiting all major forest types up to 1,500 masl (Meijaard & Widmann 2017). The species, being omnivorous, also plays an important seed disperser, particularly on fig species (*Ficus* spp.). An individual of this was captured by a local for bushmeat.

- **Palawan Tree Shrew** (*Tupaia palawanensis*) is also a Palawan endemic and is classified as Endangered under PCSD 15-521. It usually inhabits lowland forests but can seldom be found in agricultural areas and montane regions of 1400 masl (Esselstyn *et al.* 2004). Being insectivorous, this species controls population of insects in its habitat (Hayward and Phillipson 1979). One individual of this species was captured in a cage trap in the midstream transect.

Table 12. Mammalian species recorded in Malaking Patag, Culion, Palawan.

NO.	SCIENTIFIC NAME	COMMON NAME	CRN 2020	Rico & Oliver 2009	CONSERVATION STATUS		
					IUCN	DAO 2019-09	PCSD 15-521
1	*Acerodon spp.*	Giant Golden-crowned Flying Fox	+				
2	*Axis calamianensis*	Calamian Deer (a,c)		+	EN	EN	CR
3	*Hipposideros sp.*	Roundleaf Bat	+				
4	*Macaca fascicularisphilippensis*	Philippine Long-tailed Macaque (a)	+	+	NT		EN
5	*Manis culionensis*	Philippine Pangolin (a,c)	+	+	CR	EN	CR
6	*Maxomyspanglima*	Palawan Spiny Rat	+		LC		VU
7	*Mydausmarchei*	Palawan Stink-badger (a)	+	+	LC		VU
8	*Paradoxurus hermaphroditus*	Common Palm Civet		+	LC		
9	*Prionailurus bengalensis heaneyi*	Palawan Leopard Cat		+		VU	EN

10	*Pteropus spp.*	Large Flying Fox	+				
11	*Rattus cf. exulans*	Mouse	+				
12	*Sundasciurusjuvencus*	Northern Palawan Tree Squirrel	+		LC		VU
13	*Sundasciurusmoellendorfi*	Culion Tree Squirrel		+	NT		VU
14	*Sus ahoenobarbus*	Palawan Bearded Pig (a)	+	+	NT	VU	EN
15	*Tupaia palawanensis*	Palawan Tree Shrew (a)	+	+	LC	OTS	EN
16	*Viverratangalunga*	Malay Civet		+	LC		

a – Endemic
b - KBA trigger species
c - CITES listed species

5.4.4. Flora

Composed of a main island and few surrounding islands and islets, majority of Culions forest region is located in the main island. Though large portions are considered flatlands dedicated to agriculture, Culion shares a rich biodiversity in its forest areas. One notable find is the presence of "Culion Pitogo", (*Cycas wadei*) a Palm-like plant that is Palawan endemic observed to be thriving in the forest regions and in lowland areas of mix vegetation. Other species like Sahing (*Canarium asperum*), Dao (*Draconto melondao*), and Taluto (*Pterocymbium tinctorium*) were also present.

The relatively low forested regions are mostly rolling to undulating with pockets of close canopy areas which protects its soil cover. The natural vegetation of Culion not only serves as host to highly threatened forest species such as illicit Ipil (*Intsia bijuga*), Molave (*Vitex parviflora*), Kamagong (*Diospyros philippinensis*), but to the IUCN threatened endemic fauna such as Calamian deer and Palawan pangolins.

Its highly diverse upland areas serve as an important soil cover, trapping water to supply the needs in the lowlands. These important areas need strict protection not only for the highly conserved species of important flora and fauna but for the continued dependence of the community for clean and available water.

Table 13. Forest Trees species recorded in Malaking Patag, Culion, Palawan.

NO.	SCIENTIFIC NAME	Local Name	CONSERVATION STATUS		
			IUCN	DAO 2017-11	PCSD 15-521
1	*Mangifera indica*	Mangga	DD		
2	*Dracontomelondao*	Dao		VU	VU
3	*Intsiabijuga*	Ipil	VU	VU	VU
4	*Pterocymbiumtinctorium*	Taluto	LC		
5	*Canarium asperum*	Pagsahingin	LC		
6	*Mangifera longipes*	ManggangGubat/Malamangga		VU	VU
7	*Ficus glandulifera*	Katol/Kator			
8	*Syzygiumlacustree*	Malaasom/Malaasim			
9	*Kleinhoviahospita*	Tan-ag	LC		
10	*Diospyros streptosepala*	Dalandang/Dalondong			
11	*Syzygium*sp.	Bintang Sapa			
12	*Colona subaequalis*	Laho			
13	*Palaquiumluzoniense*	Nato	VU		

14	*Erythrina* sp.	Dapdap Sapa
15	*Barringtonia sp.*	
16	*Ficus sp.*	
17		Enenyoy
18		Kutat
19		Mangrove Sapa
20		Saheng/Saeng
21		Tuboy

5.4.1. Mangrove community

On a survey conducted by the Palawan Council and Sustainable Development Staff from 2003 – 2004, there was a total of 43 transects established in the Municipality of Culion, Palawan. Culion has a total mangrove area of 2,798.69 hectares (has) with close, sparse, and open canopy of 697.32 has, 2,038.29 has and 63.082 has, respectively. The survey results showed 18 true and 20 associate mangrove species were identified and recorded during the survey which belongs to 14 families and 27 genera of vascular plants, wherein *Rhizophora apiculata* (Ra) was identified as the most dominant and important mangrove species in Culion in terms of the most frequent and dense mangrove species recorded.

Of this count, the most widely distributed species in Culion are *Rhizophora apiculate, Rhizophora* mucronata*, Xylocarpus granatum, Rhizophora stylosa, Lumnitzera littorea, Ceriopstagal, Ceriops decandra, Scyphipora hydrophyllacea, Bruguiera gymnorrhiza and Heritiera littorea.*

Table 14.List of True Mangrove Species Identified and Recorded, Busuanga, Palawan, 2003 Source: PCSDS, 2006

Scientific Name	Common Name
TRUE MANGROVE	
Aegiceras corniculatum	Saging-saging
Aegiceras floridum	Tinduk-tindukan
Bruguiera gymnorrhiza	Busain
Bruguiera sexangula	Pototan
Bruguiera cylindrical	Pototanlalaki
Bruguiera parviflora	Langarai
Camptostemon philippinense	Gapas-gapas

Ceriops tagal	Tangal
Ceriops decandra	Malatangal
Lumnitzera littorea	Tabau
Lumnitzera racemosa	Kulasi
Nypa fruticans	Nipa
Rhizophora apiculata	Bakauanlalaki
Rhizophora mucronata	Bakauanbabae
Rhizophora stylosa	Bakauanbato
Sonneratia alba	Pagatpat
Sonneratia caseolaris	Pedada
Excoecaria agallocha	Buta-buta
Xylocarpus granatum	Tabigi
Xylocarpus moluccensis	Piagau

In terms of abundance (total individuals in 43 transects), *Rhizophora apiculata, Rhizophora mucronata, Xylocarpus granatum, Rhizophora stylosa, Lumnitzera littorea, Ceriops tagal, Ceriops decandra, Scyphipora hydrophyllacea, Bruguiera gymnorrhiza and Heritiera littorea* species has 3694, 2797, 355, 215, 204, 109, 106, 53, 35, and 26 individuals, respectively (PCSDS, 2006). However, based on the average index of diversity (species richness, abundance dominance and evenness), all sampling sites in Culion had very low relative values of biodiversity indices using the scale of Fernando Biodiversity (1998).

Measures of species richness made use of the following formulas:

Margalef's index $DMg = (S-1)/\ln N$

Menhinick's index $DMn = S/\sqrt{N}$

Shannon diversity index

$$H' = -\Sigma pi \ln pi$$

where pi, the proportional abundance of the ith species = (ni/N)

Evenness of the species can now be calculated using the formula:

$$E = H' /\ln S$$

and

Simpson's index

$$D = \Sigma \frac{(n1(n1-1))}{(N(N-1))}$$

where n1 = the number of individuals in the ith species,

N = the total number of individuals.

The overall Evenness (E) Index of 0.046216 of Culion is lower than the E index 0.076996 for Coron and to that of Busuanga's E index of 0.3974 which indicates that mangrove of Culion has lower value of biodiversity index compared to Coron's and Busuanga's index of diversity (based on Fernando Biodiversity Scale).

Meanwhile, in terms of species, *Rhizophora apiculata* is the species that has the highest value in terms of Relative Frequency (RF), Relative Density (RDen), and Importance Value (IV) with 29.1045; 47.8015 and 111.025, respectively. While *Rhizophora mucronata* (Rm) has the highest value of Relative Dominance (RDom).

5.5. Watershed Biophysical Situationer

Watershed is a fundamental unit in hydrology. Hence, morphometric characterization at watershed scale is advantageous and preferred. Most especially for ungauged watersheds, where information on soil, geology, etc., is scarce, morphometric analysis provides an excellent alternative in understanding the underlying factors that control hydrologic response.

The analyses applied at Malaking Patag watershed, a small watershed, include (1) linear aspect (stream order, stream number, bifurcation ratio, stream length); (2) areal aspect (watershed shape, area, drainage frequency, drainage density); and (3) relief aspect (stream slope, river profile). Its less elongated shape suggests low vulnerability to flooding while linear parameters indicated moderate vulnerability to flash flooding. Its relief parameters indicate high erosion potential. These vulnerabilities can be reduced with dense vegetation. It is recommended to maintain and enhance vegetation and prevent the river channels from being blocked.

The apparent high diversity, endemism, and varying feeding guilds of avian community indicate the presence of a healthy and balance forest ecosystem in the proposed watershed area most especially in the upstream portions therein. But on the other hand, there is an observed low abundance of stream frogs in the upstream of the proposed watershed. This was strange considering that the locals said the streams in that area never

dries out. One plausible explanation for this is that the area is disturbed, as supported by the observation of agricultural plants planted by the river. Hunting has also been reported in the area and could have caused ecological disturbance and degradation. It has also been reported that effluents from local poultry farms mixed with the river waters.

Moreover, human encroachment was already observed evident in the upstream, even in areas closer to the water source where slash-and-burn farming has been made, and some forest stands were already open and converted into upland agricultural crop production. These may very soon displace the local birds and other wildlife in the area and may also pose detrimental effects to the overall quality and quantity of the water source, if such activities will not stop and left unregulated. This entail the urgent need to establish the watershed in order to protect the surrounding habitat not just for the welfare of threatened avian species but also to maintain in long terms the numerous ecological services (e.g. potable water supply) the watershed may provide particularly to the local communities. Planting of indigenous native fruiting trees and flowering plants in both upstream and midstream portions of the watershed area is highly encouraged to reforest the degraded parts of the forest and provide better buffer zones and additional habitat for birds and other wildlife.

Community-based and sustainable tourism rules and regulation should be imposed in tourist-visited areas within the proposed watershed, particularly in the midstream portions, in order to carry out responsible ecotourism practices.

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7. ANNEXES

Annex A: Temperature and humidity data in Culion from 1980 – 2016.

Table A 1. Mean monthly minimum temperature

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	21.80	21.98	23.56	23.74	24.22	24.02	22.61	22.36	23.13	23.63	23.79	22.49
1981	21.48	21.64	22.65	24.29	25.51	22.51	22.99	22.83	22.92	22.23	21.77	21.66
1982	21.05	21.68	22.52	22.90	23.75	21.91	21.16	21.42	21.68	21.21	21.72	21.13
1983	20.91	20.77	21.43	21.62	-2	-2	21.23	20.81	20.98	21.46	21.32	21.22
1984	20.83	20.37	21.32	22.14	21.15	21.31	22.26	21.37	22.00	21.38	21.80	21.35
1985	21.35	21.90	21.49	21.86	22.12	-2	21.16	21.83	21.32	21.39	21.35	20.75
1986	20.38	20.25	21.73	22.53	21.72	21.07	20.65	21.00	20.99	21.23	21.14	22.04
1987	20.82	20.50	21.38	21.86	22.15	21.62	21.20	21.16	21.03	21.67	21.89	21.48
1988	21.75	21.83	21.92	22.08	22.75	20.98	21.01	22.01	21.64	20.99	21.59	21.35
1989	21.31	21.57	21.50	22.34	21.85	21.46	21.49	22.40	23.57	23.84	23.44	22.15
1990	22.25	22.38	22.56	23.45	23.79	23.77	23.91	24.79	24.30	24.10	23.85	23.56
1991	23.46	23.55	23.89	24.58	25.54	25.75	24.47	24.41	24.47	23.93	23.60	23.64
1992	22.51	23.20	24.42	24.77	25.22	25.01	24.14	24.32	24.44	24.15	23.37	23.49
1993	23.04	23.10	23.60	24.72	25.35	25.43	24.33	24.01	23.92	24.01	24.81	23.77
1994	-2	23.61	25.04	25.17	25.15	24.07	23.72	24.44	24.34	24.35	24.08	23.15
1995	21.72	21.94	23.64	23.92	23.18	24.10	24.17	24.32	24.25	24.42	24.56	23.99
1996	23.31	23.35	24.88	25.06	24.75	24.54	24.67	-2	24.07	24.59	24.07	23.51
1997	22.70	24.11	23.73	24.72	25.17	24.90	24.14	24.34	24.35	24.86	25.06	24.24
1998	24.30	24.04	25.23	26.18	25.80	25.27	25.19	25.00	24.10	24.92	25.24	24.95
1999	25.06	24.15	24.97	25.32	24.88	23.96	23.45	23.58	24.17	24.73	24.21	24.65
2000	23.66	24.57	25.07	25.64	24.61	24.41	23.58	24.01	24.40	24.08	24.52	24.54
2001	24.57	24.13	25.35	25.57	24.94	24.24	23.70	24.11	24.55	24.57	24.38	24.13
2002	22.92	23.46	24.14	25.51	25.34	24.83	24.13	23.58	23.69	24.62	25.25	24.71
2003	23.61	23.98	24.95	26.02	25.33	24.67	24.55	24.56	23.77	-2	24.42	23.56
2004	24.03	23.63	24.64	25.36	26.08	24.15	24.52	24.44	24.51	23.94	24.66	24.01
2005	23.25	24.21	24.77	24.75	26.02	25.27	24.63	24.41	-2	24.77	25.12	24.89
2006	24.75	24.99	24.41	24.94	24.70	24.33	23.74	23.48	23.76	23.35	24.11	23.96
2007	23.11	23.15	24.21	24.69	24.85	24.95	24.21	24.48	23.76	23.70	23.55	24.04
2008	23.69	23.45	23.63	25.03	23.99	24.28	23.82	24.09	23.77	24.30	24.51	23.31
2009	22.99	23.63	24.19	24.88	24.43	24.09	23.60	24.29	23.78	23.93	24.24	22.62
2010	23.09	23.51	24.64	25.44	25.62	24.89	24.48	24.17	24.33	24.59	24.19	24.09
2011	23.38	23.21	24.51	24.06	24.78	24.68	23.98	24.27	24.01	23.73	24.60	24.15
2012	23.82	24.31	24.63	23.49	23.23	22.92	22.61	24.58	23.99	23.45	24.90	24.34
2013	22.75	23.42	24.49	25.45	26.00	25.33	25.33	25.38	25.09	24.79	-2	25.45
2014	23.88	23.27	-2	-2	-2	24.47	23.93	23.98	23.54	23.65	24.14	24.30
2015	22.60	22.56	22.85	24.05	24.81	24.31	24.45	24.15	24.07	24.32	25.07	24.02

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	24.09	23.53	24.20	25.27	25.70	24.68	24.21	24.53	24.12	24.19	24.00	24.35
Mean	22.78	22.94	23.67	24.26	24.41	23.95	23.44	23.58	23.52	23.59	23.73	23.38
Minimum	22.78	22.94	23.38	23.38	23.38	23.38	23.38	23.38	23.38	23.38	23.38	23.38
Maximum	24.41	32.26	32.26	32.26	32.26	32.26	32.26	32.26	32.26	32.26	32.26	32.26

-2 indicates missing values

Table A 2. Mean monthly minimum temperature

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	31.87	32.36	32.46	34.26	33.15	31.83	30.96	30.69	31.14	31.68	32.22	32.24
1981	31.58	32.35	33.68	34.13	34.03	31.38	31.22	31.12	31.60	31.09	31.91	31.49
1982	31.72	32.29	33.24	33.65	34.24	31.30	29.15	29.55	30.10	31.66	33.06	32.89
1983	33.05	33.03	33.43	33.37	-2	-2	31.06	31.23	31.07	31.60	31.61	31.65
1984	31.98	32.33	32.67	33.63	32.38	30.22	31.02	30.12	31.19	30.44	32.07	32.47
1985	32.03	33.42	33.82	33.32	32.92	-2	30.94	31.65	30.93	31.26	32.32	32.21
1986	31.66	31.29	33.08	33.74	33.10	31.86	30.15	30.58	31.21	31.21	31.56	32.90
1987	31.72	31.51	32.30	33.92	34.48	32.24	31.16	31.38	30.38	32.45	32.50	32.04
1988	33.20	33.83	34.62	34.52	35.23	31.03	30.95	31.98	31.92	30.35	32.14	32.05
1989	33.03	32.74	33.26	34.97	32.93	31.52	31.88	30.69	31.17	32.07	32.92	32.73
1990	32.70	32.95	32.96	33.76	33.43	31.22	31.02	31.05	31.87	32.21	32.13	32.73
1991	32.13	32.30	32.14	33.45	33.42	32.18	31.47	30.74	30.73	32.29	32.51	32.61
1992	31.94	32.09	32.58	34.02	34.05	32.25	31.14	31.01	31.29	31.26	32.11	32.45
1993	32.04	32.62	32.74	34.04	34.38	33.67	31.36	30.22	31.03	31.35	32.86	31.14
1994	31.83	32.54	33.25	33.81	32.69	31.39	29.85	31.10	29.99	31.93	33.24	32.29
1995	32.11	32.81	33.27	34.10	33.77	32.87	31.91	31.67	31.15	31.80	33.36	32.63
1996	32.91	33.61	33.27	34.27	33.16	33.04	32.52	32.62	31.76	34.37	32.56	32.87
1997	32.27	33.04	33.04	34.31	32.99	32.43	30.51	31.24	31.61	33.20	33.78	33.88
1998	33.33	33.37	33.71	34.21	33.70	33.03	33.33	32.67	31.05	31.34	32.50	32.27
1999	32.77	33.37	33.19	32.93	33.17	30.68	29.56	30.57	31.26	32.95	31.98	32.12
2000	32.57	32.61	32.97	33.98	31.78	31.21	29.32	31.11	31.17	30.88	32.08	31.33
2001	32.69	31.60	33.14	34.21	32.64	31.30	30.35	29.30	31.90	31.90	32.16	31.64
2002	32.25	31.97	33.14	34.23	33.65	31.68	29.95	29.92	29.97	32.41	33.98	33.78
2003	33.30	33.37	33.74	34.95	32.69	31.28	31.19	31.10	30.22	-2	32.81	32.32
2004	32.81	32.73	34.18	34.15	33.29	29.16	30.93	30.06	32.77	31.43	32.58	31.96
2005	31.56	32.13	32.42	33.71	33.75	31.96	30.77	30.43	-2	32.12	32.93	31.47
2006	32.25	32.91	33.01	-2	-2	-2	-2	-2	-2	-2	-2	-2
2007	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
2008	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
2009	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
2010	-2	-2	-2	-2	-2	-2	-2	32.00	-2	-2	-2	-2
2011	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
2013	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
2014	-2	-2	-2	-2	-2	31.08	31.44	29.97	30.40	31.85	34.26	33.09
2015	32.37	32.05	32.27	33.74	34.51	33.25	31.45	31.52	31.88	32.50	34.38	33.85
2016	33.62	33.03	33.77	34.58	34.82	33.21	31.98	30.92	31.68	31.56	32.55	32.82
Mean	**32.39**	**32.63**	**33.15**	**34.00**	**33.49**	**31.79**	**30.98**	**30.94**	**31.16**	**31.83**	**32.66**	**32.41**
Minimum	**31.56**	**31.29**	**32.14**	**32.93**	**31.78**	**29.16**	**29.15**	**29.30**	**29.97**	**30.35**	**31.56**	**31.14**
Maximum	**33.62**	**33.83**	**34.62**	**34.97**	**35.23**	**33.67**	**33.33**	**32.67**	**32.77**	**34.37**	**34.38**	**33.88**

-2 indicates missing values

Table A 3. Mean monthly relative humidity

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	83.76	82.81	81.92	78.44	82.06	84.87	87.58	88.44	87.14	86.31	83.88	87.45
1981	85.08	84.02	82.90	82.20	81.05	86.51	85.59	86.01	84.64	85.03	83.45	84.76
1982	84.76	83.51	79.85	79.77	80.06	85.44	89.56	88.62	87.69	85.39	82.38	82.57
1983	81.17	82.00	79.47	78.85	-2	-2	84.96	85.67	86.72	86.46	86.67	85.49
1984	83.78	83.13	82.63	78.08	83.75	87.98	85.93	88.43	86.21	86.74	84.63	84.26
1985	84.57	82.17	80.40	80.06	80.10	-2	86.19	84.21	86.66	85.39	84.11	84.45
1986	85.08	85.72	81.99	79.83	81.49	84.54	87.08	85.64	85.04	84.32	84.47	83.12
1987	84.42	84.47	82.59	79.70	78.18	82.90	84.96	84.65	85.92	83.00	82.45	83.37
1988	81.38	80.17	78.74	78.67	77.22	84.63	85.07	82.65	83.96	85.94	82.68	84.49
1989	81.39	81.87	80.62	77.06	81.08	84.16	83.24	87.65	86.84	83.82	82.33	82.59
1990	81.11	82.54	79.08	78.77	80.38	87.78	89.57	89.70	88.92	88.81	86.75	83.47
1991	82.12	79.98	77.17	78.86	81.88	85.98	90.15	90.98	91.05	87.55	83.33	79.40
1992	82.44	77.37	75.35	77.78	82.94	87.94	89.57	89.23	89.12	89.21	83.44	79.20
1993	80.32	81.48	76.88	75.98	76.60	82.18	88.91	90.23	90.58	89.66	85.02	88.37
1994	87.03	82.98	79.63	82.21	87.19	88.68	91.72	89.65	92.55	88.53	80.19	81.01
1995	81.67	78.20	75.86	74.82	83.04	87.46	90.11	91.36	91.65	90.83	86.52	84.95
1996	81.30	77.58	78.75	82.15	87.45	86.85	88.90	88.85	91.05	87.64	86.61	78.25
1997	80.77	76.08	76.82	77.74	82.34	88.21	91.92	90.17	90.25	86.03	80.45	76.73
1998	76.15	78.26	73.26	74.36	80.31	85.99	86.45	87.29	92.43	90.10	86.21	85.17
1999	79.79	75.96	80.45	84.71	86.05	90.29	92.90	90.44	88.21	85.88	85.72	83.31
2000	77.11	78.72	79.46	78.05	87.09	89.93	91.78	88.01	87.81	88.75	84.73	84.05
2001	78.97	82.78	78.76	77.20	84.91	88.35	90.97	92.75	88.92	88.14	82.74	79.64
2002	77.47	75.64	74.28	73.08	81.93	88.06	90.34	92.09	92.76	87.43	80.16	77.55
2003	76.00	72.51	72.73	72.77	82.55	88.55	87.01	89.85	92.13	-2	84.17	79.10
2004	78.58	79.12	76.03	78.66	79.62	93.00	88.68	90.41	83.64	85.97	81.96	83.22
2005	78.05	74.41	75.39	76.35	81.63	86.35	89.52	90.09	-2	86.43	83.10	80.38
2006	78.44	73.22	78.04	76.22	81.52	87.05	88.32	89.76	91.22	87.99	81.86	82.78
2007	77.80	76.50	73.66	76.23	82.97	85.19	86.35	86.28	91.05	88.43	88.54	80.24

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	82.00	80.70	78.06	77.40	88.63	85.60	88.15	87.63	88.76	86.33	82.06	82.11
2009	81.05	77.46	74.89	79.95	85.49	88.20	90.26	87.94	89.81	87.94	80.07	78.75
2010	78.05	73.38	74.22	74.66	76.05	85.46	87.25	90.31	89.47	89.82	88.97	88.37
2011	83.78	83.64	80.92	80.36	85.56	88.99	90.41	91.98	91.40	90.82	85.43	86.64
2012	85.07	83.90	81.15	82.85	88.74	91.27	90.87	87.90	90.22	86.28	81.57	81.66
2013	84.61	78.75	81.35	78.97	82.20	87.70	85.74	84.85	-2	-2	-2	-2
2014	-2	-2	-2	-2	-2	85.78	84.39	87.55	88.36	86.89	78.62	75.00
2015	75.52	71.14	70.94	71.23	75.48	79.77	84.26	86.20	83.97	78.96	69.13	68.33
2016	67.94	68.14	66.81	66.10	69.52	75.80	80.45	83.13	82.47	82.58	75.17	74.58
Mean	**80.79**	**79.17**	**77.81**	**77.78**	**81.92**	**86.50**	**87.98**	**88.29**	**88.53**	**86.84**	**83.04**	**81.80**
Minimum	**67.94**	**68.14**	**66.81**	**66.10**	**69.52**	**75.80**	**80.45**	**82.65**	**82.47**	**78.96**	**69.13**	**68.33**
Maximum	**87.03**	**85.72**	**82.90**	**84.71**	**88.74**	**93.00**	**92.90**	**92.75**	**92.76**	**90.83**	**88.97**	**88.37**

Annex B: Wildlife Gratuitous Permit

Republic of the Philippines
(Republic Act No. 7611)
PALAWAN COUNCIL FOR SUSTAINABLE DEVELOPMENT STAFF

PCSD

WILDLIFE GRATUITOUS PERMIT (GP)

No.: 2020-08

PALAWAN COUNCIL FOR SUSTAINABLE DEVELOPMENT STAFF
RELEASED
DATE: 09-07-2020
TIME: 4:06 pm
BY:
PUERTO PRINCESA CITY

Grantee: **MR. FERNANDO A. LOPEZ**
MDRRMO Head
Calamianes Resilience Network Inc.
Poblacion I, Coron, Palawan

Wildlife Gratuitous Permit for the Conduct of Field Research Involving Terrestrial Wild Fauna Species in Coron, Busuanga, Culion and Linapacan, Palawan

Pursuant to the provisions of PCSD Resolution No. 11-423 or PCSD Administrative Order No. 12, as amended, "Detailed Guidelines in the Implementation of Republic Act 9147 and Joint DENR-DA-PCSD Administrative Order No. 01 as may be made Applicable in the Province of Palawan", a Wildlife Gratuitous Permit (GP) for utilization of terrestrial wild fauna species in Coron, Busuanga, Culion and Linapacan, Palawan purposes is hereby granted to:

MR. FERNANDO A. LOPEZ

Subject to the terms and conditions herein stated:

A. Data Gathering/Collection

1. The permittee shall gather/collect data only from the following municipalities in Palawan:
   a) Coron b) Busuanga c) Culion d) Linapacan
2. The permittee shall only collect two (2) individuals per species of the following wild fauna for research purposes only:
   a) Herpetofauna b) Invertebrates c) Volant and non-volant small mammals
3. Upon expiration of this GP, the permittee shall have no authority to possess all voucher/preserved specimens collected. Thus, the permittee must deposit all specimens collected by virtue of this GP to either of the following:
   a) Philippine National Museum
   b) UPLB Museum of Natural History
   c) PCSD
4. The permittee must furnish PCSDS a copy of "turn-over"/deposit receipts made to either of the chosen institution/s indicated in No. 3 condition, 15 days after expiration of this permit;
5. The permittee shall ensure that members of research/survey team/s under this permit shall coordinate with the Brgy. LGU and/or IP community, if applicable regarding data collection for research activities that will be conducted in the study area;
6. All collected samples shall be used strictly for scientific purposes indicated in the research proposal submitted and shall not in any manner be used for commercial purposes or for extraction of genetic material which includes pharmacological screening or toxicological tests or similar activities. Any bio-prospecting activity is not covered by this permit and shall adhere to the Joint DENR-PCSD-DA Administrative Order No. 1 whenever applicable and necessary;
7. The permittee must ensure that data collection methods shall not harm all wildlife species within the study site and the environment in general;

Vision: Palawan, an innovative and dynamic global center of sustainable development
Mission: PCSDS as the driver of environmental conservation and inclusive development in Palawan, a biosphere reserve and science-for-sustainability site, guided by the Strategic Environmental Plan

Page 1 of 2

HEAD OFFICE:
PCSD Building, Sports Complex Road
Santa Monica Heights, Puerto Princesa City, Palawan, Philippines
☎ (+6348) 434-4235 Trunkline•(+6348) 434-4234Telefax
Email: oed@pcsd.gov.ph • Website: www.pcsd.gov.ph| www.pkp.pcsd.gov.ph

METRO MANILA LIAISON OFFICE:
Room 109, G/F Westria Residences
#77 West Avenue, 1104 Quezon City, Philippines
Tel. No: (+632) 376-2061 / (+632) 376-2775

8. The permittee must observe the standard protocol for handling of wildlife species which are globally accepted/recognized by scientific communities;
9. The permittee must secure a Local Transport Permit (LTP) from the PCSD Staff before transporting collected specimens outside Palawan.

B. General

10. The permittee shall allow PCSDS personnel complete access to data/information generated from the study;
11. The permittee shall submit to PCSDS the following:
    a) Copy of final report; and
    b) Copy of all published reports generated.
12. The permittee shall formulate and submit to PCSDS a policy recommendation/s related to the output of the research;
13. The permittee must properly acknowledge in the publication/s the participation of LGU/concerned agencies, IP community and PCSDS (if present);
14. The permittee shall assume full responsibility and liability for damages to the environment that the activities may cause;
15. Any alteration, erasure, or obliteration in this permit shall be sufficient ground for the cancellation/revocation of this permit without prejudice to criminal and other liabilities of the offender;
16. The permittee shall comply with other provisions of RA 9147 and PCSD Administrative Order No. 12, as amended, which may be applicable but are not explicitly specified in this permit;
17. In case there is a need for additional condition (s) to ensure environmental integrity as a result of regular monitoring/inspection, the same shall be imposed by PCSDS;
18. This permit is **NON-TRANSFERABLE** and shall be valid only until **SEPTEMBER 2021;**
19. After the validity period, application for renewal may be submitted if necessary.

Non-compliance with any of the above conditions or the relevant provisions of PCSD Admin Order No. 12, as amended, shall be sufficient cause to suspend or cancel this permit and to impose appropriate penalty under the said Administrative Order.

Issued this 7th day of September 2020 at Brgy. Sta. Monica, Puerto Princesa City, Palawan, Philippines.

ATTY. TEODORO JOSE S. MATTA
Executive Director

CONFORME

I, **FERNANDO A. LOPEZ,** holder of the foregoing permit, hereby certify that I have read and understood the Terms and Conditions for which this permit was issued and I hereby express my conformity thereto and my commitment to abide by the provisions of PCSD AO 12, as amended.

FERNANDO A. LOPEZ
Signature over Printed Name
Date: 09-08-2020

Paid the amount of Php 110
Under O.R. No. 7486671
Date: 09-08-2020

Page **2** of **2**

Scanned with CamScanner

Annex C: Notable species listed in Malaking Patag Watershed.

Yellow-throated Leafbird (*Chloropsis palawanensis*)

Crested Serpent Eagle (*Spilornis cheela*)

Lovely Sunbird (*Aethopyga shelleyi)*

Palawan Blue Flycatcher (*Cyornis lempreiri)*

Blue-headed Racquet-tail (*Prioniturus platenae)*

Long-tailed Shrike (*Lanius schach*)

Palawan Water Monitor Lizard (*Varanus palawanensis*)

Culion Frog (*Pulchrana moellendorffii*)

Asian Leaf Turtle (*Cyclemys dentata*)

Palawan Treeshrew (*Tupaia palawanensis*)

Annex D: Photographs during fieldwork in Malaking Patag watershed. **A)** Coordination meeting with the local community together with the staff of CRN **B)** Ethnobiological interview of flora and fauna **C)** Line intercept transect for coral survey **D)** Variable transect for DBH (Diameter at Breast Height) flora survey **E)** Night time survey for nocturnal and crepuscular fauna and **D)** A non-volant mammal (*Maxomys panglima*) that was caught on one of the traps installed for mammalian survey (Caught and release). Photograph copyright to Erickson Tabayag (A) Marvin Jay R. Sarmiento (B, C and E) Jake Wilson Binaday (D and F).

Annex E: Avifauna species listed in Calamianes survey sites.

NO.	SCIENTIFIC NAME	COMMON NAME	Busuanga	Coron	Culion	Linapacan	CONSERVATION STATUS		
							IUCN	DAO 2019-09	PCSD 15-521
1	*Accipiter gularis*	Japanese Sparrowhawk	+				LC		EN
2	*Accipiter soloensis*	Chinese Sparrowhawk			+		LC		EN
3	*Accipiter trivirgatus*	Crested Goshawk	+	+	+		LC		EN
4	*Actitis hypoleucos*	Common Sandpiper		+		+	LC		
5	*Aerodramus fuciphagus*	Edible-nest Swiftlet	+	+			LC		
6	*Aethopyga shelleyi*	Lovely Sunbird (*a*)	+	+	+		LC		VU
7	*Alcedo atthis*	Common Kingfisher		+		+	LC		
8	*Alcedo meninting*	Blue-eared Kingfisher	+	+			LC		
9	*Alophoixus frater*	Palawan Bulbul (*a*)		+			LC	OTS	VU
10	*Amaurornis phoenicurus*	White-breasted Waterhen	+	+	+		LC		
11	*Anas luzonica*	Philippine Duck	+	+			VU	VU	VU
12	*Anthracoceros marchei*	Palawan Hornbill (*a,b,c*)	+	+	+		VU	VU	EN
13	*Anthreptes malacensis*	Brown-throated sunbird		+			LC		
14	*Anthus cervinus*	Red-throated Pipit		+			LC		
15	*Anthus rufulus*	Paddyfield Pipit	+		+		LC		
16	*Aplonis panayensis*	Asian Glossy Starling	+	+	+	+	LC		
17	*Ardea alba*	Great White Egret	+	+			LC		
18	*Ardea intermedia*	Intermediate Egret		+			LC		
19	*Ardea sumatrana*	Great-billed Heron		+			LC		
20	*Artamus leucorynchus*	White-breasted Woodswallow	+				LC		
21	*Batrachostomus javensis*	Horsfield's Frogmouth	+	+			LC	VU	VU
22	*Bubulcus ibis*	Cattle Egret	+	+	+	+	LC		
23	*Butorides striata*	Green-backed Heron				+	LC		
24	*Cacatua haematuropygia*	Philippine Cockatoo (*b,c*)	+	+			CR	CR	CR
25	*Cacomantis merulinus*	Plaintive Cuckoo		+	+		LC		
26	*Calidris falcinellus*	Broad-billed Sandpiper		+			LC		
27	*Calidris ruficollis*	Red-necked Stint		+			NT		
28	*Caprimulgus macrurus*	Large-tailed Nightjar	+		+		LC		
29	*Centropus bengalensis*	Lesser Coucal	+	+	+		LC		
30	*Ceyx erithaca*	Oriental Dwarf-Kingfisher	+	+	+		LC		
31	*Chalcophaps indica*	Grey-capped Emerald Dove	+	+	+	+	LC		
32	*Charadrius alexandrinus*	Kentish Plover		+			LC		
33	*Charadrius leschenaultii*	Greater Sandplover			+		LC		

NO.	SCIENTIFIC NAME	COMMON NAME	Busuanga	Coron	Culion	Linapacan	CONSERVATION STATUS		
							IUCN	DAO 2019-09	PCSD 15-521
34	*Charadrius mongolus*	Lesser Sand Plover		+			LC		
35	*Charadrius peronii*	Malay Plover		+			NT	VU	VU
36	*Chlidonias hybrida*	Whiskered Tern	+	+	+		LC		
37	*Chloropsis palawanensis*	Yellow-throated leafbird (*a,b*)	+	+	+	+	LC		VU
38	*Chrysocolaptes erythrocephalus*	Red-headed Flameback (*a*)	+	+			EN	EN	EN
39	*Cinnyris jugularis*	Olive-backed Sunbird	+	+	+	+	LC		
40	*Collocalia esculenta*	Glossy Swiftlet	+	+	+	+	LC		
41	*Columba livia*	Rock Pigeon	+	+			LC		
42	*Coracina striata*	Bar-bellied Cuckooshrike	+	+		+	LC		
43	*Corvus enca*	Slender-billed Crow	+	+	+	+	LC		
44	*Cyornis lempreiri*	Palawan Blue Flycatcher (*a,b*)	+	+	+		NT		VU
45	*Dendrocygna arcuata*	Wandering Whistling Duck		+		+	LC		
46	*Dicaeum pygmaeum*	Pygmy Flowerpecker	+	+	+	+	LC		
47	*Dicrurus hottentottus*	Hair-crested Drongo	+	+	+	+	LC		
48	*Dicrurus leucophaeus*	Ashy Drongo	+	+	+		LC		
49	*Dinopium Everetti*	Spot-throated Flameback (*a*)	+	+	+	+	NT	OTS	VU
50	*Dryocopus javensis*	White-bellied Woodpecker			+		LC		
51	*Ducula aenea*	Green Imperial-Pigeon	+	+		+	LC		
52	*Ducula bicolor*	Pied Imperial Pigeon		+		+	LC		VU
53	*Egretta garzetta*	Little Egret	+	+			LC		
54	*Egretta sacra*	Pacific Reef-Egret	+	+			LC		
55	*Erythropitta erythrogaster*	Philippine Pitta		+			LC		
56	*Eurystomus orientalis*	Oriental Dollarbird		+	+		LC		
57	*Falco peregrinus*	Peregrine Falcon	+				LC		CR
58	*Falco tinnunculus*	Common Kestrel	+				LC		
59	*Ficedula narcissina*	Narcissus Flycatcher		+			LC		
60	*Gallicrex cinerea*	Watercock	+				LC		
61	*Gallus gallus*	Red Junglefowl	+	+	+		LC		
62	*Gelochelidon nilotica*	Common Gull-billed Tern		+			LC		
63	*Geopelia striata*	Zebra Dove		+			LC		
64	*Gorsachius melanolophus*	Malay Night Heron		+			LC		
65	*Gracula religiosa*	Common Hill Myna (*c*)	+	+	+	+	LC	VU	CR
66	*Halcyon coromanda*	Ruddy Kingfisher		+			LC		VU
67	*Halcyon pileata*	Black-capped Kingfisher		+			LC		

NO.	SCIENTIFIC NAME	COMMON NAME	Busuanga	Coron	Culion	Linapacan	CONSERVATION STATUS		
							IUCN	DAO 2019-09	PCSD 15-521
68	*Haliaeetus leucogaster*	White-bellied Sea Eagle		+	+	+	LC		EN
69	*Himantopus himantopus*	Black-winged Stilt		+			LC		
70	*Hirundo javanica*	House Swallow	+	+	+	+	LC		
71	*Hirundo rustica*	Barn Swallow	+	+			LC		
72	*Hypothymis azurea*	Black-naped Monarch	+	+	+	+	LC		
73	*Irena tweeddalii*	Palawan Fairy-bluebird (*a*)	+	+	+		NT		
74	*Kitacincla nigra*	White-vented Shama (*a,b*)	+	+	+	+	LC		VU
75	*Lalage nigra*	Pied Triller	+	+			LC		
76	*Lanius cristatus*	Brown Shrike	+	+	+		LC		
77	*Lanius schach*	Long-tailed shrike	+	+	+		LC		VU
78	*Leptocoma sperata*	Purple-throated Sunbird		+			LC		
79	*Lonchura atricapilla*	Chestnut Munia		+			LC		
80	*Lonchura leucogastra*	White-bellied Munia		+			LC		
81	*Lonchura punctulata*	Scaly-breasted Munia	+	+			LC		
82	*Macropygia tenuirostris*	Philippine Cuckoo-dove	+	+			LC		
83	*Merops americanus*	Rufous-crowned Bee-eater (*a*)	+	+	+		LC		
84	*Merops philippinus*	Blue-tailed Bee-eater		+	+		LC		
85	*Monticola solitarius*	Blue Rock-thrush		+			LC		
86	*Motacilla cinerea*	Gray Wagtail	+	+	+		LC		
87	*Muscicapa griseisticta*	Gray-streaked Flycatcher		+	+		LC		
88	*Nisaetus cirrhatus*	Changeable Hawk-eagle	+				LC		EN
89	*Nycticorax caledonicus*	Rufous-Night Heron		+			LC		
90	*Onychoprion anaethetus*	Bridled Tern			+		LC	OTS	
91	*Oriolus chinensis*	Black-naped Oriole	+	+	+	+	LC		
92	*Orthotomus sericeus*	Rufous-tailed Tailorbird	+	+	+	+	LC		
93	*Otus mantananensis*	Mantanani Scops-owl (*c*)	+	+		+	NT	VU	EN
94	*Passer montanus*	Eurasian Tree Sparrow	+	+			LC		
95	*Pelargopsis capensis*	Stork-billed Kingfisher	+	+		+	LC		
96	*Phaenicophaeus curvirostris*	Chestnut-breasted Malkoha	+	+	+		LC		
97	*Phylloscopus borealis*	Arctic Warbler		+			LC		
98	*Pitta sordida*	Hooded Pitta	+	+	+		LC		
99	*Pluvialis fulva*	Pacific Golden Plover		+			LC		
100	*Prioniturus platenae*	Blue-headed Racquet-tail (*a,b,c*)	+	+	+	+	VU	VU	EN
101	*Prionochilus plateni*	Palawan Flowerpecker (*a,b*)	+	+	+	+	LC		

NO.	SCIENTIFIC NAME	COMMON NAME	Busuanga	Coron	Culion	Linapacan	CONSERVATION STATUS		
							IUCN	DAO 2019-09	PCSD 15-521
102	*Pycnonotus cinereifrons*	Ashy-fronted Bulbul (*a*)	+	+	+	+	LC		
103	*Rallina fasciata*	Red-legged Crake		+	+		LC		
104	*Ramphiculus leclancheri*	Black-Chinned Fruit-Dove	+	+	+		LC		VU
105	*Riphidura nigritorquis*	Philippine Pied-Fantail	+	+		+	LC		
106	*Spilopelia chinensis*	Eastern Spotted Dove	+	+	+	+	LC		
107	*Spilornis cheela*	Crested Serpent Eagle	+	+	+		LC		EN
108	*Sterna dougallii*	Roseate Tern			+		LC		
109	*Sterna hirundo*	Common Tern		+			LC		
110	*Sterna sumatrana*	Black-naped Tern		+			LC		
111	*Streptopelia dusumieri*	Philippine Collared Dove		+			VU	EN	VU
112	*Strix seloputo*	Spotted Wood Owl	+	+	+		LC		EN
113	*Tanygnathus lucionensis*	Blue-naped Parrot (c)	+	+	+		NT	CR	CR
114	*Terpsiphone cyanescens*	Blue Paradise-Flycatcher (*a,b*)		+	+	+	LC		VU
115	*Todiramphus chloris*	Collared Kingfisher	+	+	+	+	LC		
116	*Treron vernans*	Pink-necked Green-Pigeon	+	+	+		LC		
117	*Tringa brevipes*	Grey-tailed Tattler		+			NT		
118	*Turdus obscurus*	Eye-browed Thrush	+				LC		
119	*Turnix suscitator*	Barred Buttonquail	+	+	+		LC		
120	*Upupa epops*	Common Hoopoe		+			LC		
TOTAL			**73**	**105**	**58**	**33**			

a endemic
b KBA trigger species
c CITES listed species

Annex F: Herpetofauna species listed in Calamianes survey sites.

NO.	SCIENTIFIC NAME	COMMON NAME	Busuanga	Coron	Culion	Linapacan	CONSERVATION STATUS		
							IUCN	DAO 2019-09	PCSD 15-521
1	*Ahaetula prasina*	Oriental Whipsnake		+	+	+	LC		
2	*Barbourula busuangensis*	Busuanga Jungle Toad (a)	+	+			NT	VU	EN
3	*Boiga cynodon*	Dog-toothed Cat Snake		+					
4	*Bronchocela cristatella*	Green Crested Lizard			+		DD	OTS	
5	*Calliophis bilineata*	Two-stripped Coral Snake		+			DD		
6	*Cerberus schneiderii*	Dog-faced Water Snake				+	DD		
7	*Cyclemys dentata*	Asian Leaf Turtle (c)		+	+		NT	VU	
8	*Dendrelaphis marenae*	Maren's Bronzeback	+	+			DD		
9	*Emoia artacostrata*	Littoral Whiptail-Skink		+		+	DD		
10	*Eutropis multifasciata*	Common Mabuya	+	+	+		LC		
11	*Fejervarya vittigera*	Luzon Wart Frog (a)	+		+		LC		
12	*Gekko gecko*	Tokay Gecko (c)	+	+	+	+	LC	OTS	VU
13	*Gekko monarchus*	Twin-spotted Gecko		+	+	+	DD		
14	*Hemidactylus frenatus*	Common House Gecko			+	+	LC		
15	*Ingerophrynus philippinicus*	Philippine Toad (a)	+	+	+	+	LC		VU
16	*Limnonectes acanthi*	Busuanga Wart Frog (a)	+	+	+	+	NT	OTS	VU
17	*Malayopython reticulatus*	Reticulated Python (c)	+	+	+		LC	OTS	EN
18	*Naja sumatrana*	Equatorial Spitting Cobra		+					
19	*Occidozyga laevis*	Common Puddle Frog		+	+	+	LC		
20	*Ophiophagus hannah*	King Cobra	+	+	+				
21	*Pelophryne cf. albotaeniata*	White-striped Flathead Toad (a)		+			VU		
22	*Polypedates leucomystax*	Common Tree Frog		+	+				
23	*Pulchrana moellendorffi*	Culion Frog (a)	+	+	+		LC		VU
24	*Rhabdophis chrysargos*	Speckle-bellied Keelback		+			LC		
25	*Sanguirana sanguinea*	Calamianes Frog (a)	+	+			LC		VU
26	*Staurois nubilus*	Palawan Rock Frog	+	+	+		NT		
27	*Trimeresurus schultzei*	Philippine Pit Viper (a)		+			LC	OTS	
28	*Tropidolaemus subannulatus*	Bornean Keeled Green Pit Viper		+			LC	OTS	
29	*Varanus palawanensis*	Palawan Water Monitor (a,c)	+	+	+	+	DD	OTS	EN
TOTAL			**13**	**25**	**17**	**10**			

a endemic
b KBA trigger species
c CITES listed species

Annex G: Mammalian species listed in Calamianes survey sites.

NO.	SCIENTIFIC NAME	COMMON NAME	Busuanga	Coron	Culion	Linapacan	CONSERVATION STATUS		
							IUCN	DAO 2019-09	PCSD 15-521
1	*Acerodon spp.*	Giant Golden-crowned Flying Fox	+	+	+	+			
2	*Arctictis binturong whitei*	Palawan Bearcat (c)	+	+			VU	OTS	EN
3	*Axis calamianensis*	Calamian Deer (a,c)	+		+		EN	EN	CR
4	*Chiropodomys calamianensis*	Pencil tailed Tree mouse (a)	+				DD		
5	*Hipposideros diadema*	Diadem Leaf-nosed Bat				+			
6	*Hipposideros sp.*	Roundleaf Bat			+				
7	*Hystrix pumila*	Philippine Porcupine (a)	+	+			VU		
8	*Macaca fascicularis philippensis*	Philippine Long-tailed Macaque (a)	+	+	+	+	NT		EN
9	*Macroglossus minimus*	Dagger-toothed Long-Nosed Fruit Bat				+			
10	*Manis culionensis*	Philippine Pangolin (a,c)	+	+	+		CR	EN	CR
11	*Maxomys panglima*	Palawan Spiny Rat (a)	+	+	+	+	LC		VU
12	*Megaderma spasma*	Lesser False Vampire				+			
13	*Mydaus marchei*	Palawan Stink-badger (a)	+	+	+	+	LC		VU
14	*Paradoxurus hermaphroditus*	Common Palm Civet	+		+				
15	*Prionailurus bengalensis heaneyi*	Palawan Leopard Cat (c)	+	+	+				
16	*Pteropus spp.*	Large Flying Fox		+	+				
17	*Rattus cf. exulans*	Mouse			+				
18	*Rousettus amplexicaudatus*	Geoffroy's Rousette				+			
19	*Sundasciurus hoogstralii*	Busuanga Squirrel (a)	+						
20	*Sundasciurus juvencus*	Northern Palawan Tree Squirrel (a)	+	+	+	+	LC		VU
21	*Sundasciurus moellendorfi*	Culion Tree Squirrel (a)	+		+				
22	*Sus ahoenobarbus*	Palawan Bearded Pig (a)	+	+	+	+	NT	VU	EN
23	*Tupaia palawanensis*	Palawan Tree Shrew (a)	+	+	+		LC	OTS	EN
24	*Viverra tangalunga*	Malay Civet	+		+				
TOTAL			**17**	**12**	**16**	**10**			

a endemic
b KBA trigger species
c CITES listed species

Annex H: Forest Tree species listed in Calamianes survey sites.

NO.	SCIENTIFIC NAME	Local Name	Busuanga	Coron	Culion	Linapacan	CONSERVATION STATUS		
							IUCN	DAO 2017-11	PCSD 15-521
1	*Agathis philippensis*	Almasiga		+				VU	VU
2	*Barringtonia sp.*				+				
3	*Canarium asperum*	Pagsahingin			+		LC		
4	*Canarium hirsutum*	Salung		+					
5	*Citrus aurantium*	Kahel		+					
6	*Colona subaequalis*	Laho	+		+				
7	*Dillenia monantha*	Katmon/Katmon-bugtong		+				VU	VU
8	*Diospyros streptosepala*	Dalandang/Dalondong		+	+				
9	*Diospyros streptosepala*	Dalandang/Dalondong			+				
10	*Dracontomelon dao*	Dao			+			VU	VU
11	*Dysoxylum oppositifolium*	Kayatau		+					
12	*Elaeocarpus laxirameus*		+						
13	*Erythrina* sp.	Dapdap Sapa			+				
14	*Euphorbia plumerioides*	Baib/Bait	+	+			LC		
15	*Ficus benjamina*	Balete	+	+		+	LC		
16	*Ficus glandulifera*	Katol/Kator	+		+				
17	*Ficus sp.*			+	+				
18	*Glochidion psidioides*	Anam							
19	*Grewia eriocarpa*			+			LC		
20	*Intsia bijuga*	Ipil	+	+	+		VU	VU	VU
21	*Kleinhovia hospita*	Tan-ag			+		LC		
22	*Koordersiodendron pinnatum*	Amugis	+			+		OTS	
23	*Lagerstroemia speciosa*	Banaba		+					
24	*Madhuca leerii*	Ekuyan		+					
25	*Mangifera indica*	Mangga	+	+	+	+	DD		
26	*Mangifera longipes*	Manggang Gubat/Malamangga		+	+			VU	VU
27	*Orania paraguanensis*	Banga		+				CR	CR
28	*Pachystylidium hirsurum*	Alumigas				+			
29	*Palaquium luzoniense*	Nato			+		VU		
30	*Parkia timoriana*	Kupang		+			LC		
31	*Pterocarpus indicus*	Narra	+	+			EN	VU	VU
32	*Pterocymbium tinctorium*	Taluto	+	+	+		LC		
33	*Samanea saman*	Acacia		+			LC		
34	*Sandoricum koetjape*	Santol		+			LC		

NO.	SCIENTIFIC NAME	Local Name	Busuanga	Coron	Culion	Linapacan	CONSERVATION STATUS		
							IUCN	DAO 2017-11	PCSD 15-521
35	*Sandoricum vidalii*	Malasantol/Santol Gubat		+			VU		
36	*Semecarpus cuneiformis*	Malamangga		+					
37	*Syzygium cumini*	Duhat		+			LC		
38	*Syzygium lacustree*	Malaasom/Malaasim			+				
39	*Syzygium sp.*	Bangluan/Bamgkalauan		+					
40	*Syzygium* sp.	Bintang Sapa			+				
41	*Vitex glabrata*	Bongoog		+			LC		
42	*Wrightia pubescens*	Lanete		+			LC		
43		Amluron		+					
44		Baud		+					
45		Bochit	+						
46		Enenyoy			+				
47		Heram		+					
48		Katangalan		+					
49		Kutat			+				
50		Luhat		+					
51		Lumboy-lumboy		+					
52		Mangrove Sapa			+				
53		Pagtuan		+					
54		Saheng/Saeng			+				
55		Tibuyog		+					
56		Tiguyog		+					
57		Tuboy			+				
TOTAL			**11**	**36**	**22**	**4**			