RESEARCH ARTICLE

Impacts of Freshwater Fish Sanctuaries on Fish and Crustacean Diversity, Catch, and Household Income of Fisherfolk in Baggao, Cagayan, Philippines

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ABSTRACT

The study was conducted from February to March 2022 to assess the impacts of fish sanctuaries on fish and crustacean diversity, catch, and income of fisherfolk in Baggao, Cagayan. Data were collected from the 59 registered fisherfolk in the study areas using a structured survey instrument and were analyzed using descriptive methods. The Shannon-Weiner Diversity and Pielou indices were computed to determine fish diversity and evenness, respectively. The results showed that the diversity indices in the three study areas were 1.91 in Duba Cave, 1.66 in Hot Spring, and 1.58 in Bluewater Falls, and the average species evenness was 0.7. Further, the major species caught include *Anguilla* sp.*, Oreochromis* sp.*, Trichopodus* sp.*, Crenimugil* sp.*, Macrobrachium* sp.*, Ciprinus* sp.*, Clarias* sp.*, Arius* sp.*, Chana* sp.*, Glossogobius* sp.*, Sundathelphusa* sp.*, Hyphorhamphus* sp.*,* and *Gambusia* sp. The volume of fish catch depends on the production space in the buffer zone, the time of fishing or fishing frequency, and the fishing gears used by the respondents. The sanctuaries also served as alternative livelihood and source of income for the respondents with the development of tourism, which provided jobs (e.g., tour guides, river wardens, project monitors, and laborers) to community residents. The study's results confirmed the positive impacts of fish sanctuaries on the diversity, catch, and household income of fisherfolk.

1.   INTRODUCTION

Fishery is one of the primary income sources for Filipinos, particularly those who live near the sea, lakes, rivers, and streams. In 2012, the Philippines was listed as one of the major fish-producing countries with a total production of 3.1 million metric tons of fish and other forms of aquatic life with economic value and ranked third as a producer of farmed seaweed with 1.8 million MT production (FAO 2014). However, the 2016 Philippine Statistics Authority (PSA 2016) data revealed that fisheries production trends for both municipal marine and inland fishing are declining. Further, in 2018, fisheries production in Region 2 recorded an 11% decrease from 53,469.59 MT in 2016 to 47,572.50 MT (PSA

2018). The decrease could be attributed to the open-access nature of fishery resources, where everybody has the right to fish, allowing them to exploit the resource without considering its carrying capacity (Bulte et al. 1995). The inland fisheries resources had been burdened by collective fishing using destructive fishing gears and overfishing; infrastructure projects like dams; pollution brought by big industries and improper waste disposal from households; and environmental changes that clearly show the declining trend of production as well as the disappearance of some traditionally important fish species (Thein 2015). The inland fisheries and their freshwater habitats are now experiencing the increasing effects of multiple natural and anthropogenic pressures brought by changes in landscape due to massive

dam constructions and pollution resulting from flow diversification or alterations, sedimentations, and drought (Stokes et al. 2021). Effects of over-exploitation are now felt not only by the direct users but also by the whole population, especially in municipal inland fisheries (ZSL 2017). For the past years, freshwater habitats have deteriorated throughout the country due to agricultural activities like the conversion of riverbanks into agricultural farms coupled with rampant use of herbicides and the unregulated use of destructive fishing method practices and gears such as the use of fyke net and electrofishing (ZSL 2017). Both methods are considered non-selective types since all sizes of fish could be caught and trapped. Likewise, electrofishing affects the reproductivity of fishes when exposed to the voltage, resulting in infertility (Snyder 2003). These result in dwindling fish stock and catch in the wild.

On the other hand, introduced or invasive fish species such as mosquito fish, carps, tilapia, mudfish, gourami, and catfish are among the fish species recorded by the ZSL from 2018 to 2021. These observations were also noticed by the local fishermen in the study areas. At this point, the increased percentage abundance of these introduced species might affect the growth of native fish and crustaceans in the areas. Native and endemic fish have grown scarcer, while alien species in the country have multiplied faster in inland waters (Lacsama 2021). Invasive alien species indirectly impact native species because they prey on and compete with them, for example, through sharing resources like food and nesting grounds with them, as well as indirectly by changing habitat and altering nutrient cycling, hydrology, and other ecological processes according to Erarto et al. (2020). Other studies conducted on the invasion of alien species such as knife fish, Nile tilapia, and janitor fish were reported in the Laguna Lake area and Marikina area in 2011 and 2012, according to the DA-Bureau of Fisheries and Aquatic Resources (DA-BFAR).

Freshwater fish sanctuary is a common tool in reviving fisheries diversity by acting as reservoirs for the regeneration and restoration of aquatic life in inland resources with little or no influence from human actions. It is a protected area where target freshwater aquatic life will not be disturbed or captured. It is one of the effective tools for conserving fish stock and preserving biodiversity, hence increasing fish production (Abu Naser 2010). An area of importance to which the ZSL Philippines gave attention was the sanctuary established in Baggao, Cagayan.

Baggao is an interior municipality located in the eastern part of Cagayan in the Philippines, traversing the Sierra Madre Mountain Range, which extends to the Pacific Coast. It is gifted with clean, lively rivers, falls, caves, and beaches. It is surrounded by hills and mountains with forest cover gradually rising along the southeast corridor, which serves as a formidable wall to the Philippine Sea. With these bountiful freshwater resources, the municipality is known to host endemic freshwater fish species such as ludong (*Cestraeus* sp.), freshwater eel (*Anguilla* sp.), goby (*Glossogobius* sp.), and freshwater prawn (*Macrobrachium* sp.) (ZSL 2015).

Based on the habitat assessment conducted by the ZSL in 2015, unsustainable fishing activities such as unregulated or uncontrolled fish extraction and inland habitat degradation resulted in declining inland fish production, low income, insufficient livelihoods, and poverty, especially in far-flung barangays of the Municipality of Baggao, Cagayan. In 2016, these concerns were addressed by establishing Freshwater Protected Areas (FPAs) and Fish Sanctuaries (FSs) in Barangays Asinga-Via, J. Pallagao, and San Miguel through the initiative and collaborative efforts of the Local Government Unit (LGU) and the local community of Baggao, Cagayan, the ZSL–Philippines and the DA-Bureau of Fisheries and Aquatic Resources Regional Office No. 02 (DA-BFAR R02). A management plan for each sanctuary was prepared to address further the challenges mentioned.

This study was conducted to determine the impact and effectiveness of the established sanctuary on species richness and diversity. Generally, it aimed to assess the impacts of freshwater fish sanctuaries on fish and crustacean diversity, catch, and household income of fisherfolk in Baggao, Cagayan. Specifically, the study aimed to determine the fishing frequency and fish catch as a proxy to fish abundance, fish and crustacean species diversity, the impact of the fish sanctuary on household income, and best practices, challenges, and issues in effectively managing the sanctuaries. The result of this research is an essential input in updating the management plans of the 3 FPAs and establishing future sanctuaries.

2. MATERIALS AND METHODS

2.1 Location of the study

The three fish sanctuaries in Baggao, Cagayan, were established by virtue of Barangay Ordinance No. 2016-01, Series of 2016 (Figure 1). Hot Spring Freshwater Protected Area in Asinga-Via is located approximately 14 kilometers east of the town center. It has a total area of 2,288.13 ha, including a one-

Figure 1. Location of the study sites: (a) Bluewater Falls Fish Sanctuary, (b) Hot Spring Fish Sanctuary, (c) Duba Cave Fish Sanctuary, Baggao, Cagayan

hectare protected zone or the no-take zone (NTZ) and 0.75 ha as a buffer zone. The site has a manifestation of volcanic nature in the locality. It has a spring with hot to warm waters originating from the foot of the Sierra Madre Mountain in between huge bold-rock formations. Sulfuric chemical intrusion from the mountain's bowels makes the water medicinal and perfect for a health spa. Due to its vast and excellent resource conditions, the site is seen as an ideal home or niche for endemic freshwater fish species to thrive.

The Blue Water Falls Protected Area in J. Pallagao is located approximately 20 km northeast of the town hall. It has a total area of 1,187.72 ha with 1.0 ha and 0.75 ha NTZ and buffer zones, respectively. The sanctuary has a beautiful cave and cold river water.

The Duba Cave Freshwater Protected Area in San Miguel has the biggest area of 4,754.83 ha, with 4.5 ha NTZ and a 1.0 ha buffer zone. It is located approximately nine km southeast of the town center. This sanctuary is unique in terms of icicle-formed stalactites and dripping stalagmites.

2.2 Respondents of the study

Criteria in choosing or selecting the target respondents were established such that the respondents must have resided in three study areas for more than five years of stay, directly or indirectly engaged in fishing, listed in fish registration of the LGU and DA-BFAR as of 2021, and at legal age at the time of the survey. As a result, 59 registered fisherfolk were identified as the study respondents of which

17, 22, and 20 individuals came from the Barangays of Asinga-Via, J. Pallagao and San Miguel, Baggao, Cagayan, respectively.

2.3 Research instrument

A questionnaire consisting of five parts was used for data gathering. The first part included the personal profile of the respondents; the second part focused on fish and crustacean diversity, fishing frequency, volume of catch, and fishing gears used; the third part dwelt on the sources and estimated change in income due to the establishment of the sanctuaries; the fourth part was about the respondents' perceptions on the fish sanctuaries while the fifth part contained questions relative to the issues and challenges encountered, and best practices in relation to the management of the sanctuaries.

Pre-testing of the questionnaire was done to check the accuracy of the questions relative to the data needed.

2.4 Data collection

Prior to data collection, coordination among concerned groups was achieved—a trained enumerator conducted a one-on-one interview using structured questionnaires. Interviews were conducted using the local dialect (Tagalog and Ilocano) for coherence and comprehensibility among the respondents. Visual aids such as photographs were provided to help them recognize specific fish species and fishing gears.

Staff from the Municipal Agriculture Office (MAO), Municipal Tourism Office (MTO), Fish Sanctuary Management Board Chairman, ZSL-Philippines, and barangay officials were also interviewed as key informants to supplement and validate the information gathered from the respondents. Secondary data on monthly fish production, fish sanctuary status, and other related information were obtained from these agencies and other literature. All these activities were conducted from February 2022 to March 2022.

2.5 Data analysis

The data were consolidated and analyzed using descriptive statistics such as frequency counts, percentage distributions, and means. The results of the analysis were presented using graphs and tables. The diversity index was computed using the Shannon-Weiner Diversity Index (H') Shannon and Weaver 1949); using the formula below:

(1) $$H' = -\sum p_i \ln p_i$$

where: p_i = proportion of individuals found on the ith species; ln= natural logarithm

Species Evenness Index (J') was computed using the following formula;

(2) $$J' = H'/\ln S$$

where: H' = computed diversity index;
ln = natural log and S = total number of species. Species evenness ranges from zero to one, with zero signifying no evenness and one indicating complete evenness.

3. RESULTS AND DISCUSSION

3.1 Socio-demographic characteristics of respondents

Table 1 summarizes the socio-demographic characteristics of the respondents. Results show that the average age of the respondents ranges from 35 to 37 years old, consisting of 58 males (95%) and one female (5%) with 33-34 average years of stay in their respective barangays.

Table 1. Socio-demographic characteristics of the respondents.

Parameters/Barangay	Barangay			
	Asinga-Via	J. Pallagao	San Miguel	All sites
Number of respondents	17	22	20	59
Average age	36	37	35	36.05
Average no. of years of residence in the area	34	33	34	33.67
Gender (%)				
Male	100	100	95	98.33
Female	0	0	5	1.67
Civil status (%)				
Married	76	77	60	71.19
Single	24	23	40	28.81
In migrants (%)	11.76	31.82	15.00	19.53
Educational attainment (%)				
Elementary level	23.5	31.8	20.0	25.10
Elementary graduates	47.1	27.3	20.0	31.47
High School level	17.6	9.1	20.0	15.57
High School Graduates	0.0	27.3	35.0	20.76
College level	5.9	0.00	5.00	3.63
College Graduates	5.9	4.5	0.0	3.47
Average household size	4	3	5	4
Primary occupation	Farming	Farming	Farming	Farming

Results indicate that the respondents are in their prime age and capable of doing hard jobs such as farming, construction, carpentry, and fishing to support their family's basic needs. Further, most are married (71%), with an average household size between 3¬−5 individuals. The majority (80.47%) were born and raised in their respective villages, while the rest are migrants from nearby municipalities and provinces. The reasons for migration include job opportunities, relatives, and intermarriages. On educational attainment, some respondents in the three barangays finished elementary education; others managed to finish high school, while the rest were either elementary or high school undergraduates. The relatively low level of education may be attributed to early marriages, which forced them to work at an early age to provide for their family's basic needs. This is supported by the PSA (2021) data showing that the agriculture sector has the highest proportion (47.4%) of registered working children. Being an agricultural area, farming is the primary source of income for all the respondents.

3.2 Fishing frequency

Results of the interview indicate that 46% of the respondents are engaged in "free time" fishing (Table 2). Their fishing schedule and time spent depend on the target fish species and month. On average, respondents spend about 4-5 hours fishing and usually start early in the morning. Species commonly caught during the last quarter of the year when the weather is cold include freshwater eel (*Anguilla* sp.) and freshwater mullet (*Crenimugil* sp.). On the other hand, Tilapia (*Oreochromis* sp.), gourami (*Trichopodus* sp.), freshwater prawn (*Macrobrachium* sp.), carp (*Ciprinus* sp.), catfish (Clarias sp.), forked tail

catfish (*Arius* sp.), mudfish (*Chana* sp.), goby (*Glossogobius* sp.), freshwater crab (*Sundathelphusa* sp.), Quoy Garfish (*Hyphorhamphus* sp.) and mosquito fish (*Gambusia* sp.) are the available species during the rest of the year (Figure 4).

Other factors that affect fishing frequency include the distance of the fishing area from their residence and the schedule of crop farming activities. Fishing frequency also depends on the river currents, especially when the flow is fast and the water level is high, which limits their catch. However, some respondents take advantage of this water condition due to the possibility of catching a high-value migratory fish species such as freshwater eel (Anguilla sp.) and freshwater mullet (Crenimugil sp.). These fishes are known as catadromous species, wherein they spend parts of their life in freshwater and saltwater to spawn (Mcleave 2001).

Indigenous knowledge of the stars and phases of the moon were also used as indicators of the availability of fish. For example, the presence of stars indicates good weather, allowing them to spend more time fishing and catching more. In addition, the moon's phases also affect the fishing of the respondents (i.e., they experience difficulty catching fish during the full moon due to the clear surroundings). This knowledge is precious for fishers and is handed from generation to generation (Kurien 1985).

Before the sanctuaries were established, uncontrolled fishing using illegal methods (e.g., electrofishing, fine mesh net, and others) and habitat destructions were rampant (ZSL 2015). The volume and sizes of fish caught during that time were minimal, and they spent much time fishing (fishing effort). The establishment of fish sanctuaries and strict implementation of laws could deter violators of fishery laws within the protected areas, which led to the improvement of fishing activities and catch. They noticed that the

Table 2. Fishing frequencies of the respondents.

Parameters	Barangay							
	Asinga-Via		J. Pallagao		San Miguel		All sites	
	No.	%	No.	%	No.	%	No.	%
Fishing frequencies								
Once a week	7	41	2	9	8	40	17	29
Twice a week	1	6	6	27	4	20	11	18
Once a month	1	6	-	-	2	10	3	5
Twice a month	-	-	-	-	1	5	1	2
Free time fisher	8	47	14	64	5	25	27	46
Total	**17**	**100**	**22**	**100**	**20**	**100**	**59**	**100**

fishing ground produced more fish in the buffer zone through spill-over effects. Hence, fishing practices were observed with a big difference in the study sites at this time.

3.3 Fish production

Table 3 shows the results of recorded fish species caught in the buffer zone of the fish sanctuaries. Respondents from J. Pallagao have the highest total fish production of 576.5 kg, followed by those from San Miguel with 341.5 kg and Asinga-Via with 240 kg. Overall, an increase in fish production of 59% has been recorded, which is higher than the data gathered by the ZSL-Philippines in 2020. According to Zolderdo et al. (2019), the spillover effects of fish sanctuary recorded positive results on the catch. This occurs when the number of fish inside the sanctuary becomes too crowded, causing them to migrate to the buffer zone where local fishermen typically catch fish (Lovgren 2019).

The respondents identified and used five different types of fishing gears in the three areas (Figure 2). These include hook and line (*bingwit* or *baniit*), gill net (*sigay*), fish trap (*bubo*), fyke net (*tanggar*), and spear gun (*pana*). Major species caught were the freshwater eel (*Anguilla* sp.), tilapia (*Oreochromis* sp.), gourami (*Trichopodus* sp.), freshwater mullet (*Crenimugil* sp.), freshwater prawn (*Macrobrachium* sp.), carp (*Ciprinus* sp.), catfish (Clarias sp.), forked-tail catfish (*Arius* sp.), mudfish (*Chana* sp.), goby (*Glossogobius* sp.), freshwater crab (*Sundathelphusa* sp.), Quoy's garfish (*Hyphorhamphus* sp.), and mosquito fish (*Gambusia* sp.) (Figure 3). Most of the fishes can be caught through the use of speargun (pana), gillnet (sigay), and hook and line (bingwit or baniit) all year round. The respondents are using these fishing devices anywhere within the buffer zone. In comparison, fishing gears such as fish tarp (*bubo*) and fyke net (*tanggar*) were used at a specific time and area. The volume of fish production in the three areas depends on these fishing devices as well as the fishing time of the respondents.

Interviews revealed that catching a variety of fish and crustacean species with different fishing frequencies in the buffer zone is observed all year round. Based on the results, the volume of fish and crustaceans catch starts to rise in January with a total of 104 kg of fish, peaks in April (summer) at 179 kg and slowly tapers down in May with a total of 162.25 kg. During the peak months, all respondents generally engage in fishing because of the favorable weather and river water conditions, as presented in Figure 4. Also, farm activities are already finished during these months, resulting in more fishing frequency, which translates to more catch.

A declining trend in the volume of fish caught was recorded from July to December, with a recorded decrease from 82.5 kg to 46.75 kg (43.33%). Respondents also mentioned that this period is

Table 3. Recorded fish and crustacean production in the buffer zone in 2020 and 2021.

Fish/Crustacean species	Production per Barangay (kgs)					
	Asinga-Via		J. Pallagao		San Miguel	
	2020	2021	2020	2021	2020	2021
Freshwater eel (*Anguilla* sp.)	4.00	8.5	31.00	44.00	8.00	12.5
Tilapia (*Oreochromis* sp.)	63.00	79.8	120.00	164.75	48.00	87.00
Gourami (*Trichopodus* sp.)	1.50	2.25	-	-	-	0.25
Freshwater Mullet (*Crenimugil* sp.)	1.00	0.5	5.00	6.5	15.00	32.5
Freshwater Prawn (*Macrobrachium* sp.)	9.00	15.5	18.00	21.00	8.00	14.75
Carp (*Cyprinus* sp.)	31.00	37.00	4.00	6.5	35.00	57.00
Catfish (*Clarias* sp.)	18.00	31.00	25.00	87.25	32.00	40.5
Forked tail catfish (*Arius* sp.)	-	-	-	-	-	4.5
Mudfish (*Chana* sp.)	29.00	38.25	65.00	117.25	38.00	51.25
Goby (*Glossogobius* sp.)	9.00	11.25	45.00	69.00	7.00	24.5
Freshwater crab (*Sundathelphusa* sp.)	5.00	6.25	35.00	59.00	7.00	12.00
Quoy Garfish (*Hyphorhamphus* sp.)	6.50	9.75	1.00	1.5	1.00	2.25
Mosquito fish (*Gambusia* sp.)	2.00	-	-	-	-	2.5
Total	**179.00**	**240.00**	**349.00**	**576.75**	**199.00**	**341.50**

considered bad months for fishing due to unfavorable weather and water conditions. According to Roghair et al. (2002), migration and dispersal of stocks occur due to river overflows and flooding effects. Despite the

Figure 2. Common fishing gears used by the respondents in the three study sites in Baggao, Cagayan: (a) Spear Gun, (b) Fyke Net, (c) Hook and Line, (d) Gill Net, and (e) Fish Trap).

Figure 3. Common fish and crustacean species caught in the three sanctuaries: (a) Freshwater Eel (*Anguilla* sp.); (b) Snakeskin Gourami (*Trichopodus* sp.); (c) Freshwater Prawn (*Macrobrachium* sp.); (d) Freshwater Tilapia (*Oreochomis* sp.); (e) Freswater mullet (*Crenimugil* sp.); (f) Carp (*Cyprinus* sp.); (g) Mudfish (*Channa* sp.); (h) Freshwater Catfish (*Clarias* sp.); (i) Forked Tail Catfish (*Arius* sp.); (j) Freshwater Goby (*Glossogobius* sp.); (k) Mosquito Fish (*Gambusia* sp.); (l) Freshwater Crab (*Suldathelphusa* sp.); and (m) Quoy Garfish (*Hyporhamphus* sp.)
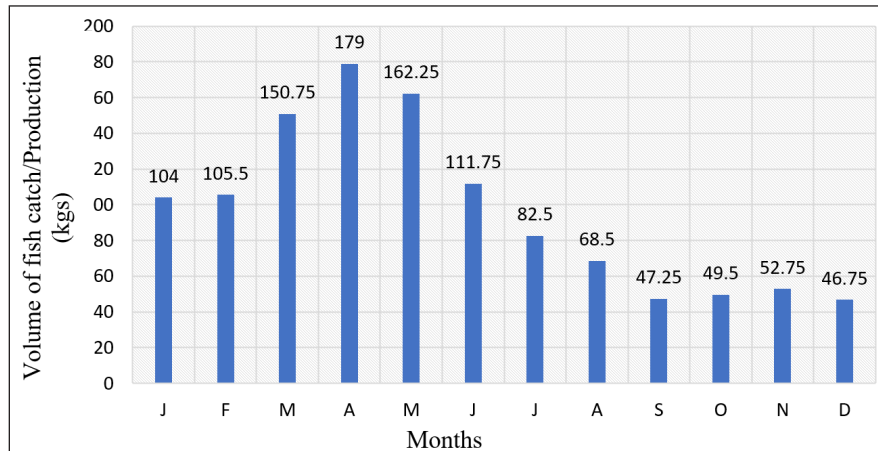
Figure 4. Total monthly fish production in the three fish sanctuaries in Baggao, Cagayan, in CY 2021

unfavorable circumstances, the sanctuaries still provided a year-round fish supply in the community.

Furthermore, the volume of fish caught depends on the fishing time and the fishing gears the respondents use. According to them, high catch (volume) is observed early in the morning or evening, depending on the target fish to catch. They observed that fishes generally prefer cooler temperatures and avoid hot midday sun. Further, they usually fish early to avoid noise from humans and their surroundings.

As to fishing gears, the volume of catch by the respondents depends on the type of gears they used and the target fish species to catch, which coincides with the study conducted by Vermeersch (2014).

3.4 Species diversity

A total of 4,026, 7,393, and 6,024 fish individuals belonging to 11, 10, and 13 different species were recorded in Hot Spring, Bluewater Falls, and Duba Cave Fish Sanctuaries, respectively (Table 4). The table also shows the variability of the diversity of freshwater fish species in the three sanctuaries in CY 2021. The computed Shannon-Weiner Diversity Indices of the three sanctuaries were 1.91, 1.66, and 1.58 in Duba Cave, Hot Spring and Bluewater Falls, respectively (Table 5). The computed species evenness was 0.7. Shannon-Weiner Diversity Index (H) values for species in communities were below 1.0, which means low diversity, and above 1.0 for a well-diverse ecosystem. Results also indicate that fish and crustacean diversity in the buffer zone has positively increased by 45.5% relative to the data generated by the ZSL-Philippines in CY 2016. This shows that the three sanctuaries are in good condition, as signified by the diversity of fish species thriving in the area. Almaden (2017) stated that the diversity and status of

endemic riverine fishes are valuable bioindicators of ecosystem health.

On the other hand, the species evenness index ranges from 0 to 1, where a calculated evenness index near 1 means all species have the same abundance, and 0 when one species is calculated (Ifo et al. 2016). This shows that the evenness of fish species in the three sanctuaries is proportionally similar. Species distribution and abundance within a particular environment are determined by tolerance to physical conditions and interactions with other organisms (Schlosser 1982). The presence of good fish habitat depends on several factors, such as water flow, water quality, sufficient natural food, and the lack of excessive predators and competitors (Aadland 1993). This makes the sanctuaries suited for the growth and reproduction of fishes. Further, fishes can swim and migrate freely to other areas through their tributaries connecting to the three sanctuaries.

Moreover, the differences in the diversity value of the three fish sanctuaries could be attributed to the fishing pressure, topography, and habitat in the areas (Encarnacion et al. 2017). This coincides with the findings of Negi and Mamgain (2013) that hydrological attributes of an area can influence fish species distribution. Further, river salinity change could affect fish species diversity during the wet and dry seasons (Nguyen et al. 2021).

3.5 Impact of fishing in the area on household income

Respondents depend on farming as their current occupation and livelihood. This could be attributed to the vast agricultural land area indicated in their (Municipality of Baggao, Cagayan 2020). Results show that on average (89.72%), the respondents have

Table 4. Freshwater fish and crustacean composition in three sanctuaries in Baggao, Cagayan, from January to December 2021.

Fish/Crustacean Species	Fish Sanctuaries			Total	% Total Abundance
	Hot Spring	Blue Water Falls	Duba Cave		
	Number of fish individual				
Freshwater eel (*Anguilla* sp.)	10	33	12	55	0.32
Tilapia (*Oreochromis* sp.)	884	1,137	824	2,845	16.31
Gourami (*Trichopodus* sp.)	8	-	4	12	0.07
Freshwater Mullet (*Crenimugil* sp.)	4	18	119	141	0.18
Freshwater prawn (*Macrobrachium* sp.)	1,320	1,570	1,251	4,141	23.74
Carp (*Ciprinus* sp.)	119	10	191	320	1.83
Catfish (*Clarias* sp.)	71	159	77	307	1.76
Mudfish (*Chana* sp.)	75	121	103	299	1.71
Goby (*Glossogobius* sp.)	580	2,775	1,720	5,075	29.09
Freshwater crab (*Sundathelphusa* sp.)	90	1,420	1,080	2,590	14.85
Quoy's garfish (*Hyphorhamphus* sp.)	865	150	210	1,225	7.02
Forkedtail catfish (*Arius* sp.)	-	-	13	13	0.07
Mosquito fish (*Gambusia* sp.)	-	-	420	420	2.41
Total	**4,026**	**7,393**	**6,024**	**17,443**	**100.00**

Table 5. Summary of fish and crustacean diversity in the three fish sanctuaries in Baggao, Cagayan.

Name of Barangays	Name of Fish Sanctuaries	Species Diversity (Shannon-Weiner Diversity Index)	
		CY 2016	CY 2021
Asinga-Via	Hot Spring	1.32	1.66
J. Pallago	Blue Water Falls	1.46	1.58
San Miguel	Duba Cave	0.76	1.91

Table 6. Current source and estimated average monthly income of the respondents in Baggao, Cagayan, in CY 2021.

Source of Income	Barangays							
	Asinga-Via		J. Pallagao		San Miguel		All	
	%	Ave. Monthly Income (PhP)	%	Ave. Monthly Income (PhP)	%	Ave. Monthly Income (PhP)	%	Ave. Monthly Income (PhP)
Farming	88.24	5,960	90.91	5,630	90	9,381	89.72	6,990
Carpentry	5.88	5,250	-	-	-	-	5.88	5,250
Construction	-	-	4.55	4,750	5.00	3,250	4.77	4,000
Bakery	5.88	4,000	-	-	-	-	5.88	4,000
Tour guide	-	-	4.55	1,500	5.00	1,750	4.77	1,625

farming as their primary source of livelihood, with those from San Miguel recording the highest average income of PHP 9,381.58. as shown in Table 6. However, not all respondents have their agricultural land to utilize. Some of them are tenants under a yield-sharing arrangement with the land owners. These findings are almost similar to the study conducted by Bhendarkar (2018), indicating that agriculture (farming) was the primary occupation in rural areas, where some were doing odd jobs to create a secondary source of income.

Other sources of income include carpentry works (5.88%), bakery (5.88%), construction works (4.55%), and tour guiding (4.55-5.00%). Indirectly, the fish sanctuaries provide income to the community as tourist destinations and through a regular supply of fish all year round for family consumption. These findings paralleled the study conducted by Vermeersch (2014) and Clegg (2015), indicating that sanctuaries were mainly used for nutritional purposes and creating sustainable community tourism.

The sanctuaries provided additional sources of income to the community because of the increase in the number of tourists visiting the area for swimming, snorkeling, forest visits, and other recreational activities. The increase in tourists and visitations necessitates the construction of cottages, provision of catering services, and tour guides, which provide employment for the community. Tourism, considered one of the most diverse industries, became the local community's source of income and employment (Goharipour and Masoud 2016). Sources of income in 2016 and 2021 were also recorded to determine the change since the sanctuaries were established.

Table 7 compares the average monthly income of the respondents from CY 2016 vs. 2021, in which changes in the source of income (livelihood) in previous years and the average monthly income were determined. Still, farming is the major source of income of the respondents, and an increasing trend was observed except from Asinga-Via, which might be caused by the looming cost of farm inputs and the increasing residential development in the area (agricultural land conversion); hence the growth of income in carpentry. The study revealed that respondents from Asinga-Via have recorded the highest average income of PHP 7,050.00 from farming.

3.6 Challenges, issues, and problems encountered

The respondents and officials in the three fish sanctuaries were asked about the current challenges, issues, and problems relevant to managing the established fish sanctuaries in their area.

A total of four different issues were raised and identified by most of the respondents, as presented in Table 8. On top of the list is the insufficient financial support from the LGU, especially for the appointed and designated river or fish wardens or "*bantay ilog*" in their respective areas. This was mentioned by almost all of the respondents from the study sites, especially in J. Pallagao. They mentioned that they receive insufficient insurance support as monitoring fish sanctuaries is very dangerous, particularly when they encounter violators (environment and fisheries) undertaking illegal fishing and logging within the FPAs activities. According to them, they used to call the violators' attention; however, they usually responded through threats and refused to follow orders. Hence, these incidents were reported to the local officials for blotter.

The second issue that over 90% of respondents identified was the insufficient number of river wardens to implement fishery and other environmental laws. Currently, there are only five designated fish wardens per sanctuary. This makes the conduct of project monitoring and law enforcement demanding, considering the sanctuaries' area and structural position.

Lack of awareness or knowledge of fishery and other environmental laws was the third issue identified by the respondents. The success of any project comes from the confidence and awareness of any individual who will implement it. However, in this study, this was one of the most pragmatic problems encountered by any individual, particularly those involved in the enforcement or implementation. It was also observed that some of the respondents were newly appointed and designated as river wardens. This means that these people are not yet fully equipped with the knowledge and awareness to implement fishery and environmental laws and, therefore, need to be capacitated.

Lastly is the issue of the power or authority of river wardens to apprehend violators against fishery

Table 7. Source and average monthly income of the respondents from CY 2016 to 2021.

Source of Income	Asinga-Via		J. Pallagao		San Miguel	
	CY 2016	CY 2021	CY 2016	CY 2021	CY 2016	CY 2021
Farming	7,050.00	5,960.00	5,369.00	5,630.00	6,116.67	9,381.00
Carpentry	2,250.00	5,250.00	-	-	-	-
Construction	-	-	3,500.00	4,750.00	3,250.00	3,250.00
Bakery	-	4,000.00	-	-	-	-
Tour Guide	-	-	-	1500	-	1750

and environmental laws. This issue is susceptible and difficult to implement, according to them (DFWs, River Wardens, Barangay, and other enforcers), despite the fact that these officers were trained and deputized by BFAR R02 and the LGU of Baggao, Cagayan. The capability to enforce the laws can be done in their respective areas; however, apprehending a particular violator is very difficult. Their safety and security and that of their respective families were their priorities. The need for more support to file a case against violators is also an additional problem for the enforcers.

4. CONCLUSION

The study reveals that fish catch depends on the current fishing frequency and fishing gears used by the respondents, and the increased number of fish catches in the buffer zone might be brought by the spillover effects from the volume of fish production on fish sanctuaries in the three areas. Data also shows that the bigger the designated strictly protected zone or no-take zone, the more diverse the area is. The increase in fish diversity confirms that the establishment of fish sanctuaries has a positive impact, as indicated in the increased diversity index. This must be due to the strict implementation of policies and good management practices that sustained the year-round fish production and diversity in the sanctuaries. For livelihoods, the sanctuaries provided indirect income to the community by creating job opportunities for residents as tour guides, river wardens, project monitors, and laborers in establishing ecotourism infrastructure and facilities.

The learnings of the local community on the mechanisms of the operation of the sanctuary in the three sites, such as regular monitoring, meetings, and continuous information, education, and communication (IEC) materials dissemination, provided the policymakers updates and information for their necessary action, adjustment, and reference. These are valuable in managing the sanctuaries and can be best practices that can be continued. In addition, the preparation and distribution of IEC materials on the "Dos and Don'ts" inside and outside of the sanctuaries and close coordination with the concerned agencies (LGUs, BFAR-R02, and ZSL-Philippines) helped in the governance of the sanctuary. These activities were easy to implement because most respondents were trained in project monitoring, community participation, enforcement, and coordination.

5. ACKNOWLEDGEMENTS

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in any way.
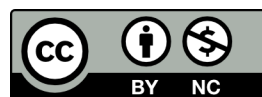
ETHICS STATEMENT

The authors obtained prior informed consent from all participants included in this study.

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