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FULL PAPER

Sustainability Assessment of the Local Knowledge Systems and Climate Change Adaptation of the Abaknon in Capul Island, Northern Samar, Philippines

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Small islands are the least likely to contribute to climate change but are the most likely to be affected by its adverse impacts. Capul is one of the small islands in the Philippines which is found to be prone to storm surges and coastal erosion, as brought about by climate and weather disturbances. Its agricultural landscape is dominated by coconut while small-scale fishing is the most dominant form of livelihood. Local knowledge systems play an important role in the Abaknon's livelihood and adaptation practices to climate change. Their intimate knowledge of the island's biophysical environment and farming systems has helped them to conserve the natural resources of the island. The study assessed the local knowledge, beliefs, and climate change adaptation practices of the Abaknon through development of a composite sustainability index which was informed by direct field observation and field interviews. The results showed that the Abaknon's local knowledge systems, together with other important social, economic, and environmental indicators are acceptable with an index value of 0.78, a good sustainability level. The study was also able to identify critical indicators that may pose threat to the environment such as ageing farmers/fisherfolks, high coastal population, low interest and entry of young people into agriculture, fair condition of live coral cover, and decreasing diversity of fish species.

Keywords: Abaknon, climate change adaptation, composite index, local knowledge systems, small islands, sustainability assessment

INTRODUCTION

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2014) highlighted the following observed changes in climate system: the atmosphere and ocean have warmed, the amount of snow has lessened, and that the sea level has risen since the 1950s. The combined global average of land and ocean temperature showed a warming of 0.85°C from 1880 to 2012. And from 1901 to 2010, the global mean sea level has risen by 0.19 m, the rate of which has been larger in the mid-19th century as compared to the last two millennia.

Climate change is a global phenomenon where small islands, which are the least likely to contribute to it, are the most vulnerable to its adverse effects (UNFCC, 2005). Santamarta et al. (2014) stated that climate change in small islands will affect both the water quality and its quantity, in terms of pollution from wastewater and inadequate supply of water, respectively. Additionally, the perceived intensity and frequency of extreme weather events such as floods and droughts are expected to increase. Water shortage, on the other hand, can lead to heat stress and changes in soil moisture and evapotranspiration, all of which are crucial to subsistence crop production. Furthermore, saltwater intrusion due to sea level rise, will likely affect crop production, especially those along the coasts (UNFCCC 2005).

Coral reefs, which are the sources of food and provide habitats for marine animals and reef fish, are also threatened by climate change (IPCC 2014). The destruction of coastal habitats and coral reefs will bring a substantial problem to the fish stocks (Dey et al. 2016). Climate change can also cause damage to the forest ecosystem, including mangrove forest destruction, loss of endemic species, change in land cover, and reduced quality and quantity of spring waters (Sapta et al. 2015).

Small islands are highly vulnerable to both climate and non-climate stressors. Some of the specific vulnerabilities of small islands to climate change are the following: almost all foods, fuels, construction materials, and other goods are imported in Barbados and many other islands; 50-80% of the land areas in the Maldives and Papua New Guinea are less than one meter above sea level; about 80% of the infrastructure and the population are concentrated along the coasts of Seychelles; limited resources are used to address the environmental problems in Grenada; and prolonged droughts are experienced in Palau and intense rainfall and tropical cyclones in the South Pacific region (UNFCCC 2005).

The Philippines, being an archipelago, is also highly vulnerable to the impacts of climate change such as rising sea level and temperature, and increased frequency of extreme weather events and rainfall (USAID 2017). According to the National Integrated Climate Change Database and Information Exchange System (NICCDIES 2024), the country ranked third as the most vulnerable country to climate change as reported by the 2017 world risk report. By 2023, the World Risk Index named the Philippines the world's most disaster-prone country, followed by Indonesia and India (BrandSpace for European Union 2024). These are all due to the country's exposure to natural hazards, vast coastline, and its dependence to the natural resources. Sea levels in the Philippines are also rising faster than the global average, thus increasing the threats of storm surges and inundation of low-lying areas (USAID 2017). Siargao in the south and Bohol in central Philippines are examples of small islands which are vulnerable to flooding, rain-induced landslides, land subsidence, and sea-level rise which will pose impacts and damages to its agriculture sector, human settlements, and biodiversity resources (DENR 2015; Jamero et al. 2017).

Capul Island in Northern Samar is one of the several small islands in the Philippines which is highly vulnerable to climate change impacts. Capul was formerly known as Abak Island, named after King Abak, the ruler of Java, Indonesia. The inhabitants of Capul Island are called Abaknon and the language they speak is Inabaknon, which according to linguists, belongs to the family of Sama-Badjau languages (Cabacang et al. 2020). The Abaknon are engage in diversified yet intertwined livelihood strategy (Cabili 2008) which mainly includes coconut farming intercropped with vegetables and root crops, and several fishing methods, including shellfish gathering and seaweed farming (Cabacang et al. 2020).

For the Abaknon, local knowledge systems play an important role in their livelihood and adaptation practices to climate change. They are still bounded by their strong beliefs and respect for supernatural beings, believed to be residing in specific areas of the island such as in trees and big rocks. The recognition of local knowledge systems in climate change studies has been significant in understanding local-level impacts of climate change and a wide range of alternatives for adaptation strategies that are deemed proper to its ecological and socio-cultural environments. Thus, proper documentation and research are fundamental in responding to climate change impacts (UNFCCC, 2013).

The farming and fishing practices and local knowledge systems are important inputs to the management of natural resources in small islands and similar ecosystems. Thus, the local knowledge systems on farming and fishing and climate change adaptation practices of the Abaknon must be documented and assessed in terms of how they sustainably use and manage their natural resources and to come up with a concrete program and policy so that other small islands and similar ecosystems can benefit from it.

METHODOLOGY

Data Collection

Primary and secondary data were gathered both at the barangay and municipal levels. Primary data gathered were on farmers' profile, agricultural, environmental, and socio-economic profiles of the barangay. These data were obtained in July 2018 through household interviews (HHI) and observation of their daily life. Key informant interviews (KII) were conducted with the members of the community who are knowledgeable on the cultural practices and beliefs on the island. Focus group discussion (FGD) was conducted in February 2020 to validate the preliminary results of the study.

The respondents of the study were farmers and fisherfolks of Brgy. Oson in Capul, Northern Samar. Purposive sampling was used to identify a homogenous target sample from the total population. The homogenous sample is believed to have a shared or common characteristics as to livelihood practices, historical knowledge about the local practices and the environment, in general. To get the target sample, three criteria were set: 1) must be involved in farming or fishing activities (to document the farming and fishing practices); 2) must be an adult, aged 31 years old and above, who are considered the head of the household (they are assumed to be more knowledgeable on the farming and fishing practices than the younger ones); and 3) have been farming or fishing for more than 10 years (they have knowledge on historical events in the island). The sample size from the identified population was computed using the formula:

$$\mathbf{n} = \frac{\mathbf{N}}{(\mathbf{1} + (\mathbf{Ne^2})}$$

where: **n** = ideal sample size
N = homogenous population
e = margin of error

A target sample size of 44 was computed, using the following values: n=50, e=0.05. KIIs were also done on household heads to get data on climate change perceptions and adaptation practices. Key informants were selected based on their familiarity with climate change.

Composite Index Development

A composite index (CI) was developed which was informed by direct field observations and field interviews. The CI aimed to assess the overall sustainability of the system concerning the three pillars, i.e., socio-cultural, economic, and environmental. In this study, the cultural component is included because it influences the livelihood and all other aspects of the life of the Abaknon.

Indicator Selection. The Sustainability Assessment of Farming and the Environment (SAFE) Framework developed by Sauvenier et al. (2005) was used as a guide in selecting the indicators used in the study. It includes a universal and comprehensive set of indicators to assess the sustainability of a system, focusing on the farming and fishing livelihoods (Table 1).

Table 1. Agri-environmental Indicators (AEIs) for the Sustainability of the Local Knowledge Systems and Climate Change Adaptation Practices of the Abaknons with their farming and fishing activities (Adapted from Van Cauwenbergh et al. 2007; Sauvenier et al. 2005)

Principles	Criteria	Indicators	Reference Value	Unit	Expression	Scale	Rating	Indicator Type*
Socio-Cultural Pillar								
Food Security and Safety								
Production Function	Quality and Diversity of food and raw materials is maintained or increased	Diversity of sources of main food types (carbohydrates, proteins, and fats)	6 (rice, corn, root crops, fish meat, fruits, vegetables)	count	↑ number of sources, ↑ sustainability	6 or more 5 4 3 1—2	excellent good average fair low	CCA
	An adequate amount of agricultural land is maintained	Total agricultural land area with the total land area	100	%	Maintained = sustainability	81-100% 61-80% 41-60% 21-40% 0-20%	excellent good average fair low	CCA / LK
Quality of Life								
Physical well-being of the farming/fishing community function	Labor conditions are optimal	Number of hr per day for farm/fish labor	5.5 hr	hr	Optimal number of hr, ↑ sustainability	5 hr 4 hr 3 hr 2 hr 1 hour	excellent good average fair low	CCA
		Age of farmers/ fisherfolks	Less than 57 yrs old (national average)	yrs	↓ age ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	
	Coastal population is limited	Number of the coastal population	At least 15% of the population	Count, %	↓ coastal population, ↑ sustainability	<15 >15	excellent low	CCA
Psychological well-being of the farming/ fishing community function	Education of farmers and farm workers is optimal	Educational attainment/ Ave yrs in school (AYS)	At least Senior HS = 12 yrs	%	↑ educational attainment, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	
	Family situation is acceptable	Gender equality in the household	Y 100	Y/N %	Y = sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	
		Sectoral emigration	0 (reciprocal)	%	↓ emigration rate, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	CCA
	Family access to and use of social infrastructures and services is acceptable	Distance to admin services	Max 5 km	km	↓ distance, ↑ sustainability	1-5 km 6-10 km 11-15 km 16-20 km 21-25 km	excellent good average fair low	
	Equity is maintained or increased	Employment rate	100	%	↑ employment, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	
Social Acceptability								
Well-being of the society function	Amenities are maintained or increased	Number of amenities	100 % Maintained/ increased	%	↑ amenities, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	
	Stakeholder involvement is maintained or increased	Participation in local rules and regulations	100	%	↑ participation, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	

Continuation of Table 1. Agri-environmental Indicators (AEIs) for the Sustainability of the Local Knowledge Systems and Climate Change Adaptation Practices of the Abaknons with their farming and fishing activities (Adapted from Van Cauwenbergh et al. 2007; Sauvenier et al. 2005)

Principles	Criteria	Indicators	Reference Value	Unit	Expression	Scale	Rating	Indicator Type*
	Production methods are acceptable	Use of acceptable fishing gears	100	%	↑ percentage, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	LK
		Use of acceptable farming practices e.g., pest and nutrient management plan	100	%	↑ percentage, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	LK
Cultural Acceptability								
Information function	Cultural, spiritual, and aesthetic heritage value features are maintained or increased	Practice of traditional farming/ fishing systems	100	%	↑ percentage, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	LK
		Performance of rituals	100	%	↑ percentage, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	LK
		Transfer of local knowledge and practices	100	%	↑ percentage, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	LK
Economic Pillar								
Viability								
Economic function	Family income is ensured	Family income	PhP 19,000.00 (Region 8 average monthly income, PSA 2018)	PhP	↑ income, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	
	Dependence on external finance is optimal	Amount of loan (capital)	0 (reciprocal)	PhP	↓ proportion (↑ capital), ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	
	Agricultural activities are economically efficient	Average rate of return on capital employed (ROI)	Positive value	ratio	(+) ROI, ↑ sustainability	(+) excellent (-) low	excellent low	
	Agricultural activities are technically efficient	Total output from total input (Returns to factors of production)	Positive value	ratio	(+) value, ↑ sustainability	(+) excellent (-) low	excellent low	
	Market activities are optimal	Diversity of agricultural income sources	3 (minimum)	count	↑ sources, ↑ sustainability	5 or more 4 3 2 1	excellent good average fair low	CCA
	Inter-generational continuation of farming activity is ensured	Entry of younger people into agriculture	Perceived increase in number	Y/N	Yes = sustainable	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	
	Land tenure arrangements are optimal	Land tenure status	100	%	↑ % owner, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	

Continuation of Table 1. Agri-environmental Indicators (AEIs) for the Sustainability of the Local Knowledge Systems and Climate Change Adaptation Practices of the Abaknons with their farming and fishing activities (Adapted from Van Cauwenbergh et al. 2007; Sauvenier et al. 2005)

Principles	Criteria	Indicators	Reference Value	Unit	Expression	Scale	Rating	Indicator Type*
Environmental Pillar								
Stock of quality soil function	Soil chemical quality is maintained or increased	Use and frequency of soil tests	At least one per year	count	1 soil test/year ↑ sustainability	1 = excellent 0 = low	1.0 excellent 0.2 low	
		Soil organic matter (carbon) content	Values greater than 6	--	>6, ↑ sustainability	>6.0 4.3 – 6.0 2.1 – 4.2 1.0 – 2.0 <1.0	excellent good average fair low	
	Soil physical quality is maintained or increased	Number of farmers practicing reduced and zero tillage and other best land management practice s including crop rotations	100	%	↑ percentage, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	LK
		Number of days per year that soil is covered	100	%	↑ % cover, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	
Stock of biotic resources function	Planned biodiversity is maintained or increased	Number of crop species	Perceived increase in number	count	↑ crop species, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	CCA
		Number of livestock species	Perceived increase in number	count	↑ livestock species, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	CCA
	Functional part of natural biodiversity is maintained or increased	Area of live and dead coral	76-100%	%	↑ % live coral, ↑ sustainability	76-100% 51-75% 31-50% 11-30% 1-10%	excellent good average fair low	LK
		Diversity of fish species	Perceived increase of catch	%	↑ catch, ↑ sustainability	81-100% 61-80% 41-60% 21-40% 1-20%	excellent good average fair low	

Data Normalization. Normalization means translating the data into a uniform, dimensionless and unitless value to make them comparable (Farrugia 2007; Mazziotta & Pareto 2013). To gauge the scores, reference values were designated for each indicator. The reference values used were target and threshold values, and regional average, depending on the indicator.

The responses for qualitative date were translated into quantitative data by counting the number of responses that adhere to the reference value and then converted to percentage. The normalization method used in this study is the indicization or the distance-to-target or reference. In indicization, the scores were obtained by dividing the actual indicator value by a reference value to get the sustainability index (SI) of the indicator. The scores were obtained by dividing the actual indicator value or mean by the reference value to get the sustainability index (SI) of the indicator. Thus, the equation:

$$SI = \frac{I}{R}$$

where:
SI = sustainability index
I = indicator value
R = reference value

Aggregation and Weight Determination. For this study, the type of indicators selected for the sustainability assessment is substitutable. A low score or index for a given indicator can be compensated by a high score of another indicator within the same criteria or principle, thus, a compensatory approach in aggregation. For the type of aggregation method, simple or linear aggregation was used. The type of comparison used is the absolute comparison of the scores versus the reference values, taking into account the time or year and spatial scale, which is at the farm level, at the time of the study. The balanced weight approach was used wherein equal weights were assigned for each of the three pillars, i.e., socio-cultural, economic, and environmental. Equal weights assumed that each pillar is equally important in the assessment of the overall sustainability of the system, as in the triple bottom line approach.

The SI of the criteria (SI_c) and principles (SI_p) were computed by getting the average of the indicators that make up the criteria and the criteria that make up the principles, respectively:

$$\boldsymbol{SI_c = \frac{(SI_1 + SI_2 + SI_3 \ldots SI_n)}{n_c}}$$

$$\boldsymbol{SI_p = \frac{(SI_{c1} + SI_{c2} + SI_{c3} \ldots SI_{cn})}{n_p}}$$

where:

SI = index value of the criteria
SI = index value of the indicators
n_c = number of indicators under the criteria
SI_p = index value of the principle and n_p is the number of criteria under the principle

The weight is calculated using the equation below,

$$\boldsymbol{w_p = \frac{1}{P}}$$

where:

w_p = weight of pillar p
P = number of pillars

The overall sustainability index is then calculated using the equation:

$$\boldsymbol{SI_t = w_p SI_{pEcon} + w_p SI_{pEnvi} + w_p SI_{pSocc}}$$

where:

SI_t = overall sustainability index
w_p = weight
SI_{pEcon} = SI for economic pillar
SI_{pEnvi} = SI for environmental pillar
SI_{pSocc} = SI socio-cultural pillar

Uncertainty and Sensitivity Analysis. The uncertainty analysis (UA) was done to test the robustness of the composite index (CI). It focuses on the ambiguity of the input factors and how they can affect the index values (OECD, 2008). Without a strong theoretical and conceptual background, the development of a CI can be subjective. Three alternative scenarios and models were established to test the robustness of the CI of the base case (original model). The base case used the distance-to-target (DTT) normalization and linear/arithmetic aggregation methods. The CI of the base case was compared to the resulting CI of the alternative models to see the effects of aggregation, normalization, and the combined effect of aggregation and normalization:

Alternative 1: same normalization (DTT); different aggregation method (geometric mean)

Alternative 2: different normalization (Min-max); same aggregation method (linear/arithmetic mean)

Alternative 3: different normalization (Min-max) different aggregation method (geometric mean).

Sensitivity analysis (SA) deals with the influence of each factor or source of uncertainty on the variance of the output (OECD 2008; Davino & Romano 2011). It looks at how the variance of each model influence the resulting CI. Generally, the variance measures the spread of a data set. After the identification of the sources of uncertainty, these models were further evaluated using the Monte Carlo simulation method to assess the influence of the uncertainty factors on the variances of the resulting CI. Random numbers were generated for each of the indicator values to get the CI of each model. These were then simulated 1000 times to test the effects of the uncertainty factors on the variances of the resulting index. A variance of 0 indicates that all data values are the same while a small variance means that the data points are close to the mean or each other. The models were analyzed using paired t-test for two sample means. The variance and the p-value will show if the differences between the means are statistically significant or not.

Interpretation of Results. The categorical scales were used to assess the rating of SI, between 0 and 1, corresponding to the metrics of environmental sustainability (from low to excellent) adapted from Manning & Soon 2016 (Table 2).

RESULTS AND DISCUSSION

Study Area

Capul is a small island in Northern Samar located at 12°25' 22'' N and 124°10' 50'' E. It is bounded by the San Bernardino Strait in the North, the municipality of Allen in the East, the province of Masbate in the West, and San Vicente in the South. It is a fifth-class municipality with a total land area of 3,500 ha and a total population of 12,679 (PSA 2015).

Table 2. Metrics used in the scoring of sustainability indicators (SI) (Adapted from Manning & Soon, 2016).

Index Value	Level of Sustainability	Interpretation
0 < SI < 0.2	Low Sustainability (LS)	The indicator shows a need for evaluation to determine areas for improvement and the prioritization for action is a high priority.
0.21 < SI < 0.4	Fair Sustainability (FS)	The indicator shows improvements are required with medium priority.
0.41 < SI < 0.6	Average Sustainability (AS)	The indicator shows a need for evaluation to determine areas for improvements, but this is of low priority.
0.61 < SI < 0.8	Good Sustainability (GS)	The indicator shows this area is under control, but continuous improvement can still be made to achieve excellent status.
0.81 < SI < 1.0	Excellent Sustainability (ES)	Sustainability is achieved.

Barangay Oson is located on the southeastern part of Capul Island (Figure 1). It has a total land area of 338.82 ha, approximately 10% of the total land area of Capul. The largest part of the island is the mountainous part where coconut, some root crops, and other fruit trees are planted. Being a coastal barangay, it is also prone to the impacts associated with coastal hazards brought about by climate and weather disturbances. Results of the 1:10,000 scale coastal geohazard survey and assessment conducted by the Department of Environment and Natural Resources Mines and Geosciences Bureau (DENR-MGB) in 2016 revealed that all barangays in Capul are prone to storm surges and coastal erosion which ranges from a few centimeters to about 1m per year. Brgy. Oson was specifically found to be prone to storm surge, coastal erosion, and coastal flooding (Capul MDRRM Plan 2018-2023).

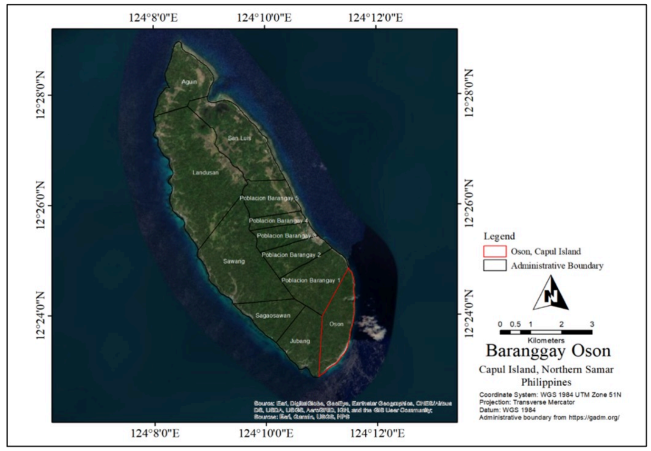

Figure 1. Location map of Barangay Oson in Capul Island, Northern Samar (ESRI USGS).

The site was selected since farming and fishing activities and climate change adaptation practices are the interests of the study. Among the seven coastal barangays of Capul, Brgy. Oson has well-disciplined fisherfolks (Cabili and Cuevas, 2016). They do not harvests corals for commercial purposes unlike others and they employ different fishing practices and gears surrounding the sacred places, which show their belief in protecting their coastal and marine resources, thus sustaining fishing as their major form of livelihood. The barangay also serves as an alternate route for boats docking from Allen, Northern Samar when winds and waves are strong in Poblacion. This makes the access to the island easier for the researcher.

Local knowledge Systems

The study integrated both the emic and etic approaches in an attempt to understand the local knowledge systems in its context and scientific terms, if possible. This makes their knowledge systems unique and an important aspect in understanding their practices and responses towards natural resource management and climate change adaptation.

Farming. In farming, site selection for planting crops differs from conventional practices wherein the traditional way of site selection considers the color of the soil, the primary cover and vegetation, and its slope (Cabili 2011; Cabili & Cuevas 2010). The old Abaknon farmers also consider the slope in planting crops. Coconuts are usually planted on steep hills and mountainous terrains. Root crops, vegetables, and other crops are planted under the coconut at varying slopes which indicates the island's vulnerability to environmental threats because of the expansion of upland cultivation (Cabili & Cuevas 2010).

The most dominant soil on the island is the mountain soil which covers 2,363 ha or 68% of the total land area, followed by faraon clay (19.4% or 680 ha), and beach sand (13.05% or 457 ha) (Cabili & Cuevas 2010). Mountain soils usually have high organic matter content because of the leaf litters accumulated and decomposed on the soil. The soil is also usually cool and wet due to coconut canopy cover and accumulation of moisture which are pre-requisites for decomposition to occur (Cabili 2021). Faraon clay are black soils that are productive which are good for crops requiring calcium (Carating et al. 2014).

Based on the Abaknon's traditional way of soil classification, a black or dark brown color (*hirom* or loam), usually planted with coconut, have a soft texture which indicates high fertility and is good for any type of crop (Cabili 2011). The black color of the soil can be associated with the organic matter content. Red (*kapiyatan*) soil is believed to be unproductive and that only few crops can thrive in it. Red colored soil is classified as lateritic soil, which is characterized as unproductive, with very low organic matter content and potassium, which is the most needed nutrient for coconut growth and fruit bearing (Cabili 2011; Cabili 2021). Cassava and sweet potato thrive when planted in red, infertile soil because these crops can tolerate low levels of water and nutrient (Salomon et al. 2014). On the other hand, lighter color and sandy or hard soil has low fertility. A metamorphosed limestone or soil from sedimentary rock *(anapog)* is only good for coconut. *Burobaybay*, a combination of sand and silt, is best for sweet potato and root crops and these are usually found near the coast (Cabili 2011).

Banzon and Velasco in 1982 (cited by Cabili 2011), through the Bureau of Soil and Water Management (BSWM), verified that *hirom* (black) and brown (silt) soils were slightly acidic while *burobaybay* (sand) has neutral pH and have low organic matter. Brown, *kapiyatan* (red), *anapog*, and *burobaybay* have low available phosphorus, while *hirom* have medium available phosphorus. *Hirom* and *hirom*-brown have sufficient potassium levels.

Traditional beliefs are being considered in deciding when to plant. Full moon and low tide are believed to be the best time to plant root crops since the size of the moon and the roots found on the shore during low tide are equated to the size of the prospective harvest. Farmers in different areas of the country also have similar beliefs and associated practices. Farmers in Leyte and Bicol planted root crops during full moon, which is believed to bring full harvest while low tides indicate an abundant harvest because the richness of the underwater is visible (Salomon et al. 2014; Guiriba 2019). Additionally, planting must be done in the morning with the first day of planting not done on a Tuesday, Friday, or when the moon is about to fade because they believe that these might bring bad luck and low yield (Cabili 2011; Cabili & Cuevas 2010). In

Batanes, corn is believed to grow full grains if planted during full moon or three days after half-moon, except Tuesdays and Fridays. They believe that if planted during these days, the grains will be eaten by a four-legged animal (de Guzman et al. 2014).

Fishing. Similar to the traditional practices of farmers, the fisherfolks also considered the phases of the moon, flow of current, and tidal activity as indicators of fish catch. According to the locals, a good time for fishing is during the dry season from March to August. May is considered as the best month because fishes undergo spawning (*pagbiyod*) during this time. The monsoons also play a role in the timing of the fishing activities of Abaknon. The southwest monsoon (*habagat*) is experienced in the island from July-October. October to February is characterized by strong winds and rough seas brought about by the northeast monsoon winds (*amihan*), the period where typhoons usually occur. However, it is important to note that the timing is not consistent as it varies every year as an effect of climate change. The sea current is calm during the *amihan* season which is good for fishing. The fisherfolks also consider low tide (*humugot*) and when the direction of the flow of current (*landos*) is towards the north, going towards the light house or the San Bernardino Strait, as two other conditions for good fishing (Cabili & Cuevas 2016).

In reference to moon phases, the perfect time for fishing is usually a few days before the last quarter (waning gibbous; *katalloluyo si kawara*) and few days before the full moon (waxing gibbous; *kaodto si kadayaw*) (Cabili & Cuevas 2016). These phases indicate that more than half of the moon is illuminated, hence, tides are relatively high and that the fishes are being pushed with the movement of water, so it is possible to catch more fish during these phases of the moon (LDISD n.d.).

The fisherfolks of Brgy. Oson employ different fishing methods depending on the gears used and the target fish to catch such as hook and line (*pamangaraw*), net fishing, and trap fishing, among others. *Pamangaraw* is the most common fishing method used. It can be done manually or by using motorized or non-motorized boats. All the methods in *pamangaraw* use nylon strings and hook, they only differ on the type and kind of baits. *Lago'lo* fishing is a type of *pamangaraw* where artificial baits are attached to the line and targets big fishes. It uses two types of artificial bait called *rapala* and *pakabad* (Figure 2). *Rapala* is usually made from colorful plastic or fiberglass which is shaped and looked like a real fish. It costs around PhP 650.00–PHP 700.00 (13.08–14.08 USD). *Pakabad,* on the other hand, is hand-made by the fishers themselves from aluminum sheets which are also shaped and polished to look like small fishes. Being hand-made, it is cheaper than *rapala*. The more these baits looked like a real fish, the more likely that the fishes will be lured to it, attracting more catch.

Other baits used in *pamangaraw* are *rambo* and *tora-tora* (Figure 2). *Rambo* uses a shrimp-like *(orang-orang)* bait made from wood and *tora-tora* (octopus-like), the material and design of the which vary from one fisher to another. Some are made from seashells, wood with hooks, and others are designed with metal

Figure 2. Fishing baits (a. *rapala*, b. *pakabad*, c. *orang-orang*, d. *tora-tora*) used in *pamangaraw* and fishing gears (e. *pukot*, f. *agahid*) used in net fishing by Abaknon fisherfolks of Brgy. Oson, Capul Island, Northern Samar.

and strings. These are baits for big fishes, squids, and octopus, since they tend to look like real shrimps and squids/octopus which serves as their food. Net fishing is also practiced where *pukot* and *agahid* are the most commonly used method (Figure 2). The size of the mesh determines the size and type of fish to catch. *Pukot* has larger holes while *agahid* have very fine mesh nets which are attached to a circular-shaped wood with a handle.

Practice of rituals. The Abaknon still practice rituals and traditions in their farming and fishing activities that show the interrelationships of humans with their environment. The main goal of the rituals is to appease the supernatural beings and spirits that are believed to be also residing in specific areas on the island. The spirits are the stakeholders of the environment and are commonly called tagtalon. Aside from the Timon-timon rock formation, old trees are also considered dwelling places for the spirits. The cutting of trees, is thus, also prohibited. There are no farming and fishing activities done in these 'sacred' places. Should an activity be unavoidable, rituals are conducted, and prayers are offered to ask permission and appease the spirits. These activities showed how the islanders respect their natural resources, which leads to their conservation, specifically those of fisheries (Cabili & Cuevas 2016).

The local knowledge and practices on farming and fishing were handed down from the Abaknon ancestors. These practices have been passed on from one generation to the next because they believed that these are helpful and are proven to be effective. These have been a product of the several generations' trials, errors, and successes as they adapt to the changing climate and other edaphic factors. The transfer of knowledge is still evident because these are still being practiced at present. Thus, making their farming and fishing activities sustainable.

Figure 3 shows the radar chart of the local knowledge systems of the Abaknon in relation to their farming and fishing practices. Indicators related to the local knowledge systems were distributed among the three sustainability pillars. These were chosen based on whether it is involved in the use/practice of traditional and local knowledge. All the indicators under this criterion achieved an index value of 1.0 which means that the current farming and fishing practices are sustainable which were attributed to the use of acceptable fishing gears and methods, cultural management practices of crops, and their traditional beliefs and practices. These knowledge were being practiced and proven to be effective since they pose no threats to the people and the environment. Also, these have been passed on from generation to generation and are still being recognized even by the youth.

Climate Change Adaptation Practices of the Abaknon

Because of the perceived changes in the climate, the Abaknon employ different practices to cope and adapt to it. The increase in temperature during the summer months resulted in reduced time spent on the farms and at the sea. The number of hours spent on fishing differs from day to day with 6.5 hours as the average. Fishing usually starts at 9:00 in the morning up to 3:00 or 4:00 in the afternoon. At the time of the study, fishermen limit the number of hours they stay at sea because they can no longer stand the scorching heat of the sun. The number of hours spent for farming and fishing depends on the weather and sea conditions.

Farmers have changed their crops over time. Corn (*Zea mays* L.) used to be planted in Brgy. Oson but because of low yield, mainly because of lack of water for irrigation and soil fertility decline, it is not planted anymore. Some farmers noted that they delay harvesting some of the root crops just-in-time for the lean months. Additionally, farmers started planting banana and fruit trees (e.g., jackfruit (*Artocarpus heterophyllus*), breadfruit (*A. altilis*), avocado (*Persea americana*), mango (*Mangifera indica*), among others) to compensate for the low availability of food during lean months and they harvest whatever is available on the farm to have enough food for the family. Vegetable production in some households with available spaces was also practiced, mainly for subsistence. Livestock were raised to be sold when they mature or during emergencies.

There are a variety of income sources employed by Abaknon aside from farming, fishing, and being employed in local government offices. At least 61% mentioned to have at least three income sources. During the lean season, 50% of families augment their income from off-farm and non-farm activities such as charcoal-making, production and selling of fish paste (*bagoong*), motorcycle driving and service (*habal-habal*) to transport people and goods, direct selling of beauty products, and having small neighborhood retail shops, commonly known as *sari-sari* stores, construction, and carpentry. The diversity of income sources translates to sustainability. The resourcefulness of the residents has helped them cope and adapt to the challenges brought about by the seasonality of farming and fishing activities.

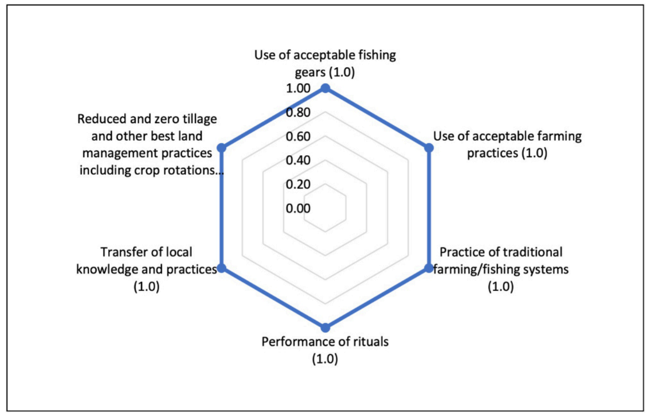

Figure 3. Radar chart of the local knowledge systems of the Abaknon of Brgy. Oson, Capul Island, Northern Samar.

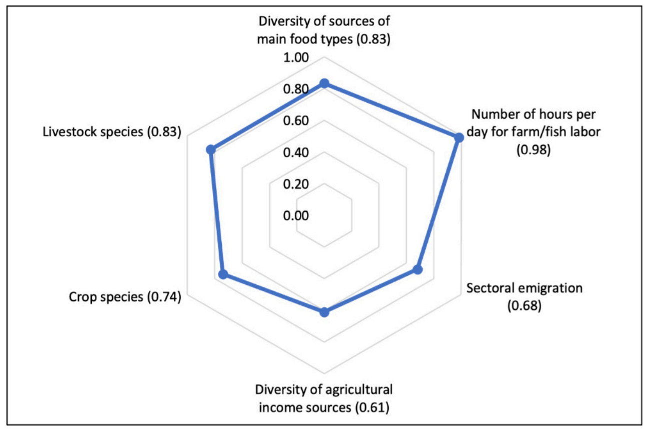

Figure 4. Radar chart of the climate change adaptation practices of the Abaknon of Brgy. Oson, Capul Island, Northern Samar.

Emigration is common for the island inhabitants, especially those who have finished higher education, because they tend to look for better employment opportunities. Thirty-two percent (32%) of the households surveyed have a family member working outside the island. This is reflected in the low number of members within a household that is engaged in farming and fishing activities.

Figure 4 shows the radar chart of the climate change adaptation practices of the Abaknon in Brgy. Oson. While these are coping and adaptation practices, these are also considered as indicators of sustainability which are embedded in the three different pillars. Some of the indicators included are the diversity of sources of main food types, integration of livestock species, diversity of agricultural income sources, sectoral emigration, and the reduction of time spent for farming and fishing the resourcefulness of the residents has helped them cope and adapt to the challenges brought about by the seasonality of farming and fishing activities. The sustainability of these indicators ranges from good to excellent.

Social Indicators

The social pillar looked into the demographic indicators and the social structures, facilities, and amenities of Brgy. Oson. Sustainability in this pillar was attributed to the administrative services (e.g., health, education, and government facilities) (1.0), employment rate (1.0), gender equality (1.0), and participation to local rules (1.0). Educational attainment (0.66) scored only a good sustainability status since there is no university in the island and the highest education available is up to senior high school only. Lastly, the age of farmers and fisherfolks (0.12) and coastal population (0.15) were identified as critical factors since older farmers contribute to the labor work force and those living near or along the coast are prone to impacts of coastal hazards (Figure 5).

Almost 40% of the population are considered adults. The younger age group comprised about 60% of the total population and the mean age is 50 years as compared to the national average of 57 years. The age of farmers and fisherfolks is negatively correlated to sustainability because the younger generation are receptive of new technologies and innovative solutions provided to them. However, the younger working groups are mostly involved in non-farm activities and are either working in or outside of Capul Island.

Educational attainment can be correlated to sustainability because it enables people to acquire knowledge, skills, attitudes, and values toward sustainable development. Though in literature, knowledge of climate change among indigenous peoples is derived from experiential learning and not from formal schooling (de Guzman et al. 2019). With the learning resources available and accessible to the Abaknon, they can perceive changes in the climate and its impacts, and later contribute to the crafting of solutions and measures to address and mitigate these.

Farming years ranged from 10-57 yrs, with a mean of 21 yrs, while the range for fishing is 10-48 yrs, with a mean of 18 yrs. It is part of the selection process of this study to choose those with at least 10 yrs of farming and fishing experience because they are more knowledgeable than the others and will likely contribute to the robustness of the data. This implies that longer farming and fishing years are sustainable because of the traditional practices being employed that have been proven to be effective for several generations already.

Brgy. Oson has the basic facilities to satisfy the needs of the community. There is one elementary school that caters to Grades 1-6 and a daycare center for younger children. The high school is in Poblacion, which is 5 km away from the barangay. There is also a chapel and a health center. The newly constructed multi-purpose hall serves as the barangay hall where members of the *Sangguniang Barangay* (SB) meet once a month to discuss concerns and issues in the barangay. The barangay plaza serves as a venue for the children to play and conduct events. The Abak Beach Resort is a privately-owned resort located in Sitio Catandukulan. These amenities and facilities are maintained to continuously provide and serve the needs of the community. Around 85% of the respondents mentioned that the facilities were maintained, and therefore gained a high SI value (0.85). A high percentage maintenance will likely contribute to the well-being of the society, and social acceptability function, in general.

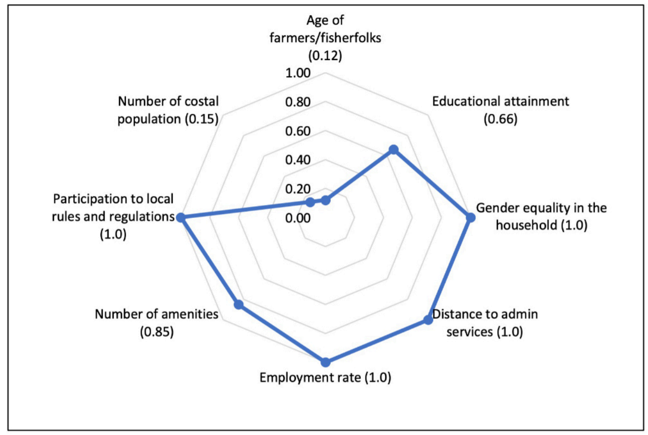

Figure 5. Radar chart of the social indicators for Brgy. Oson, Capul Island, Northern Samar.

Economic indicators

For the economic function to be sustainable, the economic systems must be viable. Economic viability is also noted to be a pre-condition to achieving sustainability in the social pillar, e.g., some social activities are dependent on the income level of the farming family. Sustainability in this pillar can be attributed to the livelihood and market activities within the barangay.

The residents have several sources of income, some of which are combined, and there is the presence of efficient market systems for the local produce. The three major sources of income identified in the study were farming (25%), fishing (16%), and farming and fishing (59%) with corresponding monthly household income ranges of PhP 5,000.00-12,000.00 (100.59-241.41 USD), PhP 7,000.00-20,000.00 (140.83-402.36 USD), and PhP 10,000.00-25,000.00 (201.18-502.95 USD). At the time of the study, 32% of the households are below the average income of PhP19,000.00 mo^{-1} (382.24 USD) in Region 8 and these households are those with limited income sources. Local traders and consolidators are present in the barangay which helps lessen the transportation cost of the farmers to deliver the copra to Matnog, Sorsogon. The computed benefit-cost ratio (BCR) values also indicate profitability in the three major sources of income and livelihood sources (i.e., BCR copra production=2.88, BCR fishing=5.35, and BCR of farming and fishing=5.14). This implies that both farming and fishing are economically and technically efficient. Technical efficiency is achieved when the product is being produced at a minimum cost which means that inappropriate use of inputs is minimized. These indicators contribute to the economic viability of the ecosystem.

The entry of young people into agriculture was considered as the critical factor (0.54) for sustainability among others in the economic pillar. The younger generations lack the motivation to venture into agriculture. Some parents want their children to find better opportunities, other than farming and fishing, outside the island. Land tenure arrangements are said to be optimal in Brgy. Oson since 75% own the land that they are working on. This means that they are more adaptive to changes in the market, institutional, and production structures which translates to higher sustainability (Figure 6).

Environmental Indicators
Soil and water were identified to be the most important resources because the Abaknon's livelihood activities mainly depend on these. Soil physical and chemical qualities were assessed through of soil analysis, organic matter content, and soil management practices. Water resources were assessed in terms of live coral cover and the diversity of fish species. Other environmental aspects such as air quality, noise, pollution, and waste management were not a concern of the barangay at the time of the study, according to the locals, but can be included in future studies as well.

Even though the farmers do not conduct soil testing, they have their own soil classification system. The results of the analysis of soil samples collected from three sites in the barangay, processed and analyzed in the soils laboratory of the Agricultural Systems Institute, College of Agriculture and Food Science, UPLB, validated the classification system used by the locals, and thus were considered to be sustainable. Despite the non-use of fertilizers, the high organic matter (OM) content of the soil can be attributed to the leaf litter and natural soil cover especially present in the mountain soils. The high amount of soil litter and cover translates to high OM content of the soil as seen from the results of the soil analysis, thus the score 1.0. Plant and crop residue cover protect soils from erosion, reduces run-off of nutrients, and provides habitat for diverse macro- and micro-organisms. The greater the cumulative soil cover, the greater the protection from soil erosion, compaction, and run-off, and the greater the contribution to biodiversity. Hence, the greater soil cover is an indicator of sustainability.

Soil OM content is a measure of soil fertility. Higher OM concentration means higher soil fertility. Results of the soil analysis revealed that the samples collected have high OM of 6. Despite the non-use of fertilizers, the organic matter content of the soil can be attributed to the leaf litter and natural soil cover especially present in the mountain soils, thus the SI value of 1.0.

The low score of the live coral cover (0.34) and diversity of fish species (0.43) can be attributed to the past resource-destructive practices of the Abaknon such as dynamite fishing, compressor fishing, shellfish gathering, and the use of poison. Diversity of fish species is related to fish catch and availability of fish resources. Only 43% of the respondents observed an increase in fish catch while the rest observed a declining fish catch and loss of fish species. This indicator can pose a threat for the fishery resource in the island. If this continues, sustainability will be at risk. In a study conducted by de Guzman et al. (2019) in Brgy. Oson, the fisherfolks mentioned that several fish species were no longer found in the island due to overfishing. The radar chart of the environmental indicators is presented in Figure 7.

Sustainability Assessment
The sustainability of the local knowledge systems and climate change adaptation practices of the Abaknon was assessed through the development of composite indices for the three pillars of sustainability as shown in Table 3. Overall, the index value is computed at 0.78 which is at a good sustainability level. This means that the current environmental conditions are under control, but continuous improvement must be made to achieve an excellent status. All three pillars, the economic (0.79), socio-cultural (0.80), and environmental (0.79) pillars have a good sustainability status but need continuous improvement to achieve an excellent status as well.

Other than the indicators related to the local knowledge systems and climate change adaptation practices, relevant indicators related to the social well-being, economic viability, and environmental

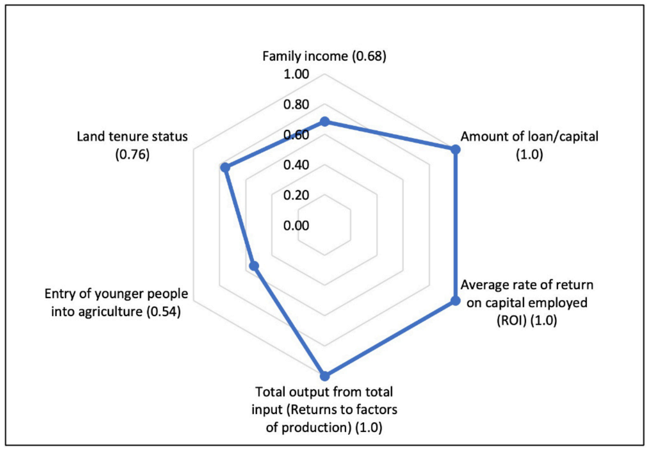

Figure 6. Radar chart of the economic indicators for Brgy. Oson, Capul Island, Northern Samar.

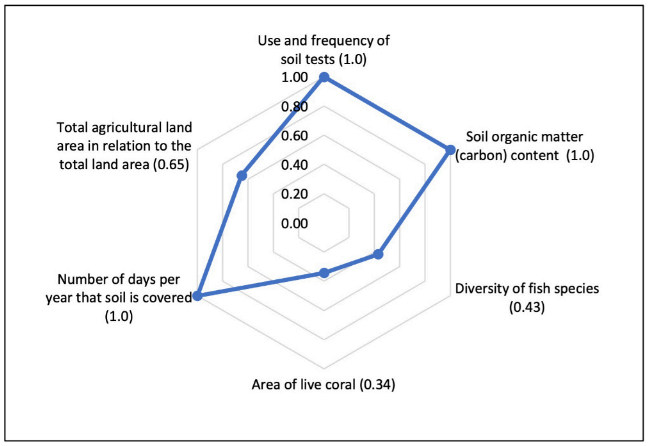

Figure 7. Radar chart of the environmental indicators for Brgy. Oson, Capul Island, Northern Samar.

Table 3. Sustainability index values of the pillars and the overall sustainability index.

Pillar	Sustainability Index (SI)*	Weight	Weighted Average Index
Socio-cultural	0.79	0.33	0.26
Economic	0.8	0.33	0.26
Environmental	0.79	0.33	0.26
Overall SI*			0.78

*0 < SI < 0.2 – Low; 0.21 < SI < 0.4 – fair; 0.41 < SI < 0.6 – average; 0.61 < SI < 0.8 – good; 0.81 < SI < 1.0 excellent conditions were used in the assessment. As in the triple bottom line, these pillars were highly considered for sustainability of the system. The social function of the system is to ensure security and safety of food and maintain the quality of life and acceptability in terms of equality, education, health care, among others. According to Van Cauwenbergh et al. (2007), one of the ecosystem's functions is to provide success and fortune to the farming and fishing communities. Economic viability is also noted to be a pre-condition to achieving sustainability in the social pillar, e.g., some social activities are dependent on the income level of the farming family. The environmental function refers to the management of the natural resources, e.g., soil and water. Soil and water resources were identified to be the most important environmental aspects in the lives of the Abaknon because their livelihood activities mainly depend on these. Soil physical and chemical qualities were assessed in terms of soil analysis and other soil management practices. Water resources were assessed in terms of live coral and the presence of marine protected areas.

The resulting SI was subjected to uncertainty and sensitivity analyses to test the robustness of the index. The overall SI of the three alternatives is close to the value of the base case or the original model (Base case = 0.78; Alt 1 = 0.75; Alt 2 = 0.72; Alt 3 = 0.70). These were further evaluated in the sensitivity analysis using Monte Carlo simulation method. The resulting CI of the Original and Monte Carlo models were compared using single factor ANOVA. Results revealed that the difference between the means of CI of the original model (UA) is not statistically significant with that of the CI of the Monte Carlo model (SA) at P-value (0.95). Therefore, the effect of aggregation, normalization, and the combined effects of normalization and aggregation does not affect the overall SI.

CONCLUSION

This study assessed the local knowledge, beliefs, and climate change adaptation practices of the Abaknon towards the sustainable use and management of the natural resources. The results of the assessment showed that the Abaknon's local knowledge systems, together with other important social, economic, and environmental indicators, are acceptable and sustainable at the time of the study. It also showed how local knowledge systems and traditions, belief in supernatural beings, and their past experiences have shaped their farming and fishing practices. While these local practices have helped them manage their natural resources sustainably, this study also revealed the critical indicators that can pose possible threats to the ecosystem, if not properly managed. These include the ageing farmers/fisherfolks, high coastal population, low interest and entry of young people into agriculture, fair condition of live coral cover, and decreasing diversity of fish species.

The introduction of technological innovations such as pest and nutrient management strategies using locally available inputs and use of artificial baits to improve farming and fishing activities is imperative to be practiced and adapted by the Abaknon. The harmonization of both the cultural practices and technological innovations can help them to conserve and properly manage their natural resources in the long run.

The critical factors that were identified to pose threats to the ecosystem should be addressed to improve condition and the sustainability of the system, in general. Addressing these concerns will then reduce the potential risks to the people and the environment. The level of sustainability status of each indicator require level of prioritization of actions as well. In this case, indicators with low sustainability status require high priority of action; fair sustainability status with medium priority; and average sustainability status with low priority.

Indicators with low sustainability but require high priority for actions are the age of farmers and fisherfolks and the coastal population. The ageing farmers and fisherfolks can be related to the declining interest of youth in agriculture and fisheries. To address this, the Sangguniang Kabataan (SK) and other youth groups must be guided in their programs towards encouraging youth participation in agriculture, solid waste management, coastal clean-up activities, and other environmentally sound practices. To encourage participation among the youth, strategies may include maximization of the different programs such as the Department of Education's (DepEd) *Gulayan sa Paaralan* Program (GPP) and the Department of Interior and Local Government (DILG)'s *Halina't Magtanim ng Prutas at Gulay (HAPAG) sa Barangay* through the promotion of home and community gardens.

Coastal population should be limited to avoid coastal-related hazards. They must be the priority of the barangay and LGU during rescue operations in times of typhoon and related calamities. On the other hand, they must also be aware of the possible impacts of these hazards to prevent the risks associated with it. Early warning systems and an integrated coastal management plan should be in place to employ proper and immediate actions.

The indicator with fair sustainability and requires medium priority is the area of live coral cover. To increase live coral cover in Brgy. Oson, the establishment of a Marine Protected Area (MPA) and/or fish sanctuary is encouraged. The increase in live coral cover is related to the increase in diversity of fish species since coral reefs serves as spawning ground for the fishes. Although it was noted during the interviews that the fisherfolks are not in favor of the MPA establishment thinking that their fishing grounds will be limited, a public consultation or dialogue must be conducted to inform the fisherfolks of its importance. Strict implementation on the prohibition of illegal fishing methods must also be employed.

RECOMMENDATIONS

Although the uncertainty and sensitivity analyses were already conducted to test the robustness of the agri-environmental sustainability index on the effects of normalization, aggregation, and the combined effects of normalization and aggregation methods, it is still recommended to use other weighting methods. Also, to avoid bias in selecting indicators and determining weights in the composite index development, Analytical Hierarchy Process (AHP) is recommended to give emphasis on which pillar is superior over the others in the context of the study.

This study is limited only to Brgy. Oson but the LGU can use the frameworks and models used to apply and assess the sustainability of the whole island, with the possible inclusion of additional indicators. Additionally, it should also be noted that the indicator values and the respective target values were gathered during the fieldwork in 2018 and 2020. Thus, there is a need to constantly update the values yearly to monitor the progress of sustainability.

This study was able to document the cultural practices, climate change adaptation practices, and human-environment interactions. To fully understand the complexities between the social, cultural, economic, and environmental cores, a quantitative analysis of the existing relations and future climate scenarios must be taken into consideration. The use of economic valuation tools, structural equation modeling, and values assessment for cultural heritage are recommended.

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