Determinants of Adaptation for Slow-Onset Hazards: The Case of Rice-Farming Households Affected by Seawater Intrusion in Northern Mindanao, Philippines

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ABSTRACT

This study aimed to address the knowledge gaps on adaptive capacity of rural farming households to slow-onset hazards such as seawater intrusion. It defined household-level variables that can potentially explain adaptive capacity by using a principal component analysis and a regression model. In addition, it aimed to develop a measure-based index (MAI) to account for adaptation processes. The developed measure-based adaptation index addressed a number of shortcomings in previous studies and captured the variation in adaptation measures that rice farmers implement. The results indicated that adaptation takes place at different levels based on the propensity to adapt, the variety and diversity of adoption of various measures, the feasibility of the various measures, and the varying conditions of seawater intrusion. The research established a model of adaptation for seawater intrusion largely influenced by the rice farmers' economic capacity, which is crucial in optimizing the adaptation measures employed.

Keywords: adaptation measures, seawater intrusion, multicriteria analysis, measure-based index, slow-onset hazard, Philippines
JEL Classification: C83, O13, Q12

INTRODUCTION

There is growing volume of evidence suggesting that, in many situations, the most successful and cost-effective actions to sustainable development is to increase locally the people's adaptive capacity in tackling the threats imposed by climate change to both lives and livelihoods (Bierbaum and Zoellick 2009; Cismaru et al. 2011; Dietz 2011; FAO 2007; Kumar et al. 2012; Saito 2013; Tessema, Joerin, and Patt 2018). Efforts to integrate adaptation into the development process must ensure that the most vulnerable groups are central to the rapidly expanding climate change research and policy agenda (Smit and Wandel 2006; Yohe and Tol 2002).

It is widely believed that different factors influence a farmer's adaptive capacity against climate change (Binh 2015; Elum, Modise, and Marr 2017; Hartter et al. 2012; Howden et al. 2007; Huang, Wang, and Wang 2015; Kim et al. 2017; Limantol et al. 2016; Menapace, Colson, and Raffaelli 2014; Truelove et al. 2015; Yohe and Tol 2002). However, prevailing studies have relatively applied the same factors to almost all types of climate-related events. The factors of adaptive capacity may be grouped as: (1) characteristics involving biophysical, demographic, socioeconomic, and sociocultural factors; and (2) institutional arrangements (Adger et al. 2007; Below et al. 2012; Binh 2015; Smit and Wandel 2006; Yohe and Tol 2002). Apart from these, knowledge and perceptions are also linked to a farmer's adaptive capacity (IPCC 2012).

This study aimed to address a number of knowledge gaps and constraints in current research approaches and insights in assessing adaptive capacity. Literature review reveals that the set of adaptive capacity determinants are few on slow-onset events in reference to local-level adaptation processes and to the adaptation of small-scale farmers on specific events. In particular, the existing literature does not sufficiently address the integrative and site-specific characteristics of adaptation processes. This is problematic because assessments that ignore the integrative aspect of adaptation merely describe a state of a system using normative arguments of what is good or bad.

Accordingly, this study included adaptation indices that allowed the determinants of adaptation to be quantitatively measured (Mabe, Sienso, and Donkoh 2014; Pandey and Jha 2012; Pandey, Bhandari, and Hardy 2007). Focusing on the farmers' adaptation index would lead to a robust measure of individual and autonomous adaptation practices (Carraro, De Cian, and Bosello 2009; Eriksen and Brown 2011; Tompkins et al. 2010). The index could be used in a simple formula that includes the most important measures that farmers consider to adapt to climate change (Hinkel 2011).

The multidimensional nature of adaptive capacity is often partially reflected on current framings and assessments, since existing Philippine studies mostly involve analyzing vulnerability. The study of Ancog, Rebancos, and Sumalde (2016) successfully tested various methodological frameworks in implementing a vulnerability assessment applicable to the context of indigenous communities. This study confirmed that an indigenous community's vulnerability level may not be consistent across the various approaches used. The results highlighted that adaptive capacity assessment needs to be concurrently implemented to enrich the usefulness of vulnerability study results. Because adaptive capacity is a complex, multidimensional phenomena, the indicators are usually composed of several subcomponents that aggregate indicating variables (Mabe, Sienso, and Donkoh 2014; Narayanan and Sahu 2016; Smit and Pilifosova 2003).

Further, most assessment approaches point out the determinants of adaptive capacity. However, these approaches mostly leave out the interrelationships of the determinants and how these factors define, support, and constrain the farming households' choice of adaptation measures (Rola, Sumalde, and Garcia 2016).

The current literature mostly provides some indications of the relative level of adaptive capacity; however, there is a dearth of studies on how to address the dynamics of decision making for adaptation measures. Accordingly, this decision making involves farmers' knowledge and perceptions of the effectiveness of the measures, which are considered to be crucial in governing adaptation interventions (Gandure, Walker, and Botha 2013; Mulenga, Wineman, and Sitko 2017; Nguyen et al. 2016). Since the Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change, there have been numerous research endeavors that have assessed the relative adaptive capacity of entities through various indices (Balasubramanian, Nambi, and Paul 2007; Hahn, Riederer, and Foster 2009; Gbetiouo, Hassan, and Ringler 2010; Iglesias, Quiroga, and Diz 2011; Malone and Brenkert 2008). These studies have taken place at various spatial levels and have two main purposes: one is to inform adaptation policy by adaptation potentials (Smit and Wandel 2006), whereas, the other is to explore quantitatively who adapts and how and why they adapt. However, all such index studies have encountered conceptual and data-related problems in selecting and aggregating the indicating variables. The composite structure of these indices particularly raises the question of how the different variables and components should be weighted. Moreover, current existing index studies have not found objective methods for selecting indicating variables and for weighing them (Hinkel 2011).

In view of the knowledge gaps discussed above, this research aimed to conceptualize adaptive capacity and to develop an analytical framework based on which effective assessment can be conducted. It attempted to apply approach-based analysis of adaptation measures specific to slow-onset events such as seawater intrusion to rice farms. The study also covered the multidimensional aspects of adaptive capacity to attain a more holistic and systematic understanding of the concept.

As this phenomenon increasingly threatens lives and livelihoods, exploring the applicability of combinations of adaptation measures and the factors influencing their choices and decisions become imperative as it is rarely studied globally and locally. To date, the vast majority of research on natural hazards in the Philippines tends to focus on risk estimation and modeling, rather than on adaptive capacity, especially in the case of seawater intrusion (DOST 2011). Although it is important to investigate the risks and vulnerabilities of changing biophysical conditions on rural farming households' livelihoods, it is equally important to analyze how they are affected by and how they react to the impacts. The answers to these questions have strong implications to their development pathways. Hence, this research was conducted to determine more comprehensively the multidimensional indicators of adaptive capacity of rural farming households to seawater intrusion, especially the most important indicators to specific adaptation measures. Studying such issue would help rural farming communities prepare for a future that would certainly entail challenges. Likewise, this study would help decision makers in devising better intervention policies for the sustainable development of the coastal zones in Northern Mindanao.

METHODOLOGY

Study Site

This study was conducted in seawater-intruded areas in Northern Mindanao, Philippines (Figure 1), specifically, in the rural coastal areas of the municipality of Plaridel, Misamis Occidental province.

Plaridel is the longest coastal municipality in Misamis Occidental and is also the largest rice producer along the coastal areas. Almost all of its barangays (districts) have been identified to be highly susceptible to coastal flooding. As of the first quarter of 2017, the total area planted with rice is approximately 1,279 ha, with a total of 3,175 farms (MAO 2017).

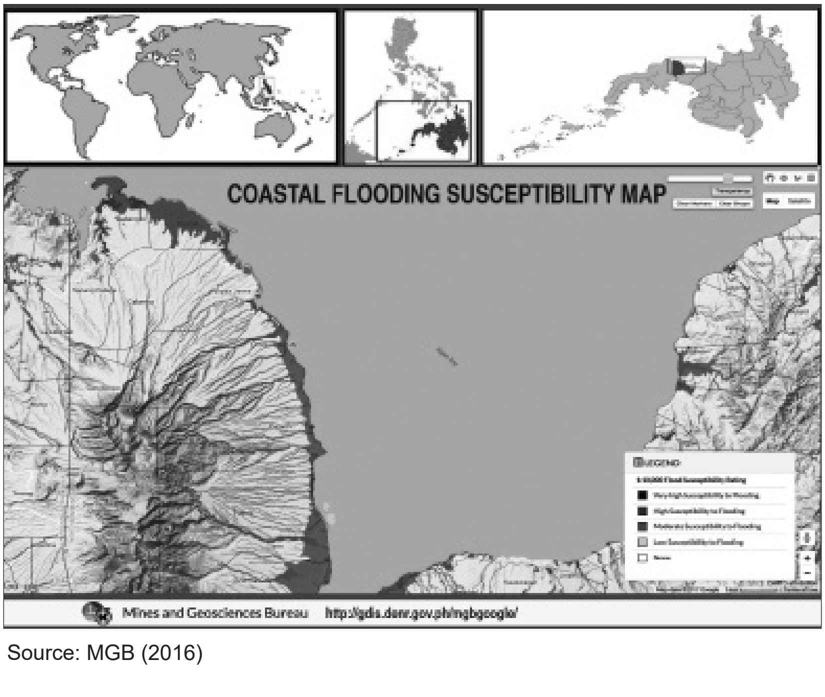
Plaridel has an average elevation of 23 meters above sea level (masl), with undulating terrain. The municipality's coastline average ground level is 4 m, with some areas going as low as 1 masl and as high as 9 m. Most of the coastal areas are at 3 masl. The geographic information system map in Figure 2 shows that six out of the 10 barangays covered in this study have elevation between 2 to 4 masl. Inland, some barangays near the river channels and creeks are only 1 masl, making them highly susceptible to coastal flooding (MDRRMO 2016).

Data Collection

The primary data used for the study were obtained from the survey of rice-farming households in Plaridel, Misamis Occidental. A socioeconomic survey on seawater intrusion-affected rice-farming household was conducted in 10 selected barangays in the municipality. The Municipal Agriculture Office and the Municipal Disaster Risk Reduction Management Office of Plaridel have identified these barangays to be the major rice producers in the municipality highly susceptible to coastal flooding.

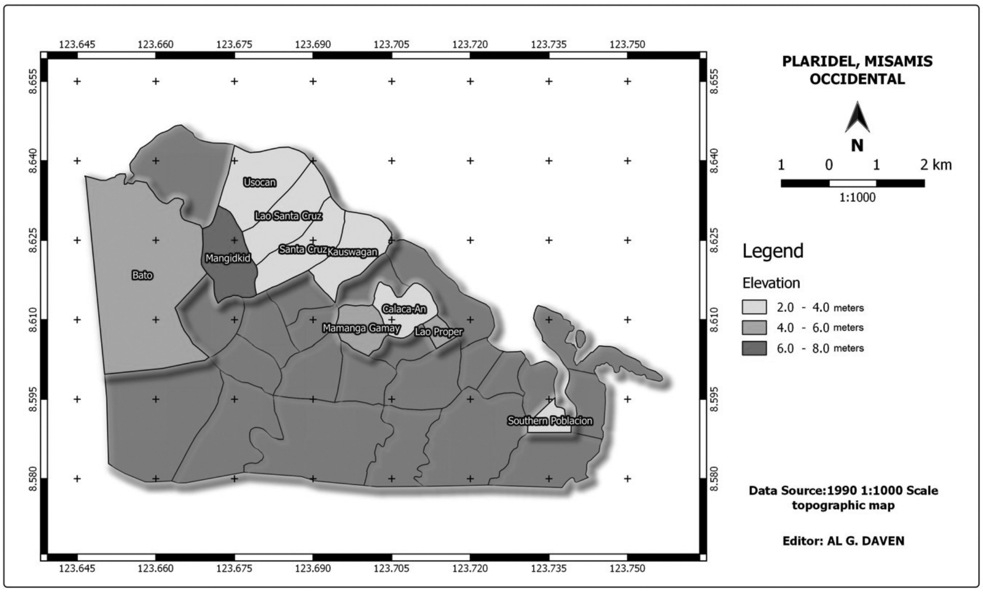
Household data were obtained from the Plaridel municipal office's official list of farmers in the selected barangays. A simple random sampling was then used to obtain the effective sample size of 312 households

Figure 1. Coastal flooding susceptibility map of Misamis Occidental



Source: MGB (2016)

Figure 2. Elevation of selected barangays Plaridel, Misamis Occidental, Philippines



Source: Daven (2016)

(Table 1). This sample size was computed based on a total population of 1,651 rice farms, confidence level of 95 percent, and margin of error of 0.05. The formula is based on the Raosoft sample size calculator, which applied proportional sampling relative to the population of rice farmers in each barangay.

A respondent is considered legitimate if he/she is knowledgeable on rice farming, which means that the respondent should be actively involved throughout the various stages of rice production. The research team conducted the survey through personal interviews. The team completed 326 questionnaires with the aid of the KoBo toolbox software.

The results from the first set of focus group discussions (FGDs) and key informant interviews (KIIs) were used to develop the survey. Ethnohistory method was also employed in collecting data on the history of the rice production and farming practices in the selected farms, and in drawing farmers' experiences in and perceptions of seawater intrusion.

The survey questionnaire consisted of four major sections to collect information on demographic and socioeconomic characteristics, rice production system and practices, perceptions and awareness of climate-related events and seawater intrusion, various adaptation measures practiced, and farmer's individual assessment of the feasibility of measures employed under varying conditions. These criteria were judged based on the degree to which each measure would help or impede its adoption. The important criteria applied in this research were: (1) ability to implement the measure, (2) effectiveness, (3) implementation cost, and (4) support from major stakeholders. To identify the adaptive strategies that held relative importance over others, the farmers were asked to assess different measures by using a five-point scale that rated the four criteria mentioned above in relation to the adaptive measures they use in farming.

Another set of FGDs and KIIs was done while the field surveys were being conducted. The second set included questions about the existing conditions of the study area and rice

Table 1. Population and sample size of rice-farming households in the coastal barangays of Plaridel, Misamis Occidental, Philippines

Barangays	Total Area for Rice Production (in ha)	Estimated Number of Farms	Estimated Number of Respondents	Percentage Share of Respondents	Actual Number of Respondents
Kauswagan	60.0	197	39	13%	40
Lao Sta. Cruz	70.0	151	27	9%	27
Sta. Cruz	180.0	266	50	16%	53
Mangidkid	30.0	103	19	6%	19
Bato	40.0	86	16	5%	20
Lao Proper	28.0	124	23	8%	25
So. Poblacion	17.0	52	10	3%	10
Usocan	117.0	319	60	19%	62
Calacaan	51.5	209	39	13%	41
Mamanga Gamay	50.0	144	27	9%	29
Total	535.0	1,651	312	100%	326

farms, access to markets and infrastructure, institutional conditions, and factors affecting rice farming, such as local climate conditions, main agroecological zone, temperature, precipitation, number of rainy seasons, soil conditions, seawater intrusion issues and concerns, and adaptation measures.

A third set of FGDs and KIIs was also conducted to triangulate the information obtained from the household survey and to confirm the various potential response options to climatic change, including listing climate events that may have influenced local strategies. The third set also sought to sketch out the main trends and changes in land use to understand the extent to which the adaptive strategies are able to explain the changes. The FGDs consisted of 8–14 participants with a group of women and a group of men in each barangay to ensure that the views were as representative of the population as possible.

Data Analysis

Three levels of analyses were conducted to process the primary data collected. The first level involved identifying and assessing the adaptation measures in order to develop the measure-based index. The second level delineated the adaptive capacity indicators, and the third level determined the influence of the adaptive capacity to the measure-based index of the households.

This research applied the multicriteria analysis (MCA) to assess the feasibility of the adaptation measures, and accordingly develop the measure-based adaptation index (MAI). MCA provides one systematic strategy to organize the wide range of information that may be relevant to making adaptation choices (Eakin and Bojórquez-Tapia 2008; Harrison and Qureshi 2000; Rolland 2013).

This research applied a quantitizing process similar to the method that Below et al. (2012) adopted in transforming the adaptation measures into MAI. The construction of the index of the potential adaptation measures begins with a step-by-step evaluation of the feasibility criteria, which reflect their strength or weakness. The index is then calculated as the sum of the weighted adaptation measures of the household. This is expressed as the individual scores since each measure is combined into a final score for the MAI. The index is then calculated as the sum of the weighted adaptation measures of the household. This is expressed as

$$MAI_{ij} = (AL_{ij} \times AW_{ij} + \ldots AL_n \times AW_n) \quad (1)$$

where:

MAI_{ij} = measure-based adaptation index of rice-farming household j for all the i measures employed from 1 to n,
i = the measure employed,
j = individual rice-farming household,
n = the last i measure employed by the jth rice-farming household,
AL_{ij} = jth rice-farming household's value for a given i measure employed ($0 \leq AL \leq 1$), and
AW_{ij} = weighting factor for each adaptation measure i employed by the jth rice farming household.

A multiple linear regression analysis was conducted in order to determine the significant factors of the farming households' adaptive capacity. The basic assumption is that adaptation measures depend on rural households' farm, sociodemographic and economic characteristics, institutional affiliations, and in their knowledge, awareness, and perceptions of seawater intrusion.

Adaptive capacity is often viewed in terms of income, basic needs, security of person and property, sustainability, and empowerment/inclusion (Lemos 2003; Ostrom 2005). These largely depend on social factors such as household size, age, and literacy of household head (Yesuf et al. 2008). The sex of the household head significantly influences the household's choice whether or not to adapt to climate change (Nhemachena and Hassan 2007).

Age is also highly important since it is reflective of farmer's experience. However, there are two contrasting effects of age (Deressa et al. 2009). It implies that the farmer has considerable experience and has extensive observation-based knowledge. Accordingly, this would mean that older farmers are better in understanding adaptation measures. Older farmers tend to be more conservative and may be wary of adopting new techniques (Nhemachena and Hassan 2007).

Most of the recent studies on adaptation have cited that economic indicators predominantly constitute the multidimensional factors identified. Some resource management agencies now stress climate change adaptation as a function of these economic indicators. Accordingly, these economic indicators are influenced by the demand for resources, environmental constraints, infrastructure, and technological change that could require changes in investment plans and business models (IPCC 2007).

In general, the poor and marginalized are the hardest hit due to their weak adaptive capacity and higher dependence on climate-sensitive natural resources for their livelihoods. Like human systems, ecological systems are also impacted by climate change. They can become degraded and lose their capacity to deliver ecosystem services, which may consequently create resource use conflicts among users. It is also argued that such conflicts would be higher among coastal resource users due mainly to their physical location at the forefront of climate change impacts, particularly to sea level rise, cyclones, flooding, saline intrusion, and erosion.

Most studies highlight that greater economic resources increase adaptive capacity, whereas a lack of financial resources limits adaptation options (Campbell, Sithole, and Frost 2000; Laville 2000; Smit and Skinner 2002; Adger et al. 2005; Eichberger and Guerdjikova 2013). Adaptive capacity is not only incumbent upon investment in human capital and access to assets; it also depends on the information and the institutional environment where the adaptation takes place, including the ongoing development process (Smit and Pilifosova 2003). Meanwhile, some emerging studies see adaptive capacity as a function of the institutional conditions in a community. Case studies in South America have shown that adopting good governance mechanisms (e.g., stakeholder participation, openness to information, accountability, and transparency) in policymaking may create the environment that is conducive to the kind of structural reform needed to build long-term adaptive capacity to climate-driven impacts (Smit and Skinner 2002; Degg and Chester, 2005; Nelson et al. 2007; Tompkins, Lemos, and Boyd 2008). These studies have reasoned that institutions are a major determinant of adaptive capacity because well-developed social institutions help to reduce impacts of climate-related risks, thereby increasing adaptive capacity.

A number of household case study survey results have demonstrated that farmer's adaptation to climate change is a function of individual perceptions and knowledge of and information on climate change. Several studies recognize that level of knowledge is an important determinant that formulates local adaptive capacity (O'Brien, Sygna, and Haugen 2004; Knutsson and Ostwald 2006; Hay and Mimura 2006; Parkins and Mackendrick 2007; Tschakert 2007; Deressa et al. 2009; Mertz et al. 2009; Marin 2010; Dilling and Lemos 2011; Westley et al. 2013).

The accuracy of farmers' knowledge and perceptions as predictors of future risk are often based on their past observations. Farmers, nonexperts, and experts, who estimate without using formal methods, often predict the likelihood of encountering a certain future event by consulting their past experiences with such events. This is a form of heuristic methods in which the likelihood of an event is judged by the ease of recalling past instances trough one's senses, perceptions, beliefs, and judgments. (Tversky and Kahneman 1974; Berke, Kartez, and Wenger 1993).

In many instances, farmers who are unaware of climate change are less likely to apply agricultural measures that are effective against climate change. Thus, farmers' successful adaptation to climate change involves a two-stage process. Farmers should first perceive that climate change has occurred before deciding whether or not to apply an adaptive measure (Maddison 2007). Farmers often do not adopt adaptation measures when they are not aware of climate change or do not recognize the problem, and thus, the necessity to adapt. Unawareness of climate change or its impact can occur if social habits and normative standards prohibit individuals from understanding the climatic stimulus.

Perceptions about the impacts of climate change could also significantly affect the derivative perception that any or all of the options would work. Low confidence in attribution or low opinion of significance would make all the options relatively less feasible because none of them would be subjected to serious evaluation; low feasibility factors should then be assigned. High confidence in attribution and widespread recognition of significant exposure would, of course, have the opposite effect (Westley et al. 2013).

In this study, the relevance of the explanatory variables attributed to the determinants of adaptive capacity was adopted from Chambers' (1989) and Yohe and Tol's

(2002) concept of adaptation, whereas, the methodology used in this study was adopted from Below et al. (2012). The resulting model was formulated using the following function:

(4)

MAI f (farm characteristics, sociodemographic characteristics, socioeconomic characteristics, institutional affiliations, knowledge, awareness, and perceptions) + ε.

The relevance of the explanatory variables attributed to the determinants of adaptive capacity and the description of the explanatory variables and their corresponding expected relationship with MAI is provided in Table 2.

RESULTS

Adaptation Measures

In terms of the ability to implement adaptation measures, engaging in nonfarming activities has the highest rating of 3.96 (Table 3). This may be because most rice-farming households engage in various activities to diversify their income sources and because most of these activities do not require huge financial investments. Other adaptation activities include draining seawater using irrigation water, which is considered a desalination process. This is the least costly to implement given that it does not require additional resources and has the highest level of support from stakeholders; most farmers and other entities within their support group practice this measure.

In view of the measures that farmers implement during the last and current cropping cycles, the farmers rated draining seawater using irrigation water as the most feasible measure; at least 55 percent of the farmer-respondents implement this measure. The farmers mentioned during the FGD that most of them use this because it does not cost much. The overall rating on its implementation cost attest to this claim, garnering the highest average rating of 3.9. This has significant implication because more than half of the farmer-respondents indicated that changing the timing of irrigation flow is difficult because they cannot control the water flow. Thus, on the occasion of seawater intrusion due to high tide or coastal flooding, the water allocated for each *cabicilla* (farming district) may not be enough to drain the seawater in the rice plots. According to the president of the Nazareno Gamutan Agricultural Development Irrigation Association (NGADIA), farmers often encounter issues on illegal widening of water canals or illegal establishment of water obstruction measures. Such activities would divert and increase irrigation flow to their plots and speed up the desalination process.

The second most feasible measure is engaging in livestock production. The livestock commonly maintained in the study areas is chicken. Chicken-raising is not too difficult to do since chickens are free range and do not require much resources. They are also a reliable source of stable food and subsistence income.

The third most feasible measures are replacing damaged plants and growing multiple crops, which are both farm-based crop management. Growing multiple crops (e.g., vegetables and fruit trees) is widely practiced in many barangays because it is a reliable source of staple food for subsistence. On the other hand, replacing dead plants is also very common in the various barangays as it helps to attain potential yield and to reduce farmers' financial losses from rice production.

The least feasible measure among the farmer-respondents is practicing crop rotation. Farmers claim that their fields are unsuitable for other crops, although some farmers have tried growing crops such as mungbean and string beans. This may be because relative to these crops, rice is deemed a more valuable crop.

Engaging in fish culture and aquaculture

Table 2. Explanatory variables and their expected relationship with measure-based adaptation index (MAI)

Dimensions of Adaptive Capacity	Indicators	Description	Code	Expected Relationship
Social	Age	Age of farmer in years	Age	Positive
	Sex	Sex of farmer	Sex	Positive
	Farming experience	Number of years respondent worked as a farmer	FarmEx	Positive
	Household size	Total number of household members	HHSize	Positive
	Total dependents	Total number of unproductive household members, i.e., younger than 15 years or household members challenged or/and older than 65 years	TDeps	Negative
	Education	Number of years in school completed	Educ	Positive
Economic	Total employed members	Total number of employed family members	TEmp	Positive
	Household income level	Total household income from all sources as a ratio to the official standard of living in the province	YLevel	Positive
	Housing tenure	Status of ownership of house and lot	HouseT	Positive
	Farm size	Total lot area for rice production	AgSize	Positive
	Farm tenure	Status of ownership of farm	AgTenure	Positive
	Valuable assets	Total number of valuable assets	TVI	Positive
Institutional	Membership to organizations	Total number of membership of farmer in relevant organizations	Orgs	Positive
	Sources of information	Total sources of information $INFO = (I_1 + \ldots I_8)/8$ INFO = total number of information sources I = information source	Info	Positive
	Trainings on adaptation measures	Total number of trainings on adaptation measures Trainings = $(T_1 + \ldots I_{13})/13$ Trainings = total number of trainings for each adaptation measure	Training	Positive
Knowledge	Level of awareness of seawater intrusion	Total score on facts about seawater intrusion $ASWI = (S_1 + \ldots S_{10})/10$ $ASWI$ = awareness of seawater intrusion $S_1 \ldots S_{10}$ = empirical statements on seawater intrusion	ASWI	Positive
Perception	Perception of climate change-related problems	Number of weather-related changes perceived by a farmer within the last decade $PI_j = \Sigma_{i=1}^{i=m} C_{ij}$ where: PI_j = perceived changes by jth farmer Ci_j = parameters (frequency, intensity, and manageability)	FreqCCE IntCCE MagCCE	Positive

Table 3. Farmers' feasibility assessment of various adaptation measures in selected barangays of Plaridel, Misamis Occidental, Philippines, 2017 (n = 326)

Measure	Ability to Implement	Effectiveness	Implementation Cost	Support from Major Stakeholder	General Average	Rank
Technology-Based Measures						
Using saline-resistant variety	2.76	2.81	3.29	1.32	2.55	10
Changing timing of irrigation	3.01	3.05	2.70	1.46	2.56	9
Changing timing of chemical use	3.27	3.24	3.24	1.51	2.82	6
Using crop rotation	3.52	3.28	2.99	1.81	1.81	12
Farm-Based Crop Management						
Growing multiple crops	3.66	3.12	3.24	2.50	3.13	3
Replacing the damaged plants	3.90	3.39	3.30	1.91	3.13	3
EBA Measures						
Desalination	3.67	3.47	3.94	2.00	3.27	1
Filtering irrigation water	3.45	2.78	2.20	1.91	2.59	9
Planting trees/mangroves	3.18	2.79	2.58	2.49	2.76	7
Fish culture in ricefields	2.40	2.60	3.30	1.60	2.48	11
Off-Farm Income Diversification						
Engaging in nonfarming activities	3.96	2.50	2.97	2.61	3.01	4
Engaging in livestock production	3.85	3.05	3.37	2.64	3.23	2
Engaging in aquaculture	2.44	2.77	3.11	1.88	2.55	10
Other Measures						
Moving to other places	2.40	2.8	3.73	1.87	2.70	8
Buying insurance	3.36	3.39	2.42	2.53	2.93	5

Note: EBA = ecosystem-based adaptation

are also among the least feasible because these practices need huge capital investments. Also, farmers think that the fish will not survive due to the various chemicals applied in the rice fields.

The results of the study are consistent with many studies conducted globally about the limited adaptation measures that farmers apply to address climate-related events, which consequently render them to be among the most vulnerable to climate change impacts (Ampaire et al. 2017; Gandure, Walker, and Botha 2013; Ingham, Ma, and Ulph 2005; Kiunsi 2013; Korres et al. 2017; Mabe, Sienso, and Donkoh 2014). This trend would likely continue in the next decades, unless corrective adaptation measures are implemented to reduce the impact of seawater intrusion on rice-farming households.

Meanwhile, the results of the rice-farming household MAI score indicated that 36 percent of the farmer-respondents are below the average levels (Table 4). This implies notable shortcomings in the implemented or planned adaptation options.

Determinants of measure-based adaptation index

Multiple linear regression, key assumptions of linear relationship, multivariate normality, absence of auto-correlation, homoscedasticity, and absence of multicollinearity were all examined in this study. The correlation matrix revealed that a number of socioeconomic variables in the study are correlated, which implies that there is a high chance of multicollinearity. Thus, a factor analysis or principal component analysis had to be done before the multiple regression analysis in order to rotate the factors. Doing this step would ensure that the factors are independent of each other in the linear regression analysis and would determine the number of factors to be retained. Accordingly, this research applied the direct oblimin technique to rotate the factor axes to ensure that the variables are loaded maximally to only one factor given that the underlying factors are correlated.

A total of 17 independent variables were derived based on the conceptual framework. The factor analysis was thus conducted on these variables using oblique rotation (direct oblimin). The Kaiser-Meyer-Olkin (KMO) criterion confirmed that factor analysis was appropriate for the sample, with value at 0.659. The Bartlett's test of sphericity should be statistically significant at $p < 0.05$, and the KMO should have a minimum value of 0.6 in order to have a good factor analysis (Pallant 2001). Barteltt's test of sphericity of χ^2 (66) = 1170.314, $p < .05$ indicate that correlations between variables were sufficiently large for factor analysis.

Table 4. MAI scores of rice-farming households in selected barangays of Plaridel, Misamis Occidental, Philippines, 2017

Rating	Score	Index	Frequency	Percentage
Low	0.00–0.20	1	56	17%
Below average	0.21–0.40	2	117	36%
Average	0.41–0.60	3	107	33%
Above average	0.61–0.80	4	40	12%
High	0.81–1.00	5	6	2%
Total			326	100%

An initial analysis had been conducted to generate eigenvalues for each data component. Six components had eigenvalues >1, which is the Kaiser criterion for the extraction of factors. The six components, which were thus extracted, together explained 62.7 percent of the variance (Table 5).

The authors considered factor loadings of absolute value greater than 0.5 to interpret the factors. High and moderate loadings (above 0.5) indicate how the individual indicators are related to the principal component (OECD 2008). With the six identified components (eigenvalue > 1) in this study, all 16 indicators have loading values after rotation of above 0.5. In component 1, six indicators have loading values above 0.5. Components 2 and 4 have three indicators, components 3 and 6 have two indicators, and component 5 has only one indicator. In sum, the first two components include 9 indicators, 3 components have 11 indicators, 4 components have 13 indicators, 5 components have 14 indicators, and 6 components have 16 indicators.

Applying a scree-test method suggests that all factors above the "elbow" or break in plot would be retained, as these factors contribute the most to the explanation of the variance in the data set (Pallant 2001). Figure 6 presents the scree plot of factor analysis, which shows the eigenvalue that suggests six components with eigenvalue >1. From the plot, there is a clear break between the second and third components. It also depicts another "elbow" after the fourth component. Therefore, the components remaining in the analysis should equal to four or less than six.

The variables that have highest loadings in component 1 include household income, total household valuable items (e.g., appliances, furniture, jewelry, vehicles), size of agricultural land, education, agricultural land tenure, and total institutional affiliations. These variables represent the economic capacity of the rice-farming households. Component 2 has three variables, namely, number of trainings, sources of information, and level of awareness of seawater intrusion. Component 3 has two variables, namely, farmer's age and years of farming experience indicated by farmers' experience expressed in years. Component 4 involves farmers' perceptions of climate-related events in terms of frequency, intensity of impact, and manageability. Component 5 is solely on the sex of the farmer, whereas, component 6 consists of two variables, namely, total household members and total number of employed members. The factors in the last component refer to the human capital of the household.

Among the six components, the factor loadings of component 4 (perceived manageability of climate-related events) and component 5 (sex) have the only negative coefficients. The signs of the coefficients are in line with the research expectations.

Factor 1 is called economic capacity, which includes six economic indicators: income level, total household valuable items (e.g., appliances, furniture, jewelry, vehicles), size of agricultural land, educational attainment, number of organizations, and agricultural land tenure. Income level (0.794) has the biggest loading value, followed by the total household valuable items (0.792), size of agricultural land (0.661), education (0.622), total number of organizational affiliations (0.568), and agricultural land tenure (0.546). Note that the six indicators have positive loadings and relate to household economic capacity. In reality, education and income are usually positively related. Higher educational attainment often leads to bigger potential income. Also, household adaptive capacity in the context of climate-related events also depends on the farmers' educational attainment, which enables them to anticipate changes and accordingly modify their livelihood opportunities in response to those

Table 5. Component matrix

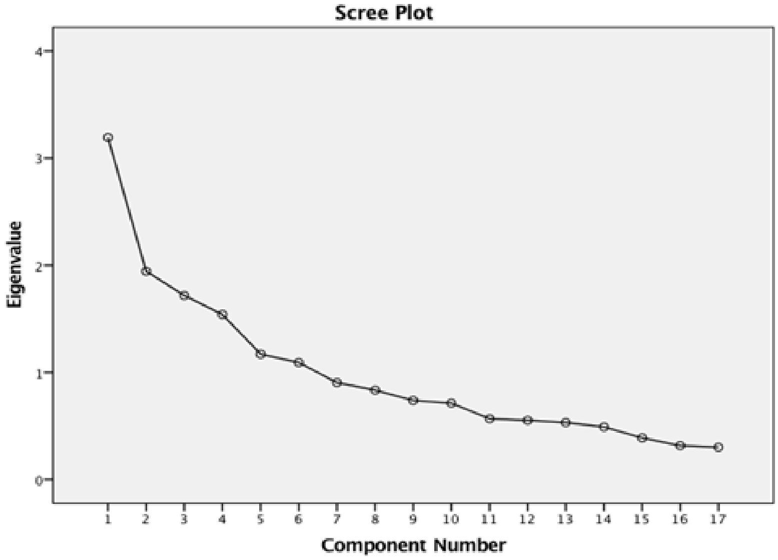
Indicators	Components					
	1 (Economic Capacity)	2 (Knowledge and Trainings)	3 (Rice Farming Experience)	4 (Perception of CRE2)	5 (Sex)	6 (Human Capital)
Income level	0.794					
Total valuable items	0.792					
Size of agricultural land	0.661					
Educational attainment	0.622					
Number of organizations	0.568					
Agricultural tenure	0.546					
Number of trainings		0.807				
Total number of information sources		0.712				
Awareness index for SI		0.707				
Farming experience			0.879			
Age			0.874			
Perception of intensity of CRE^2				0.837		
Perception of frequency of CRE^2				0.721		
Perception of magnitude of CRE^2				−0.708		
Sex					−0.826	
Household size						0.825
Total employed household members						0.720

Notes: (1) Extraction method: Principal Component Analysis.
(2) Rotation Method: Oblimin with Kaiser Normalization.
(3) SI = seawater intrusion
(4) CRE2 = climate-related events

anticipated changes (Deressa et al. 2009). In turn, under normal circumstances, income, total valuable items owned by the household, and agricultural land all have positive relationships. This positive relationship is verified by the correlation analysis. Higher income level generates more valuable assets. Likewise, higher income enables a household to use their income for multiple purposes (e.g., purchasing farm tools, motorcycles, appliances, and other furniture). In many cases, rural farmers with higher income levels often enlarge their farms by buying more land.

Farmers' membership in organizations is also associated with the economic assets of a household. The organizations that most farmers are affiliated with include farmers' association, irrigators' association, and cooperatives; memberships in all are intended for the pursuit of livelihood. Therefore, this factor represents economic capacity and security of the household.

Figure 3. Scree plot of the factor analysis



The second factor—knowledge of and trainings on seawater intrusion—involve trainings, sources of information, and level of awareness of seawater intrusion. Their loading values are positive at 0.807, 0.712, and 0.707, respectively. According to Binh (2015), adapting to seawater intrusion through knowledge management includes all sorts of practical trainings for farmers and agricultural extension officers. This measure also includes using various information sources to establish a decision support system and farmers' and stakeholders' initiatives to experiment on farming practices. Using information networks for seawater adaptation involves investing in community ties and social networks, collective provision of farm inputs, collective marketing of farm products, participating in farmer-to-farmer trainings, and informal exchanges of best practices.

Farmers' various sources of information on adaptive measures usually come from their friends, relatives, neighbors, or extension workers, who accordingly influence their adaptation assessments. Often, information sources that seem to have the most influence on farm households are those that are accessible or those they find most trustworthy. The usefulness of information on seawater intrusion and adaptive measures can significantly influence their assessments. When rice-farming households think that the information on seawater intrusion that they have received is useful, they usually perceive the adaptation measures they employ to be more effective. Thus, they have more ability to implement the adaptive measures (Nhan et al. 2010).

The third factor is farming experience, where the indicators relate to age and the number of years that the farmer has engaged in farming. The loading values are negative for age (0.874) and years in farming (0.879). As noted in literature, age has two contrasting effects (Deressa et al. 2009). It suggests the farmers' considerable experience and extensive observation-based knowledge, which implies that they have better understanding of adaptation measures. However, they also tend to be more conservative and wary of adopting new techniques (Nhemachena and Hassan 2007).

The fourth factor is perception of climate-related events, with three indicators referring to farmers' perceptions in terms of frequency, intensity of impact, and manageability. The loading values of perception are 0.837, 0.721, and −0.708, respectively. Farmers' perception of climate-related events influences their farming practices and ability to make adjustments as a response. This has implications to their adaptation actions (Binh 2015). The fifth factor is solely on the sex of the farmer.

The sixth factor is household human capital and includes farming households' characteristics, such as total members and total employed members. The loadings are 0.825 and 0.720, respectively. Family farming is one of the most predominant forms of agriculture in many developing countries. It is a means of organizing agricultural production, predominantly relying on family labor, including men, women, and children (IFPRI 2012). Moreover, the family members are the ones who often cultivate family landholdings. Thus, household members often support the farm labor needs. On the other hand, employed members of the household supplement the seasonal income from farming. These types of human capital reduce the negative effects of climate change on farm production, household income, and farmer livelihoods (Nhemachena and Hassan 2007).

A multiple linear regression analysis was conducted to determine the influence of the components on the adaptation level. Several combinations were tested; one combination applied all the six components in combination with the other independent variables. Another used the four components with the highest loadings in combination with the other independent variables. The final model used the combination consisting of the six components (Table 6).

The model has an R^2 value of 0.646 and adjusted R^2 value of 0.41, and thus explains 41 percent of the total variance in the MAI. The explanatory power of the models is much higher than what was reported by Below et al. (2012) and Nhan et al. (2010), who explored the relationship between socioeconomic variables and farmers' adaptation behavior by means of an explanatory factor analysis and a multiple linear regression model. Their models explained between 22 percent and 28 percent of the observed variance.

The results imply that there are other variables not used in this research, which

Table 6. Regression estimates (dependent variable: MAI)

Independent Variables	Standardized Regression Coefficients	Std. Error	*t*	Sig.
Economic capacity	0.089**	0.008	2.007	0.046
Knowledge and trainings on seawater intrusion	0.615**	0.008	13.726	0.000
Rice farming experience	−0.065	0.008	−1.486	0.138
Perception of climate-related events	0.025	0.008	0.578	0.564
Human capital	0.019	0.008	0.433	0.665
Sex	0.038	0.017	0.874	0.383

Notes: (1) R^2 = 0.646
(2) Adjusted R^2 = 0.41
(3) F Stat: 15.552
(4) ** indicates significance at 99 percent

determine the unexplained variance in MAI of rice-farming households. However, this is difficult to avoid when studying highly multifactorial systems of farmers' adaptation to seawater intrusion. Not all determinants that might influence farmers' adaptation choices can be measured due to the different characteristics and contexts of individuals and due to their limited willingness to participate in interviews for longer than 60 minutes. Nonetheless, the resulting model is significant based on the F-test.

Two factors emerged as positive significant indicators: (1) economic capacity; and (2) knowledge, trainings, and level of awareness on seawater intrusion. Determining the factors that influence adaptation through factor and regression analyses corresponds well to much of empirical research findings and to the literature on farmers' adaptation to climate change.

The prominent role of household economic capacity in successful adaptation has been well-established (Hartter et al. 2012; Howden et al. 2007; Huang, Wang, and Wang 2015; Kim, Elisha, Lawrence, and Moses 2017; Limantol, Keith, Azabre, and Lennartz 2016; Menapace, Colson, and Raffaelli 2014; Morton 2007; Smit and Pilifosova 2003; Yohe and Tol 2002). The economic capacity of the household influences the demand for farming resources, infrastructure, and technological change that could require changes in agricultural production strategies (IPCC 2007). Most studies highlight that greater economic resources increase adaptive capacity, while a lack of these resources limits adaptation options (Campbell et al. 2000; Laville 2000; Adger, Arnell, and Tompkins 2005; Eichberger and Guerdjikova 2013). The result further implies that rice-farming households with high income are more likely to adopt more measures than those farmers with lower incomes. Moreover, rice farming requires economic resources to make adjustments, and these adaptation measures involve inputs (e.g., seeds, fertilizer, pesticides, irrigation facilities), which are stressors on farm budgets.

Involvement in organizations is included in the first factor. The result indicates that it is positive and significantly related to adoption of adaptation measures. This implies that the probability that a farmer would adopt an adaptive strategy would be higher for those farmers who are associated with different organizations, compared with those not participating in such coordinated actions and groups. As such, this may indicate that membership and engagement in an organization encourages farmers to engage in a united strategies orientation, share knowledge and innovation ideas, discuss problems and challenges with others, and engage in collaborative decision making.

The second significant factor is knowledge, trainings, and level of awareness on seawater intrusion. The result provides some support to involvement in organizations and the expectation on the influence of information sources on the knowledge, trainings, and awareness on seawater intrusion in rice farms. The factor is positively related to adaptation measures. This parallels other studies that document the influence of climate change awareness on adaptation measures (Kibue, Liu, and Zheng 2016; Mertz et al. 2009; Uddin, Bokelmann, and Dunn 2017). This result highlights farmers' cognition and ability to adapt to seawater intrusion, which may be a function of informational and capability training needs. The significance of each depends upon the decision making structures that can have parallel effects on the choice of adaptation measures.

Awareness of the impact of seawater intrusion could have a significant effect on the derivative response that farmers would implement. Likewise, knowing the causes of seawater intrusion could also have comparable and consistent effects on the likelihood that any adaptation measure would be implemented.

Low confidence in attribution or low opinion of the potential impacts of seawater intrusion may lead farmers to adopt limited number of measures. High confidence in attribution and widespread recognition of seawater intrusion causes and impacts would have the opposite effect. This could also influence the scale dimensions when assessing the feasibility of the various measures. More measures need to be adopted as seawater intrusion in rice farms will inevitably continue to happen in the future; thus, the feasibility of the measures would partially depend on the farmers' ability to collect information and to process it properly so that more measures could be implemented accordingly.

The results on the factors of household human capital and perception of climate-related events are not significant. Therefore, the hypothesis on social characteristics and the role of perception of adaptation measures are not rejected. The coefficient of farming experience, although not significant, is negative. This confirms the results in some literature that older farmers tend to be more conservative and may be wary of adopting new techniques (Nhemachena and Hassan 2007). This may be because farmers who have been in rice farming are usually older, less educated, and more resistant to change.

Local farmers' perceptions are important because farmers often manage rice production activities according to their perceptions and beliefs. However, in these communities, meteorological information from the scientific community is rarely available. Often, farmers rely on their own observations and subjective interpretations. Farmers' perceptions may not only be based on their individual interpretation, but also on the collective interpretations of their families, relatives, or peers. Likewise, they are likely shaped by a number of interacting factors, such as access to information, formal education, social interactions, and life experience (Binh 2015). The researchers were not able to detect the significance of these variables in the model, albeit they are likely still contributing to overall perceptions.

CONCLUSION

The measure-based adaptation index (MAI) of farmers in this study has indicated potential means of reducing many of the adverse impacts of seawater intrusion on rice production and of enhancing the beneficial outcomes of adaptation. The combination of measures and the rate at which they are implemented represent practical means of adapting to changes and uncertainties due to seawater intrusion, including its variability and extremes. The results have proven that adaptation takes place at different levels (i.e., the propensity to adapt, the variety and diversity of adoption of various measures, the feasibility of the various measures, and the varying conditions of seawater intrusion).

To reduce losses and damages resulting from seawater intrusion in rice production, a series of adaptation options that are not currently being implemented must be further evaluated. Farmers' key concern is to attain the most feasible measures that would address the varying conditions of seawater intrusion. This is proving to be highly crucial since climate change has become more pronounced based on the most recent events that the farmers have experienced.

This study has shown that there are critical indicators of adaptation. It has established that the adaptation model for seawater intrusion is largely influenced by farmers' economic capacity, which is crucial for optimizing the adaptation measures employed. The adaptive capacity of rice-farming households is indicated by their socioeconomic characteristics. Economic capacity has emerged to be one of the most important factors that influence the adaptation index of rice-farming households. In many developing countries, income level, educational attainment, and household assets are very essential in improving adaptive capacity and in reducing structural deficits brought by climate-related events. In this research, the same factors have proven to be extremely important to adapt to seawater intrusion. For instance, literature have cited that vulnerable households could not take advantage of risk management measures due to the lack of money to implement them. This research found that farmers' economic assets are extremely important to implement adaptation measures that would address varying conditions of seawater intrusion. These include ability to implement agricultural technology, alternative crop varieties, and chemical use, among others. Thus, this research supports the idea that building the adaptive capacity of rice-farming households would require higher levels of economic capacity.

Any adaptation measure that addresses seawater intrusion will involve certain costs. Farmers would then be financially constrained, especially when an adaptation technology is not readily available (e.g., salinity-tolerant variety) or if the relative costs to gather information on adaptation are high. Other economic constraints are associated with prices and other benefits produced by the technology and the risks associated with its use. Therefore, farmers' economic conditions drive the choice of adaptation measures to seawater intrusion.

This research substantiated that farmers' knowledge and awareness of seawater intrusion and information sources and number of trainings enhance adoption of measures. Therefore, the model for adaptation to seawater intrusion also includes farmers' awareness and general knowledge of the incidence of seawater intrusion and its impacts.

Conclusively, the research provides empirical data that would improve understanding of adaptation to slow-onset hazards (in general) and saltwater intrusion (in particular), which have received less attention in other studies. It addresses a number of knowledge gaps and constraints in the current research approaches and insights when assessing adaptive capacity.

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