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**Authors:** Lutgardo Alcantara[1], Lota Creencia[2], Karen Madarcos[3], John Roderick Madarcos[4], Jean Beth Jontila[5], Fiona Culhane[6]

**Affiliations:** College of Fisheries and Aquatic Sciences, Western Philippines University, Puerto Princesa City, 5300, Palawan, Philippines[1], School of Biological and Marine Sciences, University of Plymouth, Plymouth, UK[2]

**Orcid ids:** 0000-0001-6423-7670[1], 0000-0002-8586-8604[2], 0000-0001-8016-9401[3], 0000-0001-6513-901X[4], 0000-0003-3452-1341[5], 0000-0002-0488-1277[6]

**Contact e-mail:** lutgardo.alcantara@gmail.com



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# Perceptions of Climate Change, Sea Level Rise and Factors Affecting the Coastal Marine Ecosystem of Palawan, Philippines

Lutgardo B. Alcantara[1], John Roderick V. Madarcos[1], Karen G. Madarcos[1], Jean Beth S. Jontila[1], Fiona **Culhane**[2], Lota A. Creencia[1]

[1]College of Fisheries and Aquatic Sciences, Western Philippines University, Puerto Princesa City, Philippines

[2]School of Biological and Marine Science, University of Plymouth, Plymouth, UK

## ABSTRACT

Understanding local community perceptions of climate change is essential in developing effective risk communication tools and in developing mitigation strategies to reduce the vulnerability of coastal areas. In this study, we examined coastal communities' perceptions of climate change as a coastal threat, as a driver of rising sea levels, and as a factor affecting coral reefs and seagrass beds. The perceptions were gathered by conducting face-to-face surveys with 291 respondents from the coastal areas of Taytay, Aborlan and Puerto Princesa in Palawan, Philippines. Results showed that most participants (82%) perceived that climate change is happening and a great majority (75%) perceived it as a threat to the coastal marine environment. Sea level rise was perceived by most participants (60%) to cause coastal erosion and affect the coastal ecosystem, but they also perceived that coastal erosion can be prevented by mangroves. On coral reefs and seagrass ecosystems, anthropogenic pressures and climate change were perceived to have a high impact, while marine livelihoods had a low impact. Furthermore, local temperature rise, excessive rainfall and declining income were found to be significant risk predictors of climate change impact perceptions. Climate change perceptions were found to vary with household income, education, age group, and geographical location. The results suggest that addressing poverty, improving basic education, and effectively communicating climate change risks can improve knowledge of climate change impacts.

Further study on local communities' engagement towards building climate change resiliency, using our results as a reference, is recommended.

Keywords: climate change knowledge, coastal threat, exposure, experience, impact, policy

## 1. INTRODUCTION

Climate change is the challenge of our generation. Its impacts can already be seen on human health [1], agriculture, water resources [2], food safety [3], food security [4], and coastal and marine ecosystems [5]. In coastal and marine ecosystems, climate change is causing two important impacts: sea level rise [6] and changing ocean chemistry [7]. Sea level rise is caused primarily by thermal expansion due to warming of the oceans and melting of land-based ice, such as glaciers and ice sheets. Meanwhile, changes in ocean chemistry are caused by anthropogenic climate drivers including increasing amounts of greenhouse gases and aerosols [8]. The ocean has absorbed over 93% of the excess heat from greenhouse gas emissions [9]. The absorption of greenhouse gases makes the oceans more acidic which makes it more difficult for corals to build their skeletons [9]. Aside from acidification, higher sea surface temperatures also increase the risks of coral bleaching, which can lead to coral death and the loss of critical habitat for other species [10]. Understanding the public's perception of these climate change impacts is key to getting public support and fostering collective action for effective climate change adaptation, mitigation, and sustainable resource management [11–13].

In the Philippines, the serious impacts of climate change are becoming more apparent, thus the need for mitigation and adaptation to climate change has become an urgent public concern. The Philippines is one of the most vulnerable countries to sea-level rise and its impacts due to its numerous low-lying coastal areas. Seven out of 25 cities most vulnerable to a 1-m sea level rise are in the Philippines [14]. Based on the survey of Marine Geological Survey Division, from 1992 to 2011 the rate of sea level rise in the Philippines was 5.8 (± 0.6) mm per

year [15]. This is much faster compared to the global rate of sea level rise averages of 3.3 (± 0.4) mm per year [16]. At the current rate of sea level rise it would lead to the inundation of more than 167,000 ha of coastal land (about 0.6% of the country's total area) and 171 towns, as well as the displacement of 13.6 million Filipinos [17]. In response to the urgency for action, the Philippines passed the Climate Change Act of 2009, which provides for the creation of a Climate Change Commission and designation of the Local Government Units (LGUs) as frontline agencies in the formulation, planning and implementation of climate change action plans in their respective areas, and requiring them to formulate their Local Climate Change Action Plan [18]. In Palawan particularly, which ranks second among the provinces in the Philippines as most vulnerable to sea level rise [19], the declaration of the province as a UNESCO Biosphere Reserve is one way of mitigating the impact of climate change [20]. A 1-m rise in sea level in the province is projected to inundate 6,428.16 ha of land [15]. The results of Marine Geological Survey Division survey suggest that the island municipalities of Palawan are moderately to highly susceptible to coastal erosion [15].

To further mitigate and adapt to the climate change impacts in Palawan, previous research has investigated adaptation strategies for enhancing climate resilience at the local level [21] and assess the impacts of long-term climate variability on the biophysical conditions of the coral reefs [22]. A study on perceptions and adaptation capacities of fishers towards climate change have been conducted [23]. However, studies on perceptions of climate change impacts towards the coastal marine ecosystem are less explored particularly in Palawan. Although there have been many studies on perceptions of climate change impacts in the Global South, most of them were site-specific on a case-by-case basis [23–25]. Research on perceptions can provide a more complete picture on which we can base conservation decisions and environmental management [26]. Moreover, understanding perceptions regarding community-based marine resource management could lead to greater participation, more suitable management measures

that fit the capacities of the involved stakeholders, and ultimately, faster restoration of marine resources [27].

This study was therefore conducted to add empirical evidence to the existing knowledge of how coastal communities perceive climate change and its impacts, specifically on coastal communities within the Palawan biosphere [28,29]. Changes in Earth's climate have different effects in different areas of the world [28], thus climate change perceptions will also vary by region. Worldwide, educational attainment is the single strongest predictor of climate change awareness [29], while the strongest predictor of climate change risk perceptions in Asia is local temperature change [29,30]. Personal experiences of extreme weather events and impacts of climate change are also strong predictors of climate risk perceptions [31–33]. Furthermore, differences in perceptions are also influenced by gender, income [29,30], age [34], geographical location [35,36], and occupation [30].

The main aim of our study was to assess how the coastal communities of Palawan, Philippines perceived the climate change impacts in the coastal marine ecosystem. The study approach was patterned with the ecosystems-enriched Drivers, Pressures, State, Exposure, Effects, Actions or 'eDPSEEA' model, which recognizes convergence between the concept of ecosystems services that provides a human health and well-being slant to the value of ecosystems while equally emphasizing the health of the environment, and the growing calls for 'ecological public health' as a response to global environmental concerns [37]. Specifically, the four research questions we addressed were as follows: (i) whether the participants believe that climate is changing or not; (ii) whether they have observed or experience climate change impacts or not; (iii) whether climate change and sea level rise affect the coastal ecosystem; (iv) whether climate change, anthropogenic pressures and marine livelihood affect the state of coral reefs and sea grass beds. Findings of this study are vital to addressing climate change impacts

at the local level and for policies, programs, and activities aimed at building resilience to climate change and managing marine resources.

## 2. MATERIALS AND METHODS

### 2.1. Study Area and Sample

This study was conducted in 10 coastal barangays or villages from the municipalities of Aborlan, Taytay, and Puerto Princesa City of Palawan, Philippines (Figure 1). The target populations were households within coastal marine areas in our three selected geographic regions; and the respondents were restricted to 18 years old and above. Literacy rates among the target populations were variable which is why we decided to use a face-to-face survey, rather than self-completion. Despite the apparent simplicity of these individuals' lifestyles, they were highly knowledgeable about local environmental conditions and causes, as we witnessed during the stakeholder workshops and in discussions with locals on site visits, so the topics of the survey were very familiar to them.

### 2.2. Survey procedure

The survey was divided into 4 questions (See supplementary material 1). The first question (Q1) aimed to understand if the participants believe that the climate in the locality was changing, using a semantic differential (bipolar) response rating scale with anchor-points (1) "fully disagree" to (7) "fully agree". Question 2 sought to understand the participants' observations and experiences of climate change impacts, using a semantic differential (bipolar) rating scale with anchor points (1) "very low" to (7) "very high". Question 3 focused on perceived climate change impacts to the coastal areas using a semantic differential (bipolar) rating scale with anchor points (1) "fully disagree" to (7) "fully agree". Question 4 focused on participants' perceived impacts of climate change to coral reef and seagrass ecosystems, using

a semantic differential (bipolar) rating scale with anchor points (1) “very low” to (7) “very high”.

A two-stage pilot testing was conducted to ensure that participants would understand the questions. An in-home face-to-face survey was conducted using a Computer Assisted Personal Interviewing (CAPI) method, employing a tablet computer (Samsung Galaxy Tab A) with a pre-loaded questionnaire available in Filipino and English languages. The questionnaire was formatted using a free data collection software (KoBo Toolbox v.2).

The development of the survey was through a co-creation approach, with most of the content emerging from discussion and workshops with local stakeholders. The survey was drafted in-line with the eDPSEEA model which integrates human health and environmental impact to the ecosystem [37]. The finalized survey was quite complex as it contained all aspects of the eDPSEEA model. In this study, the focus was only on the perceptions of climate change impact on the coastal areas of Palawan.

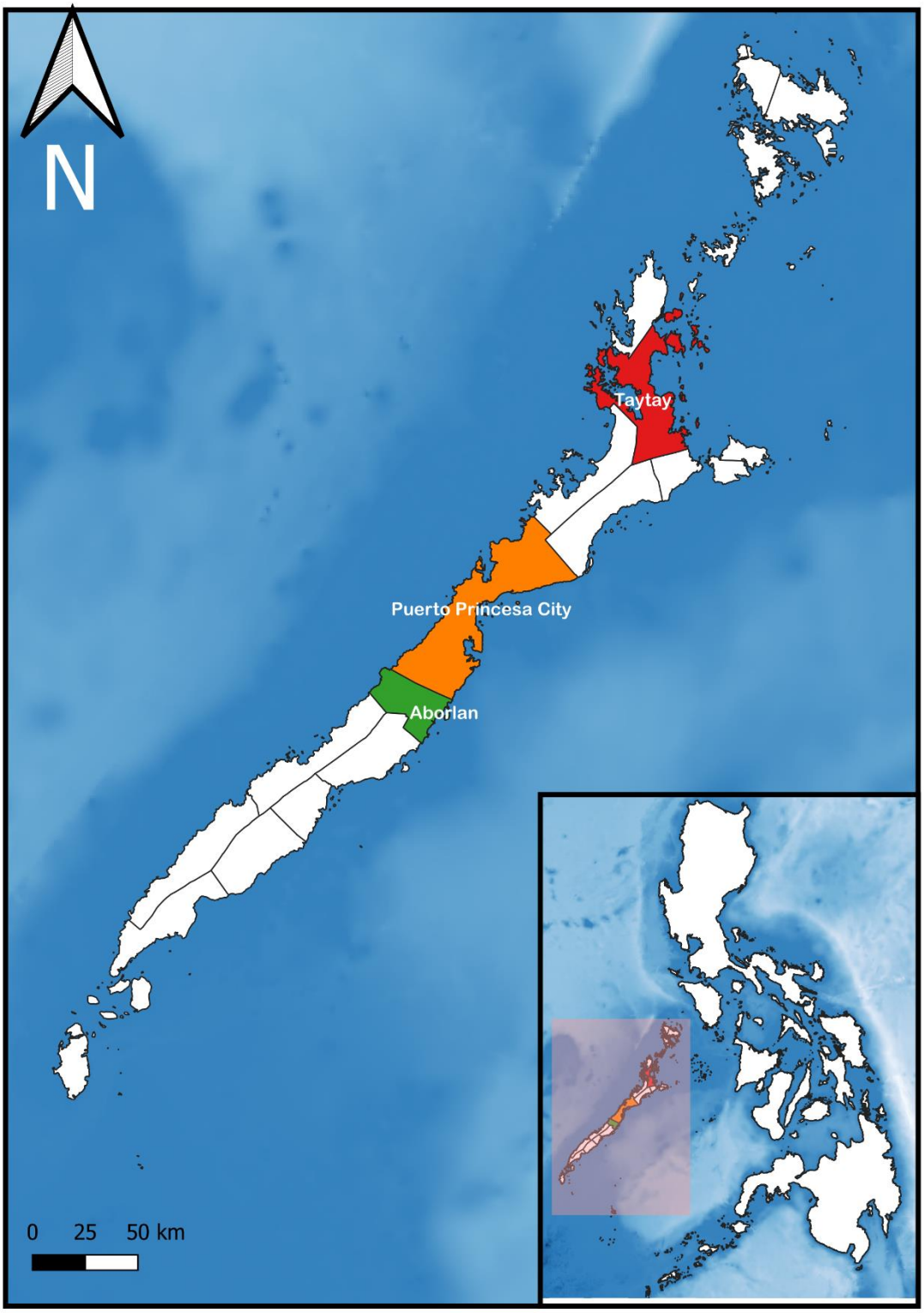


**Figure 1**

Map of Palawan showing an inset of the Philippines, with Palawan highlighted with a light red shade. Aborlan, Puerto Princesa City and Taytay are highlighted in green, orange, and red colors, respectively.

## 2.3. Data Analysis

SPSS version 26.0 for Windows was used for all data analyses. The relationships analyzed were the influence or effect of the "State", "Exposure" and "Effect" (as per the "eDPSEEA" model) to the perception of climate change impacts of the coastal communities (Fig. 2). Descriptive statistics (mean, standard deviation and standard error) were used to analyze and organize the characteristics of the data.

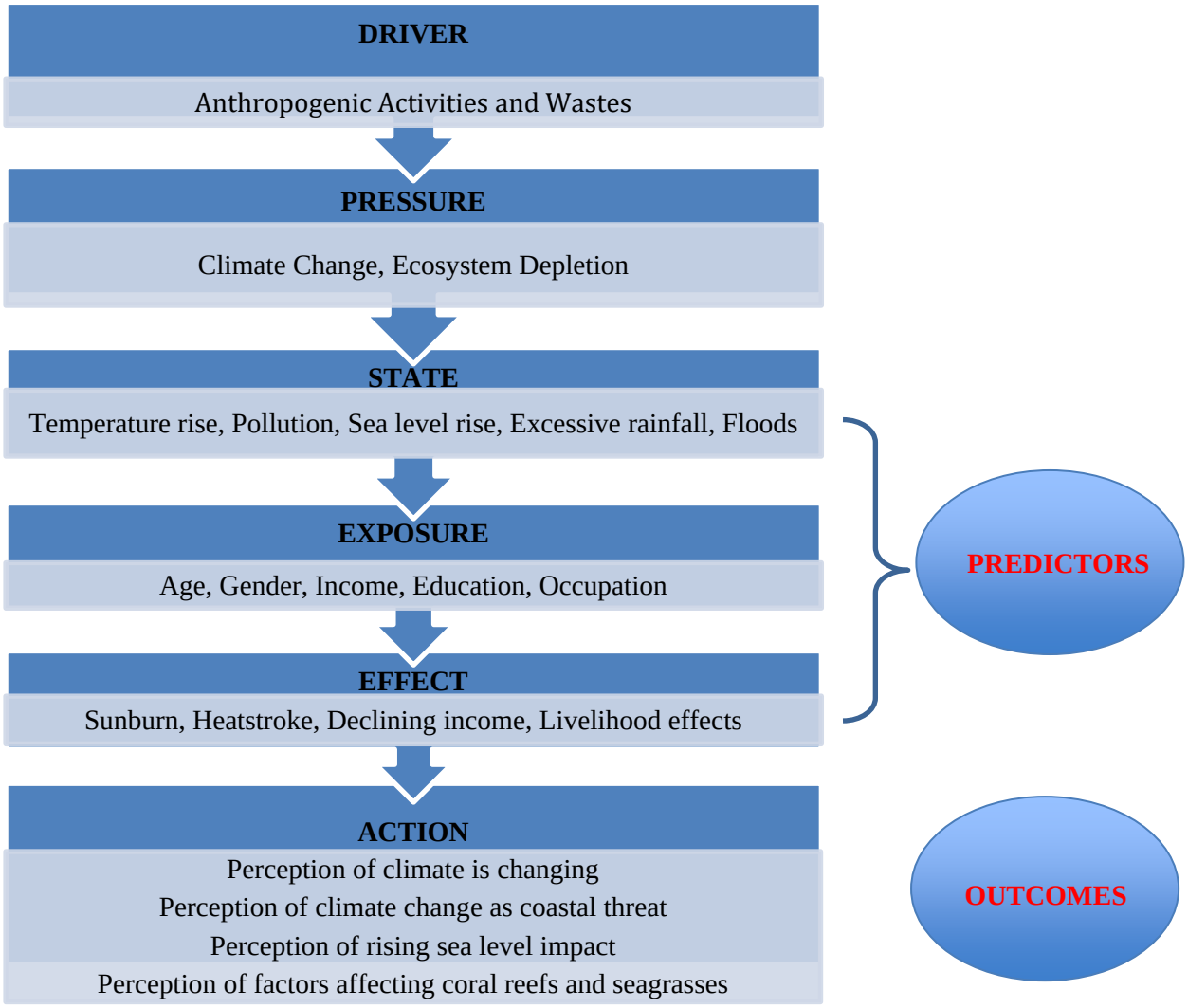


**Figure 2**

Model used on Perceptions of Climate Change Impacts based on eDPSEEA Framework

An Exploratory Factor Analysis (EFA) using Principal Component Analysis (PCA) was used to reduce data on perceptions of climate change impact in the coastal areas (6 variables) and on the perception of factors affecting coral reefs and seagrass beds (17 variables), to a smaller set of summary variables (factors) and to explore the underlying theoretical structure relating to these perceptions (Table 2 & 3) [38]. To confirm if PCA was suitable, the Kaiser-Meyer-Olkin (KMO) value was set at $\geq 0.70$ to indicate good sampling adequacy and Bartlett's Test of Sphericity was set at $p < 0.001$ to confirm highly significant correlations among the variables [39,40]. The number of the retained factors was based on the criterion of the eigenvalue (> 1.0) and examination of the scree plots. The retained factors underwent reliability analysis with Cronbach value set at $\alpha \geq 0.70$ to indicate good internal consistency [41]. Then, a correlation analysis was performed, and only the significantly correlated predictors ($p < 0.05$) to each perception were included in the regression model as per the assumptions of ordinary least squared (OLS) regression, which require the independent variables (predictors) to have a linear relationship with the dependent variables (perceptions). Finally, we used OLS to analyze the relationships between the perceptions and the predictors [42].

On sea level rise impact, we used paired samples t-test to determine if the presence of mangroves compared to absence of mangroves had a significant effect on perception of sea level rise impact. This was followed by calculating the effect size using Cohen's D.

# 3. RESULTS

## 3.1. Socio-Demographics

A total of 291 respondents participated (see Table 1) across 10 barangays: two barangays in Aborlan, four in Taytay, and four in Puerto Princesa City, with a higher number of females (59.1%) than males (39.5%). The higher percentage of female participants was in part due to the time of day the interviews were conducted (morning and afternoon), as many male household members would have left home for work at sea as elaborated in another paper from the same survey [43].

**Table 1**

*Socio-demographic characteristics of the respondents (n = 291)*

| Category | Aborlan (n = 61) | | Puerto Princesa (n = 68) | | Taytay (n = 162) | | Total Sample (n = 291) | |
|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % |
| **Gender** | | | | | | | | |
| Female | 33 | 54.1 | 44 | 64.7 | 95 | 58.6 | 172 | 59.1 |
| Male | 27 | 44.3 | 23 | 33.8 | 65 | 40.1 | 115 | 39.5 |
| Missing Data | 1 | 1.5 | 1 | 1.5 | 2 | 1.2 | 4 | 1.4 |
| **Income** | | | | | | | | |
| Poor (<₱11,000 / mo.) | 47 | 77.0 | 47 | 69.1 | 121 | 74.7 | 215 | 73.9 |
| Not Poor (₱11,000 / mo. - up) | 9 | 14.8 | 18 | 26.5 | 30 | 18.5 | 57 | 19.6 |
| Missing Data | 5 | 8.2 | 3 | 4.4 | 11 | 6.8 | 19 | 6.5 |
| **Age** | | | | | | | | |
| 18 - 24 (Gen Z) | 3 | 4.9 | 4 | 5.9 | 10 | 6.2 | 17 | 5.8 |
| 25 - 40 (Millennials) | 27 | 44.3 | 21 | 30.9 | 52 | 32.1 | 100 | 34.4 |
| 41 - 56 (Gen X) | 20 | 32.8 | 28 | 41.2 | 64 | 39.5 | 112 | 38.5 |
| > 57 (Boomers/Silent Gen) | 10 | 16.4 | 14 | 20.6 | 35 | 21.6 | 59 | 20.3 |
| Missing Data | 1 | 1.6 | 1 | 1.5 | 1 | 0.6 | 3 | 1.0 |
| **Education** | | | | | | | | |
| Lower Education | 32 | 52.5 | 32 | 47.1 | 55 | 34.0 | 119 | 40.9 |
| Higher Education | 27 | 44.3 | 35 | 51.5 | 101 | 62.3 | 163 | 56.0 |
| Missing Data | 2 | 3.3 | 1 | 1.5 | 6 | 3.7 | 9 | 3.1 |
| **Occupation** | | | | | | | | |
| Fisherfolks | 53 | 86.9 | 57 | 83.8 | 142 | 87.7 | 252 | 86.6 |
| Non-Fisherfolks | 5 | 8.2 | 10 | 14.7 | 15 | 9.3 | 30 | 10.3 |
| Missing Data | 3 | 4.9 | 1 | 1.5 | 5 | 3.1 | 9 | 3.1 |

## 3.2. Perception of climate change

Most of the respondents (82%) agreed that climate in the locality is changing, a small portion disagreed (8%) while the rest had a neutral stance (10%) (Supplementary Table 1). The local temperature rise ($\beta = 0.15$, $p < 0.05$) was found as the strongest risk predictor in the perception of climate change. Other predictors were not significant predictors (see Table 2).

**Table 2**
*Results of linear regression model predicting perceptions of climate change (outcome variable) in the coastal marine environment of Palawan, Philippines.*

| Predictors | Unstandardized B | Standard Error | Standardized β | 95% Confidence Interval | | Sig. |
|---|---|---|---|---|---|---|
| | | | | Lower Limit | Upper Limit | |
| Constant | 4.18 | 0.44 | - | 3.318 | 5.031 | .000 |
| **Local temperature rise** | 0.16 | 0.08 | 0.15 | .011 | .309 | .035 |
| **Sea level rise** | .031 | 0.07 | 0.03 | -.109 | .170 | .663 |
| **Excessive rainfall** | 0.13 | 0.08 | 0.12 | -.029 | .282 | .111 |
| **Study Sites** (ref = Aborlan) | | | | | | |
| Taytay | 0.23 | 0.27 | 0.07 | -.310 | .765 | .405 |
| Puerto Princesa | 0.50 | 0.32 | 0.13 | -.129 | 1.138 | .118 |
| **Income** (ref = poor) | | | | | | |
| Not poor | 0.32 | 0.26 | 0.08 | -.191 | .838 | .216 |

Only significantly correlated predictors with this perception were used ($p \leq 0.05$)

## 3.3. Respondents' experiences and observations of climate change impacts

The most common climate change impact experienced or observed by the respondents was local temperature rise, followed by excessive rainfall, declining income, sea-level rise, and livelihood effect. The occurrence of flood, heatstroke and sunburn were relatively low (Fig. 2).

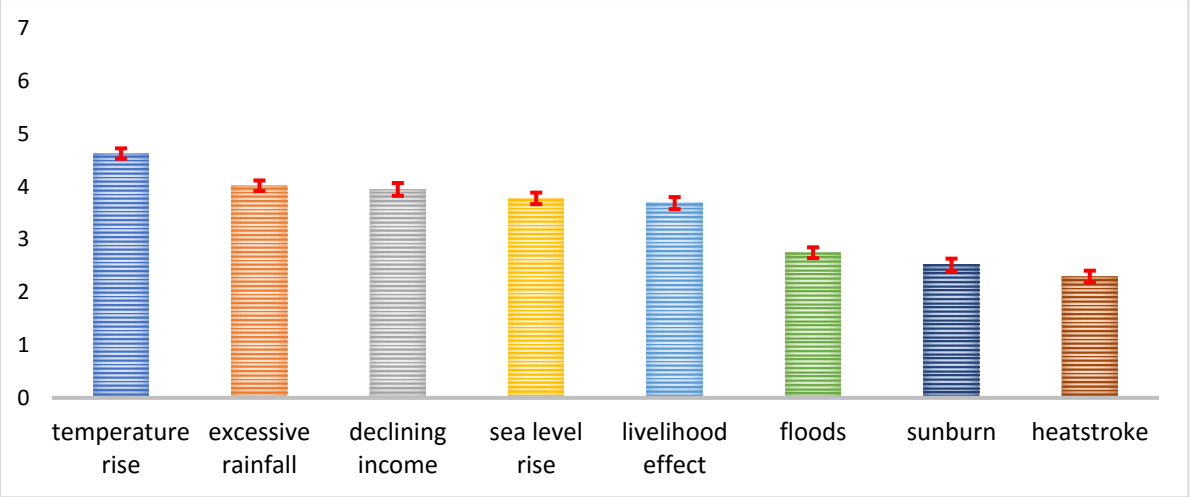


**Figure 2**
Mean score with standard deviation of the responses to the question "have you observed/experienced the following phenomenon in your area?". The response options provided to the respondents was a bipolar rating scale: 1 = very low to 7 = very high. n = 291 (graph whiskers are standard error of mean)

## 3.4. Perception of climate change as coastal threat

Most of the respondents (75%) agree that climate change is a coastal threat. The mean was 5.41 which also equates to agree (Table 2).

**Table 3**

*Perceptions of climate change impact in the coastal areas. The response options provided to the respondents was a bipolar rating scale: 1 = fully disagree to 7 = fully agree. n = 291*

| Perceptions | Responses (%) | | | | | | | Missing (%) | Mean | SD | Loadings |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | |
| **Coastal threat** | 9.5 | 0.8 | 2.9 | 11.6 | 14.9 | 21.1 | 39.3 | 16.8 | **5.41** | 1.87 | |
| Climate Change is a threat to the mangroves | 12.8 | 1.7 | 2.1 | 16.7 | 15.8 | 16.2 | 34.6 | 19.6 | 5.08 | 2.00 | 0.94 |
| Climate Change is a threat to the coastal ecosystem | 10.5 | 1.3 | 0.4 | 12.2 | 11.8 | 18.1 | 45.8 | 18.2 | 5.51 | 1.92 | 0.94 |
| **Sea level rise impact** | 11.2 | 5.2 | 9.4 | 14.6 | 14.2 | 22.8 | 22.5 | 8.2 | **4.74** | 1.97 | |
| Sea level is rising, regardless of when there is typhoon | 18.0 | 1.5 | 4.5 | 16.2 | 9.8 | 12.0 | 38.0 | 8.6 | 4.86 | 2.24 | 0.79 |
| Rising sea level has eroded the areas with mangroves | 30.4 | 1.6 | 6.5 | 17.0 | 9.7 | 13.0 | 21.9 | 15.1 | 4.0 | 2.34 | 0.72 |
| Rising sea level has eroded the areas without mangroves | 15.6 | 2.0 | 4.8 | 16.0 | 11.2 | 13.2 | 37.2 | 14.1 | 4.94 | 2.16 | 0.86 |
| Rising sea level will affect the coastal ecosystem | 15.1 | 1.6 | 4.5 | 14.3 | 13.9 | 17.6 | 33.1 | 15.8 | 4.95 | 2.10 | 0.79 |

**Bold values indicate factor mean**

Age was the strongest predictor of this perception of climate change as a coastal threat. The > 57 years old group ($B$ = 1.39, $p < 0.05$) was found to have significantly higher risk perception than the 18-24 yrs. old group (ref. group). Females were also found to have a higher risk perception ($B$ = 0.70, $p < 0.05$) than males (ref. group). Further, the not-poor group ($\beta$ = 0.75, $p < 0.05$) had a significantly higher risk perception than the poor group (ref. group). Other significant risk predictors were sea level rise ($B$ = 0.17, $p < 0.05$) and sunburn ($B$ = 0.17, $p <$ 0.05 (see Table 3).

**Table 4**
*Results of linear regression model predicting perceptions of climate change threat to the coastal area (outcome variable) in the coastal marine environment of Palawan, Philippines.*

| Predictors | Unstandardized B | Standard Error | Standardized β | 95% Confidence Interval | | Sig. |
|---|---|---|---|---|---|---|
| | | | | Lower Limit | Upper Limit | |
| Constant | 2.81 | .692 | | 1.443 | 4.170 | .000 |
| **Sunburn** | 0.23 | .068 | 0.24 | .100 | .367 | .001 |
| **Sea level rise** | 0.17 | .071 | 0.16 | .025 | .306 | .022 |
| **Gender** (ref = male) | | | | | | . |
| Female | 0.70 | .251 | 0.19 | .200 | 1.191 | .006 |
| **Age Group** (ref = 18 – 24 (Gen Z)) | | | | | | |
| 25 - 40 (Millennials) | 0.58 | .555 | 0.15 | -.515 | 1.675 | .297 |
| 41 - 56 (Gen X) | 0.60 | .553 | 0.16 | -.486 | 1.694 | .276 |
| > 57 (Boomers/Silent Gen) | 1.39 | .599 | 0.31 | .207 | 2.569 | .021 |
| **Income** (ref = poor) | | | | | | |
| Not poor | 0.75 | .303 | 0.17 | .156 | 1.351 | .014 |

**Only significantly correlated predictors with this perception were used ($p \leq 0.05$)**

## 3.5. Perception of rising sea level impact

In general, the sea level rise impact showed that many (59.5%) of the respondents agree that the rising sea level was a coastal threat (see Table 3). Analysis of the individual variables

in the sea level rise impact showed that 60% agreed that sea level was rising regardless of typhoon occurrence. A majority also agreed that the sea level rise had eroded areas without mangroves (61.7%), and that it will affect the coastal ecosystem (64.6%). A considerable portion of the respondents (44.5%) also agreed that sea level rise had eroded areas with mangroves (Fig. 3). The impact of sea level rise in coastal erosion based on the respondent's perception in areas with mangroves and without mangroves displayed a significant difference; $t = -6.65$, $p < 0.001$ (Supplementary Table 4). Further, Cohen's d value ($d = 0.42$) suggested a moderate effect size.

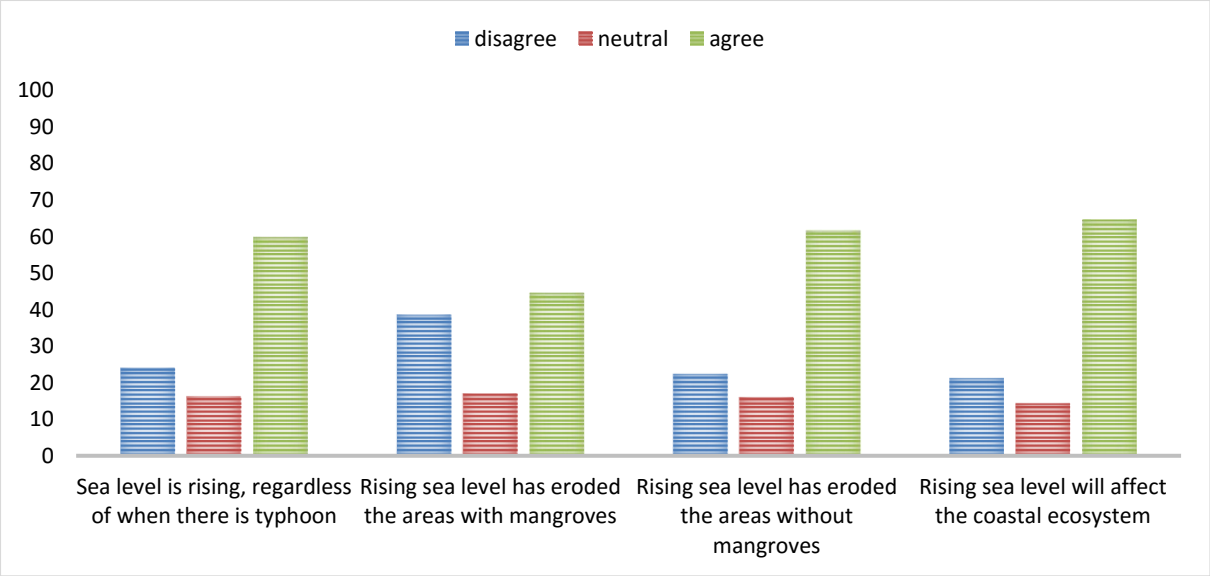


**Figure 3**

Proportion of respondents who perceived occurrence of sea-level rise impacts. n = 291

Personal observations or experiences was the strongest predictor of the perception of sea level rise impact ($\beta = 0.35$, $p < 0.001$). The > 57-year-old group ($B = 1.58$, $p < 0.01$) was found to have a significantly higher risk perception than the 18-24 yrs. old (ref group). There was also a statistically significant difference in Puerto Princesa resident ($B = 0.75$, $p < 0.05$) perceptions compared with residents of Aborlan (ref. group) (see Table 4).

**Table 5**
*Results of linear regression model predicting perceptions of sea-level rise impact to the coastal area (outcome variable) in the coastal marine environment of Palawan, Philippines.*

| Predictors | Unstandardized *B* | Standard Error | Unstandardized β | 95% Confidence Interval | | Sig. |
|---|---|---|---|---|---|---|
| | | | | Lower Limit | Upper Limit | |
| Constant | 1.94 | 0.59 | - | 0.79 | 3.09 | .001 |
| **Sea level rise** | 0.36 | 0.07 | 0.35 | 0.23 | 0.49 | .000 |
| **Age Group** (ref = 18 – 24 (Gen Z)) | | | | | | |
| 25 - 40 (Millennials) | 0.90 | 0.50 | 0.23 | -0.08 | 1.87 | .072 |
| 41 - 56 (Gen X) | 1.07 | 0.49 | 0.29 | 0.11 | 2.03 | .030 |
| > 57 (Silent Gen) | 1.58 | 0.52 | 0.35 | 0.56 | 2.61 | .003 |
| **Study Sites** (ref = Aborlan) | | | | | | |
| Taytay | 0.23 | 0.28 | 0.06 | -0.33 | 0.79 | .424 |
| Puerto Princesa | 0.75 | 0.33 | 0.18 | 0.09 | 1.41 | .025 |

**Only significantly correlated predictors with perception were used ($p \leq 0.05$)**

## 3.6. Perceptions of Factors Affecting the Corals Reefs and Seagrass Beds

Three factors affecting the coral reefs and seagrass beds were derived from PCA, namely: climate change impacts, anthropogenic pressures, and marine livelihood (Table 6). Results showed that majority of the participants perceived the anthropogenic pressures (57.6%) and climate change (50.3%) to have a high impact on the coral reefs and seagrass beds, while marine livelihoods was perceived to have a low impact (51.8%) (see Fig. 4).

The strongest predictors on the perceptions of factors affecting coral reefs and seagrasses were: (1) local temperature rise on perception of anthropogenic pressures impact; (2) declining income on perception of climate change impact; and household income (not poor) on perception of marine livelihood impact to the coral reefs and seagrasses (Table 7).

On perception of climate change impact, the not-poor participants ($B = 0.86$, $p < 0.05$) were found to have significantly higher risk perception than poor participants (ref group). Fisherfolks ($B = 0.61$, $p < 0.05$) had a significantly higher risk perception than non-fisherfolks (ref. group)

while higher education ($B$ = 0.47, $p < 0.05$) also had a higher risk perception than lower education (ref. group). Excessive rainfall ($B$ = 0.17, $p < 0.01$) was also a significant predictor (Table 6).

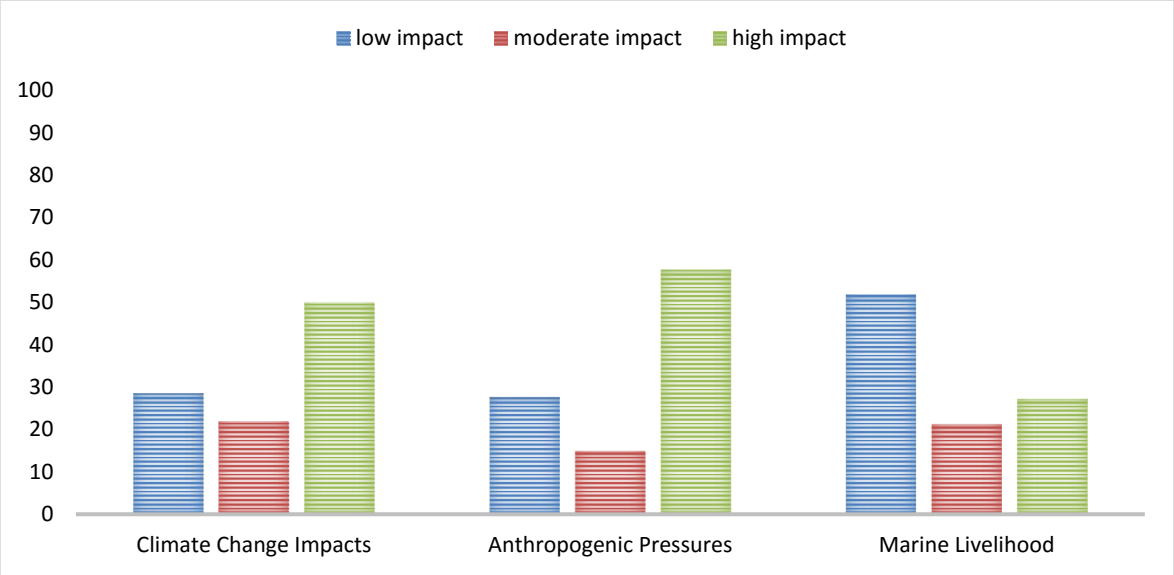


**Figure 4**
Proportion of respondents who perceive high, moderate, or low impacts to coral reefs and sea grass beds from different drivers. The response options provided to the respondents is a bipolar rating scale: 1 = very low to 7 = very high. Low category included scores 1-3, Moderate category score 4, and High category scores 5-7 n = 291.

On the perception of the impact of anthropogenic pressures, the not-poor participants ($B$ = 1.01, $p < 0.05$) were significantly different compared with poor participants (ref. group). Further, the 41–56-year-old age group ($B$ = -0.83, $p < 0.05$) had significantly lower damage perception compared with > 57 years old (ref. group). Sea-level rise ($B$ = 0.15, $p < 0.05$) and declining income ($B$ = 0.20, $p < 0.001$) were also found to significantly influence perceptions of factors affecting the coral reefs and seagrasses.

On perception of marine livelihood impact, the not-poor participants had a statistically higher damage perception ($B$ = 0.98, $p < 0.05$) than poor respondents (ref group). Among the age groups, the > 57-year age group had the highest damage perception, which differs significantly from the 41-56-year-old group ($B$ = -0.87, $p < 0.05$). Local temperature rise was

also found to be a significant predictor in perceiving the impact of marine livelihood to the state of coral reefs and seagrasses. ($B$ = 0.16, $p < 0.05$).

**Table 6**

*Perceptions of factors affecting the coral reefs and seagrass beds. The response options provided to the respondents was a bipolar rating scale: 1 = fully disagree to 7 = fully agree. n = 291*

| Factors | Responses (%) | | | | | | | Missing (%) | Mean | SD | Loadings |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | |
| **Climate Change Impacts** | 9.2 | 5.9 | 13.4 | 21.8 | 24.7 | 14.2 | 10.9 | 17.9 | **4.28** | 1.53 | |
| Temperature rise | 13.0 | 3.5 | 11.3 | 18.6 | 26.8 | 12.1 | 14.7 | 20.6 | 4.38 | 1.84 | 0.73 |
| Excessive rainfall | 16.6 | 4.7 | 9.4 | 26.0 | 21.3 | 12.8 | 9.4 | 19.2 | 4.06 | 1.83 | 0.76 |
| El niño (drought) | 13.4 | 3.9 | 7.8 | 22.1 | 22.1 | 15.6 | 15.2 | 20.6 | 4.43 | 1.87 | 0.79 |
| Frequent typhoons | 11.6 | 4.7 | 12.5 | 19.4 | 21.1 | 17.7 | 12.9 | 20.3 | 4.38 | 1.82 | 0.72 |
| Runoffs | 12.9 | 4.4 | 12.4 | 22.7 | 21.8 | 12.4 | 13.3 | 22.7 | 4.27 | 1.82 | 0.63 |
| Natural calamities | 15.3 | 4.8 | 10.5 | 16.7 | 18.7 | 21.1 | 12.9 | 28.2 | 4.33 | 1.94 | 0.42 |
| **Anthropogenic Pressures** | 9.5 | 7.1 | 11.0 | 14.8 | 18.6 | 23.3 | 15.7 | 27.8 | **4.52** | 1.60 | |
| Sewerage | 12.3 | 4.8 | 8.3 | 14.0 | 23.7 | 18.0 | 18.9 | 21.6 | 4.61 | 1.92 | 0.72 |
| Pollution | 9.9 | 4.5 | 4.9 | 13.9 | 22.0 | 20.6 | 24.2 | 23.4 | 4.92 | 1.87 | 0.79 |
| Domestic wastes | 8.3 | 3.0 | 7.8 | 13.5 | 25.7 | 21.3 | 20.4 | 21.0 | 4.91 | 1.76 | 0.67 |
| Land use change | 25.9 | 6.5 | 6.5 | 20.4 | 17.9 | 10.0 | 12.9 | 30.9 | 3.80 | 2.09 | 0.64 |
| Urbanization | 20.7 | 6.1 | 8.9 | 15.0 | 23.0 | 14.1 | 12.2 | 26.8 | 4.05 | 2.02 | 0.66 |
| Red tide | 35.4 | 3.9 | 1.1 | 20.8 | 11.2 | 12.9 | 14.6 | 38.8 | 3.66 | 2.28 | 0.72 |
| Illegal fisheries | 8.6 | 3.6 | 5.0 | 5.4 | 15.3 | 25.7 | 36.5 | 23.7 | 5.38 | 1.88 | 0.71 |
| **Marine Livelihood** | 31.2 | 11.9 | 8.7 | 21.1 | 13.8 | 9.6 | 3.7 | 25.1 | **3.22** | 1.74 | |
| Pearl farms | 41.9 | 5.8 | 6.8 | 22.0 | 6.3 | 6.8 | 10.5 | 34.4 | 3.07 | 2.12 | 0.82 |
| Fish cages | 31.5 | 8.0 | 9.0 | 31.0 | 9.0 | 5.5 | 6.0 | 31.3 | 3.19 | 1.86 | 0.83 |
| Shellfish farms | 44.8 | 4.4 | 4.4 | 26.5 | 4.4 | 6.1 | 9.4 | 37.8 | 2.97 | 2.09 | 0.90 |
| Tourism related development | 28.2 | 4.8 | 8.6 | 28.7 | 12.9 | 10.0 | 6.7 | 28.2 | 3.50 | 1.93 | 0.47 |

**Bold values indicate group mean**

**Table 7**
*Results of linear regression model predicting perceptions of factors affecting the coral reefs and seagrass beds in the coastal marine environment of Palawan, Philippines (standard errors).*

| Predictor variables | Perceptions of Factors Affecting the Corals reefs and Seagrasses (Outcome Variables) | | |
|---|---|---|---|
| | Climate Change Impact | Anthropogenic Pressures | Marine Livelihood Impact |
| Constant (B) | 1.37** (0.44) | 1.99*** (0.37) | 1.85*** 0.46 |
| **Local temperature rise** | 0.10 (0.07) | 0.26*** (0.06) | 0.16* .08 |
| **Sea level rise** | 0.08 (0.06) | - | - |
| **Excessive rainfall** | 0.17** (0.07) | 0.15* (0.07) | 0.13 0.08 |
| **Declining Income** | 0.23** (0.07) | 0.20*** (0.05) | 0.10 0.06 |
| **Affecting livelihood** | -0.11 (0.08) | - | - |
| **Education Level** (ref = Lower Education) | - | - | |
| Higher Education | 0.47* (0.19) | - | - |
| **Income** (ref = poor) | - | - | - |
| Not Poor | 0.86*** (0.23) | 1.01* (0.23) | 0.98*** 0.28 |
| **Occupation** (ref = non-fisherfolks) | - | - | - |
| Fisherfolks | 0.61* (0.30) | - | - |
| **Age Group** (ref = > 57 (Silent Gen) | - | - | - |
| 18 – 24 (Gen Z)) | - | 0.01 (0.44) | -0.29 0.54 |
| 25 - 40 (Millennials) | - | -0.14 (0.25) | -0.41 0.31 |
| 41 - 56 (Gen X) | - | -0.57* (0.25) | -0.83* 0.31 |

**Only significantly correlated predictors with perceptions were used ($p \leq 0.05$); *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$**

## 4. DISCUSSION

The results from this study contribute to a greater understanding of the relationship between coastal community perceptions and climate change impacts which, in turn, adds knowledge to the debate about how to involve the public in building climate change resilient efforts.

### 4.1. Perception of climate change

The results from this study show that most participants (82%) perceived that climate change was happening and is in line with the results from a nationwide survey conducted in the Philippines in February 2021, which found that 83% of Filipinos believe the climate was changing [11]. Local temperature rise was perceived to be the strongest predictor that climate is changing. The results are consistent with the research of Lee et al. which stated that local temperature change is the strongest predictor of climate change in Asian countries and supported by the findings of Kabir et al. [29,30]. Furthermore, the study of van der Linden (2015) also supports our findings that personal experience of extreme weather events, in this case local temperature rise, is a significant predictor of climate change risk perception [31].

### 4.2. Perception of climate change as a coastal threat

We found that coastal residents (75%) perceived climate change as a major coastal threat. This is much higher public awareness about climate change compared to the 67% in a nationwide survey in 2018 (Philippines) of those who consider climate change as a major threat [44]. The higher climate change awareness among the coastal community compared to the general public can be attributed to higher vulnerability of coastal areas to adverse impacts caused by climate stressors on their surrounding and livelihoods which shape people's climate risk perception [45,46]. Yet there is a substantial percentage of skeptics who do not consider climate change as a threat. This could be attributed to the perception of some coastal communities that the land along the coastal margin will persist permanently, and that those living there will be safe from natural coastal hazards (apart from rare storm surge events) [47].

In this study, the strongest predictor of perception that climate change is a coastal threat is the older generation group (> 57 years old), although previous studies found that the younger generation in the USA worry more about the effects of global warming than the older

generation [34]. However, scientific knowledge about the causes, impacts, and solutions to climate change generally increased with age, as would be expected with increased scientific education and exposure to information [48]. Having lived many years and experienced the various changes that have taken place in coastal areas, the older generation may have acquired enough wisdom or experienced enough changes in their youth to know about the threat climate change poses [49].

In terms of gender, we found that women have a higher risk perception of climate change as a coastal threat. This is consistent with findings that women consistently have a higher risk perception and concern about climate change compared to men [50]. In a similar finding it was reported that women express slightly greater concern about climate change than do men [51]. Since 2010, the gender gap in this form of knowledge has remained relatively stable, even though men's understanding of the consensus has improved over time [52].

This perception was also influenced by household income like another study conducted in Singapore which reported that low-income households reported lower levels of actual knowledge than those from high-income households [44]. Lower climate change risk perception for poor households compared to not-poor households could be explained by the fact that low-income households and communities develop academic skills at a slower rate than those from higher-income groups [44]. Poverty levels are strongly linked to educational attainment. In the Philippines, the heads of two of three poor households have only reached elementary education and below [53]. Further, lack of economic resources was a major barrier to paying attention to climate change, as they had more pressing priorities, such as the financial pressure of daily living [49]. For low-income households who face more financial pressure than high-income households, climate change is less likely to be a concern.

Sunburn was also found to be a significant risk predictor of climate change as a coastal threat. This could be attributed to increased coastal activities because of worsening sea

conditions due to climate change [54]. On average, coastal gleaning lasts up to 2.3 hours a day [55] and skin damage can be seen in under two hours from exposure to ultraviolet light [56].

### 4.3. Perception of sea-level rise impact

We found that sea-level rise observations, was a significant predictor of coastal risks brought about by climate change which is consistent with many studies that sea-level rise is the main threat to the coastal areas [6,14]. However, only a slight majority of coastal residents agree that sea-level rise will cause coastal erosion and affect the coastal ecosystem. The skepticism expressed by some coastal residents that sea-level rise will cause major damage to coastal areas could be attributable to various factors, like the perception that mangroves can prevent coastal erosion. The skeptical perception of sea level rise as a coastal threat is in line with findings that public perceptions of sea level rise in the US Gulf Region remain to be a temporally distant issue among coastal residents [57]. Moreover, another finding revealed that the use of maps to communicate sea level rise impacts is an effective tool in increasing risk perceptions [58].

Interestingly, research in New Zealand found that adults were overestimating the amount of sea-level rise expected by 2100 which can result in feeling anxious rather than being motivated to mitigate and adapt [47]. This is quite divergent with the skeptical perception of sea level rise impact from other studies in other parts of the world and the current study. However, these results implied that perceptions of sea level rise impact are influenced by location which is consistent with the findings of this study.

Our findings suggest that the younger generation (18-24 years old) is less aware of the potential sea level rise impacts compared with older generations. This result contrasts with the trend in the USA where younger generations have shown more climate change concern and knowledge [34]. This could be because younger generations have less experience and exposure

to the impact of rising sea level. Our findings that personal experiences influence perceptions of sea level rise impact were consistent with studies that stated, experience is one of the drivers on perception of sea level rise and how they respond to the impact [59]. Furthermore, this supports the finding that since older generations have more experience, they perceive a greater damage caused by sea-level rise compared with younger generations.

The significant differences in perceptions between Puerto Princesa and Aborlan suggests that sea level rise impact is perceived according to geographical context and different spatial patterns of different processes, as well as potential correlations between different drivers [35,60]. The differences in perceptions could also be attributed to the more publicized and people's participation in reforestation of mangroves in Puerto Princesa which resulted in the planting of millions of mangrove trees with high survival rates [61].

The positive finding of this research is that the coastal residents understand mangroves are beneficial to them in preventing coastal erosion. Thus, conserving mangroves for their protection becomes a concern. Our findings also suggest the importance of education and communication tools to effectively relay information about coastal threats and sea level rise impacts to help motivate coastal residents to act. By increasing their knowledge about climate change causes and impacts, they will be more concerned about climate change and more likely to support climate-friendly policies [62].

### 4.4. Perceptions of factors affecting coral reefs and seagrass beds

We found that coastal communities perceived anthropogenic pressures to be the major driver affecting coral reefs and seagrasses, and climate change impact was also perceived to have similar effects. On the other hand, marine livelihood is perceived to have low impact.

The results of this study are consistent with the report of the UNEP-IOC-ASPEI-IUCN Global Task Team, which states that human anthropogenic pressures pose a far greater

immediate threat to coral reefs than climate change [62]. However, on the contrary, another research study found that climate change is the main driver affecting coral dynamics and can exacerbate the impact of anthropogenic drivers [63].

The perception of the respondents that marine livelihood, especially overfishing can also impact the coral reefs and seagrasses is in line with the findings of previous research. This unsustainable fishing practice has been identified as the primary threat to coral reefs and the quality of coastal marine environment [43,64]. On the other hand, long-term fish cage operations, if poorly located and managed, will result in reduction of the abundance and diversity of local benthic species and degrade the habitats surrounding the cages [65]. A study found that the impact of long-term fish farming resulted in seagrass decline in the areas surrounding the fish farm site even though at the time of sampling the fish farm operation had already ceased [66]. This could be due to the excess organic matter remaining in the sediments, resulting in organic pollution to seagrass meadows [66].

In this study, our findings suggest that the perceptions of the coastal residents are consistent with the established scientific information that anthropogenic pressures, climate change consequences and marine livelihoods have significant impact on corals and seagrasses. This high level of climate-relevant knowledge on impact of climate change and anthropogenic pressures on corals and seagrasses is vital for preserving reef systems and accepting climate change policies [67].

Our results open an exciting new avenue of study focused on what and how the coastal communities are doing to preserve reef ecosystems. Specifically, on how they adapt and mitigate the impact of climate change and reduce anthropogenic pressures on the corals and sea grasses. Moreover, we also suggest explanatory research or applied scientific research to determine the actual impact of climatic pressures and anthropogenic pressures on corals and seagrasses.

Household income, declining income, excessive rainfall, and local temperature rise are significant predictors of perceptions of climate change and anthropogenic pressures impact on coral reefs and seagrasses. Anthropogenic pressures result in contamination of aquatic environments which is one of the leading types of pollution that has significant negative impacts on coral reefs and seagrasses [68]. Because of these negative impacts, coral reefs and seagrass farming can suffer, thus reducing the income of seaweed farmers. These negative anthropogenic pressures impacts may have significantly affected their perceptions and behavioral responses to climate change [69,70].

Participants with higher education were to have higher risk perception of climate impact on coral reefs and seagrasses compared with lower education which is in line with many studies which stated that education is the strongest predictors of climate change impacts [30]. We also found that these perceptions of factors affecting coral reefs and seagrasses are also influenced by age and type of occupation. This finding is supported by a previous study which states that age and occupation were significantly associated with the knowledge about climate change impacts [30].

### 4.5. Limitations

The findings of this study must be seen in light of some limitations. The first is that we did not include in this study questions about how they perceived the impact of climate change on their livelihood and food security. This could be significant in predicting their overall perception of climate change as a coastal hazard. However, we intend to address these limitations in future studies.

The second limitation concerns the actual status of climate change impact in the coastal areas. Directly cross-verifying the actual status of climate change impact in the coastal areas compared against their perceptions would give a good measurement of their current level of

climate-relevant knowledge. Nevertheless, their perceptions are useful in understanding their mental model. Furthermore, this limitation is another avenue for potential future research.

## 5. CONCLUSIONS

A comprehensive understanding of local communities' perception of climate change is essential to properly address its impacts and design effective communication and educational materials. This research provides a unique perspective on how coastal communities perceive climate change. The results of our analysis suggest that the perceptions of most coastal residents of the areas surveyed are in line with the established scientific trends.

While most coastal residents interviewed perceive climate change as a coastal threat, there are still a number who are unaware of the damaging effects of climate change. One key outcome of this study is the need for a climate change “knowledge management system” in coastal communities. Increasing their knowledge on climate change causes and impacts, significantly increased their concern about climate change and willingness to support climate-friendly policies [67].

Most respondents perceived that sea level rise will have a damaging impact on coastal areas. However, several respondents were still skeptical in considering it as a present hazard. This skeptical perception could be attributed to their view that mangroves can prevent coastal erosion. Their awareness of the importance of mangroves in preventing coastal erosion is another key outcome of this research. This finding supports the need for a climate change “knowledge management system” in the coastal areas to further increase awareness and concern for a healthy and sustainable coastal community.

Beside the mangroves, the coral reefs and seagrass meadows could protect coastal communities against the impacts of sea level rise and climate change [71]. For these benefits to be sustained, they need to be properly conserved and managed to further reduce the

vulnerability of coastal regions [72]. This study found that the respondents consider anthropogenic pressures as the main driver affecting the coral reefs and seagrasses. Climate change is similarly perceived as having a moderate impact, while marine livelihood is perceived as having a low impact to the coral reefs and seagrasses. These results are consistent with established scientific trends and imply a good level of awareness among the coastal residents.

This study contributes to better understanding the role of personal climate-related experiences in shaping climate change perceptions. Our findings revealed that local temperature rise is the strongest predictor of climate change, while sea level rise and sunburn are associated with perception of climate change as a coastal threat and varies with age and household income. Moreover, sea level rise impact perception is associated with their personal observations of sea-level rise and varies with age and geographic location, while perceptions of climate change impact and non-climate drivers on coral reefs and seagrass beds are associated with local temperature rise, declining income and excessive rainfall and varies with education, household income, age, and occupation.

This study contributes to the previous studies in understanding public perceptions of climate change in coastal communities [43,57,73]. Based on the findings of our study, it is recommended to explore the following areas to better address climate change:

- A study on creating a climate change knowledge management system for the coastal communities and its impact in improving level of awareness and concern.
- Further exploration on how the coastal communities is adapting and mitigating the impact of climate change and anthropogenic pressures.
- Exploration to create risk communication tools that influence coastal residents' perceptions about future risk and mitigation.

- Further investigation on climate change perceptions, cross verified scientifically with actual climate change impacts.
- Explanatory research or applied scientific research to determine the actual impact of climatic pressures and anthropogenic pressures on corals and seagrasses.

By addressing these issues from an interdisciplinary perspective, we can build adaptive capacity and reduce the vulnerability of coastal communities.

## 6. DATA AVAILABILITY STATEMENT

The datasets presented in this article and from the entire survey will be made open access after an embargo period currently under discussion with the international consortium. Requests to access the datasets should be directed to the last author.

## 7. ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the University of Exeter Medical School Research Ethics Committee (May19/B/185) and Philippines National Ethics Committee (2019-002-Creencia-Blue). The patients/participants provided their written informed consent to participate in this study.

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