

A Closer Look at the Ulot Watershed in Samar Island Natural Park (SINP): Physical Characteristics and Anthropogenic Impacts

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Abstract

The Ulot Watershed, situated in Samar Island Natural Park (SINP) Philippines, yields critical ecosystem services to the communities surrounding it. This study assessed the physical characteristics, natural landscapes, anthropogenic features and political boundaries of Ulot Watershed which prove crucial to the overall functionality of the watershed. Covering approximately 87,986 hectares, the watershed bounded by the municipalities of San Jose de Buan, Maslog and Dolores in the north, by Hinabangan and Taft in the south, by Can-avid in the east, and by San Jorge in the west, features a diverse range of physical characteristics, including significant elevation gradients (0 to 798.04 meters) and a complex hydrological network with a total stream length of 2,611 km. The analysis of slope distribution reveals a predominance of steep terrains, necessitating effective land management strategies to mitigate erosion risks. Rainfall data over 21 years indicates a moderately wet climate, influencing water availability and vegetation dynamics. Despite its ecological significance, the watershed faces pressures from anthropogenic activities of around 12,600 people, notably unsustainable farming practices and deforestation, leading to biodiversity loss and compromised water quality. This study underscores the urgent need for integrated conservation and management strategies to safeguard the Ulot Watershed's natural landscapes and ecological integrity, ensuring it continues to provide essential ecosystem services to local communities.

Keywords

Samar Island, watershed conservation, GIS, Ulot watershed, watershed characterization

Introduction

A watershed is an area of land where all the water, whether from rain or streams, flows into one common point. Rivers, wetlands, and reservoirs are all considered as watersheds (DAO, 2021; Aldridge and Baker, 2017). Also called "drainage basins" or "catchments," watersheds greatly vary in size, ranging from less than 10,000 hectares to more than 50,000 hectares (DAO 2021-41 s. of 2021). The Philippines has 421 watersheds that span 21 million hectares, covering 70% of the country's 30-million-hectare land area (ERDB, 2022). Of the 421 watersheds, 131 are categorized as critical watersheds spanning 14.2 million hectares or 47% of the total watershed area (FMB, 2021). These watersheds are incredibly important because they provide essential support to rural communities, especially those involved in farming and forestry (Baguinon et al., 2007; Baliton et al., 2017). When these areas are well managed, they offer essential services like supplying water for homes, farms, and businesses, and also providing wood and other natural resources. They also shelter a wide variety of plants and animals, while playing key roles in preventing floods, managing droughts, and keeping the local climate in check. Furthermore, watersheds are vital for industries like tourism, fishing, forestry, agriculture, and mining, making them crucial for both environmental health and economic growth (PCAARRD, 1999).

Understanding watersheds is key to managing water resources in a sustainable way. It allows us to figure out how much water is available, keep track of its use, and ensure its continued availability for the communities and various industries. In areas that are ecologically sensitive, knowing more about a watershed helps pinpoint places that need special attention, whether for protection or restoration, to maintain services like clean water, carbon storage, and wildlife habitats (Postel and Thompson, 2005). With climate change affecting water cycles, studying watersheds has become even more critical to help us handle challenges like water shortages and flooding (IPCC, 2014).

One of the Philippines' largest watersheds is the Ulot watershed, which covers around 87,536 hectares. Of this, about 56,680 hectares are part of the Samar Island Natural Park (International Model Forest Network, 2022). The name was derived from the word "Ulot" in Waray dialect, which means monkey, a common wildlife in the area. The natural landscape is rich with dense rainforests and diverse river ecosystems, which are home to endangered species like the Philippine Eagle and the Samar Tarctic Hornbill (DENR, 2019). Ulot Watershed drains mostly to the Ulot River, the longest river system in SINP playing a critical role in aquatic ecosystem sustainability and the village communities in the vicinities. However, the Ulot Watershed is threatened by human activities, particularly agriculture and eco-tourism. While these activities provide livelihoods for local people, they also create challenges for the long-term sustainability of the watershed's natural resources (Lasco and Pulhin, 2006). Furthermore, despite being one of the eight most important watersheds in the Eastern Visayas region of the Philippines, the Ulot watershed remains unexplored and underexamined. Thus, there is a need to study it. Understanding watershed boundaries is crucial for effective management and conservation, as it shows where regulation is needed (Baguinon et al., 2007). Knowing its slope, elevation, and land cover is also important since these physical features heavily influence water quality and availability (Dingman, 2015;

Ponce, 2014). Geographic Information System (GIS) has been used for many years as a tool in analyzing watersheds, including but not limited to boundary delineation, sub-watershed partitioning, and analysis of terrain, slope and drainage networks, using digital elevation models (DEMs). GIS enables scientists and researchers to have a detailed geomorphological and morphometric assessment, making it a reliable decision support tool in management (Choi et al., 2005; Colby, 2019; Kaira et al. 2024)

This study aims to conduct a characterization and assessment of the Ulot Watershed by delineating its geo-political boundaries, evaluating its physical characteristics, identifying its natural landscapes, and analyzing the potential impacts of anthropogenic activities on the Ulot River and the neighboring village communities. This will enhance understanding of the Ulot Watershed and provide data for its sustainable management. This study also hopes to provide insights on appropriate conservation strategies to adopt, support sustainable development in the area and contribute to achieving several Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 14 (Life Below Water), and SDG 15 (Life on Land).

Materials and Methods

Study Area

Ulot watershed, also known as the Can-avid Watershed, is located at the central part of Samar Island, approximately between 11° 50' 34" North, 124° 56' 38" East and 11° 59' 25" North, 125° 26' 55" East (Figure 1). It has a total land area of about 87,986 hectares. About 56,680 hectares of Ulot watershed are part of the Samar Island Natural Park (SINP) (International Model Forest Network, 2022). It is one of the largest watersheds in the Philippines, one of the 29 watersheds on Samar Island, and the eight most important watershed in the region. At the heart of this watershed is the Ulot River, the longest river in Samar, which runs over 90 kilometers and, including its tributaries, extends to more than 500 kilometers (House Bill No. 6000). The river starts in the municipalities of San Jose de Buan, Jiabong, and Motiong, flows through Paranas, and eventually reaches Can-avid in Eastern Samar. A recent study on Ulot River conducted by Ciasico et al. (2023), found that it stretches 112 kilometers from its headwaters to the river's mouth and has a span of about 52 meters and is 3 meters deep. During heavy rains, the river can rise to 6 meters, which is higher than the riverbanks at 4 meters, causing the floodplain to expand to 13 meters wide (Ciasico et al., 2023).

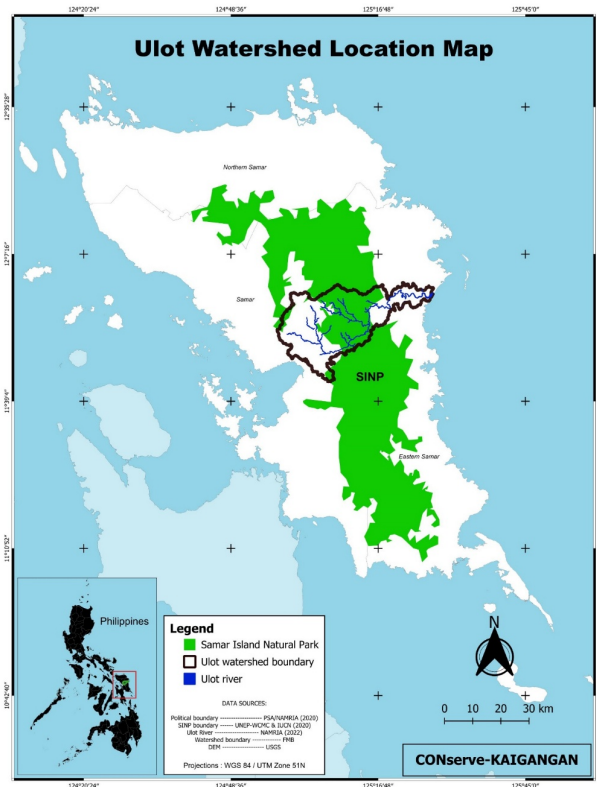


Fig 1. Location of Ulot Watershed in Samar Island, Philippines.

Data Acquisition

This study began with the acquisition of key spatial and non-spatial datasets relevant to the Ulot Watershed. The official boundary of the watershed was sourced from the Forest Management Bureau (FMB). The administrative boundary data at the provincial, municipal and barangay levels were obtained from Philippine Statistics Authority (PSA) and NAMRIA (2020). The climate type was derived from the Philippines' climate classification system under the Modified Coronas Classification (MCC). Other climate parameters, particularly rainfall records, were obtained from four meteorological stations surrounding the Ulot Watershed: Borongan (Eastern Samar), Catarman (Northern Samar), Catbalogan (Samar), and Guiuan (Eastern Samar). These data were provided by the Climate and Agrometeorological Data Section (CADS) of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). The use of multiple stations was necessary to adequately capture the spatial variability in rainfall across the watershed.

Land cover data for 2020 were obtained from Geoportal Philippines (www.geoportal.gov.ph), the national database of GIS-based spatial data, and were processed by the National Mapping and Resource Information Authority (NAMRIA). Soil data were also acquired from Geoportal Philippines and are officially provided by the Bureau of Soils and Water Management (BSWM). BSWM applies a national, series-based soil classification system that is closely aligned with the United States Department of Agriculture (USDA) Soil Taxonomy but expressed using locally named soil series for land-use and crop planning. Data on rivers and streams of Samar Island were likewise downloaded from Geoportal Philippines.

Elevation data were obtained from the Digital Elevation Model (DEM) with a high resolution of 5 m x 5 m derived from Interferometric Synthetic Aperture Radar (SAR) data, sourced from the United States Geological Survey (USGS) website (usgs.gov, 2015) and distributed by NAMRIA. Slope data were sourced from the SINP Protected Area Management Board of the Department of Environment and Natural Resources (DENR-PAMB). Information on the natural landscape feature and anthropogenic activities within the Ulot watershed was collected through actual field observations and targeted literature review.

Table 1. Data set and corresponding sources

Parameters	Data Set	Data Type	Data Format	Sources
Watershed Boundary	Ulot Watershed	polygon	Shapefile (.shp)	FMB, n.d.
Political Boundaries	Administrative boundary (Province, Municipality, Barangay)	polygon	Shapefile (.shp)	PSA/NAMRIA, 2020
Climate	Climate Type	polygon	Shapefile (.shp)	PAGASA, 2024
Rainfall	Annual Rainfall	attribute data	Comma-separated values (.csv)	PAGASA, 2024
Soil	Soil type	polygon	Shapefile (.shp)	BSWM, n.d.
Land cover	Land Cover 2020	polygon	Shapefile (.shp)	NAMRIA, 2020
Rivers and Streams	River network	line	Shapefile (.shp)	NAMRIA, 2020
Elevation	Digital Elevation Model (5m x 5m resolution)	raster	geoTIFF (.tiff)	USGS.GOV, 2015
Slope	Slope data	polygon	Shapefile (.shp)	SINP PAMB-DENR, 2013
Natural and Anthropogenic activities	Field observations and literature review	attribute data	Comma-separated values (.csv)	This study

GIS Analyses

All spatial datasets were processed and analyzed using an open-source GIS software, Quantum GIS or commonly known as QGIS (version 3.30). Prior to analysis, data cleaning and pre-processing were conducted to remove errors, resolve inconsistencies, and avoid data duplication. All datasets were projected into WGS 84/UTM Zone 51N coordinate system to ensure spatial consistency and accuracy. Standard GIS geoprocessing tools such as clipping and performing unions were applied among various datasets of the study area. Various maps displaying the physical characteristics of the Ulot watershed and highlighting the different features of the land, including political boundaries, rainfall distribution, elevation, slope, hydrological characteristics and land cover types, were created.

Climate type of the watershed is determined and laid out to determine the corresponding type per municipalities. While the rainfall data from the four PAGASA stations were used to compute the average annual rainfall over a 21-year period. Spatial interpolation techniques were applied in QGIS to generate a continuous rainfall surface across the watershed (Li and Wong, 2010; Santos et al., 2017).

Many recent hydrological and erosion studies still rely on DEMs released in the early 2000s–2010s (e.g., SRTM, ASTER, ALOS, CARTO) and use them successfully together with much more recent land cover and climate data (Buakhao and Kangrang, 2016; Admas et al., 2024). Topographic and hydrological attributes depend strongly on DEM source and resolution, but acceptable watershed delineation and streamflow simulations are obtained across DEMs of different years, as long as accuracy is adequate (Buakhao and Kangrang, 2016; Tesema, 2021; Datta et al., 2022).

The slope data was requested and obtained from the office managing the SINP, in accordance with the national standard slope classification set by the Department of Environment and Natural Resources (DENR). The elevation of the watershed was processed using a high-resolution (5 m x 5 m) DEM derived using Interferometric Synthetic Aperture Radar (IFSAR), following standard terrain analysis procedures (Burrough and McDonell, 1998). The DEM was reclassified into nine categories to better represent topographic variation and support hydrological analysis. Hydrological analyses were conducted in QGIS using the Terrain Analysis – Hydrology tools of the System for Automated Geoscientific Analyses (SAGA). Stream order was determined by first correcting depressions in the DEM using the Fill Sinks tool (Wang and Liu, 2006). Flow direction and flow accumulation rasters were then generated using the Flow Accumulation (Top-Down) algorithm. Stream networks were extracted based on a flow accumulation threshold corresponding to a drainage area of 1 km², defining the initiation of streams. Finally, the Strahler Order tool was applied using the derived channel network and flow direction rasters, and the resulting stream order output was converted to vector format for further analysis. Figure 2 illustrates the synthesized methodological framework adopted in this study.

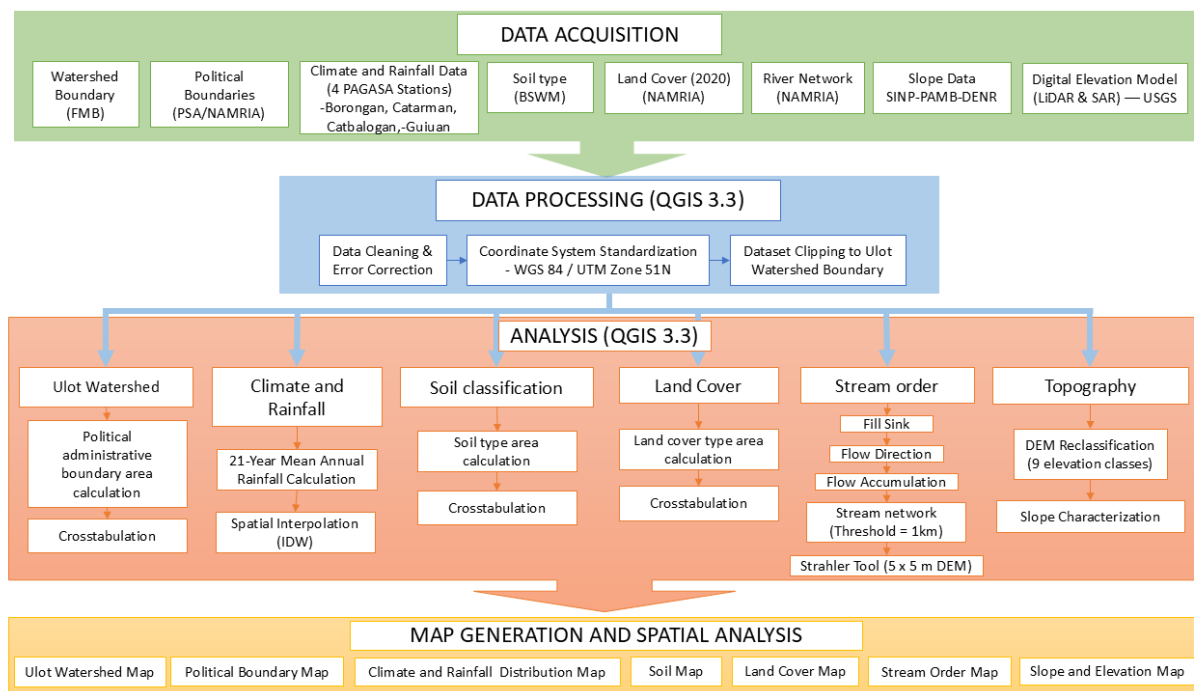


Fig 2. Flowchart summarizing the sequence of data acquisition, preprocessing, GIS analyses, and outputs.

Results and Discussion

Geo-political Boundaries of Ulot Watershed

The Ulot Watershed spans the provinces of Samar and Eastern Samar encompassing ten municipalities and 124 barangays (Figures 3 and 4). The municipality of Paranas occupies the largest portion in the Province of Samar with an area covering 54.14% of the watershed and comprises 38 barangays. The municipality of Motiong covers 9.79% of the watershed with 26 barangays. The municipality of Jiabong occupies 6.65% of the watershed with 15 barangays. The municipality of Hinabangan, with 2.42%, comprises 5 barangays, while San Jose de Buan covers 1.36% with 3 barangays, and San Jorge, with a mere 0.0001%, has only one barangay. The municipality of Can-avid in Eastern Samar province comprises of 23.06% of the watershed with 27 barangays. The municipality of Dolores, which corresponds to 1.26% of the watershed, has 3 barangays. The municipality of Taft comprises 0.74% of the watershed, has 5 barangays. Lastly, Maslog accounted for 0.57% of the watershed, with just one barangay (Appendix 1).

Overall, Paranas occupies the largest portion of the Ulot Watershed, followed by Can-avid, while the smallest areas are in San Jorge and Maslog. Additionally, the top six (6) barangays that occupy significant areas of the watershed are located in the municipalities append of Paranas [Anagasi (10,134.77 has), Tula (6,829.74 has), San Isidro (3,745.79 has), and Santo Niño (3,367.39 has)], and Can-avid [Pandol, (5,361 has) and Boco (3,504.56 has)]. This geographical distribution of barangays presents different capacities toward watershed management challenges among municipalities.

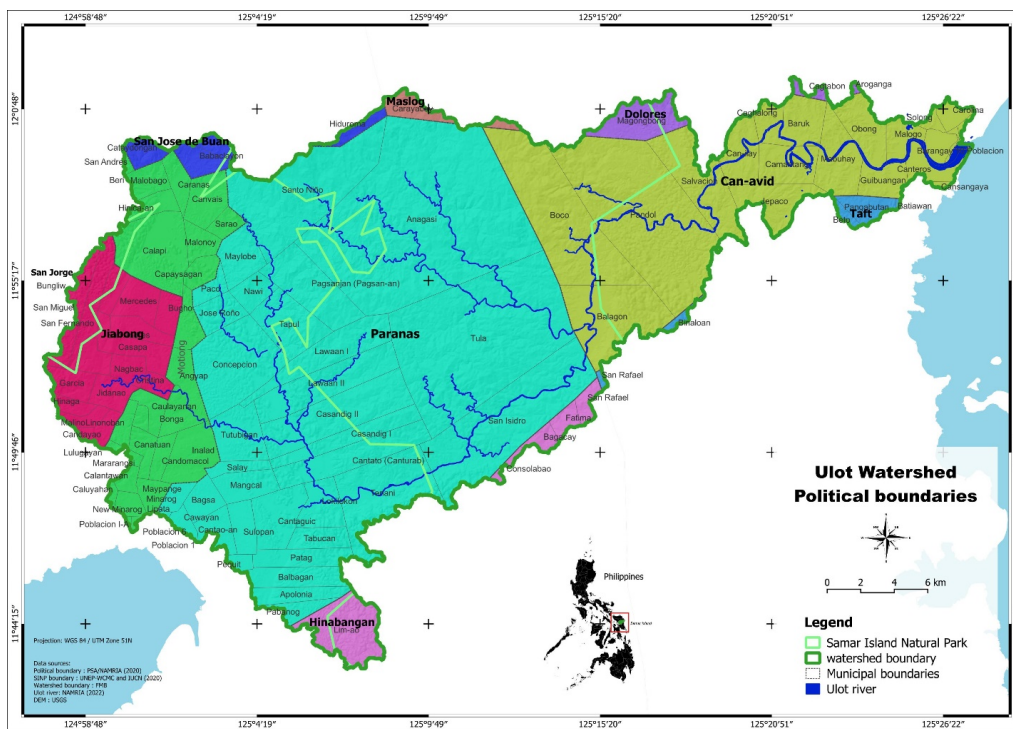


Fig 3. Political boundaries of the Ulot watershed.

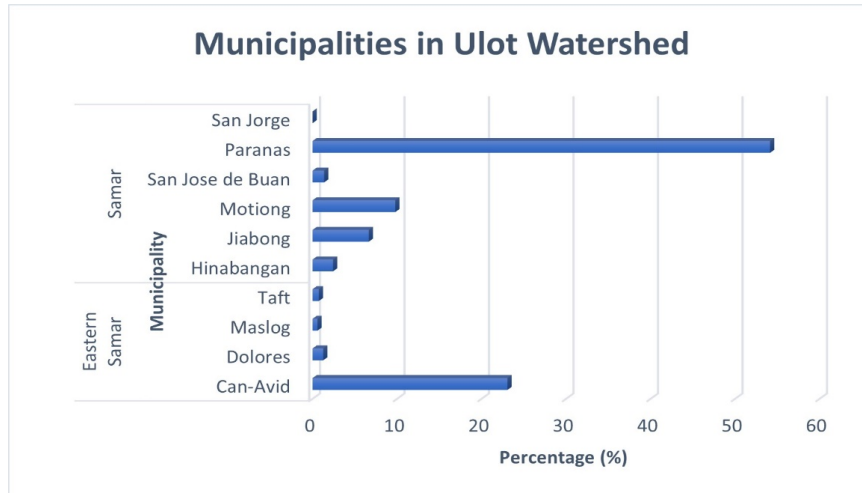


Fig 4. Percentage of the Ulot Watershed Area covered by the municipalities.

Climate Type and Rainfall

According to the Modified Corona System, the Ulot Watershed falls under two climate types: Type II and Type IV (Figure 5). Type II climate is characterized by no distinct dry season and a pronounced maximum rainfall period from November to January (PAGASA, 2020). Approximately 40% of the watershed experiences Type II climate, which is primarily covering the municipalities of Can-avid, Maslog, Taft, and Dolores in Eastern Samar. Some barangays in Paranas and San Jose de Buan in Samar province also fall under this type.

Type IV climate is characterized as evenly distributed rainfall throughout the year. Approximately 60% of the watershed falls under the Type IV climate. There is no distinct dry season, and rainfall is fairly consistent across all months. Understanding these climatic conditions is the basis of effective land and water resource management, given how they control and direct vegetation, agricultural practices, and health conditions in an ecosystem.

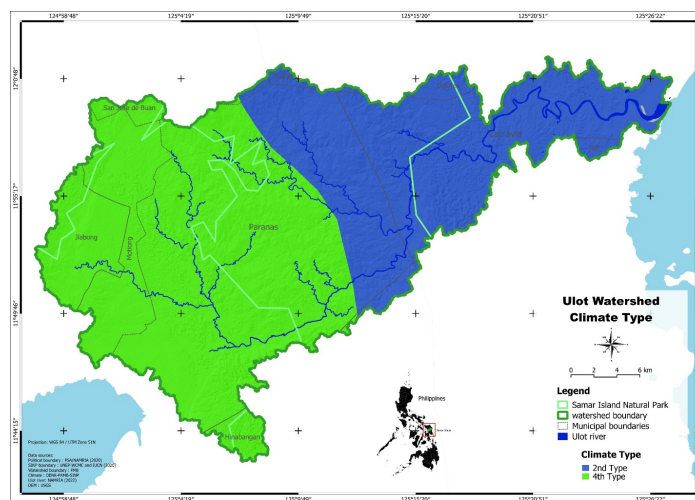


Fig 5. Climate type map of Ulot Watershed.

Type II climate is characterized by relatively uniform rainfall throughout the year with no very dry season (PAGASA, 2020). This consistent rainfall supports diversified and productive agricultural practices, which contribute to the improvement of local food security (Baguinon et al., 2007). In contrast, Type IV climate has a distinct dry season where most rainfall occurs during wet months and dry spells during the rest of the year (PAGASA, 2020). Such variability poses challenges for vegetation, threatening biodiversity, particularly in grassland and shrubland ecosystems, and especially sensitive species (Aldrich et al. 2015).

Climate greatly influences hydrology in a watershed. For Type II areas, there is generally more regularity in river flow corresponding to regular rainfall and reliable water supply throughout the year (Baguinon et al., 2007). Conversely, Type IV areas would have varied flows, with high flows during the wet conditions and lower flows during dry conditions. Such variation in water flow needs to be managed to yield adequate ecological and human water needs. Climate classification in the watershed is essential in devising effective management strategies towards an effective balance of meeting local community needs and conserving natural resources. These climatic influences ought to be recognized by policymakers and land managers while planning for sustainable land use and water resource management. A mean monthly rainfall analysis in the Ulot Watershed over a period of 21 years depicts variations ranging from 275.93 mm to 358.84 mm, indicating a moderately wet climate (Figure 6). Knowing the rainfall pattern is of high importance in determining the river flow, hydrological dynamics and water availability in the watershed. Such hydrological factors do not just impact vegetation growth, but also the health of the riparian ecosystem. The maps (Figure 5 and 6) also highlight areas through the river channels that are most susceptible to flooding. River profiles, runoff efficiency, and shifts in hydrological regimes act as indicators of changing climate and rainfall patterns (Waterman et al., 2022; Zhang et al., 2025).

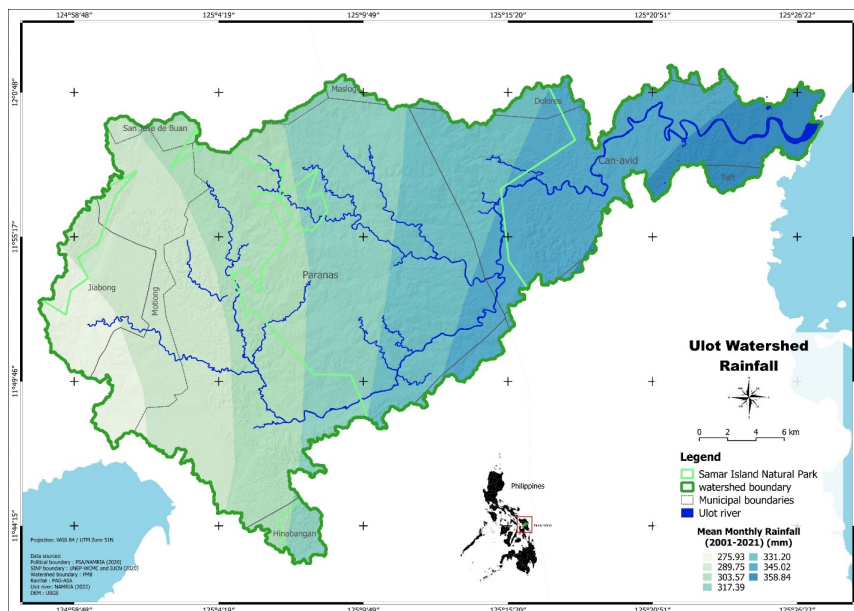


Fig 6. Rainfall map of Ulot Watershed.

Soil Classification

The Ulot Watershed has six distinct soil types that significantly impact its ecology and agriculture. Mountain soil (undifferentiated) making up 45.9% of the watershed area is commonly found in hilly areas (Figure 7). This soil type has proper drainage but is characterized by a shallow and rocky soil, making it unsuitable for agricultural use. However, it is beneficial in supporting forest cover and stabilizing slopes against erosion, especially for areas with high rainfall. Faraon clay takes up 26.2% of the watershed and dominates in hilly terrains. Famous for its retention of moisture but poor drainage, its heavy texture needs sound water management to mitigate runoff and erosion. These properties are suited for specific agricultural practices with appropriate fertility management (Baguinon et al., 2007). Catbalogan clay loam occupying 12.3% of the watershed balances drainage with water retention, providing fertile ground for various agricultural undertakings, provided that land use practices are properly planned to prevent soil compaction and maintain productivity (Postel and Thompson, 2005). Finally, Bigaa loam which has a balanced texture and nutrient-holding capacity, occupies 7.9% of the area. Its properties make it amenable for agriculture, ensuring adequate drainage that prevents waterlogging and protects root systems from degradation (Lasco et al., 2010). These categories of soils have a critical role in shaping up the watershed's agricultural landscape as well as ecological integrity.

Other soil types are the Palapaa clay loam (2.1%), Luisiana clay (2%), and San Manuel loam (1.7%). The rarest soil types that provide some variations in textural and compositional diversity are Ubay clay loam (0.8%) and Bugko loamy sand (0.5%). Sandy loam requires prudent fertility management to avoid nutrient losses (Baguinon et al., 2007). Diverse types of soil pose opportunities as well as challenges toward sustainable land use. Areas of mountain soils call for particular observation in soil conservation activities to reduce erosion; clay and loam soils, on the other hand, like Faraon clay and Bigaa loam soil, support agricultural activities if managed properly (Postel and Thompson, 2005).

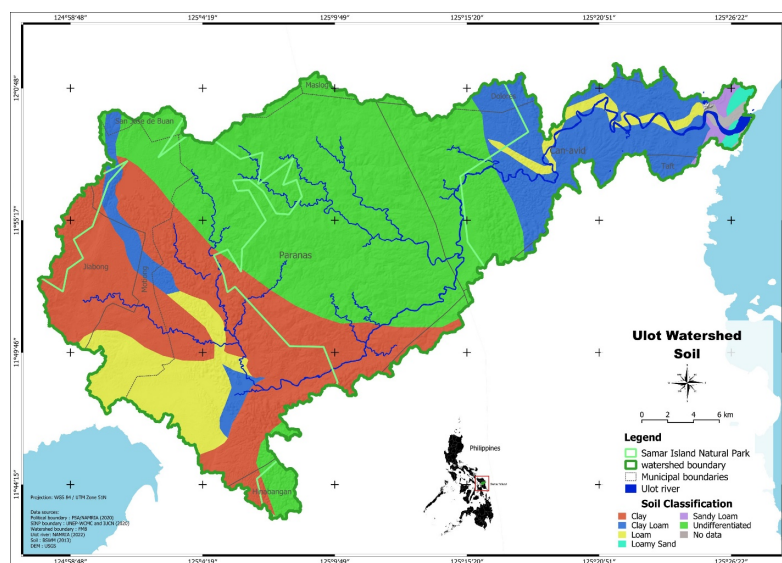


Fig 7. Soil map of Ulot Watershed.

Localized land management techniques should be applied according to soil types. In clay-dominated areas, implementing enhanced drainage strategies combined with environmentally-friendly agricultural practices in loam-rich zones, can rapidly improve the overall health and productivity of the soil (DENR-FMB, 2018). In brief, the varied soil composition plays a crucial role in the hydrology, land-use potential, and conservation priorities of the Ulot Watershed. A full mountain soil area and two notable areas of Faraon clay and Catbalogan clay loam are present. Ongoing research and monitoring of the health of soils will be important for adaptation to environmental changes and optimization of resource use in the region.

Land cover

The Ulot Watershed offers diversified land cover in Open Forest areas (46.07%), followed by Perennial crops (22.09%) and Brush/Shrub lands (18.38%) (Figure 8). Closed Forest areas constitute only 2.24% of the total land area which signifies the area needing more targeted conservation (Table 2). The predominance of Open Forest implies that it is a landscape subject to varying levels of disturbance, hence resulting in a lower canopy cover than Closed Forests. Reforestation and agroforestry can also be utilized in such zones to rehabilitate the land, increase productivity, and sustain ecological advantages (Baguion et al., 2007).

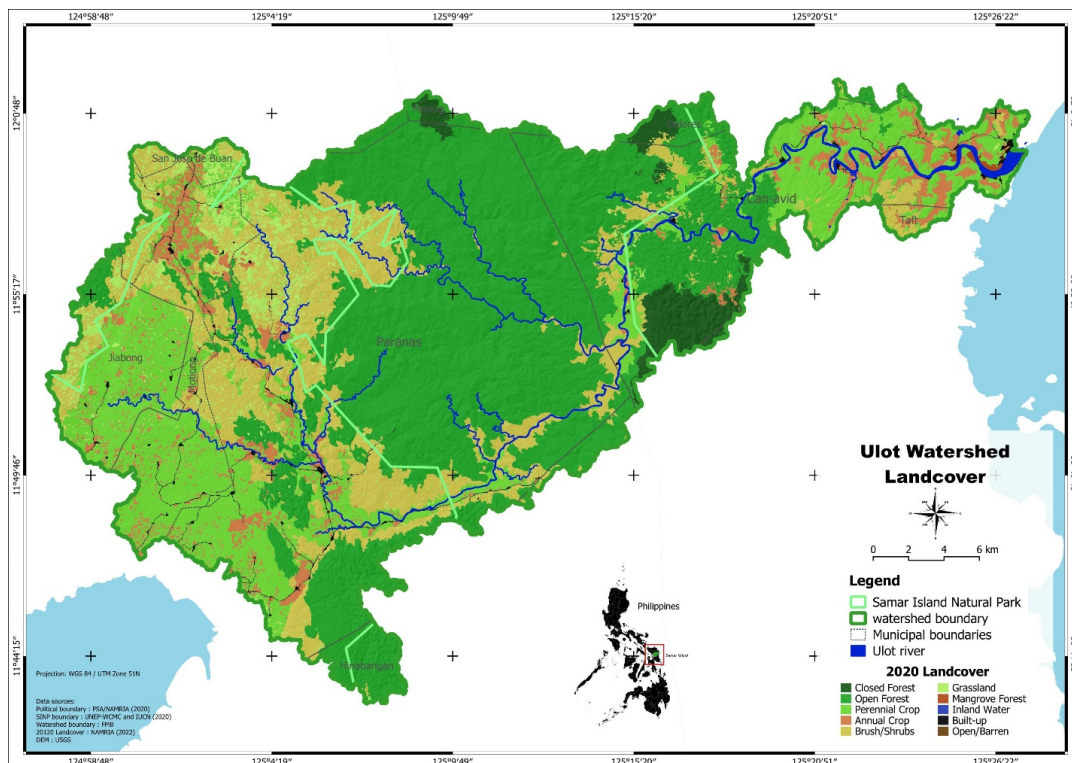


Fig 8. Land cover map of Ulot Watershed.

Table 2. Land cover types in Ulot Watershed and corresponding area in hectares

Land Cover Type	Area (ha)	Coverage (%)
Annual Crop	4,710	5.35%
Brush/Shrubs	16,168	18.38%
Built-up	663	0.75%
Closed Forest	1,972	2.24%
Grassland	3,290	3.74%
Inland Water	1,116	1.27%
Mangrove Forest	70	0.08%
Open Forest	40,538	46.07%
Open/Barren	23	0.03%
Perennial Crop	19,436	22.09%
Total	87,986	100.00%

Perennial crops covering 22.09% of the watershed area indicates massive agricultural practices. Crops such as coconut and banana ensure livelihoods and enhance food security in the area. It helps conserve soils by aiding soil structure, with less erosion as compared to annual crops (Lasco et al., 2014). Although this conversion of forest land to agricultural zones poses long-term risks for biodiversity and watershed hydrology, balanced agricultural productivity can be reconciled with good ecological health. Therefore, sustainable land management practices such as intercropping and organic farming are fundamental to modernize local farming (Postel and Thompson, 2005).

Brush/Shrub lands constitute 18.38% of the watershed, usually as a result of deforestation or land degradation. These lands lack effective erosion control and water retention just like deforested lands, hence prone to further degradation that could lead to augmented sedimentation in water bodies (Baguion et al., 2007). Reforestation improves ecosystem services due to rearing of naturally regenerating seedlings (Lasco et al., 2014). Thus, this area should be subject for reforestation to enhance soil integrity and biodiversity. Such areas covering a thousand and more hectares of brush and shrublands are located in barangays Anagasi, Maylobe, Lawaan I and Tenani in Paranas, Samar. The list of other barangays with more than 300 hectares of brushland is seen in Table 3. These barangays are recommended to be prioritized for reforestation activities.

Only 2.24% of Ulot Watershed's total land area is covered by closed forest consisting of the remaining fragments of the primary forests or mature secondary forests. Fragments of these forests are important to biodiversity conservation and offer superior ecosystem services including enhanced carbon sequestration and climate regulation (DENR-FMB, 2018). It is therefore critical to safeguard these critical zones, as further loss would worsen the biodiversity decline and climate change impacts. Implementing the laws in protecting the forests and promoting community-based conservation activities are the most vital ways of conserving such priceless ecosystems (Postel and Thompson, 2005).

Table 3. Top barangays with more than 300 hectares of land covered in brush/shrubland in Ulot Watershed

Province	Municipality	Barangay	Area (ha)
Samar	Paranas	Anagasi	1,696.51
Samar	Paranas	Maylobe	1,063.27
Samar	Paranas	Lawaan I	1,003.81
Samar	Paranas	Tenani	1,015.49
Samar	Paranas	Tula	915.22
Samar	Paranas	Pagsanjan	840.46
Samar	Paranas	Concepcion	632.45
Samar	Paranas	San Isidro	601.07
Samar	Paranas	Casandig I	518.48
Samar	San Jose de Buan	Babacloyon	476.98
Samar	Paranas	Tapul	417.26
E. Samar	Can-Avid	Guibuangan	403.89
E. Samar	Can-Avid	Salvacion	339.68
E. Samar	Can-Avid	Boco	333.55

The distribution of land covers within the Ulot Watershed presents a case in which there is an obvious need for balancing between conserving forests and agricultural productivity. High Open Forest and Perennial crops and low Closed Forest cover require integrating the ways of integrated land management that embrace sustainable livelihoods with environmentally friendly principles. The main interventions should be reforestation of degraded areas, promotion of agroforestry, and protection of the remaining Closed Forests to sustain ecological integrity and resilience in the watershed.

The physical characteristics of the watershed play an important role in determining its functions and the services it provides, such as water quality regulation, flood control, and other ecosystem services. These characteristics include the area, shape, length, stream order, slope, elevation and land cover. Understanding these characteristics is essential for effective watershed management, especially with increasing challenges from the impacts of climate change and human activities.

Physical Characteristics of Ulot Watershed

Area and Shape of Ulot Watershed

The Ulot Watershed covers a large area, with a perimeter of 257.88 kilometers as analyzed using the QGIS software. Its extensive size plays a crucial role in absorbing stormwater, reducing the intensity of floods and providing a reliable water supply during dry spells (Ponce, 2014). Watersheds defined by ridgelines that separate them from neighboring regions serve as key areas that collect and direct water, sediment, and nutrients across the

landscape (Chorley, 1969; Dunne and Leopold, 1978). This watershed is important for the region because it affects both flooding and low water levels, impacting water availability for people and wildlife (Baguion et al., 2007).

Because of its size and features, the watershed keeps the water levels steady, which is crucial for supporting different species of plants and animals. Consistent water flow is critical for aquatic life (Postel and Thompson, 2005). As climate change creates challenges for water resources, effectively managing the Ulot Watershed is essential for protecting its ecological health and meeting the needs of local communities.

Watershed length and Stream order

The hydrological structure of the Ulot Watershed is characterized by its stream network. Figure 9 shows the stream order analysis of Ulot Watershed using the Strahler method (Strahler, 1957) based on a 5m x 5m resolution. In the Strahler stream ordering system, a stream order is determined by the number of tributaries it receives. The smallest, unbranched tributaries are designated as first-order streams, and the order increases as streams of the same order merge. If streams of different orders meet, the resulting stream takes the order of the higher-order stream. This analysis highlights the critical aspects of the watershed's hydrological structure, particularly the hierarchical stream length arrangements. These describe how the water flows from small low-order streams to higher-order streams, which is an important consideration in terms of understanding the watershed's drainage network.

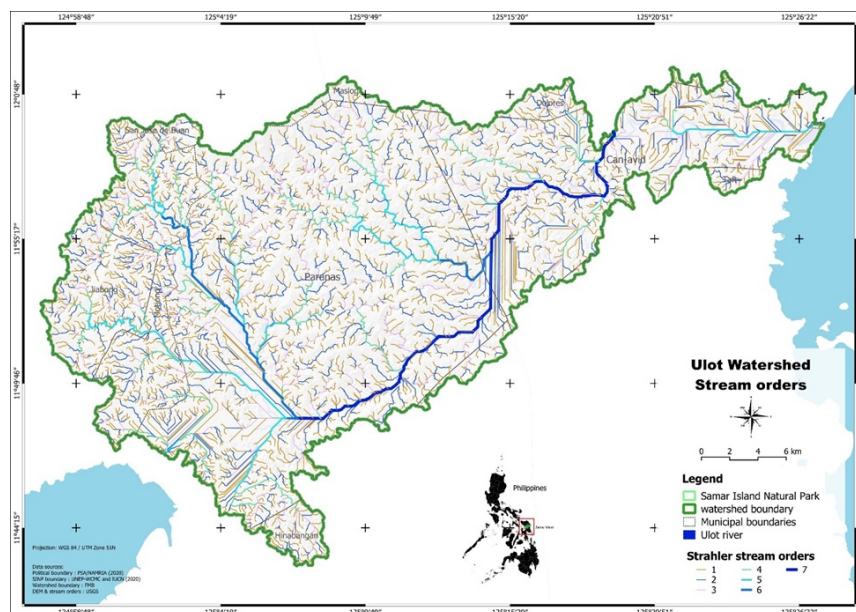


Fig 9. Map showing Ulot Watershed's stream order using Strahler method.

First-Order Streams (1,304.99 km) of the watershed are the most abundant. The long length of these streams indicates a mature network that is efficient in catching surface runoff, especially during intense rainfall events. These streams are also hydrologically sensitive and play an important role in maintaining ecological connectivity, as Horton (1945) and Leopold

et al. (1964) emphasized. Second-Order Streams (682.90 km) are formed by the integration of two first-order streams. The recession is a factor of concentration as streams coalesce, where further consolidation into the networks increases the complexity in their dynamics, this time by conditions higher upstream (Strahler, 1957).

Third-Order Streams (324.24 km) are formed when two second-order streams merge together, which is another step of network coalescence. This significantly affects water quality downstream and load transport in the watershed (Knighton, 1998). Fourth-Order Streams (152.89 km) are wider with higher volume and more stable flow regimes due to the large area of the catchment. These streams have a critical role in hydrological balance and supply habitat diversity to the aquatic ecosystems (Allan and Castillo, 2007). Fifth-Order Streams (80.87 km) represent large channels that are linked with upstream hydrological processes. In other words, these streams have significant importance in the flooding regulation and the transport of nutrients inside the watershed (Montgomery and Buffington, 1997). Sixth-Order Streams (26.20 km) are larger tributaries in the stream hierarchy, which transport greater amounts of water and sediments, contributing to major tributaries into higher-order rivers. Seventh-Order Streams (39.04 km), even though fewer in number, are components of the largest channels, playing an important role in hydrological dynamics in the watershed and having a huge impact on downstream water quality and flood management.

The total stream length of 2,611 km in the Ulot Watershed represents a complex and advanced drainage network, important in the regulation of flow, sediments, and nutrient cycling. The hierarchical arrangement of streams does reflect the hydrologic gradient, portraying the shift from the smaller scale of runoff events of the first-order streams to the larger scale of transport by the higher order of streams.

The dense network of first-order streams in a watershed can increase the risk of flash flooding in headwater areas, especially during heavy rainfall, making effective watershed management essential (Poff et al., 1997). As water moves downstream, higher-order streams play a key role in regulating flow and maintaining water quality by absorbing the combined impact of upstream runoff (Knighton, 1998). In Leyte, both low- and high-order streams are widespread, which helps explain why the region often experiences severe flooding. One of the most tragic examples was the 1991 Ormoc City flood, where water from multiple tributaries rushed into the main rivers, causing massive devastation (Bankoff, 2003). More recent studies from Eastern Visayas continue to highlight how heavy rainfall, poor land use practices, and a dense stream network contribute to recurring floods in the area (Cinco et al., 2016).

Slope and Elevation

The slope and elevation of the Ulot Watershed are key factors influencing hydrological processes such as runoff, infiltration, and erosion. The Ulot Watershed is characterized by steep and challenging terrain (Figure 10). There are five recognized slope categories according to gradients: Class I (0–8%): level to gently sloping; Class II (8–18%): gently sloping to undulating, Class III (18–30%): undulating to moderately steep, Class IV (31–50%): moderately steep to steep, Class V (> 50%): very steep. About 28.3% of Ulot watershed has

a slope that ranges from 30%-50%, classified as Hilly to Mountainous. Approximately 23.7% of the area has slopes between 18% and 30%, characterized as Rolling to Hilly terrain (Appendix 2). The rest of the watershed is classified as follows: 17.3% of the total area is Undulating to Rolling (8-18% slope), 15.3% is Level to Undulating (0-8% slope) and 15.0% is Mountainous (>50% slope).

Hilly to mountainous slopes are prone to erosion and landslides during heavy rains because they allow high runoff and a higher possibility of degrading the soil (Dela Cruz and Agpaoa, 2017). Proper management of the slopes, such as reforestation or afforestation, and terracing, is needed to avoid these situations (Lal, 2001). Rolling to hilly slopes are usually tapped for agriculture, although these areas suffer from erosion problems. Some conservation techniques like contour farming and terracing can keep the land fertile, with lesser runoff (Brady and Weil, 2008). Rolling topography also creates microclimates that bring about biodiversity (Ong et al., 2004). Undulating to rolling slopes are transitional and therefore have both the potential for agriculture and natural vegetation. However, such lands need to be taken care of with greatest caution so that they do not fall prey to practices of deforestation and overgrazing, which may result in runoff and poor soil fertility (Reynolds et al., 2007). Balanced agriculture and ecological sustainability can be amalgamated only through different land use approaches (Pimentel and Burgess, 2013).

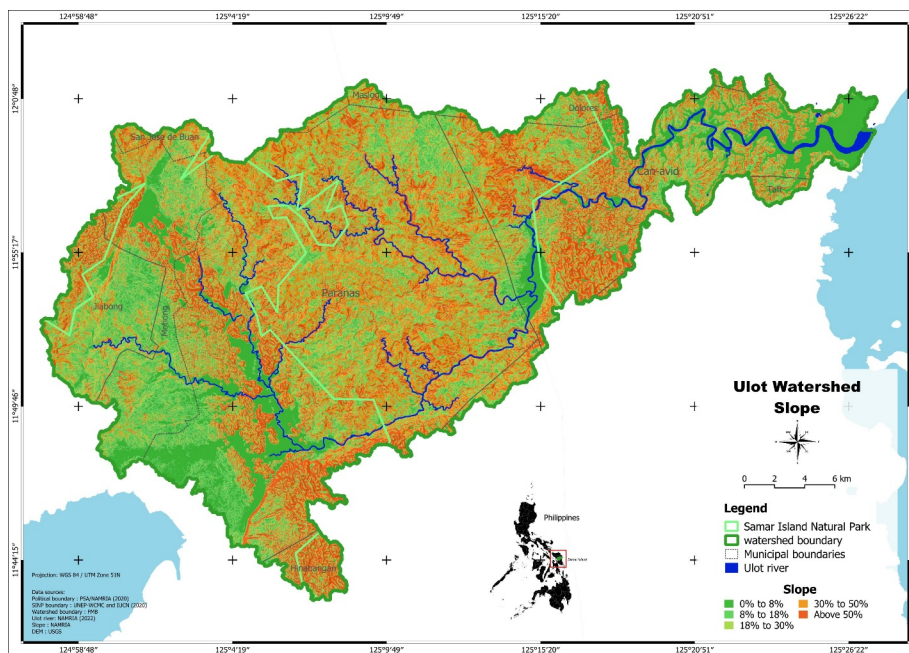


Fig 10. Slope Map of Ulot Watershed.

Elevation is a central element in the hydrology of a watershed because it will impact temperature, rainfall, and other climatic factors that influence runoff, infiltration, and evaporation, among other hydrologic processes (Dingman, 2015). The average elevation in Ulot Watershed is about 399.02 meters, while the maximum elevation is about 798.04 meters above sea level (Figure 11). Elevation affects local climate, water availability, and ecological conditions.

In midstream, the Ulot River traverses scenic small river canyons and crosses over unique rock formations (Figure 12), attracting eco-tourists who engage in activities such as torpedo boat rides and river trekking (Bordeos et al., 2020). The riparian zones with lush vegetation on the sides of the river help in preventing erosion and maintaining a stable soil structure and filter the large proportion of pollutants entering the water body, hence ensuring good quality of water. They also serve as wild-water habitats that connect between the wet and dry areas, hence acting as significant wildlife corridors, hosting species both terrestrial and semi-aquatic in nature (Lasco and Pulhin, 2006).



Fig 12. Small canyons and rock formations in Ulot River.

The landscape around Ulot River is a hotspot within SINP, encompassing riverine ecosystems, mountainous terrain, tropical rainforests, as well as several minute waterfalls and cascades along the river, which not only add to its beauty but also contribute to the oxygenation of water, sustaining aerobic aquatic life (Figure 13). Thus, preserving these landscapes is important not only to the ecological health of the Ulot Watershed but also for the resilience of the local communities who principally rely on agriculture, fishing, and eco-tourism (DENR, 2019).



Fig 13. Cascades in Ulot River.

The Ulot River has been an active site for ecotourism, with activities like torpedo boat adventures that give a scenic view of the river environment. These can, on occasion, bring in revenue to local communities apart from popularizing environmental concerns (Bordeos et al., 2020). Natural landscapes should be preserved for the eventual conservation of the cultural identity and heritage of the local residents.

Hence, the natural landscapes offered by Ulot River are considered critical to the park's ecological integrity. The variability of the tropical rainforests and mountainous terrain in the place harbors species and crucial ecosystem services that would eventually require future management and conservation efforts to preserve biodiversity, promote livelihoods, and promote eco-tourism in a culturally caring manner.

Some of the anthropogenic activities and issues inside the Ulot watershed

Various anthropogenic activities pose a threat to the ecosystem of the Ulot Watershed. Kaingin, or small-scale slash-and-burn farming (Figure 14), is one of the chief livelihoods in agricultural production that benefits a considerable proportion of the local population of about 12,600 individuals or about 3,000 households. However, these practices are not sustainable and could lead to deforestation, soil erosion, and nutrient depletion, eventually degrading forest ecosystems and biodiversity (Lasco and Pulhin, 2006; Mukul et al., 2020). Furthermore, intensive agriculture interferes with hydrological processes, deteriorating both the amount and quality of downstream water.



Fig 14. Slash and burn activities in the riparian zone of Ulot River.

Illegal logging remains a problem in the Ulot Watershed, even inside the protected area. Logging for valuable hardwood species degrades the ecological balance, damages critical habitats for wildlife, and leads to further denudation and soil erosion, adversely affecting the water quality of the Ulot River (DENR, 2019). Small-scale mining for minerals such as bauxite takes place within the watershed, particularly in Paranas and Motiong (MGB, 2021), consequently leading to land degradation, deforestation, and water pollution due to improper disposal of mining by-products that pose a threat to aquatic ecosystems and community health (Lasco and Pulhin, 2006). Charcoal making has also been a traditional income source

and often involves cutting down trees for fuel. If not managed sustainably, it may result in biodiversity loss and forest degradation, potentially reducing carbon sequestration capacity, and increasing susceptibility to flooding and land erosion (Lasco et al., 2009).

The local communities in the Ulot River rely on fishing, but it is sustainable only at the small-scale level (Figure 15). Poorly managed aquaculture systems and overfishing can degrade habitats in rivers like Ulot River or thousands of other fisheries, leading to nutrient loading, which affects water quality and the fish populations (Bordeos et al., 2020).



Fig 15. Local communities and small-scale fishponds in Ulot River.

Proposed Conservation Action Plan

A consolidated assessment was conducted, referring to the biophysical and anthropogenic issues affecting the Ulot Watershed, and the corresponding policy-aligned management strategies were identified. Table 4 synthesizes key issues and concerns in the Ulot Watershed and links them with evidence-based management interventions and relevant policies. Steep slopes and erosion-prone terrains dominate large portions of the watershed, necessitating strict soil and slope management measures such as reforestation, terracing, and agroforestry. These interventions are consistent with the Revised Forestry Code (PD 705) and DENR guidelines, underscoring the need to protect upland areas from inappropriate and unsustainable land use.

Soil-related concerns, particularly in poor drainage areas, highlight the importance of aligning agricultural practices with soil and land suitability. Drainage improvement and conservation farming techniques support sustainable productivity while minimizing erosion, in line with the Agriculture and Fisheries Modernization Act (RA 8435). Similarly, forestlands with low vegetation cover require ecological restoration and rehabilitation through reforestation and assisted natural regeneration to enhance biodiversity, stabilize slopes, and

improve watershed functions, as mandated by the Expanded National Integrated Protected Areas System or ENIPAS Act (RA 11038) and Community-Based Forest Management (EO 263) policies.

Flood-prone lowland areas along river channels reflect the cumulative impacts of upstream land-use practices. The establishment of riparian buffer zones and regulation of activities within floodplains contribute to climate change adaptation and disaster risk reduction goals under the Climate Change Act (RA 9729). The observed destructive and unsustainable anthropogenic activities, such as slash-and-burn agriculture and monocropping, further emphasize the role of human-induced pressures in watershed degradation. Addressing these requires stricter land-use regulation, site-specific suitability assessments, and the promotion of diversified farming systems.

Table 4. Key biophysical and anthropogenic issues and policy-aligned management actions in the Ulot Watershed

Issue Identified	Evidence from Results	Proposed Action	Policy/Framework Alignment	Responsible Stakeholders
Steep slopes prone to erosion	28.3% of watershed has 30–50% slopes; 15% has >50% slopes (hilly to mountainous terrain)	Implement reforestation, terracing, and agroforestry (contour farming in erosion-prone areas)	DAO 2021-41 (soil and slope management) ¹ ; PD 705 (Revised Forestry Code) ²	DENR, LGUs, local communities
Poor soil drainage	26.2% of the watershed is Faraon clay and dominates in hilly terrains.	Drainage management, agroforestry (crop rotation, cover cropping, contour farming in hilly areas)	DAO 2021-41 (soil and slope management) ¹ ; RA 8435 (AFMA) ³	DENR, DA, LGUs, PO's: farmer's associations
Low vegetation areas	18.38% and 3.74% of the watershed covered with shrubs, grasslands and disturbed areas, particularly in upland and transitional zones	Implement reforestation, assisted natural regeneration, and slope stabilization; establishment of buffer zones	RA 11038 (ENIPAS Act) ⁴ ; EO 263 (CBFM) ⁵	PAMB-SINP, DENR, LGUs, local communities
Flood-prone areas	Low-lying areas adjacent to river channels and downstream sections of the watershed	Establish riparian buffers, regulate land use in floodplains, improve watershed vegetation cover, and enhance natural drainage systems	RA 9729 (Climate Change Act) ⁶ ; DMC No. 2008-05 (Integrated Watershed Management Framework) ⁷	DENR, LGUs, NDRRMC, local communities
Unsustainable anthropogenic activities	Presence of slash and burn, small scale monoculture farms	Restrict intensive land use and require site-specific land suitability assessments.	EO 318 (SFM) ⁸ ; RA 8435 (AFMA) ³	DENR, DA, LGUs, PO's: farmer's associations

¹ DENR Administrative Order 2021-41 (Guidelines in Creation of Watershed Management Council); ² Presidential Decree 705 (Revised Forestry Code of the Philippines); ³ Republic Act 8435 (Agriculture & Fisheries Modernization Act); ⁴ Republic Act 11038 (Expanded National Integrated Protected Areas System Act of 2018); ⁵ Executive Order 263 (Community-based Forest Management); ⁶ Republic Act 9729 (Climate Change Act); ⁷ DENR Memorandum Circular No. 2008-05 (Guidelines in the Preparation of Integrated Watershed Management Plans); ⁸ Executive Order 318 (Promoting Sustainable Forest Management in the Philippines)

These highlight the need for integrated watershed governance involving DENR, Department of Agriculture (DA), local government units (LGUs), and local communities. By grounding management actions in biophysical evidence and aligning them with national and local policy

frameworks, the proposed measures support the long-term ecological integrity and sustainable development of the Ulot Watershed.

Land use management in the Ulot Watershed must balance economic development and ecological conservation, given its diverse topography. Flat areas are suitable for farming but are prone to flooding, which requires proper drainage and soil management. In contrast, mountainous areas play a critical role in habitat preservation and carbon sequestration, making them ideal for conservation efforts. Areas with both flat and steep slopes highlight the need for agroforestry and reforestation strategies, especially since most of these areas are located within SINP. This proposed conservation action plan outlines site-specific strategies for sustainable land use across different slope categories, emphasizing conservation, agricultural practices, and proper zoning to safeguard the watershed's long-term ecological health and stability (Figure 16).

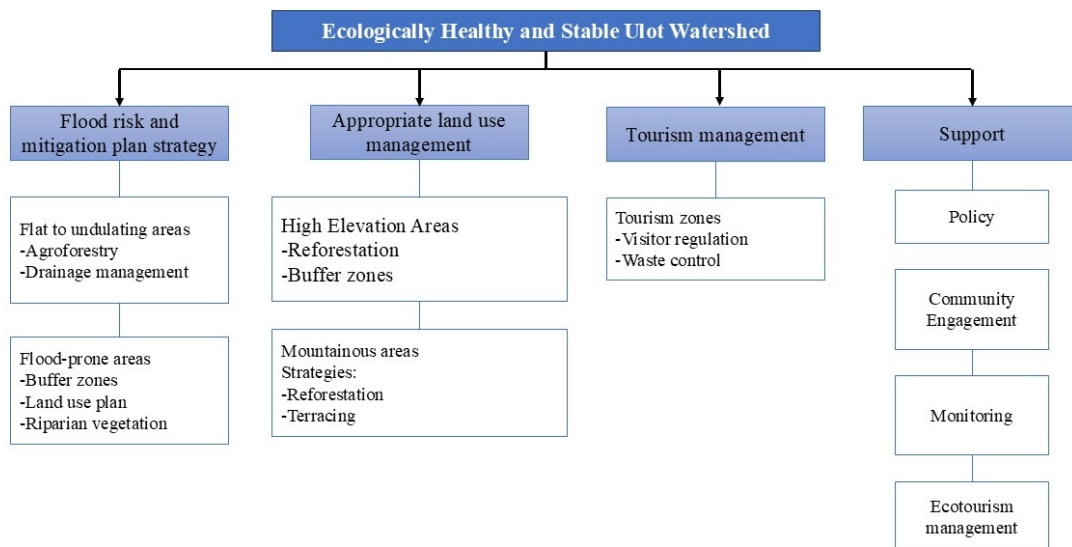


Fig 16. Proposed Conservation Action Plan for Ulot Watershed.

Flood risk and mitigation strategy for Can-avid

Dry and wet periods impact agricultural practices and flood control due to the significant seasonal variations in this area, which have been known to affect resource management (Lasco et al., 2010). Consistent or uniform rainfall ensures that high levels of forest cover and biodiversity are preserved, whereas low rainfall levels have been shown to stress vegetation and raise vulnerability to drought (Baguinon et al., 2007). Effective water resource management strategies, especially for areas involving rainwater harvesting and efficient irrigation, form an important basis for a sustainable water supply in agriculture and household uses (Poff et al., 1997). Such agricultural planning needs monthly rainfall data to guide farmers on the appropriate selection of crops, the appropriate time for planting, and irrigation practices. While consistent rainfall during critical growth periods can improve crop yields, great fluctuations would necessitate either drought-resistant crops or rain-fed farming (Lasco et al., 2010). This means that the range of monthly mean rainfall in the Ulot

Watershed, from 275.93 mm to 358.84 mm, underscores the need to understand local climate patterns as a means of informing effective resource management. This rainfall pattern implies a huge amount of rainfall received by Can-avid which further increases its risk for flooding. Thus, insights drawn from this are critical to guiding policymakers and land managers toward strategies enhancing agricultural productivity, conserving biodiversity, and sustaining the use of water resources.

Appropriate land use management according to slope and elevation

The flattest areas of the watershed are suitable for farming and development. However, these areas are highly prone to flooding and waterlogging, especially if not properly managed. For instance, it requires proper management of drainage and soil moisture so that adverse effects on agriculture and settlements are avoided (Zhao et al., 2019). Mountainous areas are primarily forested, playing a crucial role in habitat provision, carbon sequestration, and climate change regulation. These areas should be prioritized for conservation and reforestation due to landslide and erosion susceptibility (Nepstad et al., 2008; Marsh and Grossa, 2015). The Ulot Watershed's varied slopes highlight the need for site-specific land management strategies. Steep areas demand conservation to prevent erosion, while gentle slopes can support sustainable agriculture. Barangay Tula in Paranas, Samar, stands out with the largest area in both flat and steep slope categories, making it suitable for diverse land uses (Appendix 3 and 4). Agroforestry is recommended for flatter areas, and conservation methods like terracing and reforestation for steep slopes. Since much of Barangay Tula lies within the SINP, activities like forest clearing are restricted. Proper zoning and planning are essential across all top barangays to balance land use and ecological preservation.

Conserving forest cover in high-elevation barangays—such as Hiduroma, Carayacay, Santo Niño, and Lim-ao—is critical for water retention, erosion prevention, and biodiversity support (Appendix 5). These upland areas, ranging from 400 to 1000 meters above sea level, include brushlands, grasslands, and some residential zones. Reforestation and vegetative buffers are strongly recommended to enhance carbon sequestration, reduce risks from extreme weather, and support ecosystem services like soil stability and habitat protection. Sustainable management strategies that consider elevation dynamics are key to preserving the watershed and ensuring community resilience.

Appendix 6 presents the ten barangays within Ulot Watershed with the highest area categorized as highly susceptible to flooding. These areas are recommended to be included in land use planning, wherein riparian buffers with appropriate widths and vegetation will be established to enhance biodiversity, control sediment, and restore natural hydrological processes (Croke et al., 2022).

Regulating tourism to mitigate its negative impact on Ulot River

Ecotourism, including Ulot River Torpedo Boat Ride among many others, has opened up alternative livelihood and increased environmental awareness. However, unregulated tourism led to littering, wildlife disturbances, and overexploitation of resources. Hence, there is a need to balance tourism and conservation practices for sustainability (Bordeos et al., 2020). Roads and bridges infrastructure projects provide easy transportation and also stimulate

local economic development but frequently cause habitat fragmentation and destroy forests with changes in the drainage pattern leading to higher risks of landslide and soil erosion in steep areas (Baguinon et al., 2007; Buhay et al., 2023). Also, further expansion of human settlements in the Ulot Watershed transformed what otherwise would have been considered forestland into residential areas, increasing the demand for resources and clearing forests, considerably impacting ecological balance and biodiversity (DENR, 2019).

Overall, the cumulative impact of unregulated tourism includes forest degradation and deforestation that decrease the capacity of the watershed to control the water flow and make the area vulnerable to flooding. It also diminishes the carbon sink ability of the watershed. Soil erosion and sedimentation cause siltation of rivers and streams, affecting water quality and reducing reservoir storage capabilities leading to floods and water scarcity during dry seasons (Baguinon et al., 2007). Direct human activities are the main causes of biodiversity threats to endemic species reliant on the integral state of forest ecosystems. Hunting pressure, encroachment, and deforestation endanger many species, thus implying that some are critically endangered (DENR, 2019). Anthropogenic activities in the Ulot Watershed provide economic benefits but pose huge hurdles in sustainable management and ecological integrity. Proper regulation and sustainable practice will be necessary to protect this very significant ecosystem.

Conclusion

The Ulot Watershed exhibits significant variations in political boundaries, physical characteristics, and natural landscapes, which are significantly crucial to the overall functionality of the watershed. Paranas encompasses the most substantial portion of the watershed, while other municipalities such as Can-avid and San Jorge have manifold management challenges at hand. The watershed has a complex topography with steep slopes and high elevations in some areas, meriting the need for soil conservation and proper land-use planning to control erosion and avoid soil degradation and landslides. The stream network of the Ulot Watershed has a total length of 2,611 km, forming a well-developed hydrological system that aids in flood control and regulates water supply. Although the predominance of first-order streams increases vulnerability to localized floods and erosion, this underlines the significance of watershed management. Moreover, the diversity of land covers, including open forest, underscores the need for forest conservation to sustain ecosystem services.

Thus, slash-and-burn farming, among other anthropogenic activities, still exerts pressure on the watershed, which eventually culminates in deforestation, soil erosion, and loss of biodiversity. At the same time, because of the terrain, unsustainable land practice tends to exacerbate environmental degradation in this area. Therefore, it is urgent that human activities be regulated, reforestation encouraged, and sustainable land use practices adopted to both protect the ecological integrity of the watershed and to ensure that the livelihoods of community living are preserved.

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Appendices

Appendix 1. Percent area covered per municipality and barangay within Ulot Watershed

Province	Municipality	Percentage (%)	Barangays covered
Samar	Paranas	54.14	Apolonia, Balbagan, Pabanog, Anagasi, Bagsa, Cantaguic, Cantao-an, Cantato (Canturab), Casandig I, Concepcion, Jose Roño, Cawayan, Lawaan I, Lipata, Lokilokon, Mangcal, Maylobe, Minarog, Nawi, Paco, Pagsanjan (Pagsan-an), Poblacion 4, Salay, San Isidro, Santo Niño, Sulopan, Tabucan, Tapul, Tula, Tutubigan, Casandig II, Lawaan II, Buray (Binogho), Patag, Pequit, Poblacion 1, Tenani, and Poblacion 6
	Motiong	9.79	Poblacion I-A, Angyap, Beri, Bonga, Calantawan, Calapi, Caluyahan, Canvais, Canatuan, Candomacol, Capaysagan, Caranas, Caulayanan, Hinica-an, Inalad, Linonoban, Malobago, Malonoy, Mararangsi, Maypange, New Minarog, Pamamasan, San Andres, Sarao, Pusongan, and Poblacion I
	Jiabong	6.65	Bugho, Candayao, Casapa, Cristina, Dogongan, Garcia, Hinaga, Jidanao, Lulugayan, Malino, Mercedes, Nagbac, San Andres, San Fernando, and San Miguel
	Hinabangan	2.42	Lim-ao, Bagacay, San Rafael, Fatima, Consolabao
	San Jose de Buan	1.36	Babaclayon, Cataydongan, Hiduroma
	San Jorge	0.0001	Bungliw
Eastern Samar	Can-avid	23.06	Boco, Baruk, Caghalong, Camantang, Can-ilay, Cansangaya, Canteros, Carolina, Guibuangan, Jepaco, Mabuhay, Malogo, Obong, Barangay 1 Poblacion, Barangay 10 Poblacion, Barangay 2 Poblacion, Barangay 3 Poblacion, Barangay 4 Poblacion, Barangay 5 Poblacion, Barangay 6 Poblacion, Barangay 7 Poblacion, Barangay 8 Poblacion, Barangay 9 Poblacion, Solong, Balagon, Pandol, Salvacion
	Dolores	1.26	Aroganga, Cagtabon, and Magongbong
	Taft	0.74	Batiawan, Beto, Pangabutan, San Rafael, and Binaloan
	Maslog	0.57	Carayacay

Appendix 2. Slope class distribution

Slope (%)	Description	Area Covered (%)
>50	Mountainous	15
30-50	Hilly to Mountainous	28.3
18-30	Rolling to Hilly	23.7
8-18	Undulating to Rolling	17.3
0-8	Level to Undulating	15.3

Appendix 3. Top ten barangays with level to undulating slope class

Top	<i>Level to Undulating (0%–8%)</i>			
	Province	Municipality	Barangay	Area (ha)
1	Samar	Paranas	Tula	246.42
2	E. Samar	Can-Avid	Baruk	240.96
3	E. Samar	Can-Avid	Canteros	162.62
4	Samar	Paranas	Anagasi	132.92
5	E. Samar	Motiong	Capaysagan	130.98
6	E. Samar	Can-Avid	Balagon	114.27
7	E. Samar	Can-Avid	Guibuangan	100.72
8	Samar	Paranas	Cantaguic	95.18
9	Samar	Paranas	Sulopan	94.76
10	Samar	Motiong	Pamamas-An	92.38

Appendix 4. Top ten barangays with mountainous slope class

Top	<i>Mountainous (50% and above)</i>			
	Province	Municipality	Barangay	Area (ha)
1	Samar	Paranas	Tula	331.03
2	Samar	Paranas	Anagasi	307.33
3	Samar	Paranas	Tenani	244.28
4	Samar	Paranas	Maylobe	216.73
5	E. Samar	Can-Avid	Pandol	156.50
6	Samar	Paranas	Lawaan I	143.49
7	Samar	Paranas	Patag	117.70
8	E. Samar	Taft	Binaloan	117.05
9	E. Samar	Taft	San Rafael	116.32
10	E. Samar	Can-Avid	Salvacion	99.93

Appendix 5. Barangays in high elevation covered in brush/shrubs, grassland and built-up areas

Province, Municipality, Barangay	400–500 (masl)			400–500 Total	500–1000 (masl)		500–1000 Total	Grand Total
	Brush/Shrubs	Built-up	Grassland		Brush/Shrubs	Grassland		
Samar	528.27	0.09	113.28	641.64	29.86	2.45	32.30	673.94
Hinabangan	126.50		4.88	131.38				131.38
Cabalagnan	22.65			22.65				22.65
Lim-Ao	103.86		4.88	108.74				108.74
Jiabong	106.10		44.21	150.31	0.03		0.03	150.34
Casapa			1.74	1.74				1.74
Dogongan	7.36		6.37	13.73				13.73
Garcia	12.74		5.55	18.29				18.29
Hinaga	3.35			3.35				3.35
Malino	2.31		2.10	4.40				4.40
Mercedes	21.32		6.38	27.70				27.70
San Andres			0.61	0.61				0.61
San Fernando	56.31		20.89	77.19	0.03		0.03	77.22
San Miguel	2.72		0.58	3.30				3.30
Motiong	72.54		16.44	88.98	3.93	1.51	5.44	94.42
Beri	5.20		2.93	8.12	2.59	0.99	3.57	11.69
Canvais	29.70		11.52	41.21	1.34	0.52	1.87	43.08
Malobago	3.80		0.19	4.00				4.00
San Andres	33.84		1.81	35.65				35.65
Paranas	150.27		32.12	182.38	20.44	0.94	21.37	203.76
Anagasi	0.01		0.48	0.49				0.49
Apolonia	0.25			0.25				0.25
Concepcion	2.81		0.03	2.84				2.84
Maylobe	126.54		31.09	157.64	17.18	0.94	18.12	175.76
Pabanog	19.64			19.64				19.64
Pagsanjan	0.38		0.51	0.89				0.89
Tabucan	0.63			0.63	3.25		3.25	3.88
Tenani	0.01			0.01				0.01
San Jose de Buan	72.86	0.09	15.63	88.58	5.46		5.46	94.04
Babacloyon	37.96	0.09	14.79	52.84	0.08		0.08	52.92
Cataydongan	34.90		0.84	35.74	5.38		5.38	41.12
Grand Total	528.27	0.09	113.28	641.64	29.86	2.45	32.30	673.94

Appendix 6. Top 10 barangays with high susceptibility to flooding

Province	Municipality	Barangay	Area (ha)
E. Samar	Can-Avid	Canteros	592.89
Samar	Paranas	Tula	423.77
E. Samar	Can-Avid	Baruk	340.08
E. Samar	Can-Avid	Camantang	311.44
E. Samar	Can-Avid	Guibuangan	289.98
Samar	Paranas	Lokilokon	231.01
Samar	Paranas	Tutubigan	223.76
Samar	Paranas	Cantato (Canturab)	178.08
E. Samar	Can-Avid	Salvacion	174.65
Samar	Paranas	Lawaan I	170.66