INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 21, No. 2, p. 50-76, 2022
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Habitat assessment of Muleta River in Bukidnon, Philippines

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Article published on August 10, 2022

Key words: Habitat, Water quality, Inundated, Optimal, Marginal

Abstract

Muleta River is one of the river systems in Bukidnon that is considered a critical river and a watershed supporting the regional irrigation system needing immediate rehabilitation. However, the status of Muleta River in Bukidnon was not included in the rapid assessment study of the Mindanao Development Authority (MinDA) in selected rivers in Mindanao. This study was conducted to determine the water quality and habitat status of Muleta River in Bukidnon, Philippines. Three (3) assessment stations; upper stream, midstream and downstream were established with a 100 meter stretch in every sampling area in each station. Field survey was conducted with the use of visual habitat assessment field data sheet and multi-parameter probe (HORIBA U-52) for the determination of the water quality. In terms of biotic and abiotic factors among the sampling areas, results revealed the increasing degree of the river status (poor to optimal) is as follows: Lumatong< Muleta Dam< Masimag River< Malinao Bridge< Omonay< Muleta River Junction< Muleta- Bingbong River< Lalapoy River< Baguik-ikan River< Lantay River< Upper Baguik- ikan River. Physico- chemical parameters suggested poor water quality as compared to the water quality standards set by DAO 34 due to failing values of turbidity, total suspended solids (TSS) and nitrate concentration with 45.86 NTU, 127.50mg/L and 16.32mg/L, respectively. Several stressors were identified to have influenced river's integrity that includes unregulated physical resource extraction and intensive agricultural cultivation. General results of the study showed a marginal type of habitat that is less disturbed but less suitable for habitat.

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Introduction

River is a body of water that comprises hydrological-ecological networks organized by a flow of water, sediment, nutrients and the movement of animals upstream and downstream. Moreover, it is composed mainly of four dimensions, namely longitudinal (upstream-downstream), lateral (upland to channel), vertical (zone below the stream bed) and temporal components (McCluney *et al.*, 2014). Despite this multidimensionality, many ecological processes as mentioned above are influenced by the rapid flow of water from upstream to downstream which provide strong habitat connectivity. Rivers play an important part in water cycle acting as drainage channel for surface water, provides an excellent habitat and food for many organisms, and effectively irrigating hectares of farmlands planted to different crops. However, the agricultural sector has suffered a lot due to the devastation caused by flash floods and rising levels of flood waters brought about by perennial typhoon visiting the country that can no longer be contained by the river systems. The increase in population, climatic changes that resulted to flashfloods and prolonged drought together with the expansion of irrigation has contributed a lot in the greatly increased use and need for water resources.

Muleta River is one of the river systems in Bukidnon which is found in the southern portion of the province covering the municipalities of Pangantucan, Don Carlos, Kitaotao, Dangcagan, Kibawe, Kadingilan and Damulog (Paragas *et al.*, 2007). It is a tributary of the Pulangui River that flows southward and joins it at the boundary of Bukidnon and Cotabato province. Based on the preliminary survey of thecmu funded watershed project (2015-2017), along the river is mostly agriculture where uncontrolled utilization of forest resources is very visible. Muleta River is described to be surrounded by different plantations such as rubber, banana, pineapple, sugar cane, rice field and corn. An evaluation of habitat quality is critical to any assessment of ecological integrity because habitat and biological diversity are closely linked. On the other hand, water quality is also an important component of river habitat assessment that when water quality is poor, it affects not only aquatic life but the surrounding ecosystem as well.

The status of Muleta River in Bukidnon was not included in the rapid assessment study of the Mindanao Development Authority (MinDA) in selected rivers in Mindanao (Opiso *et al.*, 2015) though it is considered critical a watershed/river supporting the regional irrigation system as needing immediate rehabilitation (Paragas *et al.*, 2007).

The need to determine the present status of Muleta River was imperative because of the numerous anthropogenic activities which are taking place along the river wherein necessary data are needed as bases for policy formulation for the proper management of the Muleta River.

Materials and methods

Establishment of Sampling Sites

River shows habitat connectivity that influences the flow of water, nutrients, movements of organisms, transmission of disturbances and refuge availability from upstream to downstream. Three (3) assessment stations; upper stream, midstream and downstream areas were established with a 100 meter stretch in every sampling areas in each stations. Sampling stations were located in the following areas; upper stream- Brgy. Portulin, Brgy Kuya and Poblacion, Pangantucan, midstream- Brgy. Malinao, Kadingilan and Masimag, and downstream-Brgy. Omonay, Damulog (Fig. 1). Five (5) sampling areas were established in the upper stream station namely, upper Baguik- ikan River, Baguik-ikan River, Lantay, Muleta- Bongbong River and Muleta Dam. Muleta River in Malinao, Lalapoy River and Masimag River were the three (3) selected sampling areas in midstream part of the river. Muleta River junction, Lumatong and Omonay River were the sampling areas in the downstream part of Muleta River. Most of the recommended sampling stations are in every outlet of sub-watersheds. In situation of Muleta watershed, it is difficult to reach some outlets of sub-watersheds due to road conditions. Habitat assessment was done from the month of August to September, 2016.

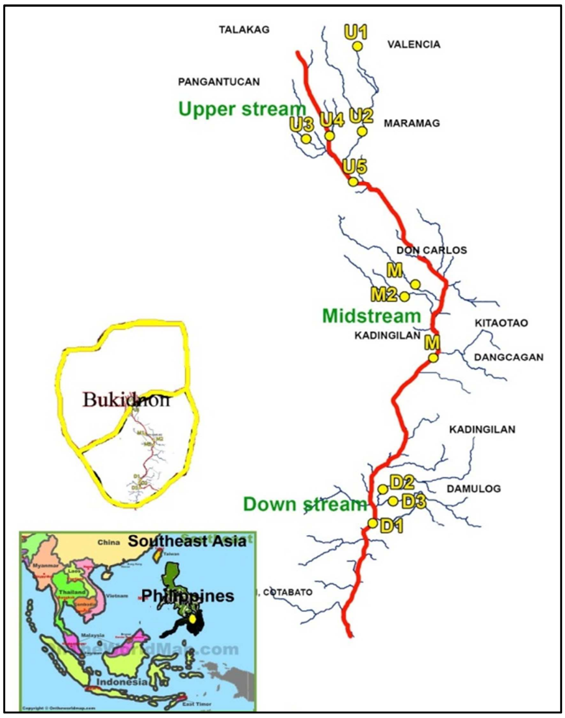

Fig. 1. Location of the study sites along Muleta River in Bukidnon (red color):

Upper stream (UL-Upper Baguik-ikan river, U2-Baguik-ikan river. U3-Lantay River. U4-Muleta-Bongbong River. U5-Muleta Dam), Midstream (M1-Malinao, M2-lalpoy, M3-Masimag River). Down stream (D1-Muleta River Junction. D2-Lumatong. D3-Omonay).

Geomorphological Features/ Characteristics of the Muleta River

Geomorphology is the study of landforms and the processes that form them (Addy, 2013). River landforms and flows constitute the basic "physical template" that influences riverine biota. The fluvial or river geomorphology input is needed for sustainable river management and restoration.

Secondary data on the geomorphologic features were used to describe the Muleta River through Geographic Information System (GIS) and Remote Sensing (RS) image. These were used to illustrate the geomorphic features, soil type, geology, and vegetative cover surrounding each sampling sites of the Muleta River.

Land Uses along the Assessment Area

The land uses associated in each sampling area were assessed through visual observation traversing the Muleta River. This data provide actual situation of the sampling area which were used for further analysis on the impacts of biotic and abiotic characteristics of the Muleta River.

Abiotic Assessment of the Muleta River

Physico- chemical parameters are important to determine the current water quality condition of the river. Current water quality condition of the river was evaluated using a multi-parameter probe (HORIBA U-52), direct field measurement of the turbidity, total dissolved solids (TDS), pH, temperature and dissolved oxygen (DO) of the river measured in a laboratory (Appendix A). The measurement of the water quality was done by dipping the multi-parameter probe into the water (central part and both sides of the river) and data reading was recorded in each sampling stations. The water sample was collected for laboratory analysis of the total suspended solids (TSS). A well-mixed sample (200mL) was filtered through a filter paper, and the residue retained on the filter was dried to constant weight at 60^{O}C (EPA, 1979). This was done incmU, College of Forestry laboratory. It was then compared to DENR Administrative Order 34 (DAO 34) for the qualification of Philippines' water quality standards. Class A Public Water Supply Class II is for sources of water supply that will require complete treatment (coagulation, sedimentation, filtration and disinfection) in order to meet the National Standard for Drinking Water (NSDW), Class B Recreational Water Class I is for primary contact recreation such as bathing, swimming, skin diving, etc. (particularly those designated for tourism purposes), Class C Fishery Water , Recreational Water Class II, Industrial Water Supply Class I is for the propagation and growth of fish and other aquatic resources; boating; for manufacturing processes after treatment and Class D is for agriculture, irrigation, livestock watering, etc. and Industrial Water Supply Class II (e.g. cooling, etc.).

As for the nitrate and phosphate content sample, the sample bottle was filled with 1 liter of water sample, only one (1) water sample with three (3) replicates in every sampling station and samples submitted to the Unifrutti Philippines, Inc. laboratory, MKAVI Compound, Patag, Alanib, Lantapan, Bukidnon.

*Abiotic Habitat Assessment with field rating sheet (*Adapted and modified by Opiso *et al.* (2015) from Barbour and Stribling (1999). This was visual based habitat evaluation consists of seven parameters that rank in-stream habitat, hydrologic connectivity, stressors (physical, landscape and hydrology), embeddedness and channel alteration for each sampling reach (Appendix B). A numerical scale of 0 (lowest) to 20 (highest) was used to rank each parameter. A parameter score was given within the condition category as Optimal (20-16), Suboptimal (15-11), Marginal (10-6) or Poor (5-0). This was done by evaluating each parameter in which of the following conditions exist at the sampling reach: Optimal (121-180), Suboptimal (91-120), Marginal (40-90) or Poor (0-39). The average of all the parameter ratings was done to obtain a final habitat ranking. The abiotic parameters are the following:

1. Hydrologic Connectivity- Stream provides adequate hydrology to utilize floodplain; with over-bankfull flows likely to inundate a broad area of floodplain; presence of floodplain supporting riparian vegetation.
2. Landscape condition stressor- absence or presence of landscape stressor (e.g. urban residential, dry land farming, dairies) as shown in Appendix D.
3. Hydrologic Condition Stressor- absence or presence of hydrologic stressor (e.g. dams, urban runoff, farm drainage, groundwater extraction) as shown in Appendix D.
4. Physical Structure Condition Stressor- absence or presence of physical stressor (e.g. trash, filling/ dumping of soils, plowing, excessive sediment or organic debris) as shown in Appendix D.
5. Physico-chemical Parameters- temperature, turbidity, pH, DO, TSS and TDS and Nitrate parameters failed to qualify DAO 34 criteria; 0-2> optimal, 3-4> sub-optimal, 5-6> marginal and 7> poor.
6. Bottom substrate/ instream cover- Includes the relative quantity and variety of natural structures in the stream, such as cobble (riffles), large rocks, fallen trees, logs and branches, and undercut banks, available as refugia, feeding, or sites for spawning and nursery functions of aquatic macrofauna.
7. Embeddedness - The extent to which rocks are buried by silt, sand, or mud on the stream bottom.*Habitat value*: *higher embeddedness means less space available between rocks for aquatic macroinvertebratehabitatorfish spawning.*
8. Channel alteration- is a measure of large-scale changes in the shape of the stream channel. Channel alteration is present when artificial embankments, riprap, and other forms of artificial bank stabilization or structures are present; when the stream is very straight for significant distances; when dams and bridges are present; and when other such changes have occurred.
9. Bank stability (condition of banks) - Measures whether the stream banks are eroded (or have the potential for erosion). Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks, and are therefore considered to be unstable. Signs of erosion include crumbling, unvegetated banks, exposed tree roots, and exposed soil.

Hydrologic connectivity and various physical, landscape and hydrologic condition stressors of the Muleta River was evaluated. Appendix B presents the abiotic assessment evaluation instrument in the characterization of each sampling stations along Muleta River together with the checklist for the context stressors shown in Appendix D.

Biotic Assessment of the Muleta River

This task was focused on assessing the present condition of the riparian vegetation and biological condition stressors on the selected sampling station along the Muleta River.

*Biotic Habitat Assessment with field rating sheet (*Adapted and modified by Opiso *et al.* (2015) from Barbour and Stribling (1999). The researcher had a closer look at the habitat features to make an adequate assessment. This was done by visually assessing the biotic parameters (Appendix E) given below throughout the stream reach. The biotic parameters are the following:

1. Canopy cover (shading)-optimal habitat has a mixture of full sunlight, full shade and filtered light.

2. Bank vegetative protection - Measures the amount of vegetative protection afforded to the stream bank and the near-stream portion of the riparian zone. The root systems of plants growing on stream banks help hold soil in place, thereby reducing the amount of erosion that is likely to occur. Stream bank surfaces covered by vegetation; scoring each bank (left and right bank).
3. Streamside cover-Optimal = shrub dominant, with trees as well; Sub-optimal = tree dominant, but few shrubs; Marginal = grasses dominant; Poor = no vegetation (rocks, soil dominant).
4. Riparian vegetative zone width-Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream. Optimal= >18m; Sub-optimal= 12-18m, Marginal= 6-12m and Poor= <6m (scoring each bank).
5. Native riparian regeneration rating- Native poles, saplings, and seedlings trees well represented; obvious regeneration, many patches or polygons with >5% cover (optimal); scattered patches or polygons with 1%-5% cover (sub- optimal); restricted to one or two patches or polygons with, typically <1% cover (marginal); 0% cover (poor).
6. Invasive exotic plant species cover- optimal= Key invasive species <1% cover; sub-optimal= 1%-5% cover, marginal= 5%-10% cover and poor= >10% cover. The invasive species found in the area was identified using the list of invasive alien species in the Philippines by the Department of Environment and Natural Resources (DENR) and Invasive Alien Species (IAS) by Joshi (2010).
7. Biotic Condition Stressors- optimal=0-3 categories for this context observed; sub- optimal= 4-6 categories; marginal= 7-8 categories; poor= 9-11 categories. Biotic condition stressors as shown in Appendix D.
8. Present condition of the biotic habitat at the study sites was evaluated using the "Rapid River Assessment Field Data Sheet" as shown in Appendix C.

Analysis of Data

The means (overall score) in each study station and the given parameters was calculated from the data gathered.

Results and discussion

As defined, watershed is a natural hydrological topographic entity from which surface runoff flows to a defined drain, channel, stream or river at a particular point (Chadha and Neupane, 2011). Moreover, a watershed represents all the stream tributaries that flow to some location along the stream channel. As cited by Paragas *et al.* (2007), Muleta River in Bukidnon has 26 tributaries. Among these tributaries, seven (7) tributaries of Muleta River were assessed in this present study, namely; Baguik-ikan, Bongbong, Lantay, Lalapoy, Masimag, Lumatong and Omonay River and two (2) sampling areas of the main Muleta River, Muleta Dam and Muleta River junction.

Geomorphological Features/ Characteristics of Muleta River

Secondary data on the geomorphologic features (InWARD Project, 2015-2017) were used to describe the Muleta River. The watershed of Muleta lies within the geographical coordinates of 7°58'7.30"N - 7°40'33.79"N latitudes and 124°46'10.08"E - 124°57'12.66"E longitude and is located in the southwestern part of Bukidnon and northwestern part of North Cotabato (Fig. 2). Muleta watershed has a total area of 104,958 hectares approximately, covering 11 municipalities namely; Pangantucan, Maramag, Don Carlos, Talakag, Valencia City, Kitaotao, Kadingilan, Kibawe, Dangcagan, Damulog and Carmen. The headwater is located in Mount Kalatungan ranges and the outlet of the river is located at Carmen, North Cotabato.

The geomorphologic features of Muleta watershed were extracted using SAR DEM 10m (INWARD Project, 2015-2017). According to Withanage *et al.* (2015), every watershed has corresponding values such as circular (0.9-0.10), oval (0.8-0.9), less elongated (0.7-0.8), elongated (0.5-0.7), and more elongated (< 0.5). Muleta River/ watershed has an elongation ratio of 0.69 and circulation ratio of 0.29 in which according to Kanth and Hassan (2012) as cited by Opiso *et al.* (2015), watershed is elongated in shape and easier to manage due to slow disposal of water with less efficient in discharge and with lower runoff rates compared to circular one which allows quick runoff. Discharge or surface runoff refers to the horizontal water flow occurring at the surface in rivers or streams and is the primary influence on sediment transport and channel morphology in alluvial streams (Doyle *et al.*, 2005).

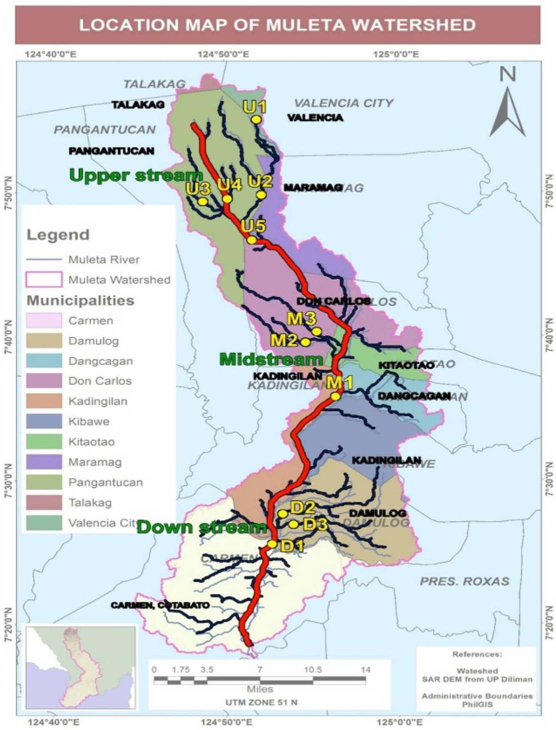

Fig. 2. Geographical location of Muleta Watershed (Lifted from InWARD project, 2015-2017).

Thus, the watershed has low susceptibility to flooding and is more manageable compared to circular one. It has low drainage density generally results in the areas of highly resistant or permeable subsoil material, dense vegetation and low relief (Tavassol and Gopalakrishna, 2016) which indicates relatively long overland travel of surface water and possibilities of high recharge and low surface runoff (Chadha and Neupane, 2011) . Drainage pattern of watershed is distorted caused by some disturbances like quarrying activities, presence of dam, and/or agricultural cultivation.

The risk of runoff and erosion is affected by small differences in soil texture. This is because texture influences the degree of percolation of water through the soil, and also the stability of soil. Muleta watershed is a clay type of soil. Clay is a type of soil with low infiltration capacity which means it is prone to surface runoff due to small spaces that slows percolation process, therefore causing surface runoff (Opiso *et al*, 2015). Decreased number of natural vegetation may increase discharge runoff especially those sampling sites with largely cultivated lands thereby increasing the risk of flooding in the watershed. Moreover, the watershed slope attributes extending from level to gently and to severely steep. The upstream area is severely steep with about 73% as the maximum slope while portions of downstream to midstream are flat to rolling and moderately steep. In addition, the Muleta watershed is composed of eight (8) classified soil properties but the watershed is mainly made up of Kidapawan clay; Kidapawan clay loam and Macolod clay dominating in greatest portion with an area of 24,496 ha (23%) and 23,982 ha (23%) repectively. Generally, Muleta watershed is a clay type of soil in which it is prone to surface run-off due to small spaces that slows percolation process and eventually it cause surface run-off. Aside from agricultural land, surface run-off is one of the causes of increasing turbidity on Muleta River.

Land Uses along the Assessment Area

Based on the land cover map of the INWARD Project (2015-2017), the watershed is primarily covered with cultivated land with an area of 54, 207 ha (52%) followed by arable land with an area of 31,203ha (30%) and crop land with an area of 7,914 ha (8%). However, only 5% and 2% of the total land area of the watershed are forested/ closed canopy and open canopy respectively and are found in the upstream areas. The major land use of Muleta watershed is agricultural (cultivated, arable, crop and plantations). Corn, sugarcane and rice grains are dominant crops present in the watershed. Table 1 showed the land uses associated in each sampling area through visual based observation along the Muleta River. Thus, most of the Bukidnons' source of living is from agriculture.

Table 1. Locations, latitudes and longitudes of each sampling area along the Muleta River.

Sampling Station	Location	Latitude	Longitude
Upperstream			
U1- Upper Baguik- ikan River	Brgy. Portulin, Pangantucan	7°55'4.33"N	124°51'55.31"E
U2- Baguik- ikan River	Pangantucan Pob.	7°48'57.47"N	124°51'41.54"E
U3- Lantay	Pangantucan Pob.	7°49'28.89"N	124°48'41.47"E
U4- Muleta- Bongbong River	Vismin Village, Pangantucan	7°49'40.24"N	124°50'12.67"E
U5- Muleta Dam	Brgy. Adtuyon, Pangantucan	7°46'44.96"N	124°51'39.20"E
Midstream			
M1- Malinao	Kadingilan	7°35'16.96"N	124°56'17.22"E
M2-Lalapoy	Bocboc, Doncarlos	7°39'10.14"N	124°54'41.57"E
M3-Masimag	New Nongnongan, Doncarlos	7°40'35.11"N	124°54'47.88"E
Downstream			
D1- Muleta River Junction	Brgy. Omonay, Damulog	7°26'3.23"N	124°52'38.66"E
D2- Lumatong	-do-	7°25'59.85"N	124°53'6.45"E
D3- Omonay	-do-	7°26'3.73"N	124°53'5.26"E

Assessment and Profiling of Muleta River

The evaluation of habitat in biomonitoring surveys is a vital component for fully understanding factors that are influencing the health and biological integrity of an aquatic community. In this study, different habitat parameters (biotic and abiotic) were numerically scored after visual observation of the river/stream reach. The numerical scores for all parameters were then summed and the value obtained categorized the river/stream within one of the four categories – Optimal, Sub-optimal, Marginal, and Poor. Abiotic parameters consist mainly of hydrologic connectivity, stressors (landscape, hydrologic and physical condition), physico- chemical parameters, bottom substrate/ instream cover, embeddeddness, channel alteration and bank stability. On the other hand, biotic parameters composed of canopy cover, bank vegetative protection, streamside cover, riparian zone, peresence of vegetation (native vs. invasive species), and vertical and horizontal patch structure. These factors affect the habitat status and the water quality of the river.

Table 2. Land uses associated in each sampling area along the Muleta River.

Sampling Areas	Land Use
U1- Upper Baguik-ikan River	Forested area; coffee and banana plantation (100m from the river)
U2- Baguik- ikan River	Presence of bridge; Urban residential; sugarcane plantation (2m from the river bank)
U3- Lantay River	bridge; sugarcane plantation (4 m from the left river bank) and bamboos 15m away from the left river bank
U4- Muleta- Bongbong River	Quarry activities and Bamboo trees; rice fields along Bongbong River affecting the transparency of the river water
U5- Muleta Dam	Hanging bridge as settlers and vehicle pathway; urban residential; dam and engineered channel; corn, rice grains and pineapple plantation
M1- Malinao	Bridge; dike; corn and rice fields; sparse banana plantation
M2- Lalapoy	Bridge; falcata plantation
M3- Masimag	Urban residential; sparse vegetation
D1- Muleta River Junction	Urban residential; rubber plantation; sparse banana plantation
D2- Lumatong	Sugarcane (right bank) and corn plantation (left bank)
D3- Omonay	Sugarcane (right bank) and rubber plantation (left bank)

Note: U4- Rice fields and U5- rice fields and pineapple plantation is found beyond the 100m stretch.

Table 3. Land cover classification in Muleta Watershed (InWARD Project, 2015-2017).

Land Use	Area (ha)	Coverage (%)
Cultivated Area	54,207	52
Arable Land	31,203	30
Closed Canopy	5,402	5
Grasslands	1,581	2
Other Plantations	1,866	2
Built-up Area	261	0
Crop Land	7,914	8
Open Canopy	2,526	2
	104,959	100

Station 1: Upperstream of Muleta River

Description of the Assessment Areas

The assessment area 1 or the upper stream station 1 has five (5) sampling points located in Pangantucan, Bukidnon; U1- Upper Baguik-ikan River (Portulin), U2- Baguik- ikan River (Kuya), U3- Lantay, U4- Muleta- Bongbong and U5- Muleta Dam. Upper Baguik-ikan River located at Brgy. Portulin, Pangantucan is steeply sloping composed a dense vegetation and forested area (Fig. 4A). Upper Baguik-ikan River is the source of potable water of the people living 3 kilometers from the river by extending hose from the source of water to the Barangay.

Only one household is living in 100m from the river. It is not usually visited area due to its steeply sloping landscape towards the river. Thus, it is less disturbed area.

Baguik-ikan River located at Brgy. Kuya has moderately steep slope and is surrounded with sugarcane, trees and shrub (Fig. 4B). A bridge is present in this assessment area. In addition, Lantay River is located in Pangantucan Poblacion where bridge is also present and is surrounded with bamboos, sugarcane, shrub and trees (Fig. 4C).

Moreover, Muleta- Bongbong River located in Vis Min Village is generally flat and is surrounded with agricultural (rice fields), trees, shrubs and bamboos (Fig. 4D). Many big rocks were dumped on a scoured road beside the river to prevent further erosion. Moreover, quarrying is present in this site.

There is a difference between the water color coming from Muleta which is clear and Bongbong River is a bit brownish in color. It is very evident at the river junction. Lastly, Muleta dam located in Brgy. Adtuyon, is generally flat with surrounding households, agricultural, shrub and some parts covered with forestland vegetation (Fig. 4E).

It is a flood prone area. Hanging bridge is present in the site utilized by residents and vehicles as a pathway.

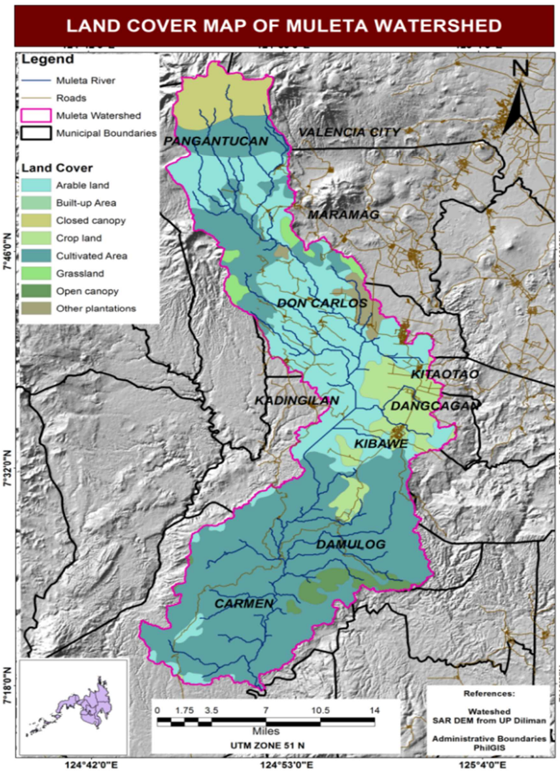

Fig. 3. Land Classification Map of Muleta Watershed (InWARD Project, 2015- 2017).

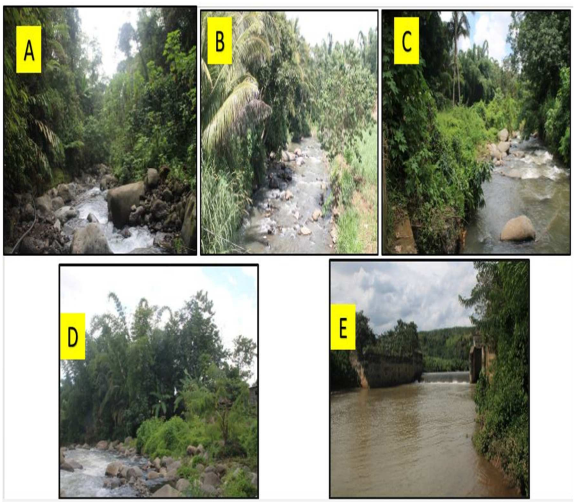

Fig. 4. Assessment Areas in Upper stream station showing (A) U1- Upper Baguik- ikan River, (B) U2- Baguik- ikan River, (C) U3- Lantay River, (D) U4- Muleta-Bongbong River, (E) U5- Muleta Dam.

Description of Abiotic Parameters

Table 4 presents the rapid assessment on abiotic components on the upper stream areas of Muleta River for each habitat parameter given and its corresponding description. For the first study area (upper stream), Muleta Dam and Muleta- Bongbong

River obtained the lowest overall rating of 75.33 and 83.7, respectively considered as a Marginal type of habitat, followed by Lantay, Baguik-ikan River and upper Baguik – ikan River with an overall rating of 100.0, 95.0 and 103.67 described as a sub-optimal type of habitat.

Table 4. Rapid Assessment of the abiotic component of the Muleta River (Upperstream).

Habitat Parameters	Pangantucan (Upper stream)											
	Upper Baguik ikan River (U1)		Baguik ikan River (U2)		Lantay Bridge (U3)		Muleta-Bongbong River (U4)		Muleta Dam (U5)		MEAN	
	Grade	Desc.	Grade	Desc.	Grade	Desc.	Grade	Desc.	Grade	Desc.	Grade	Desc.
Hydrologic Connectivity	15.00	Sub-optimal	15.00	Sub-optimal	15.00	Sub-optimal	11.00	Marginal	11.00	Sub-optimal	13.40	Sub-optimal
Landscape condition stressor	13.00	Sub-optimal	9.00	Sub-optimal	10.00	Marginal	10.00	Marginal	10.00	Marginal	10.40	Marginal
Hydrologic condition stressor	15.00	Sub-optimal	14.00	Sub-optimal	14.67	Sub-optimal	8.33	Marginal	8.00	Marginal	12.00	Sub-optimal
Physical structure condition stressor	15.00	Sub-optimal	10.00	Marginal	12.33	Sub-optimal	8.33	Marginal	9.00	Marginal	10.93	Sub-optimal
Physico- chemical Parameters	11.00	Sub-optimal	5.00	Poor	5.00	Poor	5.00	Poor	5.00	Poor	6.20	Marginal
Bottom substrate/ instream cover	9.00	Marginal	10.00	Marginal	10.00	Marginal	10.00	Marginal	7.33	Marginal	9.27	Marginal
Embeddedness	8.67	Marginal	9.00	Marginal	9.00	Marginal	10.00	Marginal	8.00	Margiinal	8.93	Marginal
Channel alteration	7.00	Marginal	11.00	Sub-optimal	11.00	Sub-optimal	10.00	Marginal	8.00	Marginal	9.40	Marginal
Bank stability	10.00	Marginal	12.00	Sub-optimal	13.00	Sub-optimal	11.00	Sub-optimal	9.00	Marginal	11.00	Sub-optimal
TOTAL	103.67	Sub-optimal	95.00	Sub-optimal	100.00	Sub-optimal	83.7	Marginal	75.33	Marginal	91.53	Sub-optimal

The floodplain which supports riparian vegetation is less frequently inundated. Where floodplains are connected to a river and periodically inundated, interactions of land, water, and biology support natural functions that benefit river ecosystems and people. Landscape stressors were urbanization, bridge, dry land farming and anthropogenic activity (quarrying) and washing of big trucks in the river which is considered as biotic stressor. Moreover, the presence of dam and small parts of engineered channel, point source and non-point source discharges were considered hydrologic condition stressor. Physical structure condition structure on the other hand were filling or dumping of soils or sediments, trash or refuse and excessive sediment deposition brought by bank erosion. Mentioned landscape, hydrologic, physical structure and biotic stressors were present in more or less 10% of the total assessment area.

Bottom substrate was made up of 30-50% mix of gravel and settled materials that can support stable and adequate habitat (Fig. 5A). Rocks were buried and surrounded 50-75% fine sediments.

This moderate occurrence of siltation especially in the Muleta Dam may be pointed to the quarrying activities occurring in Muleta-Bongbong River and agricultural cultivation specifically rice fields along the river. This is so because Muleta Dam is the catchment area of all upstream tributaries going downstream. Moderate deposition of gravel and coarse sand bars forming at the middle of the river (Fig. 5B) was caused by the occurring moderate erosions of unstable banks.

Physico- chemical parameter was rated poor water quality as compared to DAO 34 Water Quality Standards due to failing values of turbidity in the majority of the sampling areas and the nitrate concentration failed in Class A classification but rated passed in Class D classification which is purely for agriculture, irrigation and livestock watering. The occurring moderate bank erosions and run offs from intensively cultivated lands and quarrying activities within the watershed may be attributed to the poor water quality. Failing values may cause a variety of adverse impacts on human health and environment. Turbidity reduces habitat quality for biotic organisms resulting to decreased biological processes due to low light penetration (Table 5).In general, upper portion of Muleta River was evaluated and considered to be at sub-optimal condition in terms of its abiotic components.

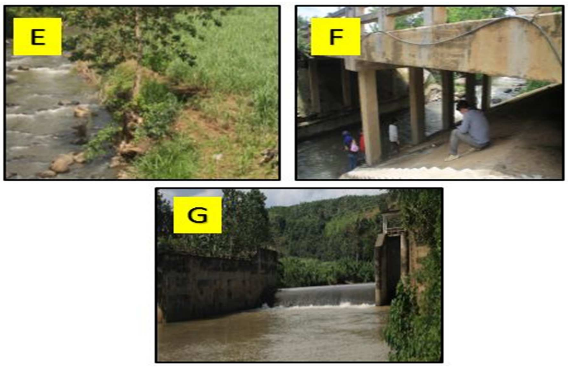

Fig. 5. Abiotic components showing (A) Steeply sloping landscape and small areas of erosion, (B) Dry Land Farming (banana and coffee plantation), (C) Quarrying activities as landscape stressor, (D) unstable left bank, (E) presence of Bridge, (F) quarry activity and (G) presence of dam and engineered channel.

Table 5. Muleta River Water Quality in upper station compared to DAO 34 Water Quality Standards (Upperstream).

Parameters	Upper Stream (Station 1)									
	Upper Baguik- n River (U1)	Baguik-ikan River (U2)	Lantay (U3)	Muleta-Bongbong River (U4)	Muleta Dam (U5)	Average	Class A*	Remarks	Class B*	Remarks
TDS (mg/L)	50.00	30.00	20.00	50.00	60.00	42.00	1000*	Passed	500	Passed
Temp. (C)	17.70	26.10	25.27	24.81	26.96	24.168	26-30	Passed	26-30	Passed
pH	7.04	6.94	7.36	7.00	7.10	7.088	6.5-8.5	Passed	6.5-8.5	Passed
Turbidity (NTU)	0.00	14.73	18.03	12.17	28.70	14.726	5	Failed	5	Failed
DO (mg/L)	10.14	9.89	11.90	10.86	9.95	10.548	5	Passed	5	Passed
	Upper Baguik ikan River (U1)									
	R1	R2	R3							
TSS (mg/L)	0.00	0.00	0.00			0.00	50	Passed	65	Passed
Nitrate (mg/L)	7.34	7.34	14.68			9.79	7	Failed	7	Passed
Phopshate (mg/L)	0.236	0.233	0.239			0.236	0.10	Failed	0.2	Passed

Legend: Class A*- Public Water Supply Class II. For sources of water supply that will require complete treatment (coagulation, sedimentation, filtration and disinfection) in order to meet the NSDW.

Class B*- Recreational Water Class I. For primary contact recreation such as bathing, swimming, skin diving, etc. (particularly those designated for tourism purposes). TDS (1000*) Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline.

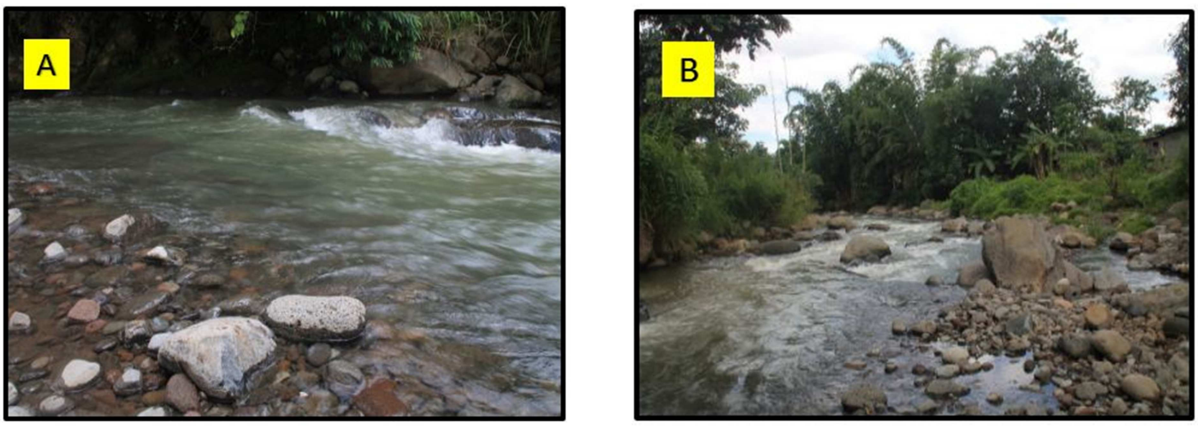

Fig. 6. Abiotic parameters showing (A) Bottom substrate of Muleta River in Upper Baguik- ikan, and (B) Channel alteration seen on the increase bar formation at the Muleta- Bongbong River and (C) Upper Baguik- ikan River.

Fig. 7. Biotic components showing (A) Canopy Cover, (B) Streamside cover, (C) open canopy, and (D) Anthropogenic activity as a biological stressor.

Description of Biotic Parameters

Three (3) sampling area in upper stream of Muleta River, namely, Upper Baguik- ikan, Baguik- ikan and Lantay were evaluated as optimal type of habitat where some areas of water surface fully exposed to sunlight, some shaded and others with various degrees of filtered light. In addition, Muleta-Bongbong and Muleta Dam were considered marginal type of habitat with a rating of 6.0 and 8.0 respectively wherein full sunlight reaching the water surface. However, upper stream of Muleta has an overall rating of 10.80 which is considered an optimal type of habitat is covered by sparse canopy wherein the entire water surface receiving filtered light as an overall rating of the station (Table 6). 70-89% of the stream bank surfaces were covered by vegetation, mostly dominated by tree forms with few shrubs. The riparian zone width has an average of only 6-12 meters. Decreasing width of riparian vegetation could be attributed to the increase utilization of riparian areas for agricultural cultivation. Moreover, present saplings and seedlings were scattered to patches and polygons of 1-5% cover. The key invasive species found in the sites are within 1-5% percent cover (Fig. 7). The observed biotic condition stressors were non-point source discharges (urban run-off, farm drainage), excessive human visitation, and the presence of exotic plants. The invasive plants observed along the upper stream of Muleta River were *Spagneticola trilobota, Chromolaena odorata, Mimosa invisa, Gmelina arborea, Dioscorea bulbifera and Saccharum spontaneum* (Fig. 8). In general, Muleta River in upper stream station was evaluated to be at optimal condition in terms of its biotic components.

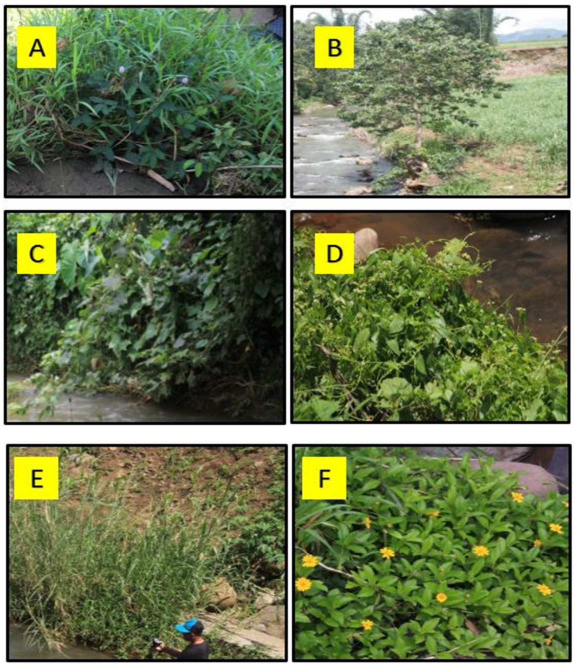

Fig. 8. Invasive species present along upper stream of Muleta River (A) *Mimosa invisa,,* (B) *Gmelina arborea,* (C) *Dioscorea bulbifera,* (D*) Chromolaena odorata,* (E) *Saccharum spontaneum* and, (F) *Spagneticola trilobo.*

Table 6. Rapid Assessment of the biotic components of the Muleta River (Upperstream).

Habitat Parameters	Pangantucan (Upper stream)											
	Upper Baguik ikan River (U1)		Baguik ikan River (U2)		Lantay Bridge (U3)		Muleta-Bongbong River (U4)		Muleta Dam (U5)		MEAN	
	Grade	Description	Grade	Desc.	Grade	Desc.	Grade	Desc.	Grade	Desc.	Grade	Desc.
Canopy cover (shading)	18.00	Optimal	11.00	Sub-optimal	11.00	Sub-optimal	6.00	Marginal	8.00	Marginal	10.80	Sub-optimal
Bank vegetative protection	12.33	Sub-optimal	12.00	Sub-optimal	13.00	Sub-optimal	11.67	Sub-optimal	7.00	Marginal	11.20	Sub-optimal
Streamside cover	17.00	Optimal	12.00	Sub-optimal	13.67	Sub-optimal	11.00	Sub-optimal	7.00	Marginal	12.13	Sub-optimal
Riparian vegetative zone width	16.00	Sub-optimal	8.00	Marginal	8.00	Marginal	12.67	Sub-optimal	7.00	Marginal	10.33	Marginal
Native riparian regeneration rating	16.00	Optimal	11.33	Sub-optimal	14.33	Sub-optimal	11.67	Sub-optimal	8.33	Marginal	12.33	Sub-optimal
Invasive exotic plant species cover	17.67	Optimal	11.33	Sub-optimal	8.00	Marginal	9.00	Marginal	16.00	Optimal	12.40	Sub-optimal
Biotic condition stressor	18.00	Optimal	11.33	Sub-optimal	16.00	Optimal	11.00	Sub-optimal	11.00	Sub-optimal	13.47	Sub-optimal
Vegetative horizontal patch structure	13.00	Sub-optimal	11.00	Sub-optimal	12.00	Sub-optimal	9.00	Marginal	9.00	Marginal	10.80	Sub-optimal
Vegetation Vertical patch structure	18.00	Optimal	12.00	Sub-optimal	11.00	Optimal	8.00	Marginal	11.00	Sub-optimal	12.00	Sub-optimal
Total	146.00	Optimal	99.99	Sub-optimal	107.00	Sub-optimal	90.0	Sub-optimal	84.33	Marginal	105.47	Sub-optimal

Station 2: Midstream Part of Muleta River

Description of Assessment Area

The assessment area 2 or the midstream part of Muleta River has three (3) sampling areas located at Barangay Malinao, Kadingilan (M1), Lalapoy (M2), and Masimag (M3). Muleta River located at Malinao has plain landscape surrounded with corn, banana plantation and rice fields (Fig. 9A).

A bridge is present in this sampling area (Fig. 9B). A constructed dike is present at the right side of the river which serves as a control and protection against flood that used to frequently hit the area. On the other hand, Lalapoy River located at the boundary of Masimag and Kadingilan is generally flat composed of shrubs, trees, banana and falcata plantation (Fig. 9C).

There is an evident of erosion on the right bank. Also, we observed a dead animal inside the cellophane with a very foul smell. Moreover, a bridge is present in this area. Lastly, Masimag River is surrounded with urban residential, sparse shrubs and trees and a very unstable left and right banks (Fig. 9D).

The river has many eroded areas and a more disturbed area compared to other sampling area in midstream part of Muleta River. A bridge is also present in the site.

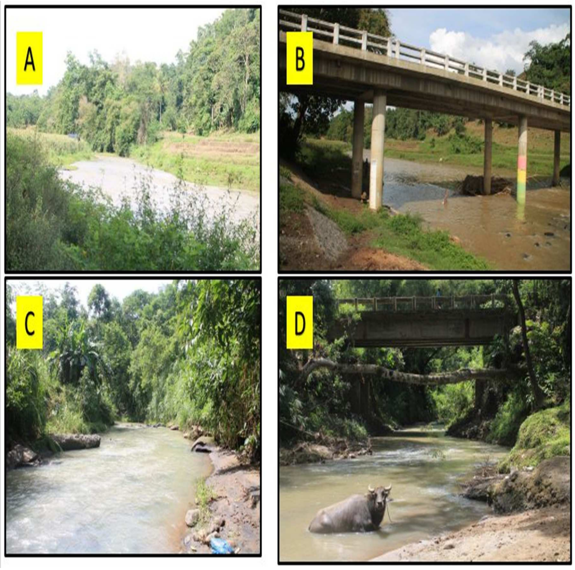

Fig. 9. Assessment Areas in Midstream station showing (A) M1- Muleta River in Malinao Bridge, (B) presence of bridge in M1, (C) M2- Lalapoy River, and (D) M-3 Masimag River.

Description of Abiotic Parameters

River has access to natural floodplain and moderately inundated more specifically the two (2) sampling area in midstream part of Muleta River, namely: Malinao and Masimag River. As cited by Opiso *et al.* (2015), hydrologic connectivity is the ability of the water to flow into or out of the wetland or inundate adjacent areas of the river. Floodplain habitats provide critical spawning and rearing habitats for many large-river fishes. Bridge, urban residential and intensive row crop agriculture were the observed landscape and the physical structure stressors in more or less 10% of the assessment area. Urban residential along the river increased solid and liquid waste pollution which is also considered a stressor. Table 7 shows the assessment of abiotic component of the midstream part of Muleta River with three (3) sampling areas.

Table 7. Rapid Assessment of Abiotic Component of Muleta River (Midstream).

Habitat Parameters	Midstream							
	Malinao (M1)		Lalapoy (M2)		Masimag (M3)		MEAN	
	Grade	Desc.	Grade	Desc.	Grade	Desc.	Grade	Desc.
Hydrologic Connectivity	11.00	Sub-optimal	12.00	Sub-optimal	12.33	Sub-optimal	11.78	Sub-optimal
Landscape condition stressor	9.00	Marginal	11.00	Sub-optimal	9.00	Marginal	9.67	Marginal
Hydrologic condition stressor	9.00	Marginal	12.00	Sub-optimal	10.00	Marginal	10.33	Marginal
Physical structure condition stressor	10.00	Marginal	9.00	Marginal	8.00	Marginal	9.00	Marginal
Physico- chemical Parameters	3.00	Poor	3.00	Poor	2.00	Poor	2.67	Poor
Bottom substrate/ instream cover	8.00	Marginal	10.00	Marginal	11.33	Sub-optimal	9.67	Marginal
Embeddedness	8.00	Marginal	11.00	Sub-optimal	8.00	Marginal	9.00	Marginal
Channel alteration	9.00	Marginal	11.33	Sub-optimal	10.00	Marginal	10.11	Marginal
Bank stability	11.33	Sub-optimal	11.33	Sub-optimal	7.00	Marginal	9.89	Marginal
Total	78.33	Marginal	90.66	Sub-optimal	77.66	Marginal	82.11	Marginal

The instream cover of the river in the midstream part of Muleta is made up of 10-30% mix of gravel showing a less desirable habitat due to lack of natural substrates to serve as habitat for aquatic organisms. A wide variety and abundance of submerged structures in the stream provides macro invertebrates and fish with a large number of niches, thus increasing habitat diversity. As variety and abundance of cover decreases, habitat structure becomes monotonous, diversity decreases, and the potential for recovery following disturbance decreases (Water Action Vounteers, 2006). The occurring siltation as observed in the 50-75% fine sediments surrounding and burying the rocks in the river may have resulted from agricultural intensification along the river. Moreover, some eroded banks and some increased bar formation mostly from course gravel may also attributed to these activities. Furthermore, the decreased amount of natural vegetation along the riparian areas may also have caused bank erosions in the three (3) sampling areas with a rating of 9.89 considered as marginal in terms of bank stability.

Among the seven (8) standard parameters, the turbidity, total suspended solids, nitrate (Class A) and phosphate (Class A) failed as compared to DAO34 water quality standards presented in Table 8. Human activities such as the use of fertilizer, burning of garbage and sewage effluent (dishwashing detergents) and intense cultivation along the river which caused erosions may be attributed to these failing values. Other parameters such as temperature, pH, TDS and DO were found to be at standard acceptable levels. In general, midstream portion of Muleta River was evaluated to be marginal type of habitat with 82.11 rating in terms of abiotic components.

Table 8. Muleta River Water Quality Compared to DAO 34 Water Quality Standards (Midstream).

Parameters	Midtream (Station 2)							
	Malinao (M1)	Lalapoy (M2)	Masimag (M3)	Average	Class A*	Remarks	Class B*	Remarks
TDS (g/L)	70	70	60	66.67	1000*	Passed	500	Passed
Temp. (C)	27.46	26.38	27.69	27.18	26-30	Passed	26-30	Passed
pH	7.35	7.08	7.04	7.16	6.5-8.5	Passed	6.5-8.5	Passed
Turbidity (NTU)	91.03	29.93	48.9	56.62	5	Failed	5	Failed
DO (mg/L)	11.37	11.99	11.31	11.56	5	Passed	5	Passed
	Malinao (M1)							
	R1	R2	R3					
TSS (mg/L)	120	90	140	116.67	50	Failed	65	Failed
Nitrate (mg/L)	14.684	14.684	14.684	14.68	7	Failed	15	Passed
Phopshate (mg/L)	0.206	0.196	0.206	0.203	0.1	Failed	0.2	Passed

Legend: Class A*- Public Water Supply Class II. For sources of water supply that will require complete treatment (coagulation, sedimentation, filtration and disinfection) in order to meet the NSDW.

Class B*- Recreational Water Class I. For primary contact recreation such as bathing, swimming, skin diving, etc. (particularly those designated for tourism purposes). TDS (1000*) - Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline.

Station 3: Downstream Part of Muleta River

Description of Assessment Area

The assessment area 3 or downstream part of Muleta River located at Barangay Omonay, Damulog, Bukidnon has three (3) sampling areas, namely; the Muleta River junction, Lumatong and Omonay. Muleta River junction has a flat to rolling slope (Fig. 13A). It is covered with dense vegetation at the right bank but little to no vegetation at the left bank due to tree/sapling and shrub removal by the settlers nearby. Also, anthropogenic activity of the nearby residents is very evident such as bathing, washing and boating (Fig. 13B). A bridge is present in the site with several residential houses located at the left side of the bank. Lumatong, on the other hand located 1 km from the main highway is surrounded by corn, banana and sugarcane plantation with few trees and shrubs (Fig. 13C). Massive and intense bank erosion observed in the left side if the river. Omonay River is generally flat to rolling slope surrounded with sugarcane, rubber plantation and sparse trees and shrubs at the left and right bank of the river (Fig. 13D). Eroded banks were visible in the area.

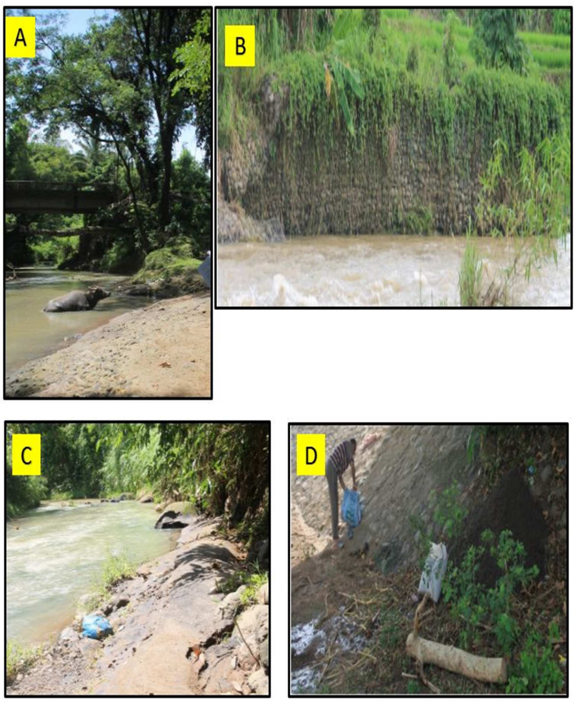

Fig. 10. Abiotic components showing (A) hydrologic connectivity (M3), (B) Channel alteration at assessment area (M1), (C) bank erosion (M2), and (D) stock sand at assessment area (M1).

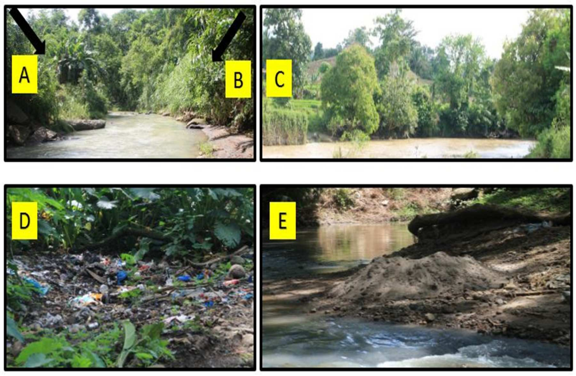

Fig. 11. Biotic components showing streamside cover at (A) right side and (B) left side of assessment area 2 (M1) and (C) patch structure, (D) trash and, (E) resource extraction as physical structure stressor.

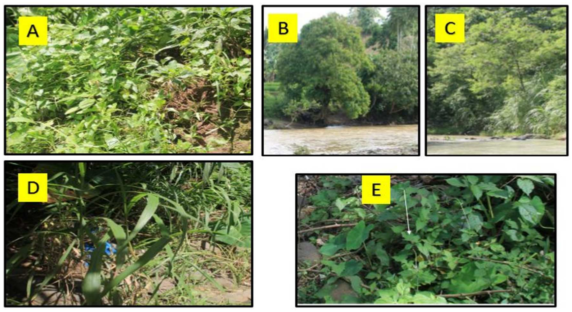

Fig. 12. Invasive species present along upper stream of Muleta River (A) *Chromolaena odorata,* (B) *Gmelina arborea,* (C) *Dioscorea bulbifera,* (D) *Leucena leucocephala,* and (E) *Imperata cylindrical.*

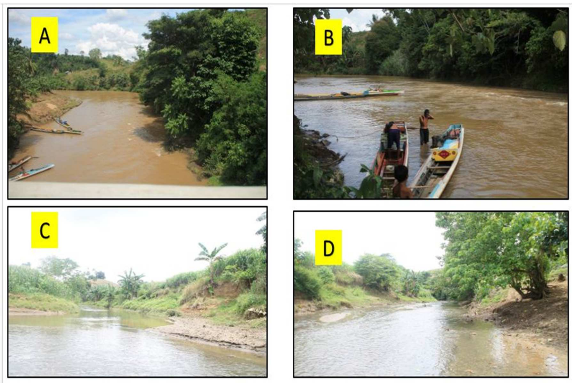

Fig. 13. Assessment area showing (A) D1- Muleta River junction, (B) anthropogenic activity of the settlers as landscape condition stressor in D1, (C) D2- Lumatong River with intense bank erosion at the left bank, and (D) D3- Omonay River with eroded banks.

Description of Abiotic Parameters

The floodplain which supports riparian vegetation is less frequently inundated (Fig. 14).

The major stressors of landscape, hydrologic and physical structures namely, dry land farming, row crop agriculture, urban residential, excessive sediment and non-point source discharges (urban run-off and farm drainage). According to Dosskey *et al.* (2010), tree stems, root wads, and large branches collectively known as plant debris lodge in channels and provide roughness to the channel bed and bank toe slopes that slows stream velocity and promotes stability and deposition. The river instream cover is made up of 10-30% mix of gravel and rocks and is surrounded with 50-75% of fine sediments. Banks are moderately unstable with moderate frequency and size of erosional areas. The occurring siltation in the site may be attributed to the occurring bank erosions triggered by the agricultural intensification and the removal of trees/ sapling and shrubs along the rivers which had also reduced the coverage of natural vegetation.

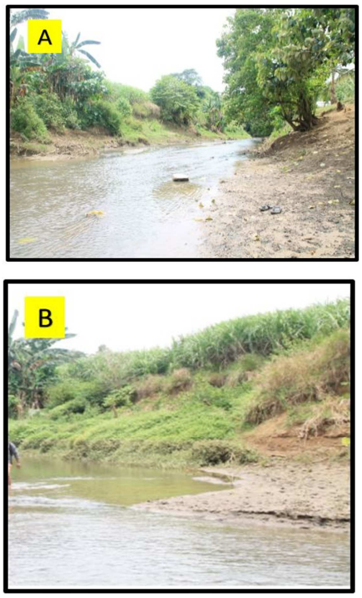

Fig. 14. Abiotic components of Muleta River (downstream) showing (A) Hydrologic connectivity, and (B) Bank erosion/ excessive siltation.

Table 9. Rapid Assessment of the Biotic Component of Muleta River (Midstream).

	Kadingilan (Midstream)							
	Malinao (M1)		Lalapoy River (M2)		Masimag River (M3)		MEAN	
	Grade	Desc.	Grade	Desc.	Grade	Desc.	Grade	Desc.
Canopy cover (shading)	6.00	Marginal	13.00	Sub-optimal	11.00	Sub-optimal	10.00	Marginal
Bank vegetative protection	8.00	Marginal	13.00	Sub-optimal	8.00	Marginal	9.67	Marginal
Streamside cover	12.00	Sub-optimal	12.00	Sub-optimal	11.00	Sub-optimal	11.67	Sub-optimal
Riparian vegetative zone width	7.00	Marginal	10.00	Marginal	5.33	Marginal	7.44	Marginal
Native riparian regeneration rating	9.33	Marginal	10.00	Marginal	6.00	Marginal	8.44	Marginal
Invasive exotic plant species cover	12.00	Optimal	11.00	Sub-optimal	15.00	Sub-optimal	12.67	Sub-optimal
Biotic condition stressor	12.00	Sub-optimal	14.00	Sub-optimal	14.67	Sub-optimal	13.56	Sub- optimal
Vegetative horizontal patch structure	9.67	Marginal	10.00	Marginal	6.00	Marginal	8.56	Marginal
Vegetation Vertical patch structure	9.67	Marginal	8.33	Marginal	6.00	Marginal	8.00	Marginal
Total	85.67	Marginal	101.33	Sub-optimal	83.00	Marginal	90.00	Marginal

Table 10. Rapid Assessment of the Abiotic Component of Muleta River (Downstream).

	Damulog (Downstream)							
Habitat Parameters	Muleta River Junction (D1)		Lumatong (D2)		Omonay (D3)		MEAN	
	Grade	Desc.	Grade	Desc.	Grade	Desc.	Grade	Desc.
Hydrologic Connectivity	11.00	Sub-optimal	12.00	Sub-optimal	11.00	Sub-optimal	11.33	Sub-optimal
Landscape condition stressor	10.00	Sub-optimal	11.33	Sub-optimal	10.00	Marginal	10.44	Marginal
Hydrologic condition stressor	9.00	Sub-optimal	11.00	Sub-optimal	11.00	Sub-optimal	10.33	Marginal
Physical structure condition stressor	10.00	Sub-optimal	9.00	Sub-optimal	11.00	Sub-optimal	10.00	Marginal
Physico- chemical Parameters	2.00	Poor	2.00	Poor	2.00	Poor	2.00	Poor
Bottom substrate/ instream cover	10.00	Marginal	4.00	Poor	13.33	Sub-optimal	9.11	Marginal
Embeddedness	10.00	Marginal	2.00	Poor	11.00	Sub-optimal	7.67	Marginal
Channel alteration	12.00	Sub-optimal	13.00	Sub-optimal	12.00	Sub-optimal	12.33	Sub-optimal
Bank stability	9.00	Marginal	8.00	Marginal	7.00	Marginal	8.00	Marginal
Total	83.00	Marginal	72.33	Marginal	88.33	Marginal	81.22	Marginal

Table 11. Muleta River at downstream part compared to DAO 34 Water Quality Standard (Downstream).

	Downstream (Station 3)							
Parameters	Muleta River Junction (D1)	Lumatong (D2)	Omonay (D3)	Average	Class A*	Remarks	Class B*	Remarks
TDS (g/L)	90	320	350	253.33	1000*	Passed	500	Passed
Temp. (C)	28.1	30.13	30.48	29.57	26-30	Passed	26-30	Passed
pH	7.61	8.04	7.89	7.85	6.5-8.5	Passed	6.5-8.5	Passed
Turbidity (NTU)	160	15.4	23.27	66.22	5	Failed	5	Failed
	11.35	11.68	12.97	12.0	5	Passed	5	Passed
DO (mg/L)	90	320	350	253.33	1000*	Passed	500	Passed

Parameters	Downstream (Station 3)							
	Muleta River Junction (D1)	Lumatong (D2)	Omonay (D3)	Average	Class A*	Remarks	Class B*	Remarks
	Muleta River Junction (D1)							
	R1	R2	R3					
TSS (mg/L)	80	100	235	138.33	50	Failed	65	Failed
Nitrate (mg/L)	29.367	22.025	22.025	24.47	7	Failed	7	Failed
Phopshate (mg/L)	0.196	0.215	0.227	0.213	0.1	Failed	0.2	Passed

Legend: Class A*- Public Water Supply Class II. For sources of water supply that will require complete treatment (coagulation, sedimentation, filtration and disinfection) in order to meet the NSDW.

Class B*- Recreational Water Class I. For primary contact recreation such as bathing, swimming, skin diving, etc. (particularly those esignated for tourism purposes). TDS (1000*) - Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline

Table 11 shows that among the eight (8) listed parameters, 3 parameters namely TSS, turbidity and nitrate concentration failed to qualify to the DAO 34 water quality standard. These parameters are associated to each other since they affect the transparency of cloudiness of water due to the presence of suspended and colloidal materials which could bring impacts to human health and environment. Turbidity in particular can be attributed to soil erosion caused by intense cultivation and human activities. Downstream part of Muleta River was evaluated as marginal type of habitat that is less disturbed but less suitable habitat after abiotic parameters were rapidly assessed (Table 10).

Description of Biotic Parameters

Nearly full sunlight reaching the water surface is evident in the area (Table 12). 50-79% stream bank surface is covered with vegetation dominated by tree form with few shrubs and corn, banana and sugarcane in some areas with an approximate width of only 6-12m.

The decreasing width of the riparian vegetation could be attributed to the increased utilization of riparian areas for agricultural cultivation. Present native poles, saplings and/ or seedlings were scattered in to patches or polygons of 1-5% cover. Moreover, the key invasive species are found at only 1-5% cover.

Table 12. Rapid Assessment of Biotic Components of the downstream part of Muleta River (Downstream).

Habitat Parameters	Damulog (Downstream)							
	Muleta River Junction (D1)		Lumatong (D2)		Omonay (D3)		MEAN	
	Grade	Desc.	Grade	Desc.	Grade	Desc.	Grade	Desc.
Canopy cover (shading)	12.00	Sub-optimal	6.00	Marginal	13.33	Sub-optimal	10.44	Marginal
Bank vegetative protection	9.00	Marginal	8.00	Marginal	8.00	Marginal	8.33	Marginal
Streamside cover	13.00	Sub-optimal	7.67	Marginal	11.33	Sub-optimal	10.67	Sub-optimal
Riparian vegetative zone width	8.00	Marginal	4.00	Poor	4.00	Poor	5.33	Marginal
Native riparian regeneration rating	13.00	Sub-optimal	12.00	Marginal	10.00	Marginal	11.67	Sub-optimal
Invasive exotic plant species cover	11.00	Sub-optimal	16.33	Optimal	11.00	Sub-optimal	12.78	Sub-optimal
Biotic condition stressor	12.00	Sub-optimal	13.67	Sub-optimal	12.33	Sub-optimal	12.67	Sub-optimal
Vegetative horizontal patch structure	8.00	Marginal	6.33	Marginal	5.00	Poor	6.44	Marginal
Vegetation Vertical patch structure	8.00	Marginal	6.33	Marginal	6.00	Marginal	6.78	Marginal
Total	94.00	Sub- optimal	80.33	Marginal	80.99	Marginal	85.11	Marginal

Table 13. Summary on the physico- chemical parameters of Muleta River.

Parameters	Muleta River						Remarks	
	Upperstream		Midstream		Downstream			
Temp	24.17	Passed	27.18	Passed	29.57	Passed	26.97	Passed
pH	7.09	Passed	7.16	Passed	7.85	Passed	7.37	Passed
Turbidity	14.73	Failed	56.62	Failed	66.22	Failed	45.86	Failed
TSS	0.00	Passed	116.67	Failed	138.33	Failed	127.50	Failed
TDS	42.00	Passed	66.67	Passed	253.33	Passed	120.67	Passed
DO	10.55	Passed	11.56	Passed	12.00	Passed	11.37	Passed
Nitrate	9.79	Failed	14.68	Failed	24.47	Failed	16.32	Failed
phosphate	0.24	Passed	0.20	Passed	0.21	Passed	0.22	Passed

Note: Nitrate results in upperstream and midstream station failed in Class A to Class C category set by DAO 34 but still qualified in Class D category but failed in the overall result of the river.

Dominating invasive plant species were *Chromolaena odorata, Leucena leucocephala and Gmelina arborea* (Fig. 16). Biological stressors observed in the sites are the excessive human vegetation, tree/ sapling or shrub removal, lack of vegetation management to conserve natural resources and presence of exotic plant species. Vegetation along the river in low degree of patch diversity and complexity with only two or three patch types mainly composed of low-structured forest with present patches of shrub-land/ herbaceous vegetation.

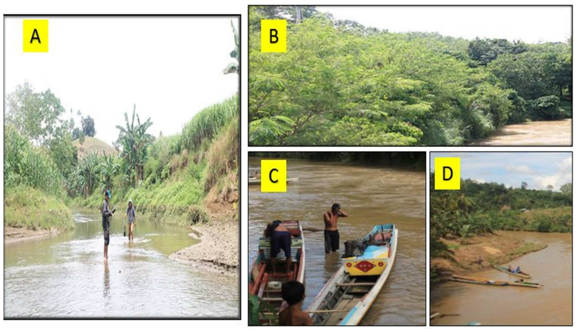

Fig. 15. Biotic components showing (A) Canopy Cover, (B) Streamside cover, (C) open canopy, and (D) Anthropogenic activity as a biological stressor.

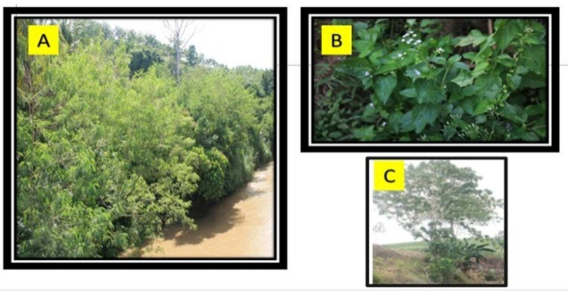

Fig. 16. Invasive species present along the midstream stations of Muleta River showing (A) *Chromolaena odorata,* (B) *Leucena leucocephala* and, (C) *Gmelina arborea.*

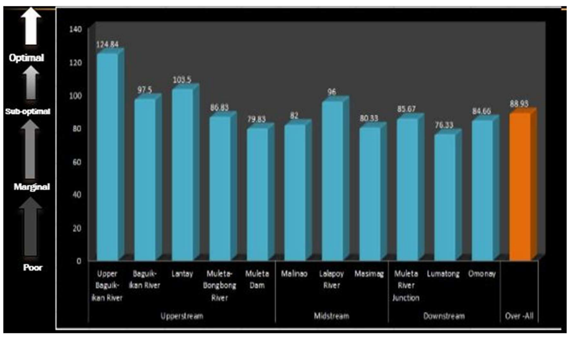

Fig. 17. Habitat Assessment Grading in nine (9) sampling areas in three (3) stations.

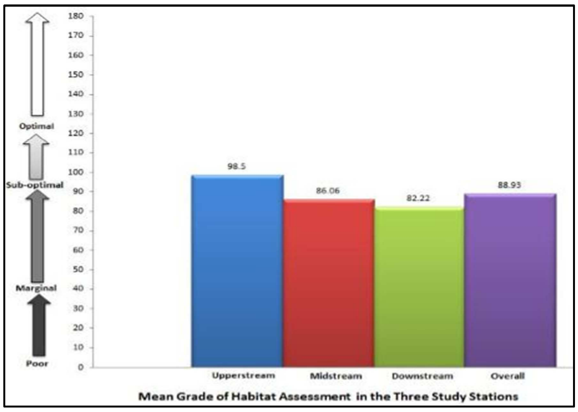

Fig. 18. Mean Grade of Habitat Assesment in the three (3) study stations.

Physico-chemical parameter was rated poor due to failing values of turbidity, total suspended solids (TSS) and nitrate as compared to DAO 34 Water Quality Standards (Table 14).

Nitrate concentration failed in both upper stream and downstream in the Class A category (Public Water Supply) but passed in Class B category which is only for recreational water primarily for bathing, swimming and skin diving purposes. Furthermore, downstream station failed in all categories set by DAO 34 in terms of nitrate concentration. These specific parameters are associated to each other since they affect the transparency or cloudiness of water due to the presence of suspended and colloidal materials.

The occurring moderate bank erosions and run offs from intensively cultivated lands and quarrying activities within the watershed may be attributed to the poor water quality. Failing values may cause a variety of adverse impacts on human health and environment. Among the eleven (11) assessed sampling areas, upper Baguik-ikan River located at the upper stream got the highest rating of 124.84 considered as optimal type of habitat (Table 14) in terms of biotic and abiotic factors.

This was followed by Baguik- ikan, Lantay and Lalapoy River evaluated as sub-optimal type of habitat that is functioning well but less suitable habitat for aquatic organisms with a rating of 97.50, 103.50 and 96.0, respectively. Lastly, two (2) sampling areas from upper stream and midstream and all three (3) sampling areas downstream were evaluated as marginal type of habitat that is less disturbed but less suitable habitat. Generally, Table 15 shows the final rating of Muleta River revealing a marginal type of habitat that the river is less disturbed but less suitable for habitat based on abiotic and biotic components. Furthermore, the landscape, hydrologic, biotic and physical structure condition stressors observed along the river contributed to the water quality of the river that makes it less suitable for aquatic organisms but still manageable.

Table 14. Overall rating of habitat status for each sampling areas.

Muleta River and its tributaries	Grade/ rating		Mean	Category
	Abiotic	Biotic		
Station 1- Upperstream				
Upper Baguik- ikan River	103.67	146.00	124.84	Optimal
Baguik-ikan River	95.00	99.99	97.50	Sub-optimal
Lantay	100	107.00	103.50	Sub-optimal
Muleta- Bongbong River	83.66	90.0	86.83	Marginal
Muleta Dam	75.33	84.33	79.83	Marginal
Station 2- Midstream				
Malinao	78.33	85.67	82.00	Marginal
Lalapoy River	90.66	101.33	96.00	Sub-optimal
Masimag	77.66	83.00	80.33	Marginal
Station 3- Downstream				
Muleta River Junction	83.00	88.33	85.67	Marginal
Lumatong	72.33	80.33	76.33	Marginal
Omonay	88.33	80.99	84.66	Marginal
Mean	84.95	92.90	88.93	Marginal

Table 15. Overall rating of habitat status for each sampling stations.

Muleta River	Grade/ rating		Mean	Category
	Abiotic	Biotic		
Upper stream	91.53	105.47	98.50	Sub-optimal
Midstream	82.11	90.00	86.06	Marginal
Downstream	81.22	83.22	82.22	Marginal
Mean	84.95	92.90	88.93	Marginal

Characteristics of Muleta River as affected by geomorphologic values, land uses associated in each sampling area, and abiotic and biotic components along the river.

Muleta watershed/ river mainly consist of clay type of soil, having severely steep upstream area and flat to rolling and moderately steep midstream and downstream areas, low drainage density, and low elongation ratio. Muleta River/ watershed is elongated in shape having slow water disposal that makes this watershed to absorb more water. Mudslides may occur especially in the steep- slope areas when ground has fully saturated due to continuous rainfall. The increasing turbidity of the Muleta River could be attributed to the clay type of soil which is prone to surface run off and land uses associated in each sampling area which led to moderate erosional areas due to unstable banks. The observed moderate channelization of rivers is caused by bank erosions which also widens the river. According to Mugade and Sapkale (2015), channel degradation refers to the general lowering of the bed elevation and also shifting the channel banks. Moreover, heavily deposited sediments brought about by soil erosion resulted into shallower rivers as well. Agricultural cultivation has been associated to river shall owing and channelization (Opiso *et al.*, 2015) along the watershed. Apart from natural processes, human intervention (land uses) affects directly or indirectly on the channel characteristics and simultaneously influenced on such erosional and depositional processes. The most common observed modifications along Muleta River and its tributaries were the poor bank stability affecting agricultural lands and even threatening nearby settlers. Majority of the sampling areas along the Muleta River display a very ruined profile with no distinct banks. According to Dosskey *et al.* (2010), riparian vegetation influences stream water quality in many ways, from direct chemical uptake and cycling by live plants to indirect influences of plant detritus on soil and channel chemistry, water movement, and erosion. Furthermore, bank vegetation holds the soil and surface run off and clear the water. This ruined bank has resulted from quarrying activities and resource extraction along the river considered as a major stressor for landscape and physical structure condition of the river.

Furthermore, the richness of vegetative protection and streamside cover of the Muleta River along with its tributaries ranges from marginal to sub- optimal, considered as functioning well to less disturbed but less suitable for habitat. This can be attributed by the growing economy and urbanizing areas traversed by Muleta River and its tributaries. In terms of riparian vegetative zone width, Muleta River along with its tributaries were considered marginal type of habitat, less disturbed but less suitable for habitat due to the large cultivated areas cover the riparian areas instead of natural vegetation that would serve as buffer against occurring soil erosion and floods. Furthermore, the observed invasive plant species found along the river could compete/shade other plants which may cause habitat alteration or loss. According to Joshi (2010), exotic species, especially those that were introduced to an area with no natural predators or competitors, will flourish in their new habitats in which once established, introduced species can become aggressive and dangerously invasive.

Determination of the level of phosphorus and nitrates are essential for the river water quality. Vegetation demand is relatively large for nitrogen (N) while demand is smaller for phosphorus (P), potassium, calcium, magnesium, and sulfur, and minor for several other mineral elements (Mengel and Kirkby, 1982). From a water quality perspective, N and P have motivated widespread concerns because excesses of these nutrients in streams, lakes, and estuaries are common and create serious ecological stresses and public health risks. Phosphates and nitrates are essential for the growth of plants and animals and acquired through the use of fertilizer which help farmer to produce more crops which can mean lower prices but human activities have altered its natural cycle. However, high phosphate and nitrate levels can cause eutrophication – an issue when there is too much nutrient in a water body (e.g. rivers and lakes) (EPA, 2011). The main sources of phosphates are drainage from farmland (fertilizers, runoff from manure, etc.), and sewage effluent (which contains dishwasher detergents, food and drink additives) while common sources of excess nitrate reaching lakes and streams include septic systems, animal feed lots, agricultural fertilizers, manure, industrial waste waters, sanitary landfills, and garbage dumps (MPCA, 2008). This can cause excessive growth of algae and other plants, which then affects water quality, damages plants and animals and stops us using the water. In terms of phosphates and nitrates concentration, Muleta River along with its tributaries failed the water quality standard set by DAO34. This is due to the fact that human activities (agricultural fertilizer, garbage dumps and bathing and washing with the use of detergents etc.) altered the natural cycle of this nutrients.

Muleta River along with its tributaries failed the water quality standards of DENR Administrative Order 34 due to high turbidity, TSS and nitrate concentrations in water implicated to have adverse impacts to environment and even to human health. Known as the Department of Environment and Natural Resources Administrative Order 34, the standard composing 8 parameters namely TDS, temperature, pH, turbidity, DO, TSS, Phosphates and Nitrate concentration were used as the basis (except for Nitrate and phosphate) for water quality assessment of rivers. Increased amount of suspended solids in river water is mainly attributed to the occurring physical resource extraction and the increase of agricultural cultivation along river banks.

The results on the habitat assessment and river water quality was found to have a relationship to the human population living (urban residential) along the river. Population density, one considered contributory factor was found to significantly affect the river system through impacts of urbanization. Human activities such as the excess use of irrigation in agricultural land and improper use of cultivation practices, sand dredging and excavation of silt from river sites are more or less effects on the aggradation and degradation of river channels (Mugade and Sapkale, 2015). Moreover, nitrate and phosphate use will increase with population growth thereby affecting river water quality. The three (3) sampling stations (upstream-midstream-downstream) were evaluated as marginal in the same context wherein landscape, hydrologic and physical stressors are present in lesser area percentage. Other identified stressors present under rivers' premise are urban residential, transportation corridors, cultivation of riparian areas, quarrying activity, engineered channel structures, and occurring sediment deposition out of natural ecological process. Considerable adverse impacts are consequently caused by the said stressors to each river's integrity. Rural population growth increases the likelihood that forested regions will be transformed, cut, or burned for extractive processes, or extensive agricultural production (Vu *et al.*, 2013) especially in the case of Upper Baguik-ikan River (U1). Moreover, a steep slope of forested land can be a natural constraint for people's access to exploiting forest products (e.g., selective logging) or to converting to permanent agricultural land, hence to help avoid forest clearance or degradation.

In a closed society, an increase in population density would increase the demand for food, and this would act as an incentive to change agrarian technology to produce more food (Vu et. al, 2013). Furthermore, the growth rate of a rural population in a poorly managed forest land also increases the possibility of slash-and-burn and selective logging activities that cause deforestation or forest degradation.

General results of the study showed a marginal type of habitat that is less disturbed but less suitable for habitat as defined by Opiso *et al.* (2015) based on biotic and abiotic parameters in all sampling stations traversing Muleta River. Upperstream stations (U1, U2, U3, U4 and U5) considered as sub- optimal type of habitat had high turbidity due to its slope attributes extending from level to gently and to severely steep. This affects directly or indirectly on the channel characteristics and simultaneously influenced on such erosional and depositional processes of the river (Opiso *et al.*, 2015). This station was still considered functioning well but less suitable for habitat because some areas still had vegetation present along the banks and the forested area present in the upstream site (Upper Baguik- ikan River). According to Vu *et al.* (2013), the richness of surrounding forest cover become important for natural restoration in abandoned degraded land.

The increasing degree of every sampling stations based on rapid habitat assessment is as follows: downstream< midstream< upperstream. This is due to the fact that despite of its slope attributes, the landscape, hydrologic, physical and biotic condition stressors and land use associated in each sampling area caused by human interventions contributed a lot in the present status of Muleta River.

Overall, habitat characterization and assessment completed as part of this study allowed for an in-depth knowledge of the river in the area. Habitat suitability is the only requirement needed for organisms to live and reproduce in an aquatic system (Killins *et al.*, 2005).

Conclusion

1. Muleta River has water temperature which varied from 24.17°C, 27.18ºC and 29.57°C with a mean of 26.97°C; the observed turbidity ranged from 14.73 NTU, 56.62 NTU and 66.22 with a mean of 45. 86 NTU; total suspended solids (TSS) values ranged from 0mg/L, 116.67mg/L and 138.33mg/L with a mean of 127.5mg/L; values of total dissolved solids (TDS) ranged from 42mg/L, 66.67mg/L and 253.33mg/L with a mean of 120.67mg/L; dissolved oxygen ranged from 10.55mg/L, 11.56mg/L and 12mg/L with a mean value of 11.37mg/L; pH values ranging from 7.09, 7.16 and 7.85 with a mean of 7.37; the mean value of nitrate

and phosphate concentration of 16.32 and 0.22, respectively.

2. Muleta River along with its tributaries failed the water quality standards of DENR Administrative Order 34 due to high turbidity, TSS and nitrate concentrations.
3. The major land use along the Muleta River is more on agriculture in which sugarcane, rice fields and corn plantations where the most dominant agricultural practice along the river system.
4. General results of the study showed a marginal type of habitat that is less disturbed but less suitable for habitat based on biotic and abiotic parameters in all sampling stations traversing Muleta River.

Recommendations

Muleta River along with its tributaries seems to have common problem with evidently eroded banks. Apart from natural forces, the existing sand and gravel quarrying operating plays a big factor in the resulting degradation of the river and the insufficiency of vegetation along the streambank. To regulate this over extraction problem, it is recommended that proper protocol on permit acquisition from the LGUs for quarrying activity be implemented.

Assessment results especially on the biotic aspect, lack of canopy in some areas, insufficient amount of vegetation along the banks due to large agricultural cultivation covering the area replacing the natural vegetation are the common observed problems along Muleta River and its tributaries. In this regard, there should be plans and programs specifically on reforestation establishment since plants prevent bank erosions and help buffer occurring floods. It was also observed that cultivation and open canopy cover most of the rivers which implies that the watershed has few natural forests which may appear to be nearly denuded. Denuded forest are prone to occurrence of erosions and flashfloods since not enough vegetative will hold the surface and absorb water. Forest conservation should be promoted as well as re-greening program promoting reforestation on denuded areas especially in upstream portions with the use of endemic plant species for a resilient landscape, slope protection and drainage structures.

Given that agricultural intensification is crucial for ensuring the food security of the landless agrarian communities, the development of new policy instruments should be a priority in the future development of national policy for agriculture. Efforts in this direction require an evaluation of the environmental cost over the life cycles of agricultural products as cited by Vu *et al.* (2013), and based on that evaluation, new policies regarding payment for ecosystem services can be formulated.

Since the study was a visual assessment, it is recommended that hydrologic analysis should be conducted. The study will help determine and model the water movement within the watersheds. This will include activities on biophysical characterization of watershed and flood forecasting and modeling. Considering the task of hydrology, it is evident that not only the natural processes have to be analyzed, but the modification of the water regime due to human intervention must also be investigated. Data from both the natural hydrological cycle and the use of water in the social sphere, therefore, should be collected and evaluated. The description of a water regime includes not only the determination of the quantities transported and stored, but also the qualitative properties of water. Hence the hydrological information systems must provide data about the instantaneous condition of and the expected changes in water quantity and quality.

Acknowledgements

This study was carried out to fill up the gap of the Watershed Project conducted by the College of Forestry which aims to characterize the Muleta watershed with standardized protocols for assessment. The authors gratefully acknowledge the help of Central Mindanao University, College of Forestry- National and Development Project for Watershed Management in the Philippines (NRDPWMP) funded by the Department of Science and Technology- Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST- PCAARRD) for lending their field instrument (HORIBA- U52) and special mention to Ronald Regan C. Forten, a Research Assistant for the said funded project for the field assistance in data gathering specifically in water quality determination.

References

Addy S. 2013. Geomorphology, river hydrology and natural processes. SNH Sharing Good Practice Event: Identifying and planning river restoration projects. The James Hutton Institute. Retrieved from http://www.snh.gov.uk/docs/A1077179.pdf.

Barbour MT, Gerritsen J, Snyder BD, Stribling JB. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates, and fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of water ; Washington, D.C.

Behar S. 1997. Testing the Waters: Chemical and Physical Vital Signs of a River Montpelier, VT: River Watch Network, ISBN-0-782-3492 Retrieve from: http://fosc.org/WQData/WQParameters.htm.

Boëchat IG, De Paival AB, Hille S, Gücker, B. 2013**.** Land-use effects on river habitat quality and sediment granulometry along a 4th-order tropical river. doi: 10.4136/ambi-agua.1232. Ambiente&Água - An Interdisciplinary Journal of Applied Science ISSN 1980-993X.

Booker DJ, Dunbar MJ, Shamseldin A, Durr C, Acremanmc. 2003. Physical Habitat Assessment in Urban Rivers under Future Flow Scenarios. Retrieved from

Chadha DK, Neupane BR. 2011**.** Significance of Geomorphic Analysis of Watershed for Optimization of Recharge Structures.

Corell DL. 1996. Buffer zones and water quality protection: general principles. Smithsonian Environmental Research Center, P.O. Box 28, Edge water, MD 21037, USA.

David AJ. 2004. Influence of land use and landscape setting on the ecological status of rivers. Retrieved from http://ddd.uab.cat/record/26087.

Department of Environment and Natural Resources. Administrative Order 34 (DAO 34). 1990. Revised Water Usage and Classification/ Water Quality Criteria Amending Section Nos. 68 and 69, Chapter III of the 1978 NPCC Rules and Regulations.

Dosskeymg, Vidon P, Gurwick NP, Allan CJ, Duval TP, Lowrance R. 2010. The Role of Riparian Vegetation in Protecting and Improving Chemical Water Quality in Streams. Journal of the American Water Resources Association (JAWRA) 1-18. DOI: 10.1111⁄j.1752-1688.2010.00419.x

Doyle MW, Stanley EH, Strayer DL, Jacobson RB, Schmidt JC. 2005**.** Effective discharge analysis of ecological processes in streams. Retrieved from http://limnology.wisc.edu/personnel/sites/default/files/ehstanley/files/doyle_et_al_wrr_2005.pdf

Ecosystems Research and Development Bureau (ERDB) and DENR. Status of Invasive Alien Species in the Philippines.

Environment Protection Agency. 1979. Methods for the Chemical Analysis of Water and Wastewater, U.S.Environmental Protection Agency.

Environment Protection Agency. 2011**.** The Impact of Nitrogen and Phosphorus on Water Quality. Ohio EPA, Division of Surface Water www.epa.ohio.gov/dsw

Environment Protection Agency. 2013. Dissolved Oxygen Depletion in Lake Erie. In Great Lakes Monitoring. Retrieved from http://www.epa.gov/glindicators/water/oxygenb.html

Fernandez D, Barquin J, Raven PJ .2011. A review of river habitat characterization methods: indices vs characterization protocols. Limnetica **30(2),** 217-234 (2011) _c Asociacio´nIbe´rica de Limnolog´ıa, Madrid. Spain. ISSN: 0213-8409

Heatherly T, Whiles MR, Royer TV, David MB. 2007. Relationships between Water Quality, Habitat Quality, and Macroinvertebrate Assemblages in Illinois Streams. American Society of Agronomy, Crop Science Society of America, Soil Science Society. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America. Retrieved from https://dl.sciencesocieties.org/publications/jeq/abstracts/36/6/1653

Herringshaw CJ, Stewart TW, Thompson JR, Anderson PF. 2011**.** Land Use, Stream Habitat and Benthic Invertebrate Assemblages in a Highly Altered Iowa Watershed. Retrieved from http://dx.doi.org /10.1674/0003-0031-165.2.274.

Integrated Watershed for Research and Development (InWARD). 2015-2017. National Research and Development Project for Watershed Management in the Philippines. On- going project of watershed in the College of Forestry, Central Mindanao University.

Joshi R. 2010. Invasive alien species (IAS): oncerns and status in the Philippines. Accessed online from http://www.agnet.org/htmlarea_file/activities/20110826121346/paper-729213301.pdf

Kanth TA, Hassan Z. 2012. Morphometric analysis and prioritization of watersheds for soil and water resource management in Wular Catchment using geo-spatial tools. Accessed online from

Kentucky Division of Water (KDOW). 2011**.** Methods for Assessing Habitat in Wadeable Waters. Kentucky Department for Environmental Protection, Division of Water, Frankfort, Kentucky.

Killins K, Veliz M, Staton S. 2005. Ausable river aquatic habitat assessment. Ausable Bayfield Conservation Authority.

Li S, Gu S, Liu W, Han H, Zhang Q. 2008. Water quality in relation to land use and land cover in the upper Han River Basin, China. ELSEVIER. Journal homepage: www.elsevier.com/locate/catena

Lunau M, Voss M, Erickson M, Dziallas C, Casciotti K, Ducklow H. 2012. Excess nitrate loads reduces nitrate removal efficiency: mechanism and implications for coastal eutrophication.

Mccluney KE, Poff NL, Palmer MA, Thorp JH, Poole GC, Williams BS, Williams MR, Baron JS. 2014. Riverine macrosystems ecology: sensitivity, resistance, and resilience of whole river basins with human alterations. Retrieved from http://onlinelibrary.wiley.com/doi/10.1890/120367/full

Meghla NT, Islam MS, Ali MA, Sultana S, Sultana N. 2013. Assessment of Physicochemical Properties of Water from the Turag River in Dhaka City, Bangladesh. Int. J. Curr. Microbiol. App. Sci. http://www.ijcmas.com/Archives/vol-2-5/Nowara %20 Tamanna%20Meghla%20et%20al.pdf

Mengel, Kirkby. 1982. The Role of Riparian Vegetation in Protecting and Improving Chemical Water Quality in Streams. Journal of the American Water Resources Association (JAWRA) 1-18.)

Minnesota Pollution Control Agency (MPCA). 2008. Nutrients: Phosphorus, Nitrogen Sources, Impact on Water Quality - A General Overview. www.pca.state.mn.us

Mugade UR , Sapkale JB. 2015. Influence of Aggradation and Degradation of Revir Channel: A Review. International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869, Volume-3, Issue-6, June 2015. Retrieved from http://www.waterboards.ca.gov/santaana/water_issues/programs/stormwater/docs/rcpermit/wap/3rd_

Opiso EM, Pun, GR, Quimpang VT, Amper RA, Cipriano JA, Labadan AJ, Bonghanoy AO, LedresmL .2015. Rapid Assessment of Flood Prone Areas of Selected Critical Rivers in Mindanao, Philippines: An initial step of MinDANOW. In DAVID, A, DAVID, A AND B. KARDON (eds). Excellent Science in ASEAN. Best Selected Papersand Posters from Young ASEAn Scientists on Water, Food and Health. www.sea-eu.net. pp 59-70.

Ouyang Y, Leininger TD, Moran M. 2015. Estimating effects of reforestation on nitrogen and phosphorus load reductions in the Lower Yazoo River Watershed, Mississippi. Retrieved from http://www.srs.fs.usda.gov/pubs/ja/2015/ja_2015_ouyang_004.

Paragas VS, Manzano JA JR, Cacanindin DC. 2007. Land Use Planning Strategies on Watershed Management and Disaster Reduction in the Philippines. Retrieved from http://wgbis.ces.iisc.ernet.in/energy/HC270799/LM/SUSLUP/Thema4/255/255.PDF.

Scannell PW, Jacobs LL. 2001**.** Technical Report: No. 01-06 Effects of Total Dissolved Solids on Aquatic Organisms. In Alaska Department of Fish and Game: Division of Habitat and Restoration. Retrieved from http://www.adfg.alaska.gov/static/home/library/pdfs/habitat/01_06.pdf

Tavassol SF, Gopalakrishna GS. 2016. GIS-based morphometric analysis of major watersheds of Tehran- Karaj, Central of Iran. Retrieved from http://oaji.net/articles/2016/736-1460488106.pdf

Vu QM, Le QB, Frossard E, Vlek, PLG. 2013**.** Socio-economic and biophysical determinants of land degradation in Vietnam: An integrated causal analysis at the national level. Elsevier. Land Use Policy. Retrieved from http://www.zef.de/uploads/tx_zefportal/Publications/mqvu_download_Vu_Le_Frossard_Vlek_2014.pdf.

Wahlcm, Neils A, Hooper D. 2013**.** Impacts of land use at the catchment scale constrain the habitat benefits of stream riparian buffers.Retrieved from. https://onlinelibrary.wiley.com/doi/10.1111/fwb.12211

Water Action Volunteers. 2006**.** Habitat assessment: the parts equal the whole. Volunteer Monitoring Factsheet Series. University of Wisconsin.

Withanage NS, Dayawansa NDK, De Silva RP. 2014**.** Morphometric Analysis of the Gal Oya River Basin Using Spatial Data Derived from GIS. Tropical Agricultural Research Vol. **26(1),** 175-188.

Appendix A

DENR Administrative Order (DAO 34) Water Quality Standard

Parameters	Unit	Class A	Class B	Class C	Class D
Temperatures (maximum rise in degree Celsius)	°C	26-30	26-30	25-31	25-32
pH		6.5-8.5	6.5-8.5	6.5-9.0	6.0-9.0
Turbidity		n/a	n/a	n/a	n/a
Dissolved Oxygen (DO)(minimum; sampling should be taken bet. 9AM-4PM)	mg/L	5	5	5	3
Total Suspended Solids (TSS)	mg/L	50	65	80	110
Total Dissolved Solids (TDS)	mg/L	1,000 (Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline)			1,000 (Do not apply if natural background is higher in concentration. The latter will prevail and will be used as baseline)
Nitrate as $NO_{3=}N$	mg/L	7	7	7	15
Phosphate as Phosphorus	mg/L	0.1	0.2	0.4	-

Denr Administrative ORDER 34, Series of 1990 and 2008

Appendix B

Rapid river assessment field data sheet

SAMPLING SITE: _______________

EVALUATOR: _________________DATE OF EVALUATION: ______________

ABIOTIC ASSESSMENT

Parameter	Category			
	Optimal	Sub-optimal	Marginal	Poor
Hydrologic Connectivity Score: _______	Stream provides adequate hydrology to utilize floodplain; with over-bankfull flows likely to inundate a broad area of floodplain	Less frequent inundation than fully connected streams described on the left. Floodplain supporting riparian vegetation present.	Somewhat modified floodplain, regularly inundated; stream no access to natural floodplain which does not have riparian vegetation	Fully disconnected from floodplain
	20 19 18 17 16	15 14 13 12 11	109 8 76	54 3 21
Landscape Condition Stressor Score: _______	Absence of Landscape stressor	Presence of Major stressor checklist with less than 10% of the assessment area	Presence of Major stressor checklist with less than 10% or more than 10% of the assessment area	Presence of Major stressor checklist with more than 10% of the assessment area
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Hydrologic Condition Stressor Score: _______	Absence of Landscape stressor	Presence of Major stressor checklist with less than 10% of the assessment area	Presence of Major stressor checklist with less than 10% or more than 10% of the assessment area	Presence of Major stressor checklist with more than 10% of the assessment area
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Physical Structure Condition Stressor Score: _______	Absence of Landscape stressor	Presence of Major stressor checklist with less than 10% of the assessment area	Presence of Major stressor checklist with less than 10% or more than 10% of the assessment area	Presence of Major stressor checklist with more than 10% of the assessment area
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Physico-chemical Parameters*+ Score: _______	0-2 parameters failed to qualify DAO 34 criteria	3-4 parameters failed to qualify DAO 34 criteria	5-6 parameters failed to qualify DAO 34 criteria	7 parameters failed to qualify DAO 34 criteria
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Bottom substrate/ instream cover Score: ____ ____	>50% mix of gravel, submerged logs, undercut banks, or other stable habitat	30-50% mix of gravel or other stable habitat. Adequate habitat.	10-30% mix of gravel or other stable habitat. Habitat availability less than desirable.	<10% gravel or other stable habitat. Lack of habitat is obvious.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Embeddedness (extent to which rocks are buried by fine sediment) Score: ____ ____	0-25% surrounded by fine sediment	25-50% surrounded by fine sediment	50-75% surrounded by fine sediment	>75% surrounded by fine sediment
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Channel alteration Score: ____ ____	Little or no enlargement of point bars above water and/or no channelization	Some new increase in bar formation, mostly from coarse gravel; and/or some channelization present.	Moderate deposition of new gravel, coarse sand on old and new bars; and/or alterations to both banks	Heavy deposits of fine material, increased bar development; and/or extensive channelization
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Bank stability (score each bank) Score: _____ (LB)_____ _____ (RB)_____	Bank stable. No evidence of erosion or bank failure. Left Bank 10 9 Right Bank 10 9	Moderately stable. Infrequent, small areas of erosion only. 8 7 6 8 7 6	Moderately unstable. Moderate frequency and size of erosional areas 5 4 3 5 4 3	Unstable. Many eroded areas. 2 1 0 2 1 0

Adapted from: Modified from: OPISO, E.M., PUNO, G.R., QUIMPANG, V.T., AMPER, R.A., CIPRIANO, J.A., LABADAN, A.J., BONGHANOY, A.O. AND M.L. LEDRES.2015. Rapid Assessment of Flood Prone Areas of Selected Critical Rivers in Mindanao, Philippines: An initial step of MinDANOW. In **DAVID, A, DAVID, A AND B. KARDON** (eds). Excellent Science in ASEAN. Best Selected Papersand Posters from Young ASEAn Scientists on Water, Food and Health. www.sea-eu.net. Pp 59-70.

+based on DAO 34

*if Nitrates and TSS fail to qualify water quality criteria, it will be automatically considered poor on the above evaluation form

APPENDIX D

Landscape Context Stressor Checklist

- Urban Residential
- Industrial/Commercial
- Military Training/ Air traffic
- Transportation Corridor
- Sports Field & Urban Parklands (Golf courses, soccer field, etc.)
- Intensive row-crop agriculture
- Orchards/Nurseries
- Commercial feedlots
- Dry land farming
- Dairies
- Ranching – moderate (endorse livestock, grazing or horse paddock)
- Ranching – low intensity (livestock rangeland)
- Active Recreation (Bird-watching, hiking)
- Active Recreation (Off-road vehicles, mountain biking, hunting)
- Physical Resource extraction mining, quarrying
- Biological resource extraction (aquaculture, commercial fisheries, horticulture & medical plan collection)

Biotic Condition Stressors Checklist

- Mowing, grazing, excessive herbivory (within occurrence)
- Excessive human visitation
- Predation and habitat destruction by non-native vertebrates, including feral introduced naturalized species (domestic livestock, exotic game animals, and pet predators)
- Tree/sapling or shrub removal (cutting, chaining, cabling, herbiciding)
- Removal of woody debris
- Treatment of non-native and nuisance plant species
- Presence of exotic plant species
- Pesticide application or vector control
- Biological resource extraction or stocking (various)
- Excessive organic debris (for recently logged sites)
- Lack of vegetation management to conserve natural resources

Hydrologic Condition Stressor Checklist

- Point source discharges, other non-storm water discharge
- Non-point source discharges (urban runoff, farm drainage)
- Flow diversions or unnatural inflows (restrictions and augmentations)
- Dams (reservoirs, detention basins, recharge basins)
- Flow obstructions (culvert, paved stream crossings)
- Weir/drop structure, tide gates
- Dredged inlet/channel
- Engineered channel (riprap, armored channel bank, bed)
- Dike/ levees
- Groundwater extraction
- Ditches (borrow agricultural drainage, mosquito control, etc.)
- Actively managed hydrology (e.g. lake levels controlled)

Physical Structure Stressor Checklist

- Filling or dumping of soils or sediments (N/A for restoration areas)
- Grading/compaction (N/A for restoration areas)
- Plowing/discing N/A for restoration areas)
- Resource extraction (sediment, gravel, oil/gas)
- Vegetation management as negative impact (terracing, root plowing, pitting, drilling seed, or other practices that disturb soil surface)
- Disruption of leaf litter/humus, or peat/organic layer, or biological soil crust
- Excessive sediment or organic debris (e.g. excessive erosion, gullying, slope failure)
- Pesticide or trace organics impaired (point source or non-point source pollution)
- Trash or refuse

Adapted from: OPISO, E.M., PUNO, G.R., QUIMPANG, V.T., AMPER, R.A., CIPRIANO, J.A., LABADAN, A.J., BONGHANOY, A.O. AND M.L. LEDRES.2015. Rapid Assessment of Flood Prone Areas of Selected Critical Rivers in Mindanao, Philippines: An initial step of MinDANOW. In DAVID, A, DAVID, A AND B. KARDON (eds). Excellent Science in ASEAN. Best Selected Papersand Posters from Young ASEAn Scientists on Water, Food and Health. www.sea-eu.net. Pp 59-70.

APPENDIX C

RAPID RIVER ASSESSMENT FIELD DATA SHEET

SAMPLING SITE:____

EVALUATOR: ______________________________DATE OF EVALUATION: __________

BIOTIC ASSESSMENT

Habitat Parameter	Category			
	Optimal	Sub-optimal	Marginal	Poor
Canopy cover (shading)	Mixture of conditions: some areas of water surface fully exposed to sunlight, some shaded and others with various degrees of filtered light	Covered by sparse canopy: entire water surface receiving filtered light	Completely covered by dense canopy, water surface completely shaded or nearly full sunlight reaching water surface.	Lack of canopy, full sunlight reaching water surface
Score: ____ ____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Bank vegetative protection (score each bank) Score: ____	>90% of the streambank surfaces covered by vegetation	70-89% of the streambank surfaces covered by vegetation	50-79% of the streambank surfaces covered by vegetation	<50% of the streambank surfaces covered by vegetation
(LB) ____	Left Bank 10 9	8 7 6	5 4 3	2 1 0
(RB) ____	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Streamside cover Score: _____	Dominant vegetation is shrub, some trees may be present	Dominant vegetation is of tree form, with few shrubs	Dominant vegetation is grasses	>50% of streambank has no vegetation and dominant material is soil, rock or culverts
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Riparian vegetative zone width Score: ____ (LB)____ (RB)____	>18 meters	12-18 meters	6-12 meters	<6 meters
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
Native riparian regeneration rating	Native poles, saplings, and seedlings trees well represented; obvious regeneration, many patches or polygons with >5% cover; typically multiple size (age) classes	Native poles, saplings, and/or seedlings common; scattered patches or polygons with 1%-5% cover; size (ages) classes few	Native poles, saplings, and/or seedlings present but uncommon; restricted to one or two patches or polygons with, typically <1% cover; little size (age) class differentiation	Native poles, saplings, and/or seedlings absent (0% cover)
Score: _____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Invasive exotic plant species cover	Key invasive species <1% cover	Key invasive species 1%-5%	Key invasive species 5%-10%	Key invasive species >10%
Score: ______	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Biotic Condition Stressors Score: ______	0-3 categories for this context observed	4-6 categories for this context observed	7-8 categories for this context observed	9-11 categories for this context observed
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Vegetation Horizontal Patch Structure Score: ______	Diverse patch structure (> 4 patch type) and complexity	Moderate degree of patch diversity (3 patch types present) and complexity.	Low degree of patch diversity and complexity. Two or three patch types may be present	Has essentially little to no patch diversity or complexity
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Vegetation Vertical Patch Structure Score: ______	Highest-structure forest (Type 1 or 3) plus shrubland (Type) 5) and/or herbaceous (Type 6) or Low-structure forest (Type 2 or 4) plus shrubland (Type) 5) and/or herbaceous (Type 6)	Highest-structure forest (Type 1 or 3) alone or Highest-structure forest (Type 1 or 3) plus only low structure forest (Type 2 or 4) or Low-structure forest (Type 2 or 4) plus shrubland (Type) 5) and/or herbaceous (Type 6)	Low-structure forest (Type 2 or 4) alone or Shrubland (Type 5) and herbaceous (Type 6)	Shrubland (Type 5) alone or Herbaceous (Type 6) alone
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Adapted and modified from: OPISO, E.M., PUNO, G.R., QUIMPANG, V.T., AMPER, R.A., CIPRIANO, J.A., LABADAN, A.J., BONGHANOY, A. O. AND M.L. LEDRES.2015. Rapid Assessment of Flood Prone Areas of Selected Critical Rivers in Mindanao, Philippines: An initial step of MinDANOW. In DAVID, A, DAVID, A AND B. KARDON (eds). Excellent Science in ASEAN. Best Selected Papersand Posters from Young ASEAn Scientists on Water, Food and Health. www.sea-eu.net. Pp 59-70.