



RESEARCH PAPER

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**Socio-ecological dimensions of intertidal gleaning: The use of local ecological knowledge to identify commercially important gastropods in Iligan Bay, Philippines**

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**ABSTRACT**

Intertidal gleaning serves as a source of food and income for numerous coastal communities in the Philippines. Nevertheless, the socio-economic and ecological dimensions of intertidal gleaning remain under-researched. This study examined the socioeconomic level of gleaners, their harvesting methods, and their perceived diversity and abundance of edible gastropods in Iligan Bay, particularly in Biga, Lugait, Misamis Oriental, Kiwalan, Iligan City, Lanao del Norte and Tacub, Kauswagan, Lanao del Norte. Data was collected through household surveys and field sampling, integrating Local Ecological Knowledge (LEK) with scientific assessment. Gleaning was mostly carried out by women, older adults, and those with elementary and high school education. Although mainly intended for household consumption, it additionally functioned as a supplementary income source. Gastropod diversity exhibited significant richness, with Strombidae, Conidae, and Cypraeidae as predominant families. Gleaning patterns varied by site: Biga and Tacub showed higher day-and-night activity, while Kiwalan demonstrated moderate daytime harvesting. Harvesting methods differed distinctly, with handpicking dominant in Biga and Tacub, and wading hand gleaning most common in Kiwalan. Gleaners reported declining gastropod populations, attributed to overharvesting, pollution, and destructive fishing practices. Current management measures face difficulties concerning enforcement and awareness. To ensure long-term viability of gastropod resources and coastal livelihoods, enhancing community-based management, environmental education, and integrating local ecological knowledge in scientific research is essential.

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## INTRODUCTION

Marine biodiversity is essential for maintaining healthy ocean ecosystems and influencing numerous processes that support ecological balance (Fan *et al.*, 2022; Snelgrove and Danovaro, 2023). Marine habitats such as coral reefs, mangroves, and seagrass beds are home to diverse species that play critical roles in nutrient cycling, habitat formation, and the global food web (Keyzer *et al.*, 2020; Mhatre, 2024). Among these species, marine invertebrates, particularly gastropods, are vital contributors to ecosystem stability. Their roles in nutrient recycling and food web dynamics make them indispensable not only for marine health but also for the livelihoods of coastal communities (Islamy and Hasan, 2020).

In coastal regions, gastropods serve as an essential source of food and income for marginalized fisherfolk (Lebata-Ramos, 2023). However, increasing global demand for marine gastropods has intensified pressure on their populations, posing a significant risk of overexploitation that threatens both species and the coastal communities reliant on them for survival (Macusi and Maynawang, 2023; Cheng *et al.*, 2021). Intertidal gleaning uses low-technology tools like buckets, knives, sticks, or hands, yet even such basic tools or tramping within the intertidal zone can harm coastal habitats like coral reefs, seagrass meadows, and rocky shorelines (Stiepani *et al.*, 2023). Continuous disturbance through harvesting, depletes marine resources and undermines the ecological balance necessary for biodiversity and fishery productivity (Gaillet *et al.*, 2022).

Despite the economic benefits of gleaning, concerns about sustainability calls for improved management and conservation strategies (Kazara-Belja, 2023). In countries like the Philippines, research on the conservation and management of seashell populations is limited, despite rising concerns over overexploitation (Macusi and Maynawang, 2023). To address this gap, researchers increasingly use Local Ecological Knowledge (LEK) from local communities, whose long-term observations provide valuable insights into species dynamics and environmental

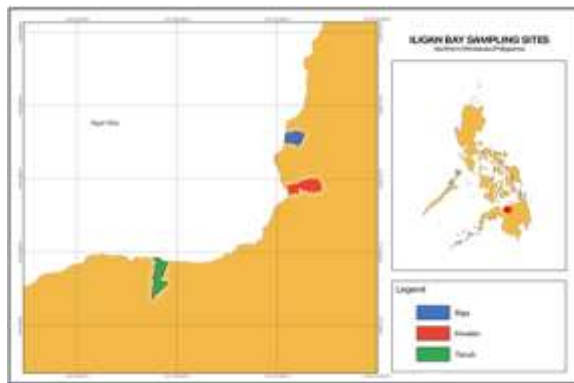
conditions (Cheng *et al.*, 2021). LEK mainly comes from the direct observation of ecological processes and the logical interpretation of what is seen by local communities (Fabanjo *et al.*, 2024). Implementing management strategies in collaboration with local communities' observations might be much more effective than those based solely on scientific knowledge (Da Silva Mourão *et al.*, 2020). While LEK is invaluable, it is important to integrate it with scientific ecological knowledge (SEK) to develop comprehensive and effective conservation strategies (Cebrián-Piqueras *et al.*, 2020).

This research aims to (1) identify commercially important gastropod species, (2) document gleaning collection patterns and harvesting methods, and (3) assess community perceptions regarding changes in gastropod populations over time along the intertidal zones of Iligan Bay, Philippines. Documenting these species and understanding their collection and harvesting practices will establish baseline information essential for developing effective conservation strategies that protect marine gastropods and the coastal communities that depend on them. The findings support Sustainable Development Goal 14 by advocating for the sustainable utilization and management of marine resources. Additionally, it contributes to SDGs 1 and 2 by highlighting how gleaning activities enhance food security and provide essential income for coastal families. Sustainability happens when the economic, social, and environmental aspects work together (Hariram *et al.*, 2023). When livelihoods, food security, and marine protection are balanced, we move closer to true sustainability, one that benefits both people and the planet

## MATERIALS AND METHODS

This study was conducted at the selected sites in Iligan Bay, Philippines (Fig. 1). These locations were chosen based on the presence of accessible gleaning grounds and its proximity to industrial zones within the intertidal zones of Iligan Bay. The study sites are the following: (1) Biga, Lugait, Misamis Oriental (8°21'18.48"N, 124°15'34.13"E); (2) Kiwalan, Iligan

City, Lanao del Norte (8°17'0.22"N, 124°15'50.00"E); and, (3) Tacub, Kauswagan, Lanao del Norte (8°11'41.42"N, 124°5'56.08"E). Between February and March 2025, 111 gleaners were surveyed using a modified questionnaire adapted from Mota *et al.* (2020).



**Fig. 1.** Map of Iligan Bay showing the three study sites

### Social survey

A field guide published by the SEAFDEC Aquaculture Department was used as the primary reference, supplemented with edible gastropod species previously documented in Iligan Bay by Lumayag *et al.* (2018) and additional images from the World Register of Marine Species (WoRMS) to aid in species identification. Data collection was carried out both directly at the gleaning grounds and in coastal households. Participants were selected based on the following criteria: (1) they must have participated in gleaning activities within the study area, and (2) they must be 18 years old or above.

### Collection of edible gastropod

Representative samples of edible gastropods were collected through random handpicking with the assistance of local gleaners (Caril *et al.*, 2023; Albarido and Tabugo, 2024). Collection took place on random days during low tide from February to March, 2025.

### Gastropod identification

In the laboratory, samples were cleaned and preserved (Supusepa *et al.*, 2023). After cleaning, each sample was carefully photographed from both the ventral and dorsal perspectives for proper

documentation (Hamli *et al.*, 2024). Photographed images were classified based on shell morphology and compared to visual references obtained from online image searches. Preliminary matches were validated through reliable taxonomic sources, including the World Register of Marine Species (WoRMS) and SeaLifeBase. The identifications were then sent to a malacology expert at Silliman University for validation. Species names were standardized in accordance with the accepted nomenclature provided by WoRMS.

### Data analysis

Microsoft Excel was used to systematically organize and tabulate all data gathered in this study. Descriptive analysis was employed to summarize socio-ecological patterns and to document gleaners' Local Ecological Knowledge (LEK).

## RESULTS AND DISCUSSION

### Socio-demographics and reasons for gleaning

Female gleaners dominated in Biga and Tacub, whereas male gleaners were more dominant in Kiwalan (Table 1). Women predominantly engage in gleaning during low tide and good weather conditions (Bantayan, 2022). Their participation is higher in Biga and Tacub, where gleaning occurs on exposed flats, requiring minimal physical exertion and offering a safer, more accessible environment. In contrast, Kiwalan has deeper tidal flats that need wading in deeper water, making the activity more physically demanding and riskier, which likely accounts for the higher male participation observed there (Stiepani *et al.*, 2023). Age distribution (Table 1) showed that while older adults (51 and above) dominate gleaning in Biga, middle-aged (31–50) gleaners are most active in Kiwalan and in Tacub, with Tacub also showing strong participation from younger adults (21–30). The data on the educational backgrounds (Table 1) indicate that gleaning is an activity engaged by individuals from diverse educational backgrounds, with a notable prevalence of elementary and high school graduates across all sites. However, this study shows that individuals with higher educational backgrounds also engage in gleaning, viewing it as an

enjoyable activity or a practical way to supplement household consumption. Across all sites, most respondents earned (Table 1) less than ₱10,000 monthly. Only a few respondents mentioned incomes exceeding ₱10,000. Most respondents gleaned mainly for household consumption (Table 1). Gleaning for consumption and income was observed at Biga and was significantly higher at Tacub. Similar patterns are

observed in Indonesia, where gleaning is largely for food (Furkon *et al.*, 2019), while in Zanzibar it supports income for the local communities (Pike *et al.*, 2024). In the Philippines, gleaned invertebrates contribute to household nutrition (De Guzman *et al.*, 2019), and income in some communities, and serve as a primary livelihood source for many women (Bantayan, 2022; Stiepani *et al.*, 2023).

**Table 1.** Sociodemographic profile of the respondents

Category	Description	Biga		Kiwalan		Tacub		Total	
		n	%	n	%	n	%	n	%
Gender	Male	15	41%	21	62%	16	40%	52	47%
	Female	22	59%	13	38%	24	60%	59	53%
Age group	21–30	7	19%	5	15%	11	28%	23	21%
	31–40	8	22%	13	38%	19	48%	40	36%
	41–50	5	14%	10	29%	4	10%	19	17%
	51–60	11	30%	5	15%	3	8%	19	17%
	60 above	6	16%	1	3%	3	8%	10	9%
Educational attainment	No formal education	0	0%	1	3%	0	0%	1	1%
	Elementary level	2	5%	6	18%	2	5%	10	9%
	Elementary graduate	5	14%	9	26%	15	38%	29	26%
	High school level	1	3%	8	24%	6	15%	15	14%
	High school graduate	18	49%	7	21%	8	20%	33	30%
	College level	7	19%	1	3%	2	5%	10	9%
Monthly income	College graduate	2	5%	1	3%	7	18%	10	9%
	Above ₱10,000	7	19%	7	21%	5	13%	19	17%
	Below ₱10,000	30	81%	27	79%	35	88%	92	83%
Reason for gleaning	Consumption	37	100%	33	97%	40	100%	110	99%
	Income	2	5%	0	0%	15	38%	17	15%
	Bait for fishing	0	0%	2	6%	0	0%	2	2%

Note: n: number of responses, %: percentage of responses

**Table 2.** Identified gastropod species by gleaners in the three study sites

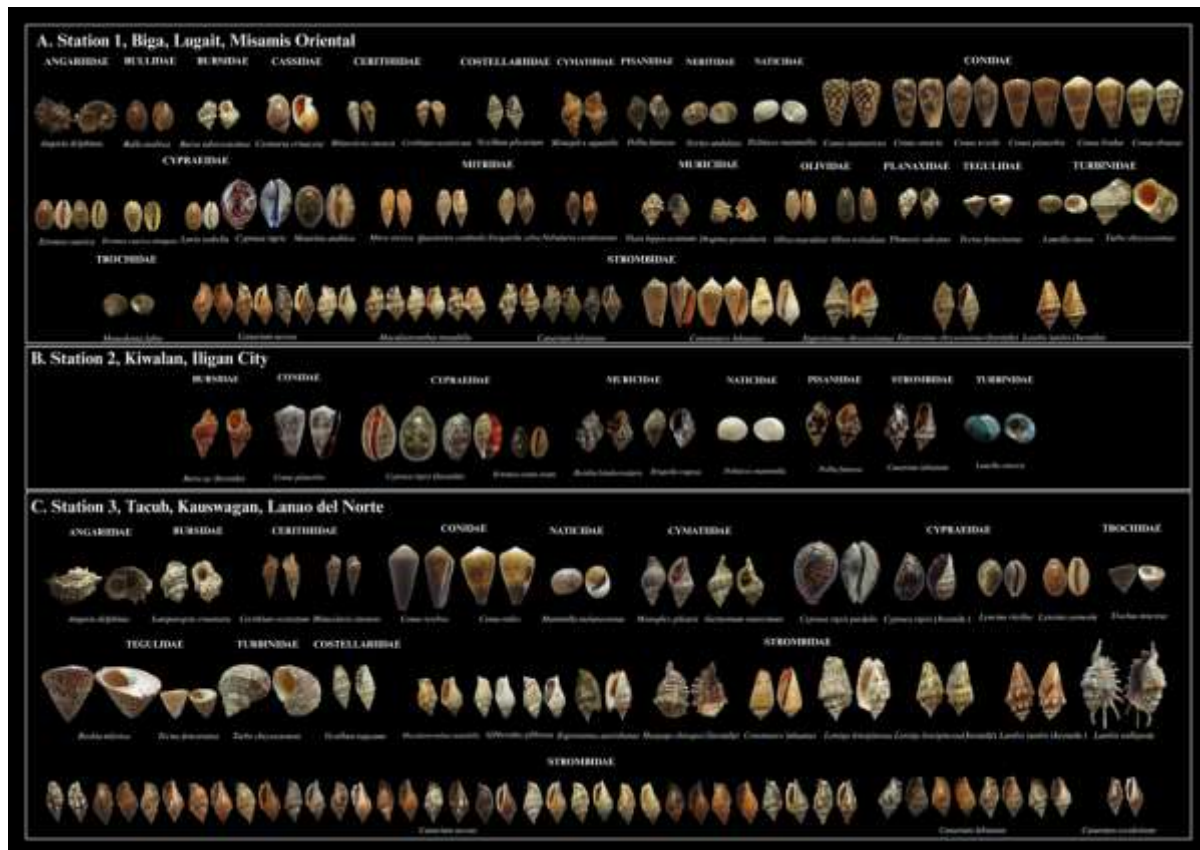
Family	Scientific name/Family	Biga	Kiwalan	Tacub	IUCN
Angariidae	<i>Angaria delphinus</i> (Linnaeus, 1758)	+	-	+	NE
	<i>Cerithium rostratum</i> G. B. Sowerby II, 1855	+	-	+	NE
Conidae	<i>Conus leopardus</i> (Röding, 1798)	+	-	+	LC
	<i>Conus omaria</i> Hwass, 1792	+	-	+	LC
	<i>Conus quercinus</i> (Lightfoot), 1786	+	-	+	LC
	<i>Conus striatus</i> Linnaeus, 1758	+	-	+	LC
Cypraeidae	<i>Monetaria moneta</i> (Linnaeus, 1758)	+	+	+	NE
	<i>Cypraea tigris</i> Linnaeus, 1758	+	-	+	NE
Muricidae	<i>Ocenebra erinaceus</i> (Linnaeus, 1758)	+	+	+	NE
Naticidae	<i>Mammilla maura</i> (Lamarck, 1816)	+	+	+	NE
	<i>Polinices mammilla</i> (Linnaeus, 1758)	+	+	+	NE
Olividae	<i>Oliva annulata</i> (Gmelin, 1791)	+	-	+	NE
	<i>Oliva efasciata</i> Dautzenberg, 1927	+	+	+	NE
	<i>Oliva tigris</i> Duclos, 1835	+	-	+	NE
Strombidae	<i>Canarium erythrinum</i> (Dillwyn, 1817)	+	+	+	NE
	<i>Canarium labiatum</i> (Röding, 1798)	+	+	+	NE
	<i>Canarium urceus</i> (Linnaeus, 1758)	+	-	+	NE
	<i>Conomurex luhuanus</i> (Linnaeus, 1758)	+	+	+	NE
	<i>Euprotomus bulla</i> (Röding, 1798)	+	+	+	NE
	<i>Lambis lambis</i> (Linnaeus, 1758)	+	+	+	NE
	<i>Lentigo lentiginosus</i> (Linnaeus, 1758)	+	+	+	NE
Tegulidae	<i>Rochia nilotica</i> (Linnaeus, 1767)	+	+	+	NE
	<i>Tectus fenestratus</i> (Gmelin, 1791)	+	+	+	NE
Turbinidae	<i>Turbo chryostomus</i> Linnaeus, 1758	+	+	+	NE
Turritellidae	<i>Turritella terebra</i> (Linnaeus, 1758)	+	-	+	NE
Volutidae	<i>Cymbiola vesperilio</i> (Linnaeus, 1758)	+	-	+	NE

Note: +: present, -: absent, NE: Not Evaluated, LC: Least Concern

**Collected and LEK identified gastropods**

With the use of a field guide, gleaners identified 26 species (Table 2). Most species are classified as not evaluated (NE) under the IUCN Red List, highlighting a significant gap in global conservation data for these taxa. Notably, only four species from the family Conidae have been assessed and are listed as least concern (LC), indicating they are not currently considered threatened.

Sampling documented 64 species (Fig. 2a, 2b, 2c), with 12 species overlaps between methods. Moreover, gastropods demonstrate significant variability in shell morphology influenced by environmental factors, this variability complicates visual identification by the respondents and may result in misidentification, particularly among closely related species (Ran *et al.*, 2020; Vinarski *et al.*, 2020).



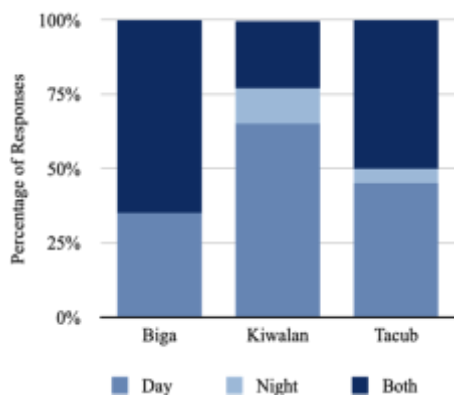
**Fig. 2.** Edible gastropods collected from (A) Biga, Lugait, Misamis Oriental, (B) Kiwalan, Iligan City, and (C) Tacub, Kauswagan, Lanao del Norte. Scientific names are italicized while family names are written in uppercase

Biga recorded the highest family richness (Fig. 2a), with 20 families identified. The most represented were Conidae and Strombidae, each with six species, followed by Cypraeidae with five species. Four species contributed to Mitridae, while two species each represented Cerithiidae, Turbinidae, Olividae, and Tegulidae. Only a single species represented the remaining 12 families. In contrast, Kiwalan showed the lowest family richness (Fig. 2b), with only eight families recorded. Both Cypraeidae and Muricidae were represented by two species each, while Strombidae, Conidae,

Turbinidae, Pisaniidae, Bursidae, and Naticidae each had only one species documented. Tacub exhibited a moderate level of family richness (Fig. 2c), comprising 11 families.

Here, Strombidae dominated with 12 species, making it the most abundant family across all sites. Five families, i.e., Cypraeidae, Cerithiidae, Conidae, Cymatiidae, and Tegulidae, each contributed two species. Each of the remaining families, Angariidae, Bursidae, Naticidae, Trochidae, Turbinidae, and Costellariidae, represented itself with a single species.

The dominance of Strombidae and Conidae observed in this study aligns with prior research conducted in the Philippines. Bangao *et al.* (2024) indicated that these two families exhibited the highest species diversity in Surigao City, additionally Caril *et al.* (2023) also identified strombidae as possessing the greatest species richness in Camarines Sur. In Sinacaban, Misamis Occidental, within Iligan Bay, Mahilac *et al.* (2023) found strombidae to be the predominant family of gastropods in seagrass ecosystems. Gastropod abundance and diversity are shaped by substrate type, organic matter, and environmental conditions (Caril *et al.*, 2023; Zalsos *et al.*, 2021), while anthropogenic disturbances, pollutants, and reduced dissolved oxygen also influence community composition (Maxwell *et al.*, 2021; Tayone *et al.*, 2020; Mustafa *et al.*, 2024; Supusepa *et al.*, 2023). These findings highlight both the ecological importance of key families and the strong influence of natural and human factors on gastropod distribution in Philippine coastal habitats.



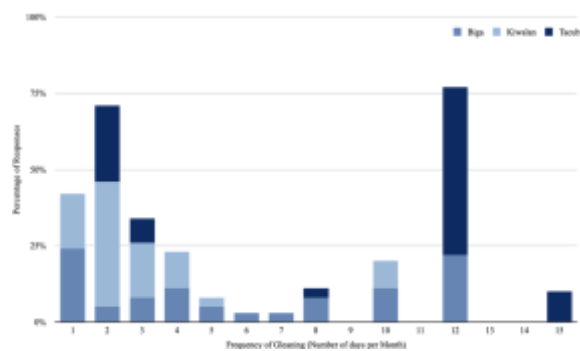
**Fig. 3.** time of the day to glean across the three sites

**Gleaning patterns and methods**

The higher proportion of day-and-night gleaners in Biga and Tacub (Fig. 3) may indicate adaptation to species’ diel activity patterns or strategies to maximize harvest yield (Jones *et al.*, 2024). In contrast, the predominance of daytime harvesting in Kiwalan may be due to the combined influence of visibility constraints, safety considerations, and potential hazards (Hoffmann *et al.*, 2022). Moreover, some respondents in Biga and Tacub preferred

gleaning during the tidal transition from low to high tide, locally known as “mag-ilog ang taob ug hunas” where they said gastropods are more visible and easier to collect.

Biga had both high-frequency and low-frequency gleaners, Kiwalan leaned toward moderate harvesting, and Tacub recorded the most intensive gleaning activity (Fig. 4). Resource availability, reliance on gleaning for income or food, and the accessibility of gleaning areas may influence these patterns (Bantayan, 2022; Stiepani *et al.*, 2022; Stiepani *et al.*, 2023).



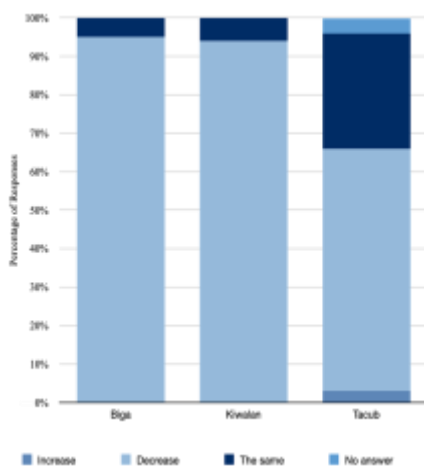
**Fig. 4.** Frequency of gleaning per month in each study site

The methods of gleaning (Table 3) varied distinctly among the three study sites, reflecting differences in habitat conditions, resource types, and local practices. Handpicking was the dominant method in Biga, with only a small number using knives to extract gastropods. In Kiwalan, no respondents reported handpicking or knife use; instead, the most common method was wading hand gleaning, which involves searching and collecting gastropods in shallow water through using hands submerged in water to feel the gastropods, followed by diving to access deeper areas. In Tacub, handpicking was again the primary method, with minimal use of knives.

**Table 3.** Methods of gleaning per study site

Methods of gleaning	Biga	Kiwalan	Tacub
Handpicking	34	0	39
Use of knives	3	0	1
Wading hand gleaning	0	26	0
Diving	0	8	0

While handpicking minimizes disturbance, during this activity, stepping on reef surfaces can inadvertently cause damage like coral breakage can occur (Aldea, 2023), and the use of knives especially for digging in seagrass beds at Biga and Tacub risks physically harming coral and non-target species (Bantayan, 2022). Furthermore, hand-wading disrupts benthic sediments and seagrass quality (Griffin *et al.*, 2024), while diving intensifies harvesting pressure on potentially slower-reproducing, deeper-dwelling populations (Bularz *et al.*, 2022).

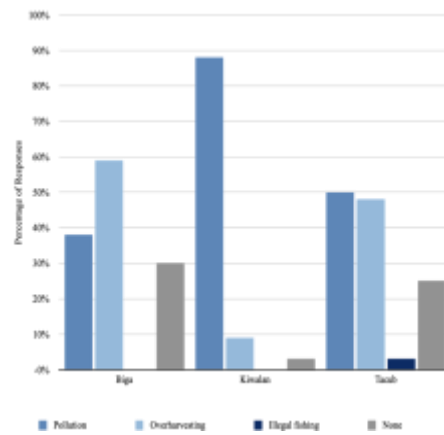


**Fig. 5.** Perceived changes in gastropod abundance per study site

**Perceived decline and threats**

Respondents across all study sites reported declining gastropod abundance (Fig. 5). The threats perceived by respondents reveal distinct patterns across sites (Fig. 6), in Biga, it shows that resource extraction pressure is a primary concern in this area, likely due to high gleaning frequency and possible competition among harvesters. Pollution here was also perceived to be associated with effluents from a nearby factory and domestic waste, both believed to degrade water quality and intertidal habitats. While pollution dominated perceptions in Kiwalan, linked to nearby industrial facilities. Reports also included sightings of oil residues from a nearby plant and warm water discharge from the local power source facility. Several respondents noted a marked decline in gastropod populations following the May 2013 fire at the copra processing plant, indicating a possible link between

industrial incidents and population changes. In Tacub, the balanced distribution of perceived threats indicates that harvesting practices, industrial activities, and domestic waste are all considered significant pressures. Pollution was perceived to be associated with the nearby power plant, with reports of coal residues in gleaning grounds, along with domestic waste believed to degrade water quality and intertidal habitats. The use of chlorine for fishing was also reported, which may pose a serious hazard due to its potential to cause acute toxicity to marine life and damage benthic ecosystems (Xin *et al.*, 2023).



**Fig. 6.** Perceived threats in gastropod abundance per study site

Across all study sites, these perceived threats, ranging from industrial discharges and domestic waste to destructive fishing methods and overharvesting are considered by the communities to be major drivers of habitat degradation and declining gastropod abundance.

**CONCLUSION**

This study assessed the socio-demographic profile of gleaners, their harvesting practices, and the diversity of edible gastropods in Iligan Bay. Gleaning was mostly carried out by women, older adults, and those with a notable prevalence of elementary and high school graduates across all sites. Although mainly intended for household consumption, it additionally functioned as a supplementary source of income. Integrating Local Ecological Knowledge (LEK) with field sampling confirmed high gastropod diversity, with Strombidae, Conidae, and Cypraeidae identified as the predominant

families. Gleaning patterns varied by site: Biga and Tacub showed higher day-and-night activity, possibly reflecting adaptation to species' diel patterns, while Kiwalan demonstrated moderate daytime harvesting intensity. Harvesting methods differed distinctly among sites, with handpicking dominant in Biga and Tacub, while wading hand gleaning was most common in Kiwalan. Gleaners reported population declines attributed to overharvesting, pollution, and destructive fishing practices. Current management measures face difficulties concerning enforcement and awareness, highlighting the urgent need for improved interventions.

The sustainability of intertidal gleaning and conservation of marine gastropod populations can be improved through several integrated approaches. Community-based management systems should be established with the active involvement of women gleaners in decision-making processes, and establishment of regulations against juvenile harvesting should be strictly enforced. Visible educational materials should be deployed in gleaning areas to promote sustainable practices, raise awareness about overharvesting risks, and provide safety information on venomous species- particularly important given the documented cases of envenomation cases among respondents in Biga. Pollution control should be strengthened through improved waste management infrastructure, enhanced multi-stakeholder collaboration, and regular water quality monitoring. Furthermore, assessment should be conducted to determine the carrying capacity and maximum sustainable yield (MSY) for local gastropod populations, to guide evidence-based harvesting limits and enhance long-term sustainability. Through these integrated measures, collaborative governance can be strengthened, gastropod populations safeguarded, coastal livelihoods supported, and long-term ecosystem resilience built.

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