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Caption: Malabar Slender Loris *Loris lydekkerianus malabaricus* © Dileep Anthikkad.



Understanding human-flying fox interactions in the Agusan Marsh Wildlife Sanctuary as basis for conservation policy interventions

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Abstract: There is no documented flying fox hunting study done in the Agusan Marsh Wildlife Sanctuary (AMWS) which is known to harbor many threatened wildlife species. The Large Flying Fox *Pteropus vampyrus* is known to be threatened by hunting in the AMWS despite existing laws, such as the Wildlife Act. We conducted semi-structured interviews from September 2017 to January 2018 with 240 hunters in 10 villages through purposive sampling to determine the socio-demographic and economic profile of the hunters, their conservation awareness, perceptions on the monitoring scheme and enforcement, possible hunting patterns, and hunting drivers. Results showed that farming and fishing are the most common livelihoods of hunters. Most hunters achieved an education at the elementary level (42.9%), and belong to a household with 4–6 members (55.5%), often with only one member having a meager daily income (80.7%). Annual flooding was the main economic constraint to the hunters. Largely comprised of indigenous *Manobos* (62.9%), the majority of hunters did not believe in avoiding taboo species (85.4%). Most of the hunters were unaware of laws protecting Wildlife (62.9%) and unable to differentiate between threatened and non-threatened species (86.3%). Poor implementation of the monitoring scheme and insufficient enforcement were also observed in AMWS. Kites with hooks (55%) and guns (31.7%) were used to hunt *P. vampyrus* mostly for local consumption (83.3%). Multivariate analysis revealed that daily income and engagement in conservation negatively affected hunting intensity. With many constraints in totally banning hunting in poor and wildlife-dependent indigenous communities in AMWS, flexible policies must be considered. It is more reasonable and realistic to consider science-based hunting quotas in policy interventions to balance conservation and human welfare. Positive behavioral change towards sustainable hunting and trading bans requires a combination of effective education campaigns, engagement of indigenous communities in conservation, improved enforcement, and sustainable livelihood programs.

Keywords: Hunting, indigenous people, Manobo, *Pteropus vampyrus*, protected area, subsistence, threatened.

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INTRODUCTION

The Philippines is a megadiverse country, recognized for its exceptional richness and endemism of wildlife (Myers et al. 2000; Posa et al. 2008). However, the country is facing rapid forest loss (WRI 2003; Apan et al. 2017) and is known to be a biodiversity hotspot (Myers et al. 2000; Gonzalez et al. 2018). To conserve and protect a high number of threatened species, a network of protected areas was established (Mallari et al. 2016). The Giant or Large Flying Fox *Pteropus vampyrus* Linnaeus, 1758 is a threatened wildlife species found in the Philippines, which also occurs in other southeastern Asian countries (Bates et al. 2008). Like other flying foxes, it plays a very important role in seed dispersal, pollination, and forest regeneration (Corlett 1998; Kunz & Jones 2000; McKonkey et al. 2006; Nakamoto et al. 2008; Shilton & Whittaker 2009; Aziz et al. 2021). It is currently listed as 'Near Threatened' by the International Union for the Conservation of Nature (IUCN 2021) but is locally listed as Endangered in the Department of Environment and Natural Resources Administrative Order (DAO 2019-09) due to intense hunting pressure, continuous roost disturbance, and reduction of its lowland forest habitat (Bates et al. 2008; Gonzalez et al. 2018). *Pteropus vampyrus* is listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and occupies broad trans-national home ranges (Epstein et al. 2009).

Half of all extant large-bodied species in the genus, *Pteropus* are unsustainably hunted across Indonesia, Malaysia, the Philippines, and several islands in the Pacific and Indian Oceans (Mickleburgh et al. 2009; Wiles & Brooke 2009; IUCN 2014). Increasing flying fox hunting pressure in North Sulawesi for example is brought about by intense trading and consumption (Sheherazadee & Tsang 2015). This is of major conservation concern because flying foxes are vulnerable to overhunting due to their slow rate of reproduction (Mildenstein et al. 2016), long gestation, and slow fetal growth (Racey & Entwistle 2000; McIlwee & Martin 2002). Hence, the survival of many chiropterophilic plant species that rely on bats particularly flying foxes for pollination and seed dispersal will be adversely affected by the decrease in their abundance and diversity (Clayton & Milner-Gulland 2000). Decreasing population of flying foxes has economic impacts which may directly affect local communities, e.g., farmers who are dependent on bat-pollinated fruit crops (Aziz et al. 2021).

There are still cases of hunting and trade even within

protected areas, e.g., flying fox trading from protected areas on Sulawesi which are supposed to protect natural habitats and animal populations (Lee et al. 2005; Worboys & Winkler 2006). Despite the enactment of the Wildlife Resources Conservation and Protection Act (Wildlife Act, RA No. 9147), the hunting of flying foxes is still prevalent in several protected areas of the Philippines such as in the Mountain Ranges of the Sierra Madre (Scheffers et al. 2012), Mt. Apo National Park (Tanalgo 2017), and in the Agusan Marsh Wildlife Sanctuary (AMWS).

Agusan Marsh is one of the most ecologically significant wetlands in the Philippines and is one of Asia's most important transit points for migratory birds. Freshwater swamp forests comprise 49% of the total area in AMWS. Three major forest types were identified, namely, mixed swamp forests, peat swamp forests or pygmy forests, and the inundated lowland evergreen forest. There were 25 threatened species recorded, of which 84% are endemic to the country such as the threatened flying foxes, e.g., the Endangered Giant Golden-crowned Flying Fox *Acerodon jubatus* and the Near Threatened Giant or Large Flying Fox under IUCN which are already Critically Endangered and Endangered respectively under DAO 2019-09 (Department of Environment and Natural Resources-Caraga 2015).

Both indigenous and non-indigenous people inhabiting the sanctuary were reported to hunt *P. vampyrus* for local consumption and local trading. Hunting is the greatest threat to Philippine bats particularly the frugivorous species such as flying foxes (Tanalgo & Hughes 2019). However, there is no known quantitative research conducted on flying foxes within the AMWS (Tanalgo & Hughes 2018).

Regulation of *P. vampyrus* hunting requires baseline information on hunting patterns and its potential drivers. The findings of hunting research in AMWS will inform adaptive wildlife conservation programs, policy interventions, resource prioritization, and a more effective protected area management (Friant et al. 2015). Understanding human-flying fox interaction is essential to effective long-term conservation, efficient law enforcement, and persistence of the flying fox population. In this paper, we show the demographic, socio-economic, and cultural profile of the hunters, their level of conservation awareness, and perceptions. Here, we also present *P. vampyrus* hunting patterns, the frequency and number of individuals hunted across different periods and the main drivers of Giant or Large flying fox hunting within AMWS. All this information is important to design an adaptive flying fox conservation



program in AMWS and other protected areas.

METHODS

A. Study Site and Focal Species

A series of surveys were conducted within Agusan Marsh Wildlife Sanctuary located at 8.316N and 125.866E covering eight municipalities in the province of Agusan del Sur, Mindanao Island (Figure 1 & Image S2). Agusan Marsh is the catchment basin for tributaries flowing from surrounding areas of Compostela Valley, Agusan del Norte and Agusan del Sur, and Bukidnon provinces. AMWS has an area of 19,196 ha which was proclaimed a protected area under RA No. 7586 or the National Integrated Protected Areas System (NIPAS) Act under Presidential Proclamation 913 dated 31 October 1996 (Department of Environment and Natural Resources (DENR-Caraga 2015). In 1999, the AMWS was designated as a Wetland of International Importance by the Ramsar Convention (Primavera & Tumanda 2007).

The *Manobos* represent the most dominant (70% of the population) indigenous group among the five identified tribes within the protected area, including the Kamayo, Higaonon, Banwaon, and Talaandig (Bendsen et al. 2017). Four Certified Ancestral Domain Titles (CADT) cover 55% of this area and one other claim is currently being processed (Bendzen et al. 2017). The biological diversity within the AMWS is being threatened by illegal destructive practices including hunting and trapping of wildlife species (PEF et al. 2008).

The Large Flying Fox is one of the world's largest bats (Stier & Mildenstein 2005). It is one of the largest flying foxes (11 species) out of the total 27 species of the Old World fruit bats (Order Chiroptera, Family Pteropodidae) recorded in the Philippines (Heaney et al. 1998; Tanalgo & Hughes 2018). By contrast, the endemic Giant Golden-crowned Flying Fox is the world's heaviest bat at up to 1.4 kg. Similar in size and weight, both have completely blackish-brown fur on the upper back. The Common Island Flying Fox *Pteropus hypomelanus* Temminck, 1853 is similar in appearance to the Giant Flying Fox but smaller in size and weight with a golden dorsal pelage that is never completely black on the upper back. It occurs from Thailand to Australia, and throughout the Philippines (Ingle & Heaney 1992; Heaney et al. 1998). Of the 13 species of bats recorded within AMWS, including nine fruit bats, *P. hypomelanus* has not been observed in AMWS (Ibanez & Bastian 2015).

Pteropus vampyrus roosts in the top of large trees, with single colonies numbering from 12 to

100,000 individuals often forming mixed roosts with *A. jubatus*. Populations of both flying foxes have declined dramatically in the last century, principally due to the loss of their natural forest habitats. To distinguish the two species in mixed roosts, the dorsal pelage of *P. vampyrus* is usually blackish-brown and golden on the upper back, with the posterior margin sharply defined by a dark brown transverse line on the lower back, that ends in a narrow "V" at the nape and shoulders (Image S2). The ear tips are nearly pointed. In contrast, the dorsal pelage of *A. jubatus* is not completely blackish-brown, and has a golden patch on top of the head extending to the ears, but lacks the dark brown transverse line on the lower back. The ear tips are bluntly rounded. *P. vampyrus* is widely distributed from Indochina to the Lesser Sundas, while *A. jubatus* is endemic only to the Philippines (Ingle & Heaney 1992; Heaney et al. 1998).

B. Study Design, Questionnaire and Ethical Note

After securing the AMWS Protected Area Management Board (PAMB) and free prior and informed consent (FPIC) approval (signed by the tribal leaders), a purposive sampling was done in the identification of *P. vampyrus* hunting "hotspots" (barangays and municipalities where illegal hunting was most prevalent) with the help of key informants such as the protected area superintendent, and local government officials. Snowballing was also used to identify hunters where the preceding hunter-interviewees provided contacts to be included in the succeeding interviews. The first draft of the questionnaire was tested with 30 respondents in one of the identified hunting hotspots (not subsequently included during actual surveys) for questionnaire validation in September 2017. Feedbacks from the respondents on the construction of questions (degree of comprehensibility, flow of questions, length of questionnaire, and level of sensitivity) served as the basis for questionnaire revisions. Actual interviews with a total of 240 hunters (face-to-face semi-structured interviews in Cebuano dialect) were carried out in six municipalities within AMWS including San Francisco (33.3%, n= 80), Loreto (13.3%, n= 32), La Paz (17.1%, n= 41), Talacogon (9.6%, n= 23), Bunawan (12.9%, n= 31), and Rosario (13.8%, n= 33) from October 2017 to January 2018. The head of the household was the main target of the interview. Alternatively, if the head of the household was already deceased, the eldest male child who also participated in hunting was instead interviewed.

In the first part of the questionnaire, we asked about the socio-demographic and economic information such as age, the number of family members, ethnicity, length

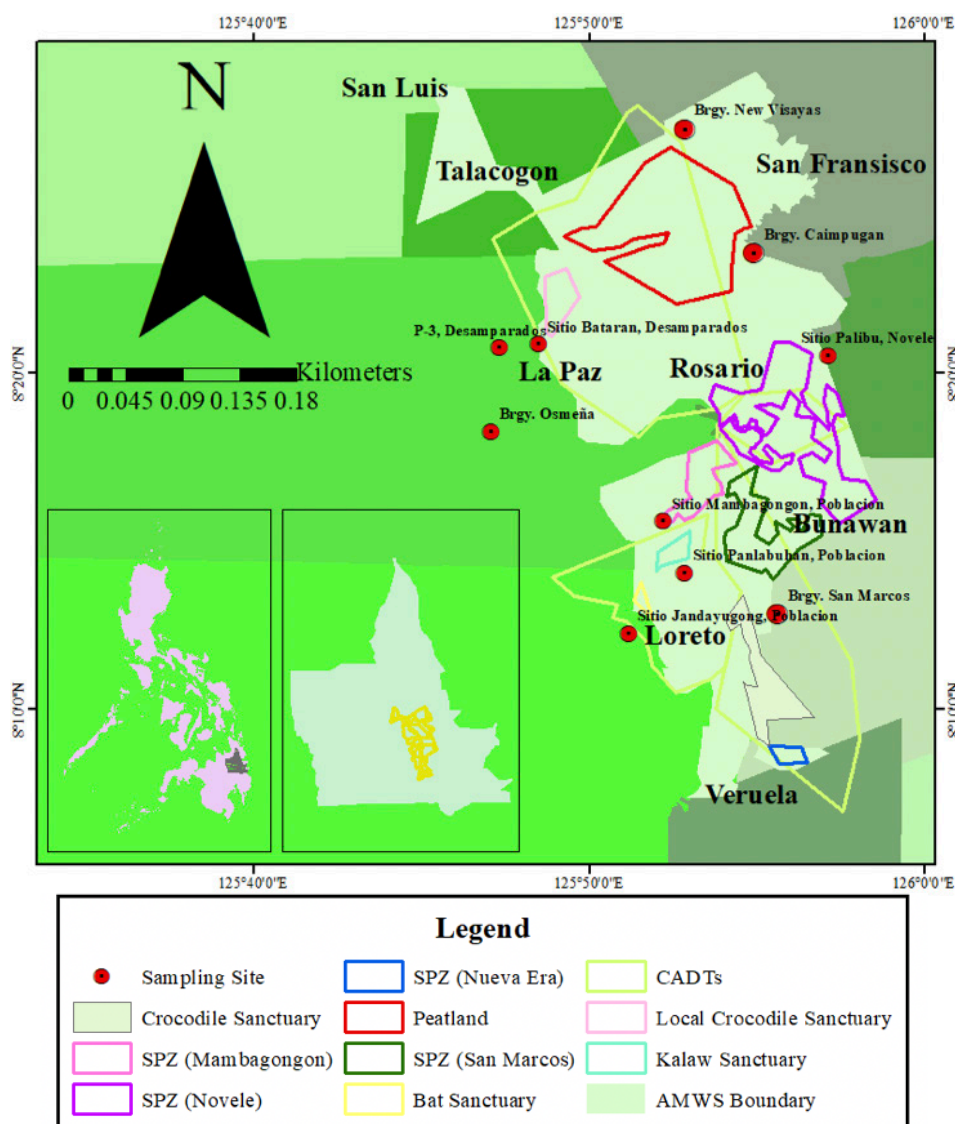


Figure 1. Map showing sampling sites within and the surroundings of Agusan Marsh Wildlife Sanctuary (AMWS) including the municipalities, special protection zones and the major zones.

of residency, and educational attainment (Appendix 1). Socio-economic data were also gathered, such as the main source of livelihood, supplementary livelihood, average daily income incurred during the dry and wet seasons, number of family members with income, and constraints to economic opportunities. We also asked for cultural information in the second part of the questionnaire such as the hunter's beliefs on 'species-specific taboos' and traditional cultural practices related to hunting.

In the third part of the questionnaire, we asked questions about the awareness and perceptions of the hunters such as their awareness of conservation-related activities (1 – no; 2 – yes), Wildlife Act (1 – not totally aware of the law, and its content; 2 – aware of

the law but do not fully understand the content and its implication to wildlife conservation; 3 – fully aware of the law and understand its content and conservation implication) and recognition and differentiation of threatened and non-threatened species (picture cards were shown and the concept of 'threatened species' were explained first to the respondents using their dialect before asking this question). Hunter's attendance to information, education, and communication campaigns (IEC) explaining the ecological services provided by flying foxes were also assessed (1 – did not attend any IEC on flying foxes; 2 – was able to attend but IEC did not include the ecological services provided by flying foxes; 3 – was able to attend and the IEC included the ecological services and importance of flying foxes). This



information is essential to inform adaptive and effective awareness and outreach campaigns.

We also asked about hunters' engagement in conservation-related activities, e.g., reforestation, conservation of flying fox, and other wildlife (1 – no; 2 – yes). Information on patrolling schemes and law enforcement is quite useful as a basis for designing a sustainable flying fox protection plan without compromising the welfare of the indigenous communities. Hence, the frequency of monitoring, hunting, and trade by the local forest wardens, and the patrolling frequency by the DENR enforcers at AMWS were also determined as perceived by the hunters (1 – never; 2 – hardly ever or <once a month; 3 – regularly or more than once a month; 4 – frequently or more than once a week). The extent of Wildlife Act enforcement was also investigated such as the number of violators fined, convicted, or jailed (anyone that they know in the community). The willingness of hunters to regulate hunting and minimize consumption of *P. vampyrus* was also assessed.

Quantitative assessment of hunting patterns was also carried out through direct interviews. Picture cards of bats were shown to each respondent to confirm the identity of the species hunted, and their motivation for hunting flying foxes was recorded. The most used hunting places within AMWS were identified and distance from the hunter's dwelling in kilometers was estimated. Moreover, hunting techniques used were also described and documented. The estimated hunting frequency (number of times a hunter hunts per time period) and hunting success (number of individuals hunted per time period) were investigated across different periods (conducted a month before the interview - 2017, also in 2016, and in 2012 with data spanning five years).

Descriptive statistical analysis in Paleontological Statistics or PAST (Hammer et al. 2001) was done for the demographic and socio-economic characteristics of the hunters and their hunting pattern responses. Mann-Whitney U test was performed to test if there was a significant difference between the hunting frequency and hunting success recorded between 2016 and 2012 at p value = 0.05 (per year basis). Multiple regression analysis in SPSS was used to determine the factors that influence hunting frequency and hunting success (number of bats taken in 2016). Numerical predictor variables included the hunter's age and length of residency at AMWS (in years), average daily income in Philippine peso (PHP), distance to the hunting zone from the hunter's dwelling (in kilometers), and allocated time for hunting time (in hours). Categorical predictor variables used were the

hunter's educational attainment, engagement in any conservation-related activities, attendance to IEC, and awareness of conservation-related activities conducted within AMWS. The dependent and independent variables were subjected to diagnostic tests to check the normality of the residuals. Pearson's correlation analysis was conducted before running the regression models to avoid multicollinearity among independent variables. All reported statistical tests were conducted at a 95% confidence level.

RESULTS

Demographic and Socio-economic Profile of Hunters

All the respondents engaged in hunting *P. vampyrus* ($n = 240$) within AMWS were males. Nearly 75% ($n = 174$) of the hunters were between 21–50 years old (Table 1). Most of the hunters have a family size of 4–6 members (55.5%, $n = 132$). More than half of the hunters were comprised of the 'Manobo' ethnic group (62.9%, $n = 151$), followed by migrant ethnolinguistic groups, Bisaya (18.5%, $n = 44$), and Hilonggos (17.6%, $n = 42$). Half of the hunters (50%, $n = 121$) lived in their respective villages for 21–40 years. A good number of hunters (42.9%, $n = 102$) graduated with elementary education, followed by high school undergraduates (23.1%, $n = 76$) which formed nearly a quarter of the total. Only a few were considered illiterate (1.7%, $n = 4$) and there was a very low percentage of those who finished college (3.3%, $n = 8$).

Most of the hunters engaged in rice farming during the dry season (60%, $n = 144$), and some of them did fishing during the wet season (35.4%, $n = 85$) (Table S1). Most of the hunters considered flood (87.9%, $n = 211$) as a key constraint to economic opportunities and agricultural productivity followed by bad roads (38.8%, $n = 93$) and drought (25.8%, $n = 62$).

Most of the hunters (80.7%, $n = 192$) mentioned that there is only one family member with income. We also found that more than half of the hunters had no supplementary source of income during the dry season (51.3%, $n = 123$) and there were even more of those who do not have any supplementary income source during the wet season (66.7%, $n = 160$) (Table 2).

The 42.1% ($n = 101$) of the flying fox hunters have an estimated daily income of Php 101–200 (42.1%, $n = 101$). The average daily income earned during the dry season (Php 182.50) was found to be significantly higher than during the wet season (Php 123.63) ($p < 0.001$).

More than half of the hunters interviewed were ethnic 'Manobos' (62.9%). Most of them (85.42%, $n =$

Table 1. Demographic Characteristics of the *P. vampyrus* hunters in Agusan Marsh Wildlife Sanctuary (n=240).

	Frequency	Percentage (%)
Age (years)		
11-20	5	2.1
21-30	60	25.0
31-40	57	23.8
41-50	57	23.8
51-60	39	16.3
61-70	17	7.1
71-80	5	2.1
Number of Family Members		
1-3	63	26.5
4-6	132	55.5
7-9	37	15.5
10-12	7	2.9
13-15	1	0.42
Ethnicity		
Bisaya	44	18.5
Butuanon	1	0.42
Hilonggo	42	17.6
Ilocano	21	8.8
Manobo	151	62.9
Length of Residency		
1-10	23	9.7
11-20	17	7.1
21-30	76	31.9
31-40	45	18.9
41-50	43	18.1
51-60	20	8.4
61-70	12	5
71-80	3	1.3
81-90	1	0.42
Educational Attainment		
None (illiterate)	4	1.7
Elementary undergraduate	8	3.4
Elementary graduate	102	42.9
Highschool undergraduate	55	23.1
Highschool graduate	29	12.2
College undergraduate	34	14.3
College graduate	8	3.3

Table 2. Socio-economic Profile of *P. vampyrus* hunters (number of supplementary income sources and estimated daily income in peso (PHP) during the dry and wet season in Agusan Marsh Wildlife Sanctuary

	Wet Season (%, n)	Dry Season (%,n)	Overall (%,n)
Number of supplementary income sources			
0	66.7%(160)	51.3% (123)	59.1% (142)
1	24.20% (58)	27.9% (67)	26.3% (63)
2	7.5% (18)	7.9% (19)	7.9% (19)
3	1.7% (4)	2.9% (7)	2.5% (6)
Estimated daily income in peso (PHP)			
0	10.3% (25)	8.3% (20)	0
50-100	44.2% (106)	31.7% (76)	39.2% (94)
101-200	23.3% (56)	40% (96)	42.1% (101)
201-300	13.8% (33)	23.8% (57)	18.3% (44)
301-400	0	3.3% (8)	0

Table 3. Awareness of *P. vampyrus* hunters in Identifying and Differentiating Threatened and Non-threatened Flying Fox Species, Wildlife Act (RA 9147) and their attendance to Information, Education and Communication Campaign on Flying Fox Conservation in Agusan Marsh Wildlife Sanctuary.

	f	%
Knowledge on identifying and differentiating threatened and non-threatened flying fox species		
No	207	86.3
Slightly Yes	31	12.9
Definitely Yes	2	0.83
Awareness of Wildlife Act (RA 9147)		
No	151	62.9
Slightly Yes	60	25
Definitely Yes	29	12.1
Attendance to Information, Education and Communication Campaign on flying fox conservation		
Never (Did not attend any IEC on flying fox conservation)	180	75
Slightly Yes (Attended but IEC did not include the ecological services provided by flying foxes)	28	11.7
Definitely Yes (Attended the IEC including the ecological services and importance of flying foxes)	32	13.3

205) did not believe in the practice of species-specific taboos (avoidance of wildlife as food or cultural taboos on hunting and killing certain species). Only eight of the respondents (3.3%. n= 8) mentioned that *P. vampyrus* and other flying foxes were recognized as taboo species (flying foxes are considered as sacred and can most likely cause misfortune or death when they are killed and eaten).

Awareness and Perceptions of Hunters

Most of the hunters (89.58%, $n = 215$) were not engaged in any conservation-related activities in their respective villages although, most of the hunters (87.5%, $n = 210$) mentioned that they were aware of the existing conservation-related activities implemented in AMWS such as reforestation projects, field research conducted by students and visiting scientists as well as the patrolling of the lake and swamp forest by forest wardens.

More than half of the hunters (62.9%, $n = 151$) were totally unaware of the Wildlife Act and its content, while 25% ($n = 60$) were aware of this law, but did not fully understand its content and its implication to wildlife conservation (Table 3). A large proportion of hunters (86.3%, $n = 207$) reported that they were unable to identify and differentiate threatened from non-threatened species of flying foxes. Three-quarters of the hunters in AMWS (75%, $n = 180$) were not able to attend any flying fox conservation-focused information education and communication (IEC) campaign in their village. However, some 28 hunters (11.7%) mentioned that they were able to attend IEC campaigns conducted in their village (mostly by DENR personnel and some by NGOs), but the ecological services provided by flying foxes were not given emphasis.

Half of the respondents (50%, $n = 120$) mentioned that local forest and lake wardens within AMWS rarely (less than once a month) performed their duties in patrolling known hunting areas for illegal poachers and detect trading of wildlife products (49.6%, $n = 119$) (Figure 2). Moreover, many hunters (74.2%, $n = 178$) also observed that government employees duly assigned as enforcers hardly ever visited the hunting areas. In terms of enforcement, no *P. vampyrus* hunter has been fined, convicted, or jailed within AMWS during the period 2017–2018 as mentioned by 100% of the hunters. Nevertheless, most of the hunters expressed

high willingness to regulate the hunting of *P. vampyrus* in AMWS (69.2%, $n = 166$) and to effectively regulate the consumption of Large Flying Foxes in the area (87.1%, $n = 208$) (Table 4).

Hunting Patterns of Large Flying Foxes

Results showed that *P. vampyrus* was hunted mostly for subsistence (83.3%, $n = 212$) (Figure 3). Some hunters (9.6%, $n = 9.6$) hunted Large Flying Foxes both for consumption and local trading (selling residual catch). Flying fox hunting mostly occurs in open spaces, e.g., dry rice fields, unplanted cornfields, roadways, and cleared spaces, during fly-out in the late afternoon (55%, $n = 132$) (Table 5). Other common hunting grounds for flying foxes were in the inundated forest (25%, $n = 60$) and in peat swamp forest (4.6%, $n = 11$). Some other hunters (5%, $n = 12$) also mentioned that they shot *P. vampyrus* while feeding at night in fruiting trees like Marang *Artocarpus odoratissimus* and Mango *Mangifera indica*.

The five most common hunting grounds for large flying foxes were on average <2 km from the hunters' dwellings which implies that it was accessible and easy for them to hunt flying foxes. Kite and hook trapping was the most used hunting technique (55%, $n = 132$) (Table 6; Image S3-S5), particularly in open areas. Shooting was the next common technique used by the hunters (31.7%, $n = 76$) while the large flying foxes were in their roost sites or while feeding on fruiting trees.

A few respondents who were engaged in fishing sometimes observed Large Flying Foxes being caught in fishhooks (3.8%, $n = 9$) and fishnets (2.9%, $n = 7$). Using slingshot (2.5%, $n = 6$) was the least common hunting technique used. Hunters incurred the least time in shooting (0.8 h) and in hunting flying foxes using a slingshot (0.83 h). On the other hand, hunters spent an average of three hours hunting flying fox using a kite trap. Hunters revealed that the length of time incurred

Table 4. Willingness of the flying fox hunters to regulate hunting and consumption in Agusan Marsh Wildlife Sanctuary.

	f	%
Willingness to regulate flying fox hunting		
No	35	14.6
Slightly Yes	39	16.3
Definitely Yes	166	69.2
Willingness to regulate consumption of flying fox		
No	20	8.3
Slightly Yes	11	4.6
Definitely Yes	209	87.1

Table 5. Five Most Common Hunting Grounds of *P. vampyrus* in Agusan Marsh Wildlife Sanctuary with their respective Proximity (in kilometer) from the Hunters' Dwellings.

Hunting Place	N	%	Range (km)	Average Distance (km)	Standard Error
Open space/ areas (rice field, roadways, cornfield etc)	132	55	0.001 - 6	1.3	0.120
Inundated forest	60	25	0.02 - 7	1	0.270
Fruiting trees (feeding ground)	12	5	0.02-3	1	0.270
Peat swamp forest	11	4.6	0.03-4	1.9	0.390
Settlements	7	2.9	0.001-3	0.67	0.330

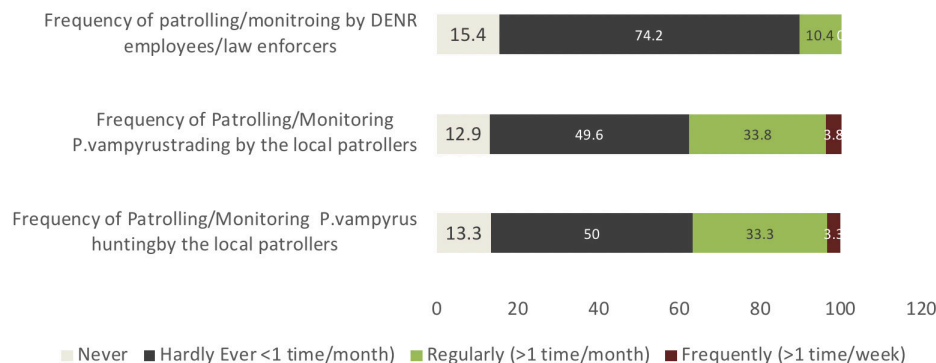


Figure 2. Frequency of Monitoring or Patrolling by the forest wardens and government enforcers in the hunting grounds of *P. vampyrus* as perceived by the hunters in Agusan Marsh Wildlife Sanctuary.

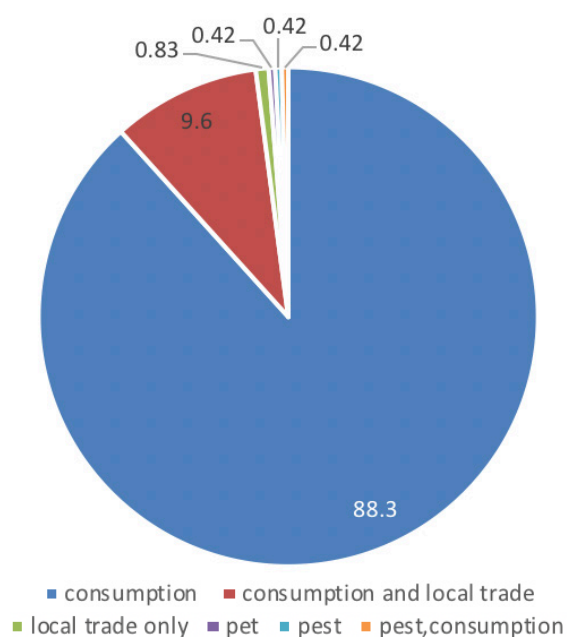


Figure 3. Motivations of hunters in hunting *P. vampyrus* in Agusan Marsh Wildlife Sanctuary

for hunting is primarily dependent on weather, wind direction, hunting skill, and location. Hunters using kite traps usually set up the kite at 1600–1900 h.

It was also found that the hunting frequency in 2012 (mean= 9.5) was higher than in 2016 (mean= 4.6) (Table S2). A Mann-Whitney U test indicated that this difference was statistically significant, $U (N_{2012} = 188, N_{2016} = 91) = 7969.5, z = -0.932, p < 0.01$. Likewise, the number of individuals hunted per year was also higher in 2012 (mean= 25.6) than in 2016 (mean= 10.3). A Mann-Whitney U test indicated that this difference was statistically significant, $U (N_{2012} = 188, N_{2016} = 91) = 7568, z = -1.5639, p < 0.01$.

Table 6. Five Most Common Techniques Used in Hunting *P. vampyrus* in Agusan Marsh Wildlife Sanctuary with their respective Hunting Time Allocation (hour).

Hunting technique	N	%	Range (hr)	Average Time (hr)	Standard Error
Kite and hook trapping	132	55	1-5	3	0.060
Shooting (gun)	76	31.7	0.2-4	0.80	0.050
Fishhook	9	3.8	5-8	7	0.410
Fish netting	7	2.9	5-12	7.6	1.050
Using slingshot	6	2.5	0.5-1	0.83	0.110

Driving Factors that Influence Flying fox Hunting

A multiple regression model explained a statistically significant amount of variance in hunting frequency, $F = 4.123, p = 0.003, R^2 = 0.07$ (Table S3). Average daily income was a significant predictor of hunting frequency, $\beta = -0.019, t = -2.025, p = 0.04$. The lower the daily income of the hunter, the more likely that he would hunt *P. vampyrus* more often than those with higher income. Engagement of the hunter in any conservation-related activities ($\beta = -4.728, t = -0.230, p = 0.20$) and distance of the hunter's dwelling to the hunting area ($\beta = -0.965, t = -2.025, p = 0.04$) were likewise predictors of hunting frequency. Hunters who are not engaged in any conservation-related activities and those who live nearer to the hunting area are those who would hunt more frequently.

Similarly, a statistically significant amount of variance in hunting quantity was explained by a multiple regression model, $F = 5.084, p = 0.02, R^2 = 0.06$ (Table S4). Average daily income ($\beta = -0.046, t = -2.50, p = 0.010$) and hunter's engagement in any conservation-related activities ($\beta = -11.285, t = -2.51, p = 0.010$) were also found to be negatively associated with hunting quantity.



Moreover, hunting time allocation ($\beta = 1.495$, $t = 2.077$, $p = 0.040$) was found to be positively associated with hunting quantity. The more time allocated in hunting *P. vampyrus*, the higher the catch.

DISCUSSION

Understanding human-flying fox interaction is essential to effective long-term conservation, efficient law enforcement, and persistence of the flying fox population without compromising human welfare. This study shows the importance of determining the demographic, socio-economic and cultural background of flying fox hunters; level of conservation awareness, perceptions, and hunting drivers in informing adaptive flying fox conservation in AMWS and other protected areas in the Philippines and in other tropical countries.

Socio-demographic and economic background of hunters

The study shows the socioeconomic vulnerability of the indigenous and local communities in AMWS due to low daily wage (Php 182.50 or <4 USD during the dry season and Php 123.63 or <3 USD during the wet season) which is below the poverty threshold (Albert et al. 2018). Other contributing factors to the poor economic condition in AMWS include a high number of household dependents, lack of diversified income sources, and annual flooding. Most economic activities are influenced by the seasonal flood cycle in the marsh, availability of natural resources, and occurrence of drought (DENR 2001; Tomas et al. 2011). Rice and corn farming and fishing are the most common livelihoods in AMWS. It is during the first quarter of the year (December–March) that hunger among the communities is greater due to reduced economic activities and decreasing food supply, e.g., limited farm produce and low fish catch as this is the flood season (Tomas et al. 2011). Switching from farming to fishing is a common survival strategy in the flooded areas. It has been more challenging to those who do not have any fishing skills and no other supplementary income during the flood season.

The second quarter (April–July) is the dry season and the financial crisis is still commonly experienced due to the depletion of financial resources during the flood period and high expenses incurred for land preparation (planting season) and for school expenses of their children in March and June as the closing and opening of classes, respectively (Tomas et al. 2011). Drought is one of the most challenging phenomena to farmers

during the dry season which adversely affects their produce. Unpredictable weather is experienced from August to November resulting in varying crop yield and fish catch (Tomas et al. 2011). The study also shows that only a few households have a supplementary source of income, e.g., rubber tapping, fish vending, food peddling, livestock raising (pigs and chickens), small stores, seasonal carpentry, farm services, motor driving, boat driving, and domestic services.

Flying Fox Hunting Patterns and Intensity in AMWS

Excessive hunting is considered a major threat particularly to the pteropodid bats (Schipper et al. 2008; Mickleburgh et al. 2009; Mildenstein et al. 2016). Flying fox hunting is rampant in southeastern Asian countries where bats are abundant; poverty and food insecurity are high and enforcement is poor (Jenkins & Racey 2008; Scheffers et al. 2012; Raymundo & Caballes 2016; Mildenstein et al. 2016; Tanalgo et al. 2016; Tanalgo 2017). Hunting aside from logging and agricultural conversion is identified as the major threats specifically to Philippine bats (Tanalgo & Hughes 2019). But even in protected areas of the country, subsistence hunting is rampant, e.g., Sierra Madre (Scheffers et al. 2012) and Mt. Apo National Park (Tanalgo 2017). Financially poor communities are more likely to hunt wildlife to satisfy their basic needs (Duffy et al. 2016), e.g., households with low living standards and smaller farms in Palawan were found to more likely hunt wildlife and spend greater hunting effort (Shively 1997). Likewise, this study shows that the low income of the hunters explains the prevalent flying fox hunting in AMWS.

The use of kite with string hooks was the most common flying fox hunting tool (Image S3) in AMWS which according to some indigenous key informants was introduced by a non-indigenous hunter. Although the use of kites and hooks has become famous in the area, some hunters still use air guns to hunt flying foxes in their roost sites. It is of major conservation concern when kite-and-hook hunters frequently catch females with lactating pups due to a lack of seasonal hunting regulation. Likewise, shooting is also of conservation concern because flying foxes have high roost site fidelity and they likely return to their preferred roost sites where hunting occurred (Stier & Mildenstein 2005; Mildenstein 2016) which will likely cause population reduction (Mildenstein 2012).

Most of the flying fox hunters are 21–50 years old since the kite-and-hook trapping technique requires skill, strength and stamina. It requires a kite operator to fly the kite at 1600 h in the afternoon when the flying foxes

start to come out from the roost sites. Ideal kite-and-hook hunting sites are in open areas such as dried rice fields and unused corn fields. Hunters who live nearer to hunting areas are those who hunt more intensely due to greater ease and better accessibility. The adult kite operator would skillfully maneuver the kite and hooks with two other assistants (mostly 9–12 years old) who kill the catch by smashing the head with a hard object (Image S4). Both adult and child hunters did not mind the hunting risks at all, e.g., snake bite and injury, to meet their subsistence needs.

Some of the adult Manobo hunters (40–50 years old) mentioned that in 2000–2005, they used to see plenty of flying foxes and catch >10 Large Flying Foxes in 2–3 hours. Currently, based on ocular observation, they said that there is a gradual decrease in the flying fox population in AMWS and their catch has reduced to <10 in 2–3 hours. Hunting time allocation came out as one of the significant factors that influence hunting quantity in this research. If the hunters wanted to have more catch, they had to extend their kite trapping time. Besides, some older hunters also observed that flying fox roosting sites are now farther from the settlements, usually in undisturbed areas. Hence, kite and hook hunting has become more commonly preferred technique.

If the three hunters catch more than five flying foxes, the residual catch will be sold to their neighbors for Php 25–50 (<1 USD) each for quick cash to buy food, e.g., rice, viand, spices, and snacks in school for the kids. Some hunters will sell the residual catch to a certain middleman or reseller nearby who would resell the flying foxes (live or dressed) to a nearby town for Php 40–150 (<1–3 USD) depending on the flying fox size and the buyer. In Pisan, Cotabato, the price is also <1 USD (Tanalgo et al. 2016). The price in Sierra Madre is >3 USD where even local officials and law enforcers actively hunt *Pteropus* bats (Scheffer et al. 2012). Some local officials, government employees, enforcers and businessmen in AMWS were also mentioned by the hunters as their flying fox buyers on an order basis via mobile phone for Php 50–150 or 1–3 USD each usually for social drinking. There was one restaurant owner in a certain town who mentioned that in 2012–2013, he used to buy dressed flying foxes for Php 40 (<1 USD) each on an order basis or from walk-in peddlers. He served best seller cooked flying fox meat for Php 200 (4 USD) per serving. Warning from some enforcers has eventually stopped him from serving flying fox meat.

POTENTIAL SOLUTIONS TO REGULATE FLYING FOX HUNTING IN AMWS

Based on what we have learned from the socio-economic, cultural, and environmental conditions as well as the hunting intensity in AMWS, we propose the following bottom-up conservation approaches:

Engagement of indigenous and local communities in conservation

The current study has emphasized that engagement of the communities with any conservation-related activities is negatively associated with hunting intensity in AMWS. This suggests that the involvement of indigenous and local people in relevant activities is vital for sustainable conservation action in the sanctuary and in other protected areas. Engaging local communities coupled with the increase of conservation awareness may effect positive changes in attitudes and behavior (Aziz et al. 2017). Encouraging participation of the local communities can help instill positive support to successful governance including law implementation and human-wildlife management (Velho et al. 2016; Milda et al. 2020) particularly if the local communities have high motivation towards wildlife protection (Conney et al. 2017).

The majority of them have recognized conservation-related activities in the sanctuary. However, only a few of them were engaged in the said activities. Hence, training and hiring them as local research assistants in any flying fox research, e.g., population monitoring, human-bat conflict investigations, and involving them in the establishment of local conservation sites (e.g., Baral et al. 2014), creation of wildlife information centers, and in local outreach programs might increase their conservation awareness and divert their time to hunt. With proper capacity building, empowerment, and good incentives, hunters can be employed as patrollers to protect flying foxes using the “poachers to protectors” mechanism.

Adaptive Information, Education and Communication Campaign (IEC)

The involvement of 9–12-year old kids as hunting assistants to either their father, uncle, brother or neighbor is quite disturbing. This suggests the urgent need to integrate wildlife conservation in K-12 curricula. Conservation education must be provided to school children since conservation attitude is developed right from the earliest years (Jacobson 1995). The academe (nearby universities) and conservation experts must coordinate with the Department of Education to train



the grade school and secondary (junior and senior levels) school teachers on flying fox conservation. Science books and lessons must integrate ecological services of threatened flying foxes, e.g., *P. vampyrus* and the implication of Wildlife Act or RA 9147 to conservation. Younger audiences might be receptive to positive information about flying foxes (Aziz et al. 2017). Educating the kids will surely have positive outcomes in their attitudes and disposition (Ardoin et al. 2018) towards wildlife conservation. Hence, flying fox-conservation-themed science fair activities, e.g., quiz bees, debates, essay writing contests, and the poster-making contests might help develop the emotional attachment of children to flying foxes.

The parents and teachers association assembly can be a strategic avenue where the trained teachers can promote conservation to the older generation. The environmental education programs and approaches for schools and the local communities shared by Trehwella et al. (2005) and Kingston et al. (2006) can be adopted. It must include a simplified and comprehensible illustration of the indirect benefits of flying foxes to their livelihood as farmers and fishermen and the disadvantages of excessive hunting. Given the hunters' low awareness of the Wildlife Act, there must be a clearer explanation of its content and its conservation implication.

The target audience of conservation IECs must also include enforcers, government employees, and business owners since some of them were found to be part of the local trade chain. Flying fox conservation and wildlife act posters must be posted in hunting areas, e.g., fly-outs and roosting sites; public places, e.g., churches, markets, public transport terminals, government offices, and schools. Famous festivals, e.g., the 'Naliyagan' festival in Agusan del Sur may also include flying fox mascot parade, relevant film showing, games, and contests. Periodic assessment of IEC impacts is also important to improve awareness and outreach programs in regulating hunting, trading, consumption, and protecting habitats.

Improved law enforcement

It is stated in Chapter 3, Article 1, Section 7 of the Philippine Wildlife Act or RA 9147 that the collection of wildlife by indigenous people may be allowed for traditional use (e.g., food and medicine) and not primarily for trade: Provided, furthermore, that collection and utilization for said purpose shall not cover threatened species (DENR 2011). The difficulty of enforcing RA 9147 in AMWS can be explained by the strong dependence of the indigenous and local communities on the threatened flying fox, e.g., *P. vampyrus* meat for consumption. There

were already confiscations of kites and guns, warnings, and restrictions given by the DENR in 2015–2016. But the poor communities in AMWS who lack adequate understanding of RA 9147, ecological values of flying foxes, and their conservation status continued hunting and engaged in local trading.

Furthermore, the infrequent or irregular patrolling scheme of the local wardens and the DENR enforcers could be attributed to a few local wardens and their minimal compensation (more or less Php 1,500 or <30 USD per quarter). No flying fox hunter was fined, convicted, and jailed in 2017–2018. Is the criminalization of hunting a threatened flying fox (e.g., *P. vampyrus*) an ethical or practical solution to protect the species in areas where hunting is part of their culture and which also serves as their safety net? This question is not only for AMWS context but also to other areas where the main hunting motivations are subsistence and economic incentives.

In this context, hunting limits (science-based quota per week or month) or perhaps allowing the hunters to focus on non-threatened (locally abundant) mammals may be a more effective and culturally adaptive regulation scheme than through strict legal enforcement. However, to balance species conservation and human welfare, there must be sustainable and seasonal hunting policies. This primarily requires hunting sustainability studies that include periodic flying fox population monitoring, hunting yields, hunting intensity, consumption rate, human population, and scenario building which are among the major research gaps in the Philippines. These are important information to accurately quantify the impacts of harvest in the future and the species extirpation tipping point. More research of this kind must be conducted within and outside Protected Areas to inform sustainable hunting policy interventions.

Increased investment in patrolling is necessary for hunting regulation and for increased detection of illegal activities (Jachman & Billeouw, 1997; Johnson et al. 2016), e.g., flying fox trading and violation against science-based hunting quotas in AMWS. The government must provide funds for capacity building, regular patrolling, a sufficient number of patrollers with good compensation, patrolling equipment, and technology. These are very important for hunting regulation (Milda et al. 2020) particularly to monitor hunting considering hunting quotas and prescribed hunting season.

Local food security and sustainable livelihood

As discussed above, flying fox hunting in AMWS has been part of 'Manobo's' culture and has become

the safety net (protein source) of the poor indigenous communities. The strong dependence on wild meat in AMWS is quite common in rural areas of other marginalized and poor countries where wildlife provides immediate food security, protein source, livelihood, and income source (MEA 2005; Paillet 2005; Nasi et al. 2008; Brashares et al. 2011; Swamy & Pinedo-Vasquez 2014; Fa et al. 2015).

Hence, poverty alleviation will likely help in regulating wildlife resources (Robinson & Bennett 2002; Swamy & Pinedo-Vasquez 2014). Alternative income-generating strategies must be promoted in AMWS to reduce dependence on flying foxes. Appropriate and adequate support must be provided for the fisheries and agricultural sector to increase local food security. Support measures must include capacity-building for sustainable agriculture (e.g. organic vegetable farming, livestock husbandry, use of flood and drought-resistant crops) and sustainable fisheries (no using of electric and other illegal fishing techniques), indigenous handicraft making, providing micro-finance for farming, subsidizing farming and aquaculture inputs and improvement of farm-to-market accessibility.

Further measures to increase livelihood security include eco-tourism. AMWS has been identified as the primary tourism resource of the province of Agusan del Sur (DENR 2011). With appropriate planning, adequate government support, and effective implementation, ecotourism in AMWS will provide livelihood and income source diversification to the local communities and promote conservation. AMWS has terrestrial, wetland, and freshwater ecosystems (59 lakes and 5 rivers), harboring unique and pristine types of habitats, several species, and important nesting sites for migratory and resident birds (DENR 2011). Appropriate eco-tourism products and packages will be developed employing the local communities, e.g., river cruise, bird and flying fox watching, kayaking, and eco-trail on boardwalks, among others.

CONCLUSIONS

Flying fox hunting in AMWS is intricately linked with the economic, social, cultural, environmental, and ethical challenges. Low income, lack of engagement in conservation-related activities, the proximity of hunter's dwelling to the hunting area, and hunting time allocation came out as the significant contributing factors to hunting intensity in AMWS. Although low awareness of the Wildlife Act, no attendance to IECs on ecological

values of flying foxes, infrequent patrolling, and poor law enforcement were not among the significant drivers but to some extent, are also important factors to consider in the design of long-term flying fox conservation programs. To make policy interventions more realistic and sustainable, the approaches in regulating flying fox hunting in AMWS must not be solely focused on flying fox conservation at the expense of livelihood and food security, nutrition, and well-being of the communities.

Adaptive and flexible approaches that reconcile and balance the dependence of the poor communities on wild meat and the conservation of threatened flying fox population, e.g., *P. vampyrus* must be considered. With many constraints in totally banning hunting in areas with poor and wild resource-dependent indigenous people, sustainable flying fox hunting is the most reasonable option to promote conservation and food security. This requires intensive research on the dynamics of flying fox hunting, consumption and trading extent, population data (spatial and temporal) and scenario building for the predictive impacts of hunting on the depletion particularly of threatened flying fox species, e.g., *P. vampyrus*. This will scientifically inform policy interventions on the setting of sustainable hunting quota (number of catch per time period) in the sanctuary with the prescribed hunting technique, in the right hunting areas during the prescribed season.

Achieving successful conservation and positive behavioral change requires a combination of effective information and education communication to different sectors, engagement of the local communities in research and conservation, improved patrolling scheme to assure sustainable hunting limits (quota) and to ban trading, capacity building for sustainable livelihood programs and diversification of income sources.

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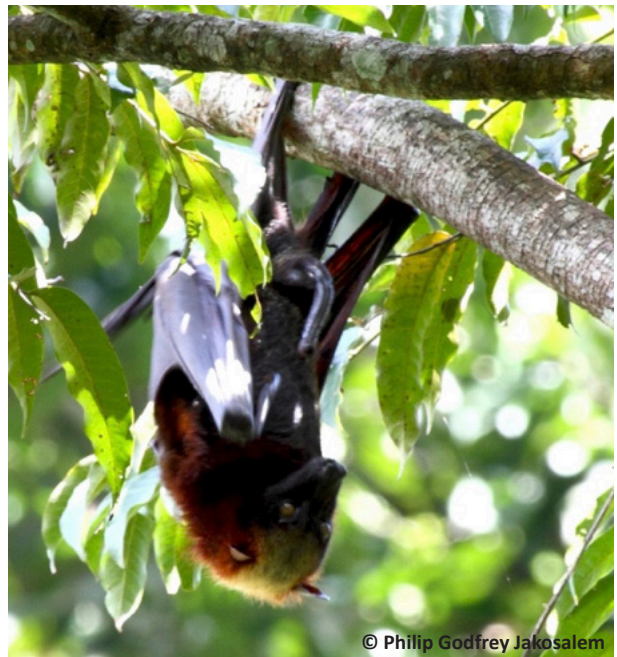
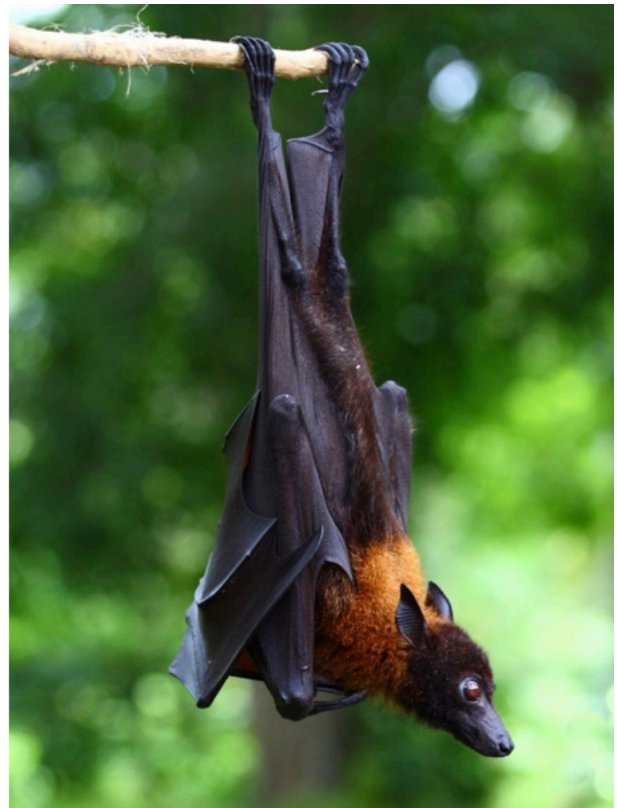
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Image S1. Agusan Marsh Wildlife Sanctuary (Sitio Panlabuhan, Poblacion, Loreto, Agusan del Sur, Philippines).



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Image S3. Kite and hook materials commonly used in hunting flying foxes in Agusan Marsh Wildlife Sanctuary (upper picture: kite used by hunters; lower picture: kite string hooks to trap flying foxes)



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Image S2. Morphological differences of the Endangered *P. vampyrus* (Large Flying Fox) shown in the top picture and Critically Endangered *Acerodon jubatus* (Golden-crowned Flying Fox) shown in the bottom picture. The dorsal pelage of *P. vampyrus* is usually blackish brown and golden on the upper back, with the posterior margin sharply defined by a dark brown transverse line on the lower back, that ends in a narrow “V” at the nape and shoulders. Whereas, the dorsal pelage of *A. jubatus* is not completely blackish brown, and has a golden patch on top of the head extending to the ears, but lacks the dark brown transverse line on the lower back.



Image S4. Kite and hook hunting of flying foxes in Agusan Marsh Wildlife Sanctuary starting at 1600–1700 h in the afternoon (upper left picture: adult kite operator (main hunter); upper right picture: child hunting assistant with a wooden material used to kill the catch; lower picture: young hunting assistants (9–12 years old)).



Image S5. *Pteropus vampyrus* caught by a hunter using kite and hook hunting technique in Agusan Marsh Wildlife Sanctuary.

Table S1. Five most common livelihoods of the *P. vampyrus* hunters in Agusan Marsh Wildlife Sanctuary during the dry and wet season (n=240).

Main livelihood	Dry Season		Wet Season	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Rice farming	144	60	84	35
Corn farming	26	10.8	9	3.8
Fishing	14	5.8	85	35.4
Rubber tapping	11	4.6	8	3.3
Motorcycle Driving	8	3.3	5	2.1
None	2	0.83	37	15.4

Table S2. Hunting Frequency and Quantity of *P. vampyrus* across different periods (1 month before the surveys in 2017, 2016 and 2012) in Agusan Marsh Wildlife Sanctuary as revealed by the hunters.

Variables	1 month before the surveys in 2017 (n=27)			2016 (n=91)			2012 (n=188)			Sig. 2016 vs 2012
	Range	Mean	SE	Range	Mean	SE	Range	Mean	SE	
Hunting Frequency	0–12	0.54	0.13	0–96	4.6	0.70	0–50	9.5	0.79	0.001
Hunting Quantity	0–50	1.5	0.41	0–100	10.3	1.4	0–100	25.6	1.9	0.001

Table S3. Driving factors of the frequency of hunting *P. vampyrus* in Agusan Marsh Wildlife Sanctuary.

Variables	Unstandardized Coefficients		t	p-value
	Estimates, B	Std. Error		
(Constant)	11.415	3.299	3.460	0.001***
No. of Family Members with income	0.581	0.317	1.835	0.070 ^{ns}
Average Daily Income	-0.019	0.009	-2.025	0.040*
^a Engagement in conservation-related activities	-4.728	2.287	-2.067	0.040*
Distance to the hunting area (in km)	-0.965	0.419	-2.303	0.020*

Legend: *** highly significant (significant at $\alpha=0.001$); ** significant at $\alpha=0.01$; * significant at $\alpha=0.05$ ^{ns} not significant at $\alpha\geq 0.05$

^a categorical variable: 1= member; 0= non-member

Dependent Variable: Frequency of Hunting; $R^2=0.07$; ANOVA, F-statistic= 4.123 with p- value=0.003

Figure S5. *Pteropus vampyrus* caught by a hunter using kite and hook hunting technique in Agusan Marsh Wildlife Sanctuary.

Variables	Unstandardized Coefficients		t	p-value
	Estimates, B	Std. Error		
(Constant)	26.022	6.114	4.256	<0.001***
Average Daily Income	-0.046	0.018	-2.500	0.010**
^a Engagement in conservation-related activities.	-11.285	4.492	-2.512	0.010**
Hunting Time Allocation	1.495	0.720	2.077	0.040*

Legend: *** highly significant (significant at $\alpha=0.001$); ** significant at $\alpha=0.01$; * significant at $\alpha=0.05$ ^{ns} not significant at $\alpha\geq 0.05$

^a categorical variable: 1= member; 0= non-member

Dependent Variable: Frequency of Hunting; $R^2=0.06$; ANOVA, F-statistic= 5.084 with p-value=0.002.

Tagalog abstract: Walang dokumentadong pag-aaral sa panghuhuli ng mga paniki ang ginawa sa Agusan Marsh Wildlife Sanctuary (AMWS) na kilalang nagtataglay ng maraming nanganganib na mga buhay-ilang. Ang mga uri ng paniki tulad ng Large Flying Fox o *Pteropus vampyrus* ay nanganganib sa AMWS dahil hinuhuli sila ng mga tao kahit ito ay pinagbabawal ng Wildlife Act. Nagsagawa kami ng semi-structured na panayam mula Setyembre, 2017 hanggang Enero, 2018 kasama ang 240 na mga mangangaso mula sa sampung nayon upang malaman ang pang-sosyolohiya, pang-ekonomiko at pangkultura na mga katangian ng mga mangangaso pati ang kanilang kaalaman at pang-unawa sa Wildlife Act, pangangalaga at proteksyon sa nasabing paniki, pagpapatupad ng batas, pagmamamanman, mga impormasyon tungkol sa kanilang panghuhuli ng paniki at mga kadahilanan sa panghuhuli. Ipinapakita sa resulta na ang pagsasaka at pang-ingisda ay ang pinakakaraniwang pangkabuhayan ng mga mangangaso. Karamihan sa mga mangangaso ay nakamit ang edukasyon sa antas ng elementarya (42.9%), at nabibilang sa isang sambahayan na mayroong 4-6 na miyembro (55.5%), madalas na may isang miyembro lamang na mayroon kunting kita sa araw-araw (80.7%). Ang taunang pagbaha ay ang pangunahing hadlang sa ekonomiya ng mga mangangaso. Mga katutubong Manobo ang karamihan sa mga mangangaso (62.9%) at karamihan din sa kanila ay hindi naniniwala sa pag-iwas sa mga taboo species (85.4%). Karamihan sa mga mangangaso ay walang kamalayan sa Wildlife Act (62.9%) at hindi alam ang pagkakaiba ng nanganganib at hindi nanganganib na species ng paniki (86.3%). Ang pagmamamanman ng mga bantay-gubat at bantay-lawa at mga tagapagpatupad ng batas ng gobyerno ay napag-alamang hindi regular (mas mababa pa sa isang beses kada buwan) at walang ni isa man lang na mangangaso ang nakitang nahuli o nakulong sa AMWS sa taong 2017-2018. Ang mga saranggola na may mga kawit (55%) at baril (31.7%) ay kadalasang ginagamit sa panghuhuli ng mga paniki na *P. vampyrus*. Karamihan sa mga mangangaso ay nanghuhuli ng paniki upang may makakain (83.3%). Napag-alaman din sa pag-aaral na ito na ang mababang pang-araw araw na kita at kakulangan sa pakikipag-ugnayan sa konserbasyon ang posibleng dahilan sa mas madalas na pangangaso at mas maraming huli na paniki. Samakatuwid, mas makatwiran at makatotohanang isaalang-alang ang mga science-based quotas sa pangangaso sa AMWS kung saan naninirahan ang mga mahihirap na katutubo. Ang pagpapabuti at pagpapatupad ng mga batas na may kinalaman sa proteksyon sa mga buhay-ilang sa AMWS ay dapat nakabatay sa masusing pag-aaral upang mapanatili ang balanse ng pangangalaga sa kalikasan at kapakanan ng mga tao along lalo na ang mga mahihirap na katutubo. Ang positibong pagbabago sa pag-uugali at ang mas mabisa na pagbabawal sa pangangaso at pagbibinta ng mga paniki ay nangangailangan ng kumbinasyon ng mabisang mga kampanya at edukasyon, pakikipag-ugnayan ng mga katutubo sa konserbasyon, mas mahusay na pagpapatupad ng quota sa panghuhuli ng paniki at napapanatiling mga programa sa pangkabuhayan. Ang regular na pag-aaral sa populasyon ng mga *P. vampyrus* at iba pang uri ng mga paniki ay mahalaga din upang silay mas lalo pang mapangalagaan ng wasto at hindi tuluyang mauubos.

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