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Physical Profile of the Sub-watersheds of Southern Cauayan Municipal Forest and Watershed Reserve in Negros Occidental, Philippines

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ABSTRACT

The Southern Cauayan Municipal Forest and Watershed Reserve (SCMFWR) is a 6,000-hectare area in the forests of southwestern Negros in the Philippines. It is part of the Greater Calatong Watershed, which supplies water to farmers in Cauayan and Sipalay City. This study describes the profile of the sub-watersheds within the SCMFWR. The data may be used as basis for management purposes and monitoring of the overall health of the reserve. Specifically, the study delineated boundaries, and drainage areas, classified sub-watersheds, described land use, and determined water discharge of three major river tributaries Cabanbanan, Tinagpito, and Banso and their physical characteristics. The drainage areas of the three rivers were delineated using Topographic Map from the Philippine National Mapping and Resource Information Authority, Google Map, and ASTER GDEM 2011, and secondary data/maps from the Provincial Environment Management Office. DENR manual on watershed characterization was used for the sub-watershed classification. The measurement of water discharge was done by measuring average cross-sectional areas of the river and water velocities obtained through the floatation method. Other watershed and river characteristics were gathered by ocular observation. The study determined that SCMFWR is divided into three sub-watersheds with a total area of 2944.78 ha. that feeds the three river systems.

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Cabanbanan and Tinagpito watersheds are classified as small and Banso as micro. Cabanbanan and Tinagpito are dominated by a mix of agricultural and open grassland while most of Banso is covered by forest. The total discharge of the three rivers is 2.0261 m3/s with Cabanbanan yielding the most volume at 1.3078 m3/s.

Keyword: floatation method *sub-watershed, SCMFWR, watershed, water, management*

INTRODUCTION

SCMFWR is a 6,000-hectare area in the forests of southwestern Negros in the Philippines. It includes the remaining limestone forests of Cauayan. The area contains a significant portion of forest patches that are found in Sitio Pinamay-an, Barangay Camalanda-an. The area is inhabited by a large farming community situated close to the forest and contains three river systems of Cabanbanan, Tinagpito, and Banso that supply water to the surrounding farming communities. The rivers flow southwest to become the Calatong River, which drains into the coastal area of Sipalay City. The health of this watershed is crucial to the water needs of some 1,000 farming residents in the Cauayan municipality and Sipalay City areas (UNDP, 2012).

The forest patches are what remained after previous logging operations in the area. It was the subject of several government protection efforts that eventually led to the formation of the Camalandaan Agroforestry Farmers' Association (CAFA). The success of CAFA earned them the U.N. Development Programme's Equator Prize in 2008. Prior to that, in 2001, CAFA worked with biologists from Silliman University's Angelo King Center for Research and Environmental Management (SUAKCREM) in the monitoring and documentation of the rich biological diversity in the forests of Cauayan. In fact, identification of unique and threatened species of flora and fauna in the forests led to the declaration of an area comprising 6,000 ha as a forest and watershed reserve in 2003. This declaration attracted subsequent community projects and biodiversity studies, but until now, no study has been done on the hydrological characteristics of this watershed.

The main objective of the study is to describe the physical profile of the sub-watersheds of SCMFWR in Negros Occidental, Philippines. The specific objectives of the study are to delineate the drainage and forest reserve areas in each sub-watershed, characterize the sub-watershed in terms of classification and land use, and characterize the three major rivers within the reserve in terms of discharge or volumetric flow rate and physical attributes.

Data from watershed characterization, which includes the determination of the present state of the watershed, are used in the preparation of the Integrated Watershed Management Plans (DENR Memorandum Circular 2008-05). It may be used for management and monitoring of SCMFWR and the greater part of the watershed in accordance with DENR MC 2008-05 and other management guides that require watershed management plans to be holistic, integrated, and participated in by all stakeholders concerned.

The delineation of watersheds within a large drainage basin and their prioritization was recognized by Rahaman, Ajeez, Aruchamy, & Jegankumar (2015) as a requirement for proper planning and management. Specifically, delineation of the drainage area will help determine which sub-watershed has the largest potential to affect hydrology in the area.

Meanwhile, land use data are utilized to determine development and rehabilitation requirements of the watershed in relation to the problems on deforestation and soil erosion (DENR MC 2008-05). Also, the quantity of stream flow, rate of sedimentation, and economic activities to be maintained by stakeholders are used as determinants of the nature and extent of best watershed use.

Watershed hydrological characteristics are used as bases for reports and evaluation of the watershed as watershed health is affected by land use, vegetative cover, and the interactions of both. Forest ecosystem regulates the water yield and water quality (Hlásny, Sitková, & Barka, 2013). Studies also show that stream flow pattern, magnitude, frequency and quality of most small watersheds are significantly affected by forest changes (Khasanah et al. 2010; Cui, Liu & Wei, 2012; Liu et al. 2016; & Arceo, Cruz, Tiburan, Jr., Balatibat, & Alibuyog 2018) and land use (Welde & Gebremariam 2017). Hence, management of the forest is essential in watershed hydrology (Stednick 1996 as cited by Hlásny et al. 2013).

METHODOLOGY

Location

The study site is in the upland barangay of the Municipality of Cauayan. It covers three barangays namely Camalanda-an, Yao-yao, and Baclao. There are three main river systems and nine forest patches within the watershed. Map of the SCMFWR showing the locations of the forest patches and river tributaries is shown in Figure 1.

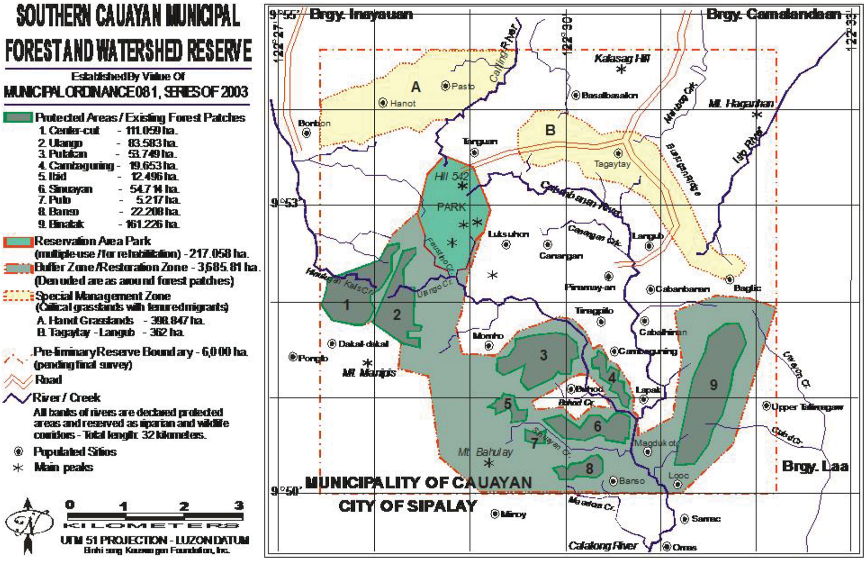

Figure 1. Map of the SCMWFR showing the locations of the forest patches and their river tributaries.

Delineation of sub-watershed

Drainage and Forest Reserve Areas

The drainage areas of the three rivers were manually delineated using the Topographic Map (Inayauan, Sheet 3449) from the Philippines' National Mapping and Resource Information Authority. These were then validated using Google Map and ASTER GDEM 2011 downloaded from philgis.org and processed using the Quantum GIS (QGIS) software. The forest patches were integrated into the map based on the existing maps provided by the Provincial Environmental Management Office of Negros Occidental. Data were then used as input for additional analysis of the three sub-watershed.

The land use within the watershed was described in two steps. First, by using 2010 Satellite Image Google Earth Pro view of the area, and second by ocular observation of the portions of the sub-watershed and areas within the gauging stations of the river tributaries. Also, GPS was used to locate important infrastructures such as schools, churches, residences, and location of the gauging station.

Sub-watershed classification

The land area for each delineated sub-watershed was computed using the GIS software. The watershed area was then classified based on the DENR training manual on Watershed Characterization and Vulnerability Assessment using Geographic Information System.

Drainage/River basin >1,000 km^2 (> 100,000 ha)
Large 500 to 1,000 km^2 (50,000 – 100,000 ha)
Medium 100 to 500 km^2 (10,000 – 50,000 ha)
Small 10 to 100 km^2 (1,000 – 10,000 ha)
Micro <10 km^2 (<1,000 ha)

River discharge and physical characteristics

Water discharges along the downstream sections of Cabanbanan, Tinagpito and Banso rivers were determined by measuring the cross-sectional area of the river and multiplying it with water velocity obtained by the floatation method. The physical features of the rivers in the gauging stations were also described in terms of flow characteristics, channel and bed profile, presence of siltation, obstruction and anthropogenic activities. The study was conducted during the start of the wet season from July 25 to 27, 2015.

Discharge (Q) determination

Gauging points of the river sampling sites were established below at the headwaters and in sections above river junctions (at least 100 m away from the river junction). The measurements were taken along a straight channel (at least 10 m long), free from obstruction and with uniform river flow.

Three sections in each station, up, mid and down, were profiled and used as the cross-sectional area of the station. The width of this section and its depth in 1-2 meter interval along this width was measured using a calibrated staff gauge. The average of the three sections was used as the cross-sectional area of the station.

The discharge (Q) in m^3/s was computed by multiplying the average cross-sectional area (m^2) by the average velocity (m/s). To compensate for the bottom friction, a correction factor based on the roughness of the riverbed (i.e., 0.75 for the rocky substrate; 0.8 for pebble, and 0.9 for muddy and silty substrate) was multiplied into the equation.

A spherical wooden ball (designed specifically for the floatation method) was used as a float. To determine the river velocity, the researchers measured the amount of time the float traversed over a fixed length (10 m) of the river. The process was done at least three times to get the average. River velocity was computed by dividing the fixed distance traversed by the float (i.e., 10 m) over travel time (meters/second).

Physical Characteristics

Observations of river flow characteristics, channel and bed profile, presence of siltation, obstruction and anthropogenic activities were done during transect walk on portions within the gauging stations of the river tributaries. The observations were limited by the condition of the area.

RESULTS

SCMFWR is divided into three main sub-watersheds. Two small and one micro- sub-watersheds: Cabanbanan, Tinagpito, and Banso. The three covers a total of 2944.78 ha with Cabanbanan occupying the largest at 1496.18 ha. The watershed is covered by a forest area of 499.1 ha, the largest of which is 306.5 ha at Tinagpito. Banso has the smallest sub-watershed area of 252.95 ha but has the highest percentage of forest cover at 32.14%. Cabanbanan and Tinagpito watersheds are classified as small and Banso as micro.

The sub-watersheds are mostly dominated by a mix of agricultural and open grassland. The total discharge of the three rivers is 2.0261 m3/s with Cabanbanan yielding the most volume at 1.3078 m3/s.

Sub-watershed drainage and forest reserve areas

Figure 2 shows the delineated drainage boundaries for Cabanbanan (green), Tinagpito (red) and Banso (violet) sub-watersheds. The light green areas are forest patches. Cabanbanan and Tinagpito.

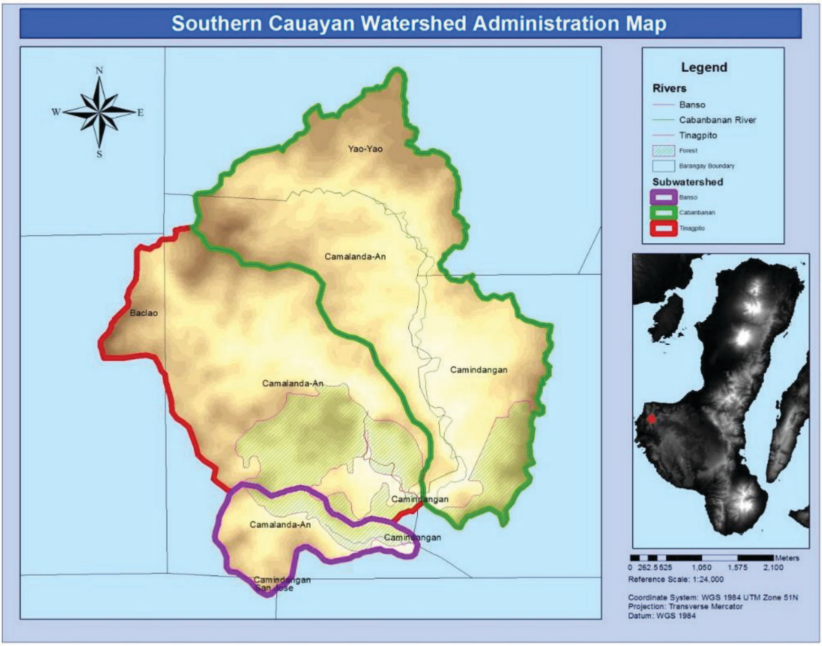

Figure 2. SCMWFR map showing the watershed boundaries and sections of the three rivers.

Table 1 shows that Cabanbanan sub-watershed has the largest area of 1496.18 ha, which is spread in the three barangays of Cauayan. Tinagpito has the second largest area of 1195.65 ha spread within two barangays Camalanda-an and Baclao. The sub-watershed of Banso has the smallest area of 252.95 ha which is distributed in three barangays, two of which are in Sipalay City.

For the forest patches, majority or 306.5 ha is located in the sub-watershed of Tinagpito and comprises 25 percent of the total area of the sub-watershed. Banso has the smallest forest patch at 81.3 ha but is the largest (32.14%) in terms of percentage of total area.

Table 1. *Drainage and Forest Areas Within SCMWFR*

Station	River	Area (ha)	Barangay	Forest Area (ha)	% of the Drainage area
1	Caban-banan	1496.18	Yao-yao, Camind-angan, Camalan-da-an	111.3	7.44
2	Tinagpito	1195.65	Camalanda-an, Baclao	306.5	25.63
3	Banso	252.95	Camalanda-an, San Jose, Camind-angan (Sipalay)	81.3	32.14

Sub-watershed classification and land use

The sub-watershed classification and land use within SCMWFR are presented in Table 2. Based on land area, Cabanbanan and Tinagpito are classified as small watersheds, and Banso micro watershed. Cabanbanan is highly dominated by a mix of agricultural land and open grassland areas in the upland. Tinagpito has the same condition except that there is a forest reserve in the mid to downstream portions. Banso shows the most forested area.

Based on the ocular observation, forest patches remained at the upland portion of the mountain. Crop raising was also observed to rise upwards towards forest covers. *Palay* was widely grown using contour farming and terracing. Corn and peanuts were also grown in the area using the same technique. No evidence of slash and burn farming were observed and other crops of considerable size were not observed. Sugarcane was notably absent in the area.

Table 2. *Watershed Classification and Land Use Within SCMWFR*

Station	River	Area (ha)	Class*	Present land use**
1	Cabanbanan	1496.18	Small	Highly dominated by a mix of agricultural land, open grassland areas in the upland
2	Tinagpito	1195.65	Small	Highly dominated by a mix of agricultural land in the upland, forest reserve in the mid to downstream
3	Banso	252.95	Micro	Presence of Forest Area

* *based on RBCO – DENR Watershed Classification*

** *based on 2010 Satellite Image Google Earth Pro*

The remaining forest for Cabanbanan and Tinagpito Watershed (Figure 3) was located at the top portion of the mountain and towards the downstream of the river. The midstream to the upstream portions was dominantly used for agricultural purposes.

Figure 3. A portion of the forest reservation within Tinagpito.

Figure 4 shows that the portions at the top of the mountain were still farmed and planted with crops such as rice and peanuts. The same farming practice was also evident in the Tinagpito drainage basin. Most of these areas can be considered as rainfed. A large portion of the upland area that was not farmed nor forested was covered by grass. However, cogon was not predominant. Observation made on the characteristics of the watershed was made near the forest patches.

Figure 4. Farming reaching up near the top of a mountain at Cabanbanan drainage basin.

Water discharge and characteristics of the rivers

The location of each gauging station and the parameters in the determination of the water discharge for the three rivers are presented in Table 3. The result shows that Cabanbanan river has the highest discharge at 1.3078 m^3/s, which is more than the combined discharge of the other two rivers. Cabanbanan river has the broadest cross-sectional area and fastest average velocity. The total discharge of the three rivers is 2.0261 m^3/s.

An interview with the *Bantay Lasang* (deputized forest guards), who served as guide during the conduct of the study, revealed that there hadn't been any rain in the area in the last two weeks prior to the conduct of the survey; hence, the river was not flooded in that span of time, and thus, can be characterized as having base flow condition.

Table 3. *Channel, Bed Profiles and Discharge of the Three Major Rivers*

Sta	River	Coordinates		Cross-sectional area (m2)	Average velocity (m/s)	River-bed	Cor-rection factor	Discharge Q (m3/s)
		Lat	Long					
1	Cabanbanan	9.8434	122.5130	4.03	0.382	muddy, rocky	0.85	1.3078
2	Tinagpito	9.8435	122.5128	2.08	0.238	muddy	0.9	0.4448
3	Banso	9.8379	122.5122	1.72	0.212	rocky	0.75	0.2735

Table 4 shows river flow characteristics and evidence of siltation and anthropogenic activities near the gauging stations. Station 1 at 9°50′ 36.14″ N, 122°30′ 46.80″ E along the Cabanbanan River has slow-moving water that almost stagnated towards the sides of the stream. The river had the widest drainage area and was the longest among the three rivers. The mid- to downstream sections of the river where the assessment was mostly conducted were characterized by areas of stagnant waters and few areas of flowing water in shallow, narrow sections. Siltation was observed along river channels with slow-moving water and along river bends. The same characteristic was found in Station 2 at 9°50′ 36.14″ N, 122°30′ 46.80″ E along the Tinagpito River. No obstruction such as boulders, trees, and roots was found within the two stations.

A different feature was observed in station 3, along the Banso River at 9°50′ 16″ N, 122°30′ 44″ E. The river flowed at a winding course at a more turbulent condition with no stagnant portions. The station was characterized by a shallower depth and a slower flow on the right side (facing downstream) where siltation was mostly deposited and a deeper portion towards the left side. Boulders were also present in the test area. No stretch of water ran with a steady flow, at a straight course and free of obstructions along with a uniform cross-sectional area and a length of more than 10 meters.

Most households were upland and very few along the riverbanks. The downstream of the junctions of Cabanbanan and Tinagpito as well as the downstream of Banso river were more forested and free of nearby households. Crops were planted along the midstream portions of Cabanbanan river. However, downstream, endemic vegetation was present. There were fallen trees washed away by strong water currents along eroded banks and some boulders that had fallen into the river. Aside from these, no evidence of man-made intervention was observed such as cuttings or slash burning.

The river was mainly used as drainage of the watershed basin. There were no observed impounding and structures to divert water from the river for irrigating crops. The effect of siltation was notable as evidenced by the widening of the junction of the Cabanbanan and Tinagpito rivers. A large part of sand was exposed in that area. Other than the direct and indirect effects of erosion, there was little indication of human-induced destruction along the river. There was scant evidence of washed off garbage or algal blooms in stagnant areas.

Table 4. *River Flow Characteristics and Evidence of Siltation and Anthropogenic Activities*

River	Flow	Siltation	Evidence of anthropogenic activities
Cabanbanan	Slow-moving to stagnant	siltation with the widening of the river junction	Downstream is free of nearby households Free of human-induced interventions scant evidence of washed off garbage or algal blooms in stagnant areas
Tinagpito	Slow-moving to stagnant	siltation with the widening of the river junction	Downstream is free of nearby households Free of human-induced interventions Scant evidence of washed off garbage or algal blooms in stagnant areas
Banso	Winding, turbulent, no stagnant portions	siltation on one side	Downstream is free of nearby households Free of human-induced interventions

DISCUSSION

The study determined that SCMFWR is divided into three sub-watersheds whose total area of 2,944.78 ha feeds the three river systems Cabanbanan, Tinagpito and Banso. The delineation of the sub-watersheds revealed that not all of the areas drain to the three major rivers. Only 2944.78 ha drains to the three rivers, while the rest contributes to the other rivers within Cauayan. The three sub-watersheds act as headwater that contributes to the bigger Sipalay watershed where Calatong River drains. As DENR MC 2008-05 directs planner to draw up watershed management plans that are holistic, integrated, and participated in by all stakeholders concerned, results of the study could be used to request for the support of the Sipalay City in coming up with an integrated management plan that will involve Sipalay and Cauayan. Another study could be made on the midstream towards the downstream portions of this river along the Calatong River to help determine if there is indeed a direct utilization of the water, what volume was utilized and to what extent do households and residents in the area depend on the river.

The importance of delineating the sub-watersheds for management prioritization, as suggested by Rahaman, Ajeez, Aruchamy, & Jegankumar, (2015), may be highlighted in this study by pointing out that the 2,944.78 ha covered by Cabanbanan, Tinagpito and Banso watersheds may be recommended as priority area out of the 6,000 ha in terms of conservation when coming up with management plans. In terms of effect on hydrology, Cabanbanan watershed has the largest drainage area and thus, has the largest effect on water recharge and discharge.

The present land use of the watershed indicates farming activity prevalent in the area with others reaching near the peak of the mountain. An indication that the area utilized for farming will continuously increase if not controlled, is the observed presence of clearing patches. In the study of Welde and Gebremariam (2017), the change in land use such as the increase in agricultural areas leads to increase in seasonal and annual stream flow as well as the volume of sediment yield with greater effect on the latter. In the study area, if the current land use is not appropriately managed, this could prevent the growth of the remaining forest patches within the area. Agricultural activities will also threaten the remaining forest as well as the existing wildlife. The findings are important in determining the development and rehabilitation requirements of the watershed in relation to problems on deforestation, erosion (DENR MC 2008-05).

The study did not use hydrological model to relate the effect of forest cover with the surface runoff and river discharge. Nonetheless, results support the findings of Cui et al. (2012); Hlásny et al. (2013), Liu et al., 2016, Arceo et al. (2018) on the regulatory effect of forest cover in the area. The study of Hlasny et al. (2015) relates the effect of deforestation on decreasing the infiltration and evapotranspiration while increasing runoff while the studies of Khasanah et al. 2010 & Liu et al. 2016 showed the positive effect of reforestation especially on hydrology. Furthermore, the study of Arceo et al. (2018) showed that forest vegetation leads to high infiltration and recharge and a lower surface runoff. This study supports these findings: the discharge of Banso and Tinagpito were lower compared to Canbanbanan since both have higher percentage of forest area to its total area with 25.63% and 32.14%, respectively, compared to Cabanbanan, which is only 7.44%.

The study was constrained by the researchers' limited access to other portions of the sub-watershed due to the expanse of the area and mountainous terrain, and few areas of the river flowing at a steady and straight course, free of obstructions along a uniform cross-sectional area of more than 10 meters for the measurement of water velocity. Also, there were no available data that could relate rainfall volume to stream flow. Nonetheless, the data gathered in the study may be used as basis for management decisions and policy formulation. Overall, results could serve as baseline data for future researchers to determine the decline or improvement of the health of SCMFWR.

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