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Physical Profile of the Major Rivers in Eastern Samar inside the Samar Island Natural Park (SINP)

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Abstract

The study was conducted to illustrate the physical profile of the three major rivers of Eastern Samar inside the SINP to serve as a reference for the river landscape. Highlights of the profile are river width, depth, water velocity and water flow rate, potential source, river stretch, flood height and flood plain as inputs to development and disaster planning. Data presented here were based on field surveys supported and guided by reference maps. Based on the survey, a potential source of Oras and Ulot-Can-avid Rivers is San Jose de Buan, Samar while Suribao River flows from the closed-canopy forest from Borongan-Maydolong-Llorente (Eastern Samar). Flooding and erosion were observed in the three rivers, but the highest silt deposits and the widest flood plain were in Oras River, with the highest water flow rate in the upstream. Erosion and quarrying were observed in all rivers. Bamboo reforestation is conducted in Suribao River as river bank erosion control measures. Results of the survey revealed the high risk to our rivers and river villagers due to flooding and erosion, in addition to the loss of properties and livelihood, and the ecological conservation of the landscape. Collective rehabilitation measures should be crafted for a unified action to address environmental issues parallel to development plans to promote but sustainably manage our resources and protect our villagers.

Keywords

SINP, Oras River, Ulot-Can-Avid River, Suribao River, Eastern Samar

1. Introduction

Rivers were the most common network avenue of transportation in the previous time, when the road network was not yet developed. Still, at present, rivers provide a lot of ecosystem services, including those with adverse impacts. Extensive anthropogenic activities mostly for livelihood in the upland are concealed with the economic benefits [1] [2] [3] [4]. However, rivers are fragile bodies of water that has a close proximity and interdependence with the terrestrial ecosystem. As such, the interplay of these two ecosystems shapes the river. In previous years, flooding was experienced only during strong typhoons, but recently, it has been observed frequently and the scale of coverage is increasing, as an impact of climate change [5]. This fluvial process changes the landscapes and river channels by various factors [6] [7]. The frequent occurrence of flooding and other disasters has been brought to the attention of our policymakers. However, policies should be stronger if it is supported with scientific data. Light Detection and Ranging (LiDAR) Survey and flood mapping were conducted in Dolores [8] and Oras Rivers [9], which identified areas exposed to flooding. With the many rivers on the Samar Island, the profile of which is limited to none.

The 333,300 hectares Samar Island Natural Park (SINP) is geographically located at 11.8141˚N, 125.1608˚E. It encompasses the three provinces of the Samar Island. As rivers are very dynamic, their landscape is influenced by hydrogeomorphic processes. This paper will serve as one of the references to the river landscapes of the three major rivers in the area. The cross-section profiles of each river segment are the most visible observations for a change in the landscape, which can provide inputs in disaster management and development plans.

Eastern Samar is classified as high susceptibility to flooding (*i.e.* likely to experience flood heights of more than one meter and/or flood duration of more than three days) as frequently visited by tropical cyclones. Two of the Top 10 Deadliest Weather-related Disasters in the Philippines (1970-2019; 2008, 2013) were experienced; and likewise, a maximum wind speed of 270.1 - 300 kph for a 200-year return period may be experienced in the area [10].

2. Methodology

2.1. Location and Sampling Points

The Ulot-Can-avid, Oras and Suribao Rivers are the major rivers of Eastern Samar inside SINP. The potential sources of the rivers were located based on the Google maps and validated with the field observations, and collective information from the key informants in the area, *i.e.* farmers and forest guards in the headwaters of the three rivers.

The profile of the rivers was based on the observations collected from 2021 to 2022. Data were collected from the two 200-meter sampling stations of each river segment: up-, mid-, and downstream, with at least three kilometres distance. The geographical locations of the sampling stations are shown in **Table 1**. Sampling stations were established along a straight channel, free from obstruction and with uniform river flow. For consistency of data, procedures were all conducted towards the downstream.

Table 1. Geographical locations of the sampling stations of the three rivers.

River/River Segment	Geographical Locations	Reference
Ulot-Can-avid River		
Headwaters	11˚59'45.00"N; 125˚03'05.6"E	San Jose de Buan, Samar
Upstream 1	11˚53'00.4"N; 125˚04'15.2"E	Conception, Paranas, Samar
Upstream 2	11˚51'41.93"N; 125˚05'01.03"E	Lawaan 2, Paranas, Samar
Midstream 1	11˚51'46.22"N; 125˚13'49.7"E	Deni Point, Paranas, Samar
Midstream 2	11˚53'7.74"N; 125˚14'53.13"E	Tula, Paranas, Samar
Downstream 1	11˚58'24.55"N; 125˚19'01.55"E	Salvacion, Can-avid, Eastern Samar
Downstream 2	11˚59'19.70"N; 125˚21'30.84"E	Camantang, Can-avid, Eastern Samar
Oras River		
Headwaters	12021'28.60"N; 125010'14.31"E	Catubig River, Northern Samar
Upstream 1	12˚17'18.45"N; 125˚14'14.40"E	Town Proper, Jipapad, E. Samar
Upstream 2	12˚17'02.43"N; 125˚14'14.34"E	Town Proper, Jipapad, E. Samar
Midstream 1	12˚14'35.98"N; 125˚15'02.02"E	Concepcion, Arteche, E. Samar
Midstream 2	12˚13'25.78"N; 125˚17'25.91"E	Tawagan, Arteche, Eastern Samar
Downstream 1	12˚11'17.21"N; 125˚23'51.96"E	Iwayan, Oras, Eastern Samar
Downstream 2	12˚09'35.00"N; 125˚24'53.93"E	Agsam, Oras, Eastern Samar
Suribao River		
Headwaters	11˚31'53.79"N; 125˚14'58.73"E	Pinanag—an Borongan City
Headwaters	11˚25'16.32"N;125˚25'36.42"E	Magtino, Llorente Eastern Samar
Upstream 1	11˚29'20.20"; 125˚20'7.42"	Patag, Maydolong, Eastern Samar
Upstream 2	11˚29'39.06"; 125˚20'51.23"	Baras, Maydolong, Eastern Samar
Midstream 1	11˚29'9.09"N; 125˚23'14.70"E	Benowangan, Borongan, Eastern Samar
Midstream 2	11˚29'2.34"N; 125˚24'47.19"E	Guindalitan, Borongan, Eastern Samar
Downstream 1	11˚30'7.78"N; 125˚25'2.45"E	Malobago, Maydolong, Eastern Samar
Downstream 2	11˚30'8.55"N; 125˚26'3.57"E	Canluterio, Borongan, Eastern Samar

2.2. River Discharge and Physical Characteristics

The physical characteristics of the river were observed in each cross-section of the river segment. Water velocity and discharge were measured by floatation method [11]. The physical characteristics of the river segments were described in terms of sediment type of the channel bed, river width, floodplain, height of the river bank, and river depth. River bed sediment type was based on the 100-gram sediment samples.

2.3. River Profiling

Sampling points were identified along the three river segments—upstream, mid-stream, and downstream. Two plots of 200 m sampling points were established in each segment where, the river width, depth, water velocity and water flow rate, substrate type, floodplain and flood height were measured based on the average readings. Observations were taken from three points, the both sides and the center of every 0, 100 and 200 meters. In deeper points of the river and in areas where the current was strong, observations were taken using a boat.

The river width was measured based on the distances covered across the river margins with reference to the 20 GPS readings at every 10 meters from both sides of the river margins plotted in the Google Earth map. The river depth was measured using a digital echo sounder. A 5-kg plumb bob was used to manually validate the depth and to collect the sediments. A 50 g fabricated float was deployed for two minutes in three trials to measure the water flow rate, which was translated into water velocity using the standard formula with reference to the width and depth.

The floodplain was based on the horizontal regions reached by the over flow of the river. Flood height refers to the vertical reach of the water brought by the additional volume of water during regular days. This information was revealed by the key informants of the community through a focused-group discussion, in addition to the observations along the river, *i.e.* height of trash left in the trunks and the watermarks both on the river banks and in the community.

3. Results and Discussion

Ulot-Can-avid River and Oras River flow from San Jose de Buan, Samar, (11˚59'45.00"N; 125˚03'05.6"E) which is located at the heart of the Samar Island at 850 m above sea level (MASL). The former stretches to Can-avid, Eastern Samar through the western side. Oras River starts from Jipapad, Eastern Samar, and is the convergence of their local Cagmanaba Falls and the Catubig River from the northern side of the Samar Island, which was also traced from San Jose de Buan, Samar. The third major river is the Suribao River located at the center of Eastern Samar. It was traced from the close canopy forest of the three municipalities from Borongan, Maydolong and Llorente (Eastern Samar). The river serves as the boundary of two municipalities, Borongan in the north and Maydolong in the south.

3.1. Ulot-Can-Avid River

Ulot-Can-avid River has an estimated stretch of 112 km towards the river mouth at Can-avid, Eastern Samar. The river has a span of 52 meters with a depth of 3.0 meters. The flood height is 6.0 meters that overflows the 4.0 meters river bank, extending the flood plain to 13.0 meters. On fluvial dynamics, the water velocity is 0.23 mps with a water flow rate of 12.9 m^3/sec. Generally, the substrate is composed of pebbles (4 - 64 mm) from the upstream to the midstream, with very coarse sand (1 - 2 mm) to granules (2 - 4 mm) in the downstream. The cross-section profile of the river segments is shown in **Figure 1**.

The upstream segments of the river are wadeable, which could be attributed to the steep elevation and the absence of activity or movement in the area. The

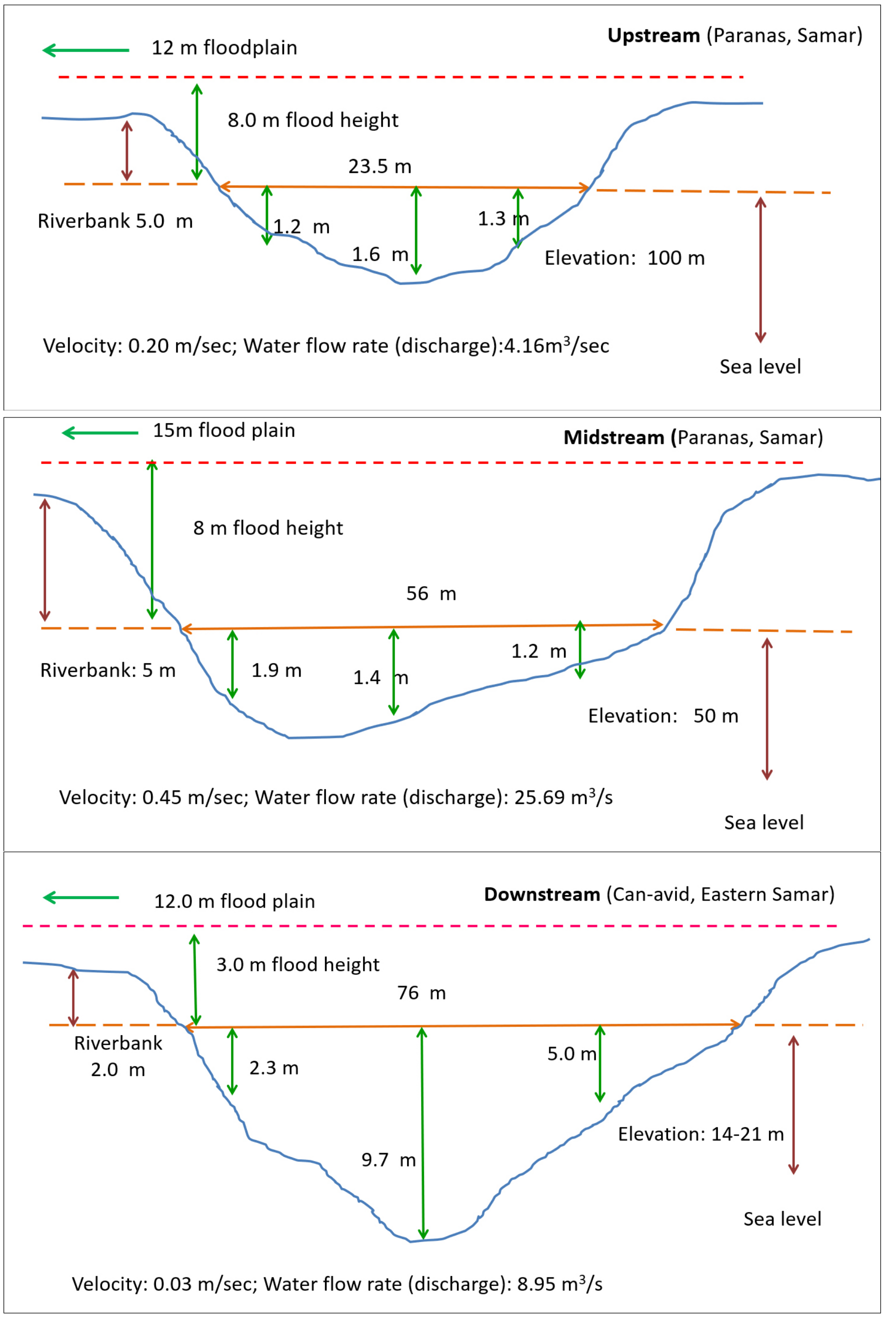

Figure 1. The cross-section profile of the river segments of Ulot-Can-avid River (drawn not to scale).

segment was abandoned as a transportation access along the area when the road going up to San Jose de Buan, Samar was constructed. However, the midstream and the downstream of the river remained as the major access route of transportation for the communities along the river to reach the border barangays of the adjacent provinces, Samar through the municipality of Paranas and Eastern Samar through the municipality of Can-avid.

The midstream has the highest flow rate brought by the overflow from the upstream and the steep difference of elevation. The shallow depth is due to erosion of the river bank including its vegetation such as coconut trees. The river channel migration in this segment is observed due to growth of vegetation in the deposited sediments in the north river margin, while the zone of erosion is increasing in the opposite river bank. Erosion was observed in all river segments as shown by the dilapidated structures along the river bank. The downstream is a busy segment with various anthropogenic activities that include quarrying, fishing and bivalve collection, in addition to being the major access route of the upstream barangays.

3.2. Oras River

The segments of the 39.0 km river stretch across the three municipalities of Eastern Samar, Jipapad (upstream), Arteche (midstream), and Oras (downstream). Jipapad is one of the two upstream municipalities of Eastern Samar, and is along the border of the province connecting to Northern Samar in the east. The river has a span of 47.44 meters and a depth of 3.0 meters. The flood height is 6.0 meters, higher than the 4.0-meter river bank, hence the occurrence of flood. The flood plain reaches to 100 meters, submerging the residential community in a meter. On fluvial dynamics, the water velocity is 0.35 mps, with a water flow rate of 25.3 m^3/sec. Generally, the substrate is sand from the upstream to the midstream, with an estimate of 0.25 meters clay to silt deposits in the downstream.

The water velocity and the water flow rate decrease as it flows downstream with wider width, with a decrease of the depth at the midstream. The cross-section profile of the river is shown in **Figure 2**.

The upstream is non-wadeable with the highest depth of 4.0 meters and with the strongest water flow rate over the midstream and downstream segments. Flooding had been experienced by the communities in the upstream (Jipapad) and midstream (Arteche). The strong water velocity can be attributed to the steep elevation and the volume of the water from the convergence of the two sources of the river, from the north and west regions. The shallow midstream can be attributed to erosion, exposing the hard rock layer of the river bed, and silt deposition of 0.5 meters (thigh-depth) was observed along the river bank in the downstream (Oras). Runoff velocity is positively and exponentially correlated with D_{50} index sediments (98.5 μm) [12]. The major composition of the river bank is sand which is vulnerable to erosion.

3.3. Suribao River

The source of Suribao River was traced from the *Bihid Falls* along the border of Maydolong, Eastern Samar, within the closed-canopy forest of Borongan, Maydolong and Llorente (Eastern Samar) with an average elevation of 85 meters (range is 22 to 134 meters). The river has an estimated stretch of 59 km, with a span of 88 meters and a depth of 3.0 meters. With the flood height of 7.0 meters, the water overflows the 8.0-meter river bank, submerging the community in a flood

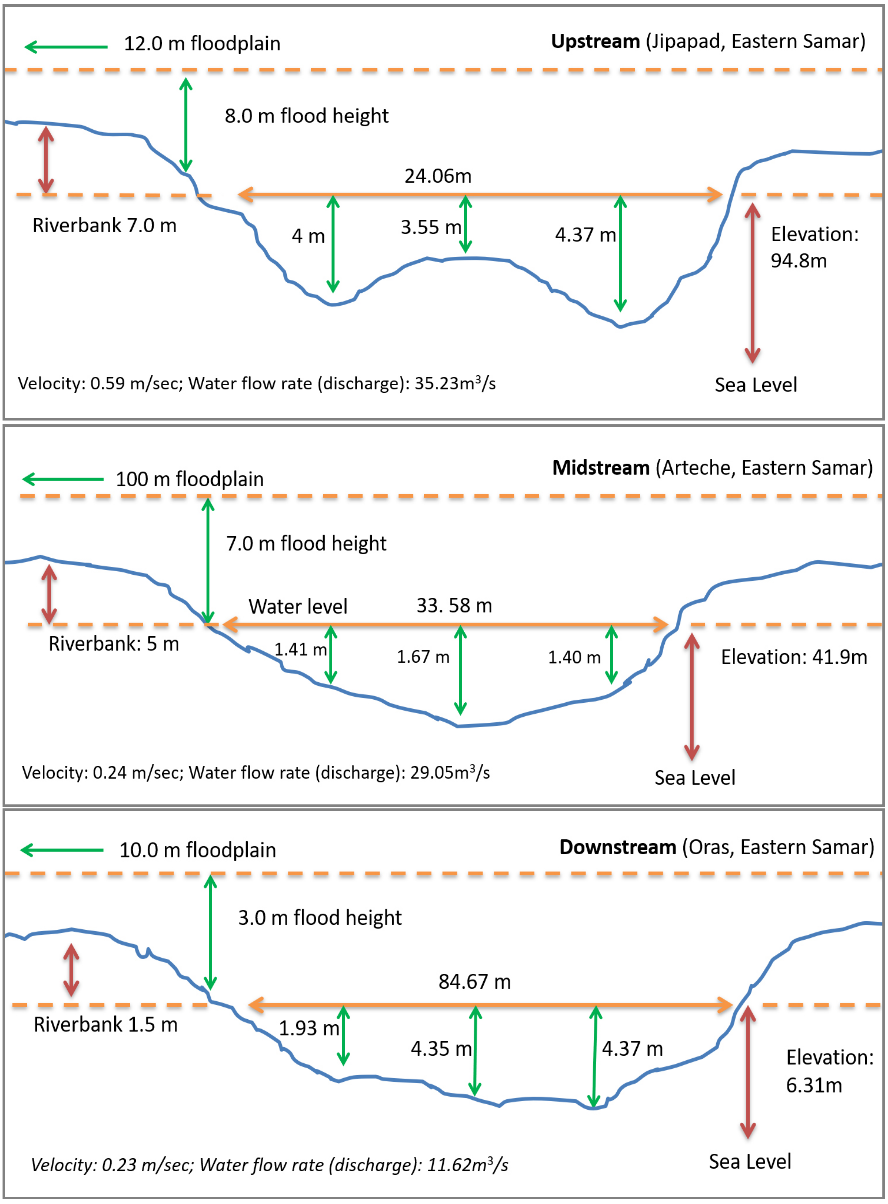

Figure 2. The cross-section profile of the river segments of Oras River (drawn not to scale).

plain of 7.0 meters in the upstream and midstream to 2 meters the highest. On the fluvial dynamics, the water velocity is 0.19 mps with a water flow rate of 14.74 m^3/sec. The velocity is highest in the upstream with the most shallow depth and least width. The river bed is composed of pebbles in the upstream to the midstream (4 - 64 mm) and sand in the downstream. The profile of the river segments is shown in Figure 3.

Generally, the river is non-wadeable in all segments, though there are certain spots in the upstream that are wadeable and hard to navigate due to strong currents. The composition of the river bank in the southern side (Maydolong) is clay while a solid rock cliff in the northern side (Borongan) with high elevation. Flooding is experienced in the upstream and midstream barangays of the southern

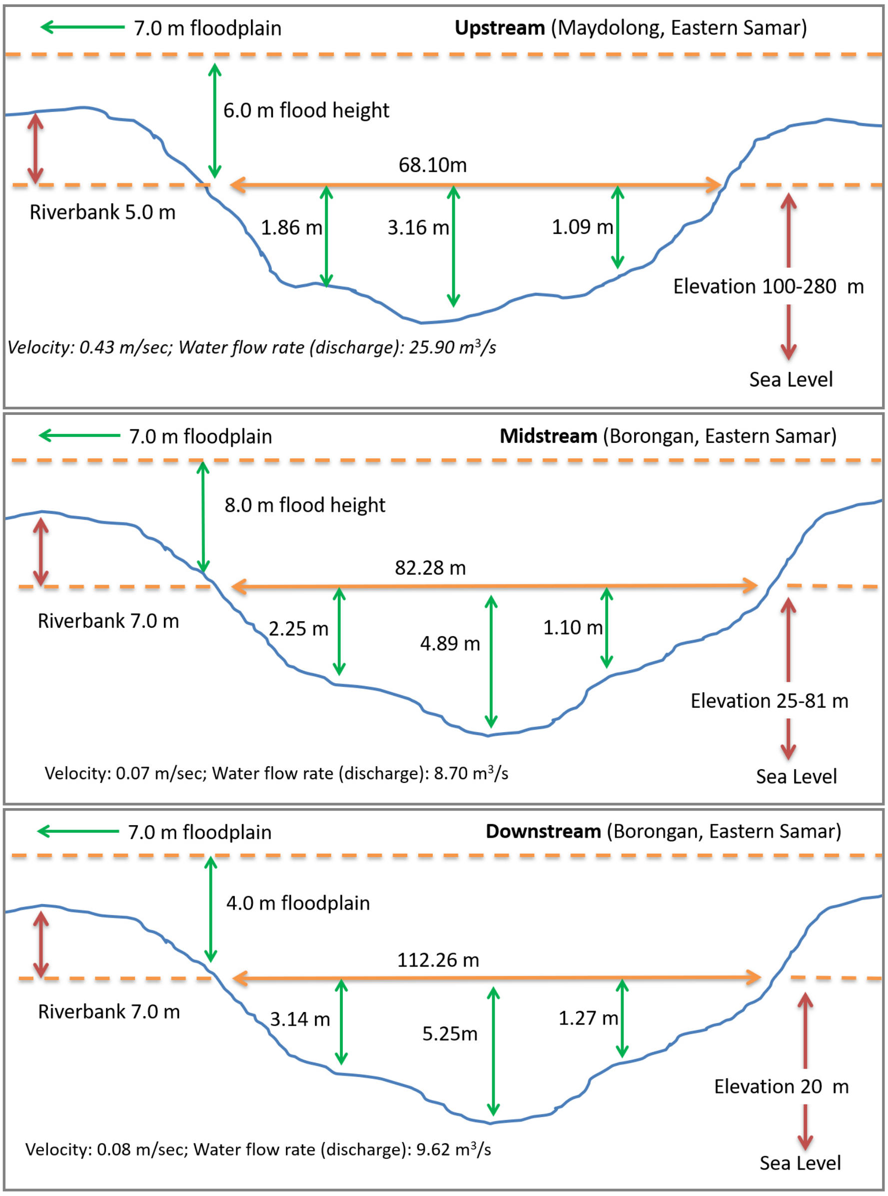

Figure 3. The cross-section profile of the river segments of Suribao River (drawn not to scale).

side of the river. The river still remains as the major access route to the upland barangays of Maydolong.

In-stream quarrying is a continuing activity in the downstream of all rivers which was raised as the environmental issue of the residents. This does not only degrade water quality [13], but also damage the river channel [14]. Such anthropogenic activity alters the physical environment, especially if digging goes below the existing river bed [15]. Moreover, it influences soil erosion [16], change of water flows, and flood regulation [17]. Dredging for sand and gravel quarrying can lower the bottom channel [18] river bed widening and lowering [19] which could be attributed to the high water depth of the downstream segments of the rivers.

Moreover, the rivers are still the major access route of transportation using motorized boats. The weight of the load and the frequency of trips per day are contributing factors of propeller scouring of the river bottom [20], a similar case in Calbiga River in the Samar Province [21]. Elevation, strong velocity and flow rate discharge support the erosion process. The elevation and meandering shape of the rivers are attributed to the flow rate (discharge). It facilitates erosion and sedimentation, though it promotes diverse riparian ecosystem [5], especially in steep watersheds subjected to frequent heavy rains despite heavily vegetated conditions [22]. River banks with high silt-clay contents are the most susceptible to erosion by sub-aerial processes. High susceptibility may influence spatial variations in bank erosion processes and rates, including downstream changes in the effectiveness and significance of sub-aerial erosion [23]. Sediments are key aspects that shape the environment brought by the dynamic behaviour of surface watercourses [24]. This is a possible disaster threat that could displace a community or a reduction of land property, farms and other livelihood in the area.

Flooding leaves a heterogeneous imprint, consisting of remnant vegetated patches, remnant physical patches, and newly created physical patches, which may result in multiple trajectories of ecological response to the flood, with important consequences for biodiversity conservation [25]. The experienced flooding in the areas of Arteche and Oras conforms to the identified areas in the flood maps of Dolores and Oras [8] [9]. Riverbank erosion, on the other hand, introduces displacement, hidden hunger and poverty, loss of land and identity of coastal people [26]. The loss of coconut trees and farms observed along the communities in Ulot-Can-avid River due to river bank erosion is a social issue that needs to be addressed. During the survey, a reforestation of bamboo along the river bank was observed in Suribao River as erosion control measures. With the fluvial dynamics of rivers, water channel migrates by 30 m/yr [27].

4. Conclusions and Recommendations

The study revealed the high risk of our rivers to flood and erosion, which consequently brings the villagers at risk. The highest flood height and widest floodplain were observed in Oras River, which affected the communities in the upstream and midstream areas. This indicates that Oras River is the most vulnerable considering the volume of water brought by the convergence of two river sources and the type of sediment material of the river bank.

Enhancing watershed protection, regulating the quarrying activities and reforestation along the river bank, and quantifying the sand/gravel extraction and sediment balance to provide scientific information as inputs in policy formulation of quarrying activities, are only a few of the measures to address the recurrence of flooding in the area.

Collective rehabilitation measures should be crafted for a unified action to address environmental issues parallel to development plans to promote but sustainably manage our resources and protect our villagers and their sources of income.

The findings of the study can be used as a reference in monitoring the change of the river landscape and predicting the potential magnitude of the flood plain with a reference to the flood height. These are very useful in crafting Disaster Risk Reduction Management Plans and Development Plans along the riverine areas.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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