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RAPID RIPARIAN ASSESSMENT OF SELECTED CRITICAL RIVERS IN MISAMIS ORIENTAL, PHILIPPINES

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ABSTRACT

Due to threats of agricultural expansion and urbanization, riparian areas of rivers are on the brink of deterioration impacting their ecological functions such as the attenuation of flood disasters. In the urbanizing cities and municipalities of El Salvador, Gingoog and Jasaan in Misamis Oriental in southern Philippines, rivers are considered critical due to its high risk to flooding occurrence. In order to implement appropriate river management practices in sustaining its ecological services, understanding the rivers' riparian status is necessary. Hence, this study was conducted to evaluate the current status of Molugan, Solana and Odiongan rivers riparian condition. Using a check list as a guide, abiotic and biotic components of the upstream, midstream and downstream sites of the rivers were rated and evaluated. Other factors such as land use and land cover pattern, population density, stream order and slope were also taken to account in the assessment. Results showed that all rivers are still in the sub-optimal conditions implied with minimal disturbance and deterioration. However of the three rivers, Odiongan was with the least ideal general riparian habitat condition which may be attributed to the river's larger size and accessibility to disturbance. Regardless of the good results, conscious regulation for the expansion of agricultural cultivation especially in the upstream areas of the watersheds is still recommended. In addition, appropriate land use zoning must be implemented giving emphasis on the establishment of appropriate riparian vegetation buffer widths and integrating natural conservation strategies.

Keywords: Abiotic component, biotic component, land cover/land use, riparian, rivers

INTRODUCTION

Riparian is the transition area between the uplands and water starting at the river and extending across the area influenced by the waterway (Garssen et al., 2017). Varying in width and extent, riparian land diversifies in soil, biological and physical characteristics that exerts influence to and is influenced by water and hydrological processes (The City of Calgary, 2014). Riparian areas can be characterized through its traits of hydrology as it involves both groundwater and surface water as driving forces behind the physical, chemical and biological processes; connectivity in allowing the transfer of materials between terrestrial and aquatic ecosystems; and its big influence to aquatic ecosystems as it is regarded as the most influential among all land cover types (The City of Calgary, 2014). Its uniqueness holds a variety of economic and ecological services (Iakovoglou et al., 2012). One of its major hydrological functions is being a natural storage of excess water that helps attenuate floods (Aldridge, 2011).

The occurring riparian fragmentation brought about by the continuing introduction of environmental stressors disrupts ecosystem services. Riparian areas are among the most disturbed and threatened ecosystem due to the expanding human developments and agricultural cultivations mostly concentrated in these areas (Lubos et al., 2015; Iakovoglou, et al., 2012; Poff et al., 2012). River banks are usually modified and there is removal of riparian vegetation that leads to stimulation of erosion, siltation, and degradation of water quality. The resulting changes in river morphology may aggravate flooding situations where storm water overflows shallow rivers with no definite banks affecting urbanized and cultivated floodplain areas. Rivers with degraded riparian areas are associated to increased flood risks in rivers due to the reduction of vegetation which supposed to buffer floods. Agricultural expansion and urbanization are the common problems in rivers threatening riparian areas. This observation is also true to the rivers in Misamis Oriental namely Molugan, Solana and Odiongan which are considered critical due to their high risk to flooding as experienced in the past years. Assessing the riparian condition will indicate the current status of each river's capacity to provide optimum ecological services including its function as flood control. Moreover, understanding the hydrologic and ecological conditions is necessary in implementing appropriate restoration plans and management practices to sustain the rivers' ecological services (Amper et al., 2019). Hence, this study was carried out to evaluate the current status of the riparian habitat condition in Molugan, Solana and Odiongan rivers to be used as bases for restoration and conservation measures. Specifically, this study aims to evaluate the abiotic and biotic component conditions of the river, assess other contributory factors considered significant in shaping

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up the condition of the riparian areas, and provide recommendations for the restoration and conservation of the riparian areas of selected rivers in Misamis Oriental.

METHODOLOGY

Study Area

Riparian habitat was assessed in Molugan, Solana and Odiongan rivers located in El Salvador, Jasaan, and Gingoog City in the province of Misamis Oriental, Philippines (Figure 1). Molugan river geographically lies 8° 27′ to 8° 32′ north latitudes and 124° 26′ to 124° 31′ east longitude. It has an approximate catchment area of 64.71 square kilometers (km2), 15.37 kilometer (km) long and an average width of 4.11km. Molugan drains to Macajalar Bay. Solana watershed geographically lies in 8° 35′ to 8° 39′ north latitudes and 124° 45′ to 124° 54′ east longitude. It has a total area of approximately 67.65 km2. Its river is about 17.60 km long and with an average width of 3 km.

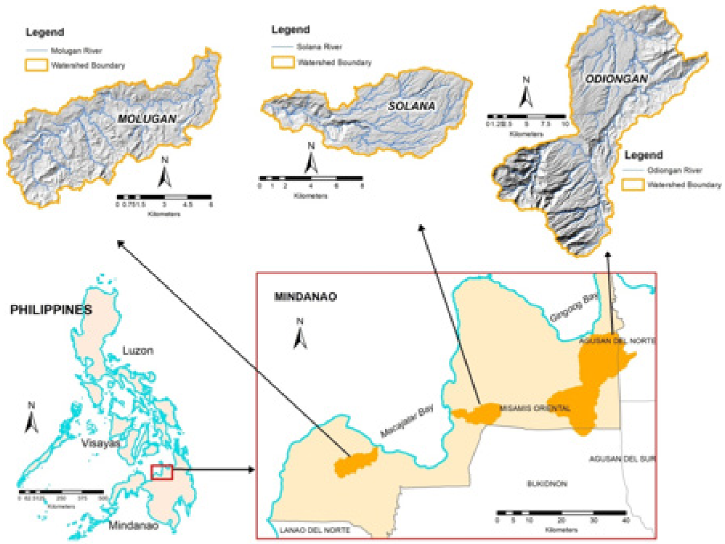

Figure 1. The geographic location of Molugan, Solana and Odiongan Watersheds.

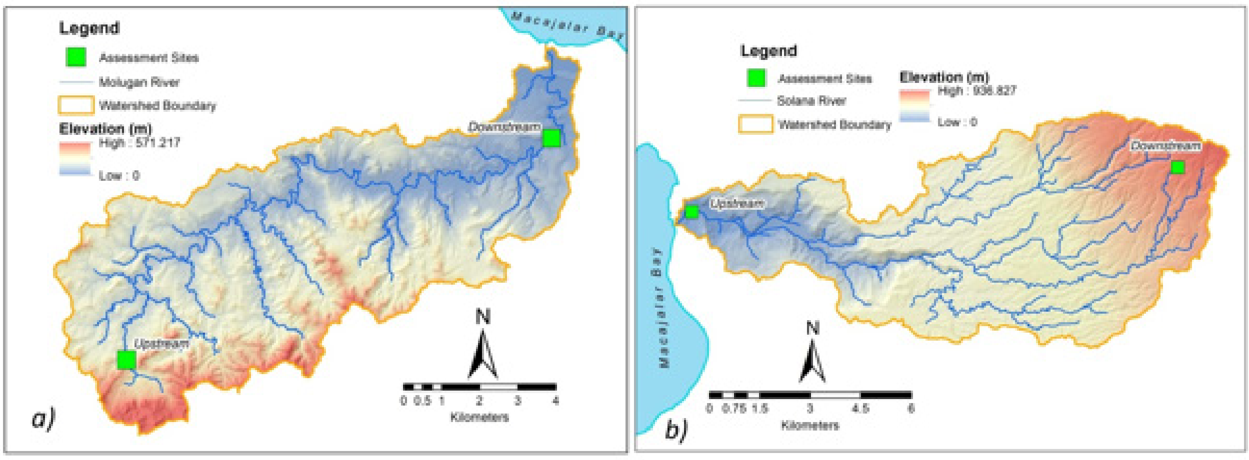

Figure 2. Location of assessment sites in the (a) Molugan and (b) Solana watersheds

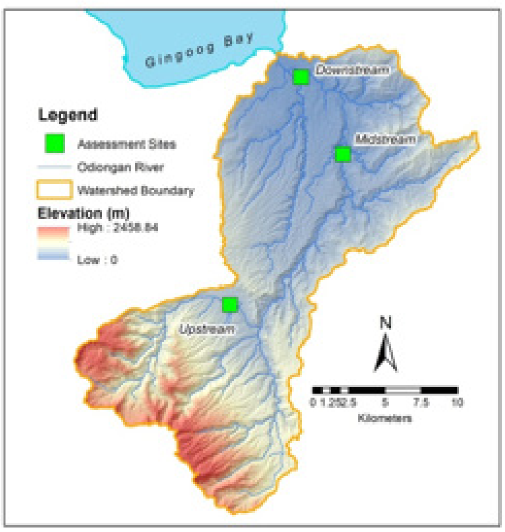

Figure 3. Location of assessment sites in the Odiongan watershed

Solana river traverses the municipalities of Claveria and Jasaan and eventually drains to Macajalar Bay. Odiongan watershed geographically lies within 8°33′ north to 8°51′ north latitudes and 124°48′ east to 125°17′ east longitude. It has an approximate drainage area of 367 km2 and around 13km average river width and 29km long. Odiongan drains to Gingoog Bay.

Two locations in Molugan and Solana watersheds were selected for the rapid riparian assessment to represent the upstream and downstream sites (Figure 2). One additional assessment site was selected to represent the midstream section for Odiongan watershed due to its larger catchment area (Figure 3).

Assessment of abiotic component

The landscape, physical and hydrological conditions of the riparian habitat of the rivers including hydrologic connectivity, bottom substrate, embeddedness, channel alteration and bank stability were assessed. A checklist based on Barbour et al. (1999) which was also utilized in other related studies (Amper et al., 2019; Opiso et al., 2015) was used as a guide for the assessment. Each parameter under this component was evaluated through ocular survey and was rated from 1 to 20 based on its condition with 1 as lowest and 20 as the highest classified as poor, marginal, sub-optimal or optimal. Overall condition of the component was determined by summing the scores of each parameter and interpreted according to the rating scheme in Table 2.

Water quality assessment

Water quality was one parameter considered under the abiotic component. Collection of data was conducted every three months from April 2017 to March 2019. A multi-parameter water quality meter probe (Horiba U-G) was utilized to measure the basic water quality parameters such as pH, temperature, dissolved oxygen (DO) and total dissolved solids (TDS). The probe was dipped in the water for less than a minute until it stabilizes and automatically analyzes and store data in a data logger. Water samples were collected to examine additional parameters such as Total Suspended Solids (TSS), and nitrates analyzed at the Chemical Testing Laboratory of Department of Science and Technology-Regional Office 10 at J. Seriña St, Cagayan de Oro, Misamis Oriental and Soil and Plants Analysis Laboratory (SPAL) of the College of Agriculture, Central Mindanao University at Musuan, Maramag, Bukidnon. Three replicates were collected in every assessment. Collected data were compared with the DENR Administrative Order (DAO) 2016-08's water quality guidelines and general effluent standards of 2016 (DENR, 2016), DAO 34 (DENR, 1990), and Philippine National Standards for Drinking Water (PNSDW, 2007).

Assessment of biotic component

This component constitutes vegetation condition including canopy cover, bank vegetative protection, streamside cover, and riparian vegetative zone width, presence of biotic condition stressors, vegetative horizontal patch structure and vegetation vertical structure. A checklist based on Barbour et al. (1999) and also utilized in previous studies (Amper et al., 2019; Opiso et al., 2015) was used as a guide in evaluating the parameters under this component. The same with the other component, each parameter was assessed through ocular survey and rated from 1 to 20 with 1 as the least ideal condition and 20 as the best optimal condition. The general condition for this component was determined by summing up the scores and interpreted according to the rating scheme in Table 2.

Contributory factors

Factors namely stream order, slope, land cover/land use (LULC) pattern, and population density that contribute to riparian habitat condition were assessed. Stream order was determined through watershed delineation using

Table 1

Rating scheme for the general habitat condition for abiotic component.

Scores	Component condition	Interpretation
0-45	Poor	Most disturbed, loss of function
46-80	Marginal	Disturbed
81-135	Sub-optimal	Less suitable, less disturbed
136-180	Optimal	Most suitable condition, least disturbed

Table 2

Rating scheme for the general habitat condition for biotic component.

Scores	Component condition	Interpretation
0-34	Poor	Most disturbed, loss of function
35-80	Marginal	Disturbed
81-106	Sub-optimal	Less suitable, less disturbed
107-180	Optimal	Most suitable condition, least disturbed

geoHMS extension tool of HEC-HMS in ArcGIS 10.2.2. The slope was derived using the Interferometric Synthetic Aperture Radar (IfSAR) Digital Elevation Model (DEM) from NAMRIA processed using ArcGIS 10.2.2. The land use/ land cover was derived from the Sentinel-2 2016 image, a remote sensing product of Sentinel-2 satellite of European Space Agency (ESA) (Wang et al., 2016), using eCognition software and enhanced in ArcGIS 10.2.2. A population density map was generated in ArcGIS 10.2.2 using the latest available population data of the Philippine Statistics Authority (PSA, 2015).

RESULTS AND DISCUSSION

Abiotic Component Condition

Figure 4 shows the results of the assessment of riparian habitats focusing on the abiotic component in the rivers of Molugan, Solana and Odiongan. Of the three, Odiongan has the lowest score falling within the marginal to sub-optimal thresholds while Molugan and Solana thrives at sub-optimal to optimal conditions. General conditions of the abiotic component of Molugan, Solana and Odiongan riparian habitats are optimal, optimal and sub-optimal, respectively implying a suitable abiotic condition with very minimal disturbance for Molugan and Solana, and a less suitable with observable disturbance in Odiongan.

Hydrologic connectivity mostly referred to transfer of matter, energy and substances through water mediation (Pringle, 2003) was rated optimal in both Molugan and Solana rivers. This is based on the adequate hydrology in the streams inundating the floodplains. Meanwhile, Odiongan was rated marginal for this parameter due to the observable modified floodplain disconnecting access of stream to the natural floodplain.

Stressors to the landscape condition were identified in these rivers. Molugan was considered at optimal condition due to the relative absence of stressors in areas of the assessment sites. Solana was rated sub-optimal for this parameter as characterized by the presence of stressors in less than 10% of the assessment areas. Some of the observed stressors are the transport corridor, low intensity to moderate ranching, presence of sports fields and parks, industrial and commercial buildings and urban residential which are mostly found in the river's downstream assessment site. Odiongan river is rated marginal for this parameter due to the presence of thriving stressors in around 10% of the assessment areas. Observed stressors were the presence of orchards/nurseries, existing dry land farming, low intensity to moderate ranching, physical resource extraction mining/quarrying, presence of transport corridor and urban residential. Houses along rivers are potential sources of pollution from domestic wastes. Moreover, the presence of road can incite threat of recreations and urbanization mostly associated to mining, forest harvesting and agriculture and potentially is a source of sedimentation and/or pollution (Poff et al., 2012).

Hydrologic condition stressors in the rivers were likewise identified. Molugan was rated optimal for this parameter while Solana and Odiongan are both rated sub-optimal condition. Hydrologic conditions stressors that were identified in Molugan are only in minimal areas. These are non-point source discharge such as urabn runoff and farm drainage, and point source discharges and other non-storm water discharge which are also common to Solana and Odiongan. The two other rivers are observed with presence of hydrologic stressors in less than 10% of the assessment areas. Ground water extraction is an additional

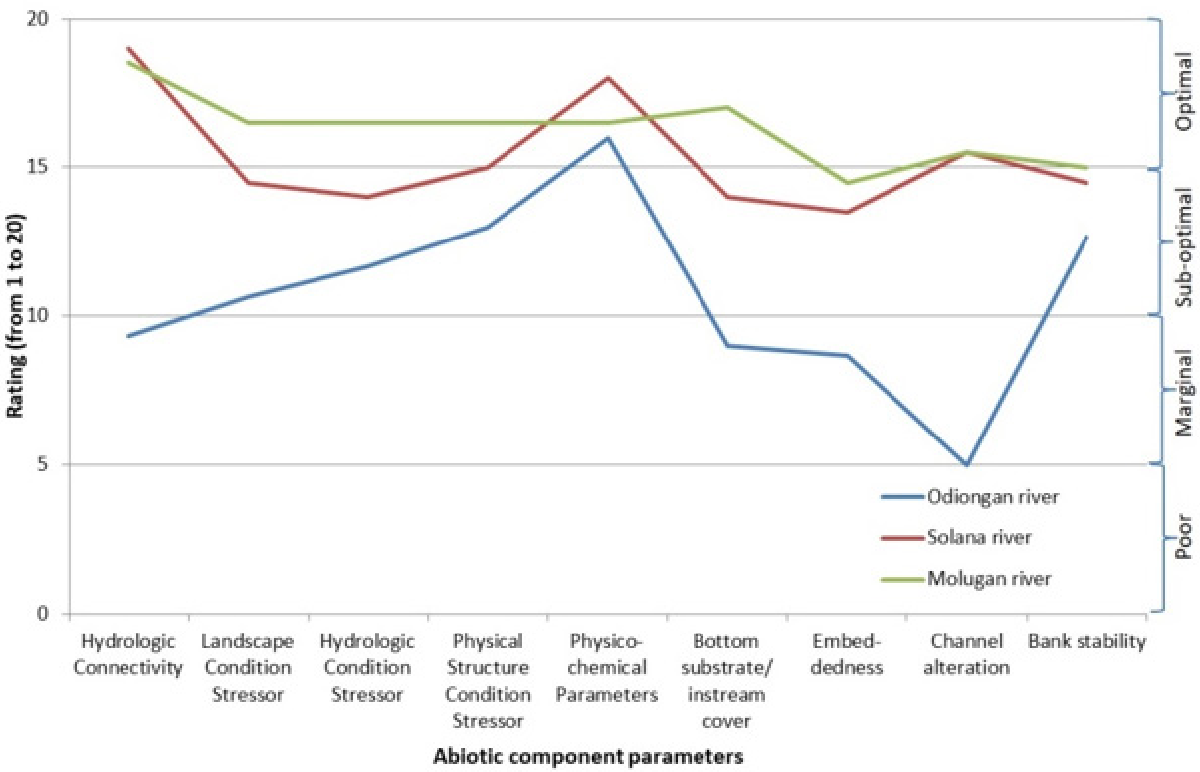

Figure 4. Rating of the parameters under the abiotic component

Table 3

Physico-chemical water properties in Molugan, Solana and Odiongan rivers.

Parameters	Molugan				Solana				Odiongan					
	Upstream		Down-stream		Upstream		Downstream		Upstream		Midstream		Downstream	
DO (mg/L)	8.67	P	8.14	P	8.13	P	8.46	P	9.06	P	8.99	P	8.69	P
Electrical Conductivity (mS/cm)	0.46	n/a	0.57	n/a	0.09	n/a	-18.08	n/a	0.1	n/a	0.11	n/a	0.12	n/a
Nitrate (mg/L)	0.74	P	0.78	P	1.81	P	0.72	P	0.66	P	0.73	P	0.67	P
ORP (mV)	238.58	n/a	246.7	n/a	336.83	n/a	284.42	n/a	288.92	n/a	289	n/a	263.75	n/a
pH	8.71	F	8.48	P	6.78	P	8.14	P	7.58	P	8.07	P	8.13	P
pHmV	-131.17	n/a	-18.18	n/a	-45.83	n/a	-98.17	n/a	-84.92	n/a	-92.33	n/a	-111.25	n/a
Salinity (ppt)	0.2	n/a	0.26	n/a	0.03	n/a	0.08	n/a	0.03	n/a	0.03	n/a	0.03	n/a
TDS (g/L)	0.3	P[b]	0.37	P[b]	0.06	P[b]	0.12	P[b]	0.07	P[b]	0.07	P[b]	0.08	P[b]
TSS (mg/L)	5.96	P	39.8	F[a] P[a+]	2.66	P	7.8	P	2.49	P	16.23	P	30.9	F[a]
Turbidity (NTU)	3.99	P[c]	26.64	F c	4.62	P[c]	6.42	F[c]	0	P[c]	17.12	F[c]	32	P[a+]
Temp. °C	26.75	P	29.34	P	25.39	P	28.63	P	25.26	F	25.49	F	26.93	P

P-passed; F-Failed; n/a-not applicable/no set standard; [a] based on DAO 2016-08 river class AA; [a+] based on DAO 2016-08 river class A and B; [b] based on DAO 34; [c] based on PNSDW

observed stressor in Solana. In Odiongan, other observed stressors were flow diversions or unnatural inflows such as restrictions and augmentations, flow obstructions due to presence of culvert and paved stream crossings, dredged inlet/channel, and ground water extraction.

Stressors to the physical structure of the rivers were also evaluated. Molugan was rated optimal for this parameter while both Solana and Odiongan were considered as sub-optimal. The same with the previous stressors, relative absence of stressors in minimal area was observed in Solana, while approximately less than 10% of the assessment sites were observed with stressors in the Molugan and Odiongan rivers. Presence of trash and traces of pesticides are the common stressors observed in the three rivers. Unsustainable vegetation management practices were also observed in Molugan and Solana rivers, while resource extraction of sediment and gravel and excessive sediment due to erosion and slope failure were observed in Odiogan river.

Physico-chemical analysis of water is another parameter considered under the abiotic component. All rivers were considered to have an optimal condition for its water quality based on its physico-chemical properties with only 1 or 2 parameters failing to qualify water quality standards. Table 3 shows the results of the water quality assessment through physico-chemical analaysis for the three rivers. These are the average of the four water quality test and sampling. For Molugan in particular, pH slightly went beyond the standard range of 6.5-8.5 of DAO 2016-08. Turbidity and TSS also failed in the downstream site of Molugan. Turbidity went beyond the allowed maximum threshold of 5 NTU based on PNSDW while TSS failed the maximum allowed level of 25mg/L of DAO 2016-08 for river class AA but passed for other river classes A, B and onwards. For Solana river, water quality in the upstream site passed the set standards of DAO 2016-08, DAO 34 and PNSDW. In downstream site, turbidity slightly went beyond the maximum level of 5NTU. For Odiongan, temperature in the upstream and midstream sites slightly went below the lowest set standard range. Turbidity in upstream site is within acceptable threshold level while in midstream and downstream sites, turbidity is very high going beyond the set maximum level. TSS is within an acceptable level in midstream but failed in downstream site. Generally, waters in the Molugan, Solana and Odiongan are still with good quality conditions classified as class A or Public Water Supply Class II water source requiring conventional treatment to meet latest PNSDW (DENR, 2016). However, turbidity remains a common problem in the three watersheds. Along with TSS, it acts as primary indicators of deteriorating water quality.

Bottom substrate which also known as the instream cover refers to the presence of materials in the stream that could serve as the habitat for organisms. These include large woody debris and litters that are necessary for the productivity of organisms in this habitat as influenced by the physical, chemical and biotic characteristics of the river

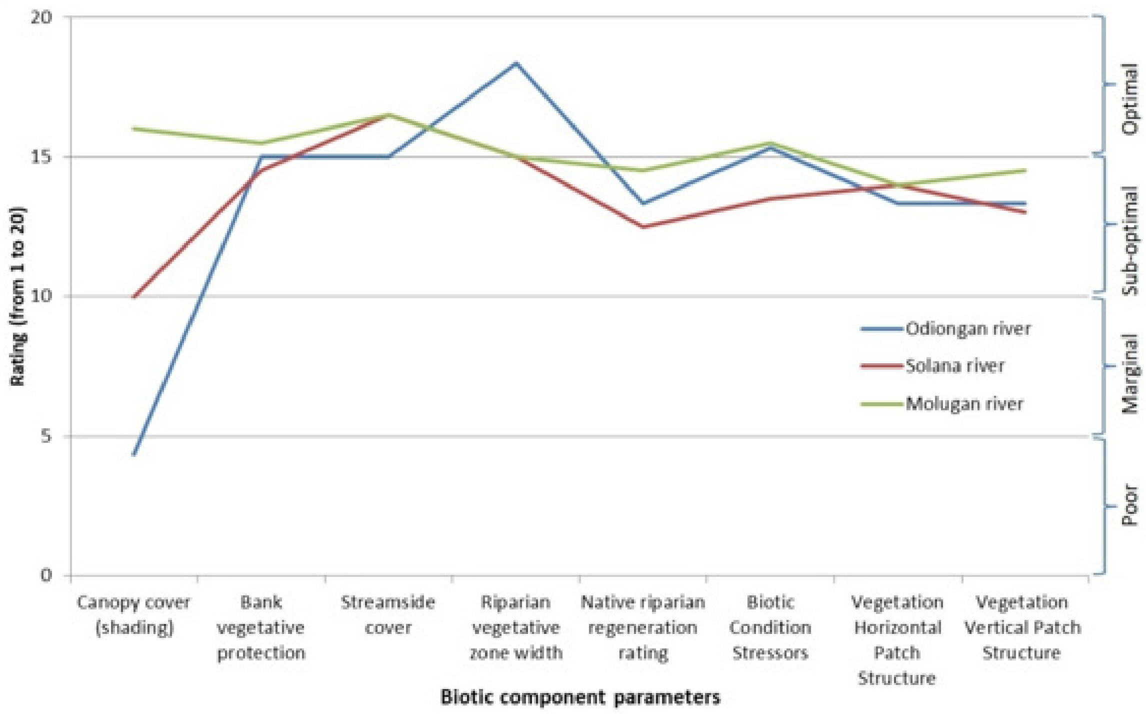

Figure 5. Rating of the parameters under the biotic component.

(Poff et al., 2012). Of the three rivers, Molugan attained the highest rating still considered as optimal, followed by Solana at the sub-optimal condition and lastly by Odiongan rated marginal in condition. Molugan assessment sites are observed with greater than 50% of mix gravels with submerged logs, undercuts banks and other stable habitat in the stream. Solana is with only around 30-50% of mix substrates present in the assessment sites while around 10-30% were only observed in the streams of Odiongan.

Embeddedness is the parameter that refers to the presence of fine sediment in the river bed determined through the extent to which rocks are buried by these fine sediments. Both Molugan and Solana are considered at sub-optimal condition with the rocks in the river surrounded by 25-50% fine sediment. Odiongan was rated marginal observed with 50-75% of fine sediments in the river bed. Embeddedness is one factor used in characterizing stream bed which is commonly associated to degraded habitat (Sennatt et al., 2006).

Channel alteration is another parameter considered in the assessment of the rivers in Misamis Oriental. The change of course of rivers which may result from eroding banks and incrased deposition of the gravel and sediment bars in the stream can be an indicator of degraded river. Molugan and Solana rivers were rated sub-optimal for this parameter as characterized by an observable formation of sand bars most from course gravel with presence channelization or changing course of water flow. Odiongan on the other hand was rated poor considered as having a degraded condition as characterized by heavy deposits of fine material, increased bar development and extensive channelization. Bank stability which refers to the stability of the river banks against erosions were assessed and found out at sub-optimal condition for all the three rivers characterized with moderately stable with infrequent occurence and presence of small erosions in some areas. The stability is singificant in regulating flow and sediment routing (Amper et al., 2019).

Biotic Component Condition

Biotic component of riparian areas in this study refers to the vegetation as one of those which constitutes the ecosystem that provide a variety of ecological services such as the filtering out of sediments, nutrients, pesticides, wastes and other non-point source pollution (Poff et al., 2012). Different parameters in touch with this component were assessed. Figure 5 shows the results of the assessment of riparian habitats focusing on the biotic component in the rivers of Molugan, Solana and Odiongan. The rivers general riparian habitat biotic conditions are all at optimal which imply suitable biotic condition with very minimal disturbance.

Canopy cover is a parameter used as an indicator of vegetation stand density in the riparian areas of the rivers. Of the three rivers, Odiongan obtained the lowest rating classified as poor due to relative lack of canopy with full sunlight reaching the water surface. This is mainly due to the larger width of the river, disenabling full coverage of the canopies in the river. Molugan is rated optimal with a mixture of canopy cover conditions with some areas of water surface fully exposed to sunlight and with some areas shaded with filtered lights reaching the water. Solana was rated marginal for this parameter due to absence of canopy especially in the downstream site of the river. Absence of shading may result to increased river water temperature affecting aquatic biota (Iakovoglou et al., 2012).

Bank vegetative protection which is evaluated through the coverage of vegetation in the streambank surfaces is all at sub-optimal in three rivers. Molugan, Solana and Odiongan streambanks are generally covered with 70-89% vegetation. For the streamside cover, both Molugan and Solana are rated optimal in condition as characterized by the presence of shrubs and some trees are the dominating vegetation in the streambanks.

Odiongan on the other hand is rated sub-optimal with presence of some shrubs and trees on the streambanks. Riparian vegetative zone width refers to the width of vegetation cover in the riparian areas. Molugan and Solana were rated sub-optimal with existing vegetation cover width of 12-18m from the river banks towards adjacent riparian areas. Odiongan river however was rated optimal and has an observed vegetation width of more than 18m. The presence and extent of width of riparian forest buffers play significant roles in denitrification process reducing introduction of nitrates in streams, hence protecting water quality (Iakovoglou et al., 2012).

Native riparian regeneration rating parameter refers to the presence of saplings and seedling trees with obvious regeneration in the riparian areas. All rivers are rated sub-optimal as seen in the presence of scattered seedling patches with 1%-5% cover in the assessment areas.

Activities in the surrounding riparian areas considered as stressors to biotic condition were identified in this assessment. All rivers were rated sub-optimal with several stressors observed in the sites. Biotic condition stressors identified in Molugan are presence of exotic plant species and the lack of vegetation management to conserve natural resources. In Solana, observed stressors are presence of mowing, grazing and herbivory, excessive human visitation, and habitat destruction by domestic livestock. Excessive human visitation, habitat destruction by domestic livestock and presence of exotic plant species were also observed in Odiogan river.

For vegetation horizontal and vertical patch structures parameter, all rivers are rated sub-optimal as characterized by the presence of moderate degree of vegetation patch diversity for the horizontal structure and the presence high structure forest with shrubs and herbs for the vertical patch structure. The types of vegetation determine the capability of the riparian zone to regulate flooding by slowing transit of rainwater in the catchment. With more diverse and higher structure vegetation comes with more "roughness" which can hold back flood peak in high flows (Opiso et al., 2015).

Land Use/Land Cover

The land cover/land use pattern in the watersheds of Molugan, Solana and Odiongan (Figure 6) were mapped and derived from Sentinel-2 satellite image of ESA using eCognition software and ArcGIS 10.2.2. Figure 7 subsequently shows the percent coverage of classified land cover/land use patterns in each watershed. Trees classification which may interchangeably refer to as forest is the most common land cover pattern in the three watersheds. Specifically, Molugan watershed is dominantly covered by tree and brushland classifications. Moreover, a considerable area is grassland followed by coconut and fallow/cultivated areas. Meanwhile, the majority of Solana is covered by fallow and/or cultivated land. Tree forest only covers a small potion. In Odiongan watershed, over half of the watershed area is covered with trees. Other dominating land cover classification is brushland and coconut.

Land use and land cover change is considered as one of the most detrimental factor in impacting soil loss and deteriorating water quality (Sharma & Tiwari, 2009; Dumago et al., 2018). Of the three watersheds, Solana is most prone to soil loss due to the large area occupied by the cultivated land. However its impact is not directly observed in the riparian areas of Solana which is still considered optimal in condition for both the abiotic and biotic components. Urban cover which includes the residential and road classifications is relatively low in percent coverage for each watershed. However, it must be taken note that the increase of urban land use in watershed also increases degradation or removal of riparian vegetation (Iakovoglou et al., 2012).

Population Density

Population growth is one factor that drives physical modification of the watershed through changes of land cover and land use patterns among others placing strain to the environment. Figure 8 illustrates the density of human population in the watersheds of Molugan, Solana and Odiongan. The downstream areas along the watersheds' outlets are all with dense populations. In Molugan watershed in particular, the barangays or the smallest

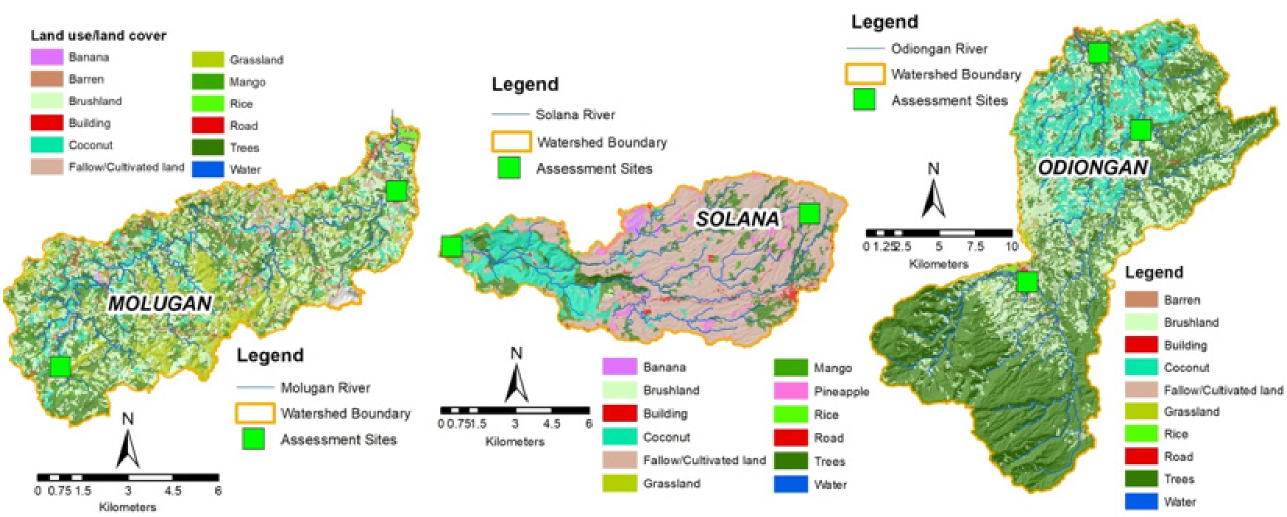

Figure 6. Land cover and land use pattern in Molugan, Solana, and Odiongan.

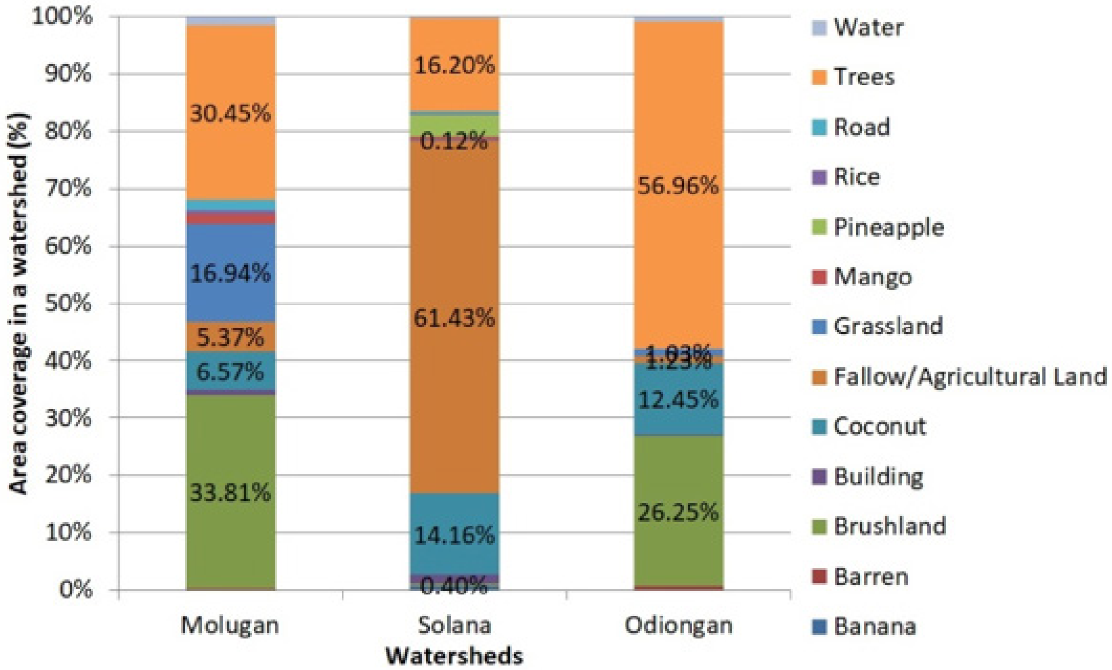

Figure 7. Percentage of land cover/land use classifications in Molugan, Solana, and Odiongan watershed.

administrative divisions in the country with the highest population is in the downstream section of the watershed with a population reaching up to over 5000. Conversely, barangays in the upstream section are with the lowest population. In Solana watershed, the downstream portion of the watershed is likewise with high population. However, population in a portion of the watershed's midstream and upstream is also considerably dense. Lastly, Odiongan's downstream areas are also with dense population. A small portion in the midstream and upstream areas are also with high population. Lowest population is located in the lower midstream section of the watershed.

Population is expectedly high in the coastal areas where most of the establishments are built and national road network is established. The growth of population is translated to the reduction of forest covers due to its conversion to settlements and agricultural cultivation. Even worse, the change in the environment may lead to environmental hazards and exacerbates disasters (Weng, 2010; Wang et al., 2012). Human interventions which maybe indicated by the density of population, type of land cover and use pattern, and other human driven stressors are regarded as critical as it has cumulative effects to riparian ecosystems (Poff et al., 2012). Moreover, with population explosion, water quality degradation in adjacent stream networks is expected. However, for the case of all the study sites, results of river waters are still in good quality.

Stream Order

The stream order represent the longitudinal dimension of the river (Ekness & Randhir, 2007) which was determined using the delineated stream network derived from IfSAR DEM using GIS approach. The ArcGIS 10.2.2 and HEC-geoHMS tool were used in the watershed delineation. The stream ordering was based on the Strahler (1957) ordering system. In this study, identified stream order of assessment site was until 4th order which is mostly the most disturbed stream with the greatest size. Figure 9 illustrates the stream orders of reaches in Molugan, Solana and Odiongan watersheds.

The upstream site in the Molugan is a 2nd order stream while the downstream site is a 3rd order stream. Solana's upstream site is a 1st order stream which is the lowest in all assessment sites while the downstream site is a 4th order stream. The upstream site in Odiongan is a 3rd order. The midstream and downstream sites are classified as 4th order.

The lowest stream orders are those smaller in size mostly located in the upstream areas as the head waters while high stream orders are those near the drainage mouth. Due to its remote location from possible disturbances, lower stream orders are associated mostly with riparian habitat condition. This is in conjunction with the result of this study where scores for both abiotic and biotic components are higher as implied with better habitat condition in upstream than the downstream sites. Moreover, upstream sites in each watershed are scored higher than the downstream sites for the water quality assessment because almost all of the parameters passed the set water quality standards.

Stream order, along with other factors, influences habitat quality for animals. Streams with higher orders are less likely to have less protection for the natural animal inhabitants. Moreover, it is much suggested that habitat protection must focus on the headwaters with lower stream order for the benefit of the whole drainage basin (Ekness & Randhir, 2007). Especially in Solana basin where cultivated land dominates even in the upstream site of 1st order, management must be critically considered to protect downstream sections of the watershed.

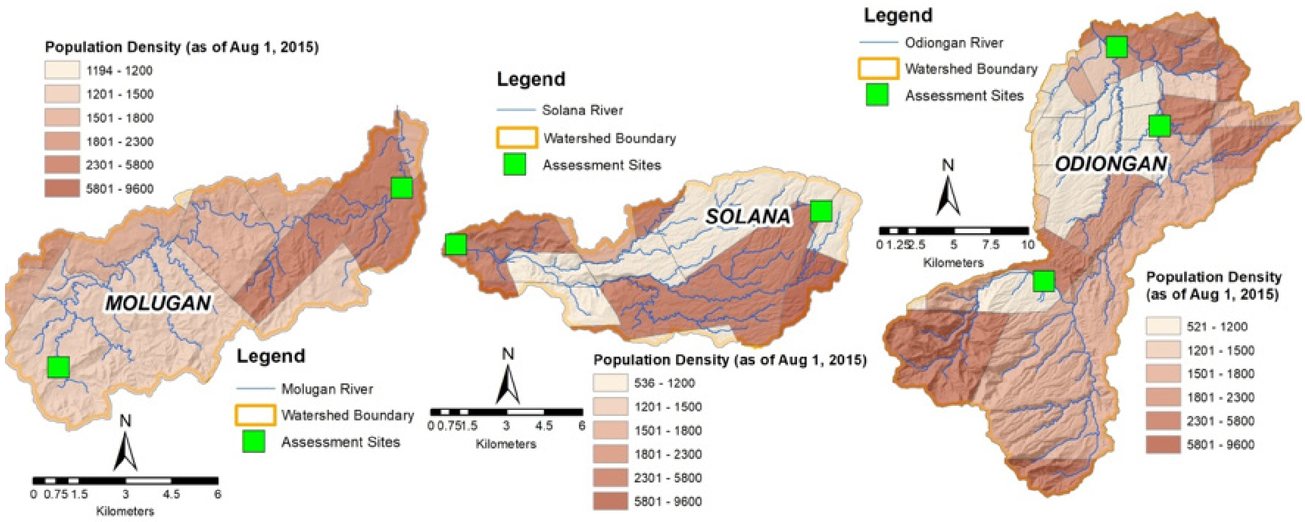

Figure 8. Density of Population in Molugan, Solana and Odiongan watersheds according to PSA (2015)

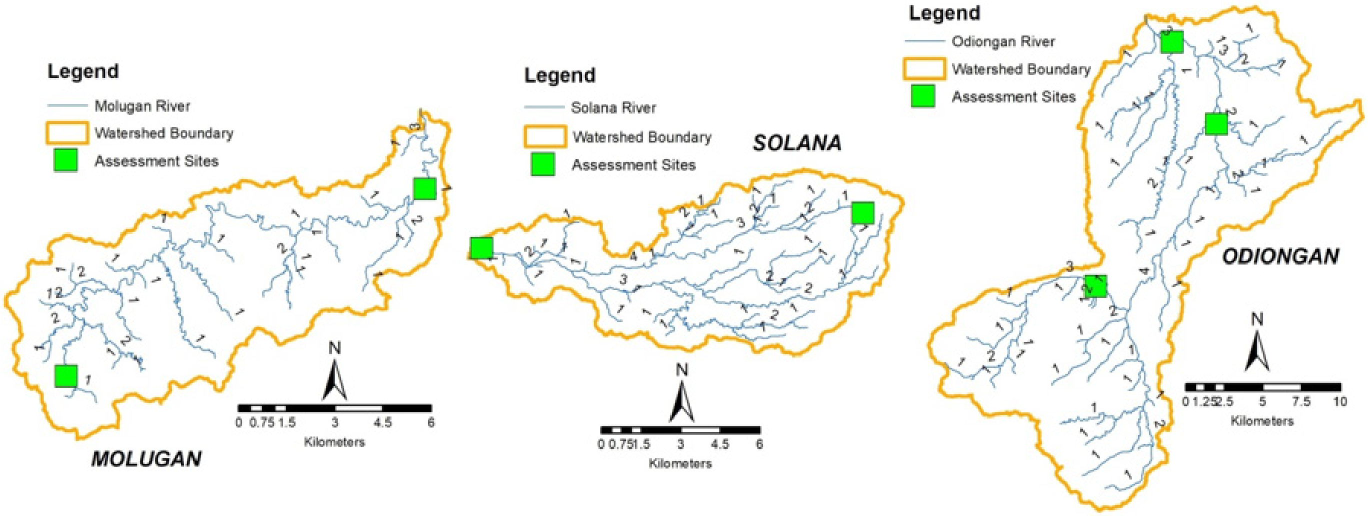

Figure 9. Stream order of the tributaries of Molugan, Solanam and Odiongan watershed.

Slope

Figure 10 depicts the slope classified according to DENR (2008) slope classification. The Molugan upstream specifically the surrounding 500m is mostly made of 30-50% slope followed closely by 18-30% slopes characterized by a very steep and steep slope, respectively. Majority of downstream site of Molugan is level to gently sloping which is the category with the lowest slope percent. Moderate slope follows which occupies 33% of the surrounding area of the assessment site. Almost half of the upstream site in Solana is dominated by moderate slope with slope within 8-18%. Moreover, the downstream site is mostly with level to gently sloping topography. More than half of Odiongan upstream site consists of level to gently sloping areas. The midstream site meanwhile is almost equally distributed with varying slope classification. For the downstream site of Odiongan, majority of the area is level to gently slope.

Slope is inherently a landscape factor that affects environmental conditions and disturbance regimes (Mendez-Toribio et al., 2016). Mostly, presence of stressors to habitat condition are available on lower reaches of hill slopes especially in moderate slope of less than 7% slope and near human settlements which may be attributed to slope instability with higher slopes being more unstable than those with lower slope (Mendez-Toribio et al., 2016; Punchi-Manage et al., 2013). In all downstream sites of the three watersheds including the upstream site of Odiongan, majority are with level to gently sloping topography. As mentioned, these areas are mostly exposed to disturbance of anthropogenic activities. Moreover, the moderate slope to steep including the very steep slopes in in some assessment sites areas may imply the less access of these areas to disturbances such as human visitation and grazing of animals.

CONCLUSIONS

This study revealed that the Odiongan river has the least ideal general riparian habitat condition followed by Solana and lastly by Molugan. The presence of different stressor indicators in Odiongan specifically in the midstream assessment area pose as the threat to the condition of the riparian habitat. Moreover, the relative size of the river particularly from the midstream section down to the mouth of the river makes it harder to regulate occurring erosions along the river banks, siltation and occurring channelization which are the worse observed deteriorations in this river. This problem is exemplified in

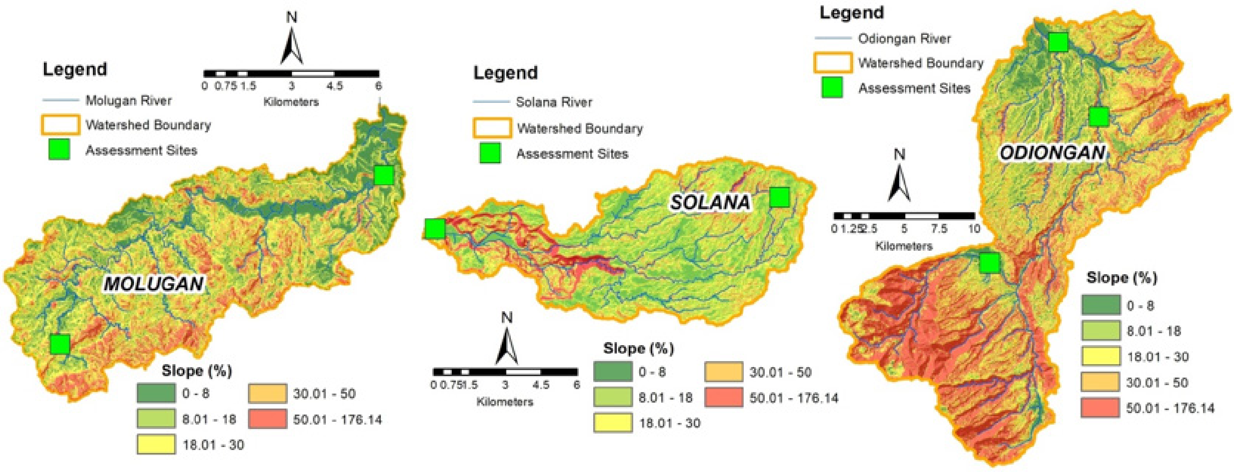

Figure 10. Slope map of Molugan, Solana and Odiongan watersheds.

the water quality condition of the river which failed in set standards for the turbidity and TSS parameters. Moreover, in between the two components considered in the assessment, the abiotic component appears to be more disturbed in Odiongan river than the biotic component.

Hence, recommendations in managing the watershed of Odiongan should put weight more on the abiotic component with the regulation of stressors such as the presence of residential houses, dry land farming, ranching and physical resource extraction or quarrying along the stretched of the river. Conversely, the biotic component of the riparian areas appear to be more disturbed than the abiotic component observed both in Molugan and Solana rivers. Therefore, management practices in these rivers should focus more on conserving riparian vegetation without neglecting the regulation of the stressors existing in the watershed.

Water quality assessment revealed that the water in Molugan, Solana and Odiongan rivers are recognized as applicable for domestic use when applied with conventional water treatment classified as class A water body. However, turbidity is the common problem in the three watersheds going over the maximum allowed set standard specifically on the downstream sites of the three rivers including the midstream site of Odiongan. TSS is also very high and failed in the downstream sites of Molugan and Odiongan which along with turbidity are primary signs of water deterioration. Conservation measures to improve water quality conditions must be implemented in the downstream portions of the rivers. These measures may include the establishment of a riparian buffer such as planting of shrubs and trees and maintaining the prescribed buffer width. Moreover, the encroachment of residential houses should be regulated in these areas.

Of the three watersheds, Solana showed the greatest percentage of cultivated land hence conservation measures must be placed with utmost attention for this watershed through appropriate agricultural practices and the maintenance of vegetation buffer in stream networks. The implementation of greenbelt establishment must be stricter in the downstream portions of the watersheds where the population is denser and the slope is more level giving the greatest accessibility for disturbance.

Generally, all watersheds are still considered with suitable riparian habitat conditions with the presence of minimal disturbances. However, it is still recommended that conscious regulation for the expansion of agricultural cultivation must be observed especially in the upstream areas of the watersheds. Moreover, appropriate land use zoning must be implemented giving emphasis on the establishment of appropriate riparian vegetation buffer widths along stream networks and the integration of natural conservation strategies. Through these measures, riparian areas will be repopulated with vegetation restoring ecological functions especially in attenuating flood scenarios among others.

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