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Household level adaptive capacity of fishing communities in Western Mindanao, Philippines to the changing climate

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Abstract

Climate change has been affecting many coastal communities around the world. With the location of the Philippines in the tropics, the country is vulnerable to the impacts brought by this phenomenon affecting the safety, livelihood and income distribution of the fishing communities in particular. Quantifying adaptive capacity to climate change is critical in reducing the vulnerability of these affected communities. This study was conducted to assess the adaptive capacity in the household level of the different social groups in the fishing communities of the Municipality of Sindangan, Zamboanga del Norte, Philippines. Using the interval-level scale generated from the eight indicators of adaptive capacity comprising human agency, capacity to change, occupational mobility, material assets, occupational multiplicity, social capital and infrastructure and the Analytical Hierarchy Process (AHP), the data revealed differentiation between social groups. The result showed that fishers who are land tenants, members in fishing boats, large household sizes, fishers belonging in the age group of 29 to 36 years old and fishers who finished High School are least prepared for the changes in climate. Findings of this study supports previous findings of the adaptive capacity conducted around the world. These results highlight the most vulnerable sectors of society, which will help guide local policymakers to formulate environmental adaptation plans appropriate for the social groups in a fishing community.

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Introduction

Acceleration of the changing climate has already been affecting coastal communities. It is projected that the Philippines will experience by the end of the century a warmer and acidic seas, longer and more intense flood and droughts, increasing sea-level, more intense cyclones and typhoons and the Pacific Ocean will become more "El Niño-like" which will have profound impact to the surrounding countries in the region (Hoegh-Guldberg *et al.*, 2009). This projection will result to changes in primary production, shifts in marine fish-stock distribution and changes in catch potential, which will bring either positive or negative impacts to coastal fishery-dependent communities (Poloczanska *et al.*, 2013; Cheung *et al.*, 2010; Hoegh-Guldberg and Bruno, 2010). This will also leave countries vulnerable to climatological changes affecting safety, livelihood and income distribution.

In the northern region, areas like the UK and Irish "Seas", climate change has brought positive feedback to their economies that resulted in the opening of new fishing opportunities (Cheung *et al.*, 2010). Although this impact of the changing climate benefited the Northern part of the world, some fishers and fish farmers in West Bengal, Philippines, Bangladesh, and Nigeria experience decreasing catch (Roy, 2012; Pana and Su 2012; Aphunu and Nwabeze, 2012). These studies have confirmed the extent of the impacts of climate change; however, results vary from respective areas when taking into consideration the different anthropogenic activities that exist in an area. For example, stock levels of marine resources are highly influenced by exploitation patterns but differ in the degree of intensity. The use of fishing methods and localized climate differs among fishing communities as well. Recently, many of the world fishery resources are in serious trouble from over-fishing and poor management. With the threat of climate change, this problem would exacerbate (Hollowed *et al.*, 2013).

Vulnerability studies to climate change is essential particularly in coastal communities since these areas are more at risks to the phenomenon and quantifying it requires three components: exposure, sensitivity and adaptive capacity (Cinner *et al.* 2012). Although measuring exposure and sensitivity can identify impacts of a climate-induced change, adaptive capacity have more influence to the likelihood impacts to the community down to the household level. Previous papers showed that Indian Ocean fishing communities has less adaptive capacity to the changing climate and are vulnerable to climate change (Cinner *et al.*, 2012; Cinner *et al.*, 2015) however few studies explored on this matter in the fishing communities in other parts of the world particularly in the Southeast Asia.

With the observed increase in temperature of 0.64°C in the Philippines from the year 1951-2010 (Climate Change Commission, 2011) and being an archipelagic region in the tropics, a localized baseline assessment is necessary to identify the vulnerable sectors of the community. Quantification of the adaptive capacity in the household level of the fishers belonging in different social groups is vital information in guiding local policymakers to formulate environmental adaptation plans appropriate for the community. It is also imperative to identify what aspect of the adaptive capacity needs improvement to lessen the likelihood impact of climate change in different groups in a fishing community.

This study aims to quantify adaptive capacity in the household level in the Municipality of Sindangan, Zamboanga del Norte, Philippines. Specifically, it aims to address the following:

a. Identify the household level adaptive capacity of the social groups when grouped according to age, educational attainment, household size, land ownership and boat ownership; and
b. Identify the differences of the household level adaptive capacity between the social groups.

Materials and methods

Study area and sample population

The study was conducted last July to September 2015 in 22 coastal barangays of Sindangan, province of Zamboanga del Norte in Region IX of the Zamboanga Peninsula.

Target populations of the study were fishermen selected through systematic random sampling. Prior to the survey, entry protocol commenced through a courtesy call to the municipal Mayor down to the designated Barangay captains that also served as Key Informants for recognition purposes and solicitation of information on whereabouts of the respondents' household. Lists of fishers were gathered from each barangay to estimate the total sample size. Of the 3,926 fishers, a total of 178 fishers were surveyed with a 6% margin of error and a 90% confidence interval.

Survey instruments and statistical analyses

A structured survey questionnaire and key informant interview were generated and adapted from previous studies which solicited data on the adaptive capacity of the fishing communities. Eight (8) indicators were used (Table 1) to provide an interval-level scale of adaptive capacity adapted from the study of McClanahan *et al.* (2008). Using the Analytical Hierarchy Process (AHP) of Saaty in 1980, ten researchers made a pairwise comparison of the importance of the eight indicators. The similarity indices between the different researcher's weightings ranged from 73% to 92%. The average of the weightings was then used to calculate the adaptive capacity for each fishers' household (Equation 1). Each indicator was normalized to provide a scale of adaptive capacity that will range from 0 to 1. The survey questionnaire was translated to Cebuano which is a major local language of the study area and was pre-tested to assess the adequacy, suitability of the survey frame and operational procedures. It was then modified to improve its data-gathering ability. The completed questionnaires were checked, coded, and stored for data entry. The data were then subjected to Mann-Whitney U-Test and Kruskal-Wallis Test for statistical analyses.

Adaptive capacity = Human agency x 0.10 + Capacity to change x 0.11 + Occupational mobiliy x 0.11 + Occupational multiplicity x 0.19 + Social capital x 0.10 + Material assets x 0.15+ Technology x 0.13 + Infrastructure x 0.12 (Equation 1).

Table 1. Indicators that comprise the adaptive capacity score in the fishing communities of Sindangan bay.

Indicators	Measurement
Human agency (Tompkins 2005)	Whether interviewee suggested factors that affect fish populations and/or interventions to improve fish populations.
Capacity to change (Brooks & Adger 2005)	Stated response of fishers to a hypothetical 50% decline in catches.
Occupational mobility (Allison & Ellis 2001)	Changes of employment within last 5 years, whether forced or voluntary, and whether new occupation preferred.
Material assets (Pollnac & Crawford 2000)	Presence of 15 principal component of material assets: vehicle, electricity, television, fan, piped water, refrigerator, radio, cd player, mobile phone, car battery, satellite dish and the type of walls, roof and floors
Occupational multiplicity (Allison &Ellis 2001	Total number of person-occupations per household (square- root transformed)
Social capital (Pretty & Ward 2001)	Whether the interviewee is a member of community organizations
Gear diversity (IPCC 2007)	Number of different gears or fishing method used by fishing households (square-root transformed)
Infrastructure (Pollnac 1998)	Presence of 30 principal component of infrastructure items in the community. Infrastructure are as follows: hospital, medical clinic, doctor, dentist, primary school, secondary school, piped water,sewer, electricity service, phone service, food market, pharmacy, hotel, restaurant, petrol station, public transportation, paved road, banking facilities, radio, internet facilities, emergency services, telephone landline,daily newspaper, police station, mechanic, fish freezer, Ice plant, fishers' shed, boat jetty.

Result and discussion

Quantifying the adaptive capacity score of each social groups revealed that fishers who were land tenants and members of fishing fleets, fishers with small household size (0 -5 members), fishers belonging in the age group of 29 to 36 years old and fishers who finished High School had lesser adaptive capacity compared to their counterparts (Fig. 1). This implies that these social groups are vulnerable to climate change and should be the priority groups for capacity building of the government for them to be ready and adaptive to the changing climatic condition.

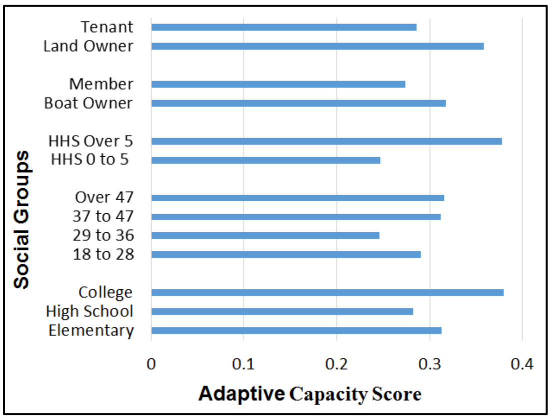

Fig. 1. Adaptive capacity score of the different social groups of fishers in Municipality of Sindangan, Mindanao, Philippines.

In terms of adaptive capacity indicators, findings of the study showed that adaptive capacity scores differ between social groups of fishers in the Municipality of Sindangan (Fig. 2A-E). Significant differences were observable between age groups (Table 2). Older individuals (over 47) as indicated in Fig. 2A had higher material wealth compared to the younger generations. This indicates that older fishers accumulate wealth over time and were adaptive to the changing resources. In addition, older fishers had a higher understanding of human agency and higher capacity to change compared to other age groups. The result of this study on age groups is opposite to a study conducted on Kenyan communities by the group of Cinner *et al.* (2015). On the other hand, respondents who have reached college had a higher understanding of human agency than the fishers who were high school or elementary graduates. This suggests that fishers with higher educational attainment are more knowledgeable in environmental phenomena and may develop strategies for adaptation (Fig. 2B; Table 3).

Table 2. Kruskal-Wallis Test between age groups.

Adaptive capacity indicators	18 to 28	29 to 36	37 to 47	Over 47	p-value
Human agency	0.031707	0.031579	0.035849	0.046429	0.5421
Capacity to change	0.01	0.005789	0.012453	0.014405	0.9564
Occupational mobility	0.015	0	0.012453	0.010476	0.8788
Material assets†	0.06123	0.053529	0.065128	0.068193	0.08173
Occupational multiplicity	0.035271	0.030519	0.0383	0.030182	0.3604
Social capital	0.086364	0.073684	0.088679	0.086905	0.8026
Gear diversity	0.008923	0.006488	0.015919	0.016505	0.3623
Infrastructure	0.041567	0.043993	0.043331	0.042512	0.5111

***p = 0.001; **p = 0.01; *p = 0.05; †p = 0.1

Table 3. Kruskal-Wallis Test between educational attainment.

Adaptive capacity indicators	Elementary	High School	College	p-value
Human agency†	0.047	0.028571	0.05	0.1093
Capacity to change	0.0121	0.009429	0.04125	0.4073
Occupational mobility	0.011	0.007857	0.0275	0.7508
Material assets	0.065235	0.063605	0.074191	0.8669
Occupational multiplicity	0.034042	0.032169	0.035923	0.7823
Social capital	0.085	0.087143	0.0875	0.9693
Gear diversity	0.016474	0.011488	0.00818	0.4005
Infrastructure†	0.042166	0.042325	0.054828	0.1303

***p = 0.001; **p = 0.01; *p = 0.05; †p = 0.1

Significant differences were also found between social groups belonging to small and large household sizes (Fig. 2C; Table 4). Families with over 5 members have higher human agency, capacity to change, occupational mobility and gear diversity. This implies that household heads ensure the sustenance of their families by having multiple gears and mobility between occupations. Also, they venture on other occupations as a source of income when the need arises. On the other hand, fishers with small household size (0 to 5 members), although they had multiple occupations and affiliations to community organizations, they are deficient in the other indicators of adaptive capacity, and are vulnerable to changes in climate. Interestingly, the size of the household was not related to material asset indicators as observed in Fig. 2C. Further differences were observed between social groups who owned a boat compared to those who were just members in a fishing boats (Fig. 2D; Table 5). Undeniably, owners had higher material assets compared to their counterparts, giving them higher purchasing power. This is because, in fishing, owners who encountered a favorable catch will be able to enjoy the harvest solely, however, fishers who were just members had to share with the owner regardless of the volume of the catch. This makes them vulnerable to any changes in the fishery resources brought by the changes in climate. In addition, owners had higher human agency meaning, they are more knowledgeable in fishing and had variable options of occupations.

Possessions of land also gives leverage to fishers to survive in changing fishery resource. Ownership of a piece of land gives them another avenue of livelihood when fishing is not profitable. Significant differences were observed to social groups like tenants or those who do not own land and fishers who are landowners (Fig. 2E; Table 6). Landowners had higher scores in the four indicators of adaptive capacity including human agency, capacity to change, occupational mobility and gear diversity social capital. Government formulating policies for adaptation should be geared towards improving the adaptive capacity of this vulnerable sector. This study uses theoretically informed indicators of adaptive capacity, however, there are limitations to this approach that need further testing to establish the relationship between the indicators and adaptive behavior in response to changes in climate.

Further research is recommended particularly into adaptation methods taking place between fishers to understand the mechanisms by which these different components of adaptive capacity support adaptive action and interact with one another.

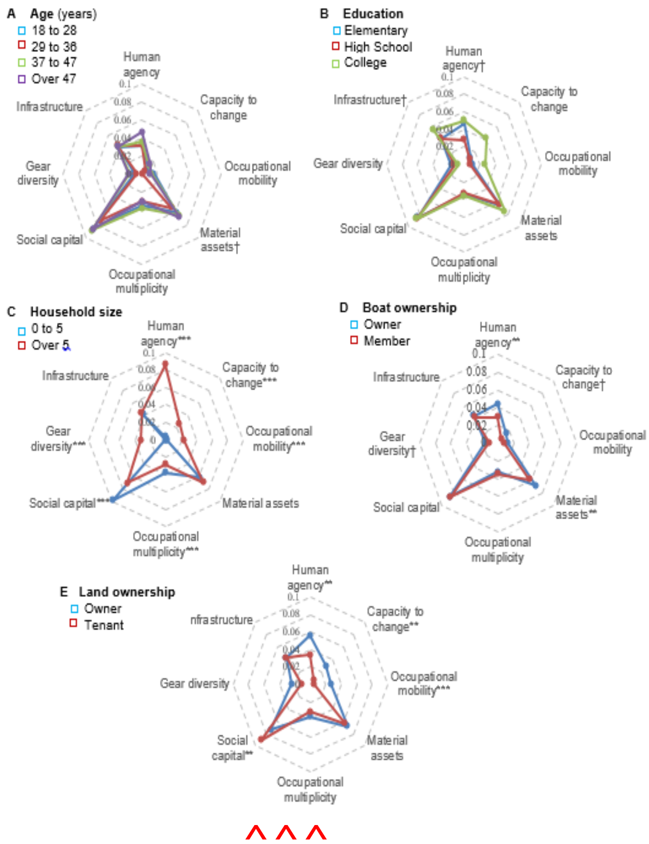

Fig. 2. Differences in the adaptive capacity of different social groups in Sindangan bay. **A**–**E**, Spider plots of the variation of adaptive capacity indicators among factors aggregated across all sites by age (**A**), level of education (**B**), between small and big size households (**C**), among those with boat owners and members (**D**) and between landowners and tenant (**E**). ***p = 0.001; **p = 0.01; *p = 0.05; *p = 0.1.

Table 4. Mann-Whitney U-Test between household sizes.

Adaptive capacity indicators	0 to 5	Over 5	p-value
Human agency***	0.004	0.085897	2.49E-28
Capacity to change***	0.0022	0.025385	1.07E-05
Occupational mobility***	0.0011	0.022564	1.19E-05
Material assets	0.061794	0.068778	0.1582
Occupational multiplicity***	0.037504	0.027828	1.17E-06
Social capital***	0.098	0.070513	1.79E-07
Gear diversity***	0.000327	0.032269	1.86E-22
Infrastructure	0.041628	0.044297	0.3214

***p = 0.001; **p = 0.01; *p = 0.05; †p = 0.1

Table 5. Mann-Whitney U-Test between fishing boat owners and members or renters.

Adaptive capacity indicators	Owner	Member/Renter	p-value
Human agency*	0.044715	0.029090909	0.0503
Capacity to change†	0.015203	0.006	0.104
Occupational mobility	0.011626	0.008	0.4925
Material assets**	0.067963	0.057903743	0.007884
Occupational multiplicity	0.032539	0.034884871	0.9001
Social capital?	0.086179	0.085454545	0.109
Gear diversity†	0.0159	0.010800173	0.1042
Infrastructure	0.043364	0.041529781	0.3269

***p = 0.001; **p = 0.01; *p = 0.05; †p = 0.1

Table 6. Mann-Whitney U-Test between land owners and tenants.

Adaptive capacity indicators	Owner	Tenant	p-value
Human agency**	0.055556	0.034586	0.01335
Capacity to change***	0.029333	0.006617	0.000158
Occupational mobility***	0.026889	0.004962	8.92E-05
Material assets	0.068543	0.063609	0.2166
Occupational multiplicity	0.037557	0.031812	0.3789
Social capital**	0.073333	0.090226	0.004979
Gear diversity***	0.024554	0.010863	8.74E-05
Infrastructure	0.042759	0.04281	0.5363

***p = 0.001; **p = 0.01; *p = 0.05; †p = 0.1

Conclusion

This study shows how indicators of adaptive capacity within a particular group were socially differentiated by age group, educational attainment, household size, boat ownership, and land ownership. The analysis showed that vulnerability is differentiated socially. Specifically, it was found that the social group of fishers with small household size, a member in the fishing boats, land tenants, fishers belonging in the age group of 29 to 36 years old and fishers who finished High School has relatively low adaptive capacity.

Recommendations

Although causality was not demonstrated in this study, the results suggest that community-level interventions such as additional livelihood training may help to increase aspects of adaptive capacity. There may be different needs between younger and older people; fishers with different educational attainment; fishers with different household sizes; and land and boat ownership. Thus, appropriate government intervention should be initiated for these groups to be capacitated.

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