Establishing Adaptive Strategies towards a Climate-resilient Seaweed Farming: A Case in Panobolon Island, Guimaras, Philippines

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Seaweeds are ecologically important primary producers, competitors, and ecosystem engineers (Harley *et al.*, 2012), support complex food webs in coastal zones, and provide habitats and food for associated organisms, from apex predators to invertebrates (Reisewitz, Estes, & Simenstad, 2006). Seaweeds are intimately linked to human cultural and economic systems via the provision of ecosystem goods and services ranging from food, medicine, to cosmetics (Pickering, 2006) and storm protection (Rönnbäck, *et al.*, 2007). There is strong scientific consensus that coastal marine ecosystems, along with the goods and services they provide, are threatened by anthropogenic global climate change (IPCC, 2001). However, the impacts of ongoing and future anthropogenic climate change in seaweed-dominated ecosystems remain poorly understood (Harley *et al.*, 2012). It is therefore, timely and relevant to provide better understanding of the experiences of seaweed farmers and their capacity to anticipate, cope with, resist, and recover from the impact of natural hazards (Blaikie, Cannon, Davis, & Wisner, 1994). The Philippine-based SEAFDEC/AQD is currently conducting a three-year (2015-2018) study on the economic benefits and losses of seaweed farming due to climate change indicators. With pilot site in Panobolon Island, Nueva Valencia, Guimaras, Philippines, the study highlights the adaptive strategies and the effects of climatic change on the productivity of small-scale seaweed growers in a community.

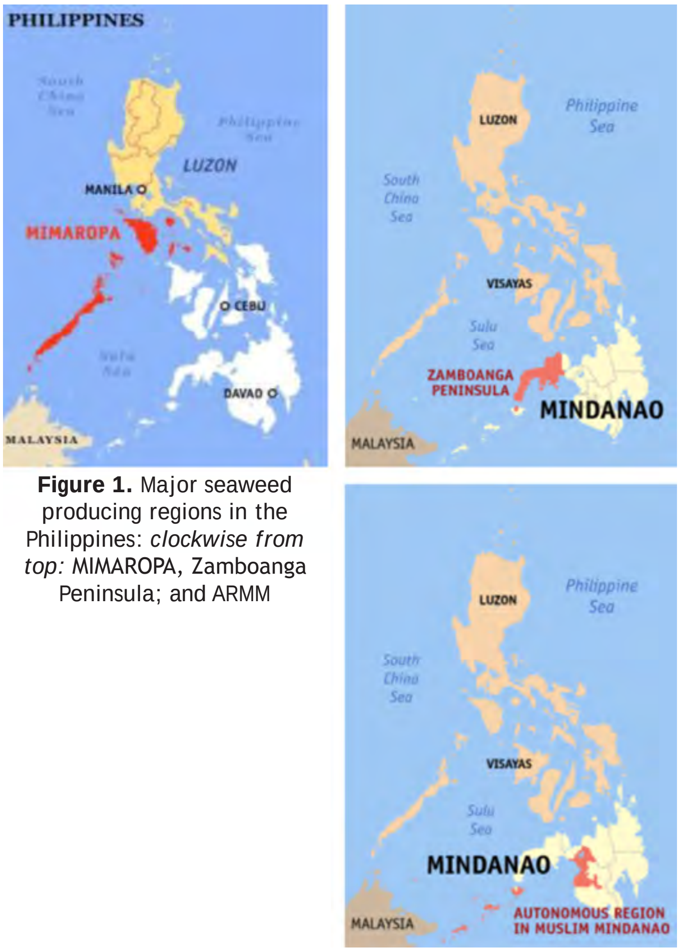

Figure 1. Major seaweed producing regions in the Philippines: *clockwise from top:* MIMAROPA, Zamboanga Peninsula; and ARMM

Seaweed is one of the major exported commodities of the Philippines, and the country is one of the top farmed seaweed producers in the world (FAO, 2018) as shown in **Table 1**. Seaweed farming is being widely adopted and practiced in many coastal communities in the Philippines. As of 2014, the major producing areas (**Figure 1**) were in Region IVB (Southern Tagalog Region also known as MIMAROPA, comprising the Provinces of Mindoro, Marinduque, Romblon, Palawan); Region IX (Zamboanga Peninsula, comprising the Provinces of Zamboanga del Norte, Zamboanga Sibugay, and Zamboanga del Sur); and in the Autonomous Region in Muslim Mindanao or ARMM consisting of five predominantly Muslim provinces: Basilan, Lanao del Sur, Maguindanao, Sulu, and Tawi-Tawi (Philippine Statistics Authority, 2018).

BFAR (2014) also indicated that in 2014 (**Table 2**), the Philippine production of seaweeds was mainly contributed by ARMM (622,995.6 MT) contributing about 40 % to the total seaweeds production of the country; followed by MIMAROPA (361,352.59 MT) accounting for about 23 %, and Region IX (206,161.12 MT) about 13 %. In 2004, the data from the Seaweed Industry Association of the Philippines indicated that all over the country, more than 116,000 families consisting of more than one million individuals were utilizing more than 58,000 ha of the seas for seaweeds farming.

Seaweed Farming in Panobolon Island

Panobolon Island is an island barangay (village) located in the municipality of Nueva Valencia, Guimaras, in Western Visayas, Philippines (**Figure 2**). It has a total land area of 310.50 ha and comprises four sub-villages, namely: Aminhan, Bagatnan, Punta Sur, and Punta Norte. The main source of livelihood of the people is fishing. Small-scale seaweed farming (**Figure 3**) has become the secondary source of livelihood that led to the creation of an organization known as the Panobolon Unified Fisherfolk Association (PUFA).

In Region VI: Western Visayas Region, the Provinces of Antique and Guimaras are the main producers of seaweeds. Guimaras had its highest production in 2009 at 1,641 MT. From 189 MT production in 2000, it gradually decreased to 22 MT in 2004 and started to increase from 2005 (187

Table 1. Major farmed seaweed producers in the world, by country in 2005-2016 (in thousand MT, live weight)

Country	2005	2010	2011	2012	2013	2014	2015	2016
China	9,446	10,995	11,477	12,752	13,479	13,241	13,835	14,387
Indonesia	911	3,951	5,170	6,515	9,299	10,077	11,269	11,631
Philippines	1,339	1,801	1,841	1,751	1,558	1,550	1,566	1,405
Republic of Korea	621	902	992	1,022	1,131	1,087	1,197	1,351
Democratic People's Republic of Korea	444	444	444	444	444	489	489	489
Japan	508	433	350	441	418	374	400	391
Malaysia	40	208	240	332	269	245	261	206
Tanzania	77	132	137	157	117	140	179	119
Madagascar	1	4	2	1	4	7	15	17
Chile	16	12	15	4	13	13	12	15
Solomon Islands	3	7	7	7	12	12	12	11
Viet Nam	15	18	14	19	14	14	12	10
Papua New Guinea	0	0	0	1	3	3	4	4
Kiribati	5	5	4	8	2	4	4	4
India	1	4	5	5	5	3	3	3
Others	25	14	15	16	13	12	16	8

Source: FAO, 2018

Table 2. Seaweeds production of the Philippines in 2014, by region (in metric tons: MT)

Region/Provinces included	Production (MT)	% of country's total seaweeds production
National Capital Region (NCR): Metro Manila	-	-
Cordillera Administrative Region (CAR): Abra, Apayao, Bengeut, Ifugao, Kalinga, and Mountain Province	-	-
Region I (Ilocos Region): Ilocos Norte, Ilocos Sur, La Union, Pangasinan	34.97	0.0
Region II (Cagayan Valley): Batanes, Cagayan, Isabela, Nueva Vizcaya, Quirino	527.18	0.0
Region III (Central Luzon): Aurora, Bataan, Bulacan, Nueva Ecija, Pampanga, Tarlac, Zambales	2,368.53	0.2
Region IVA (CALABARZON): Cavite, Laguna, Batangas, Rizal, Quezon	32,617.7	2.1
Region IVB (MIMAROPA): Mindoro, Marinduque, Romblon, Palawan	361,352.59	23.3
Region V (Bicol Region): Albay, Camarines Norte, Camarines Sur, Sorsogon, Catanduanes, Masbate	59,863.75	3.9
Region VI (Western Visayas): Aklan, Antique, Negros Occidental, Capiz, Guimaras, Iloilo	77,466.93	5.0
Region VII (Central Visayas): Bohol, Cebu, Negros Oriental, Siquijor	104,943.47	6.7
Region VIII (Eastern Visayas): Biliran, Eastern Samar, Leyte, Northern Samar, Samar, Southern Leyte	17,925.84	1.2
Region IX (Zamboanga Peninsula): Zamboanga del Norte, Zamboanga Sibugay, Zamboanga del Sur	206,161.12	13.3
Region X (Northern Mindanao): Misamis Oriental, Misamis Occidental, Bukidnon, Camiguin, Lanao del Norte	40,784.83	2.6
Region XI (Davao Region): Compostela Valley, Davao del Norte, Davao Oriental, Davao del Sur	6,005.49	0.4
Region XII (SOCCSKSARGEN): South Cotabato, Cotabato, Sultan Kudarat, Sarangani, General Santos City	144.05	0.0
Region XIII (Caraga Region): Agusan del Norte, Agusan del Sur, Surigao del Norte, Surigao del Sur, Dinagat Islands	16,383.89	1.1
Autonomous Region in Muslim Mindanao (ARMM): Basilan, Lanao del Sur, Maguindanao, Sulu, Tawi-Tawi	622,995.60	40.2
TOTAL	**1,549,575.98**	**100.0**

Source: BFAR, 2014

Figure 2. Seaweeds study site in Panobolon Island, Nueva Valencia, Guimaras, Philippines

Figure 3. Small-scale seaweed farmers in Panobolon Island, Nueva Valencia, Guimaras, Philippines

MT) until 2009 (1,641 MT). However, abrupt declines in production were observed in 2010 as well as in 2014-2015 (**Figure 4**). Despite the gradual recovery of production of seaweeds farming in Guimaras in 2016-2017, production of the small-scale growers in Panobolon Island declined from 2016 to 2018 because of extreme weather conditions, lack of good quality seedling cultivars that can resist diseases and withstand erratic weather conditions, as well as low market selling price of dried produce.

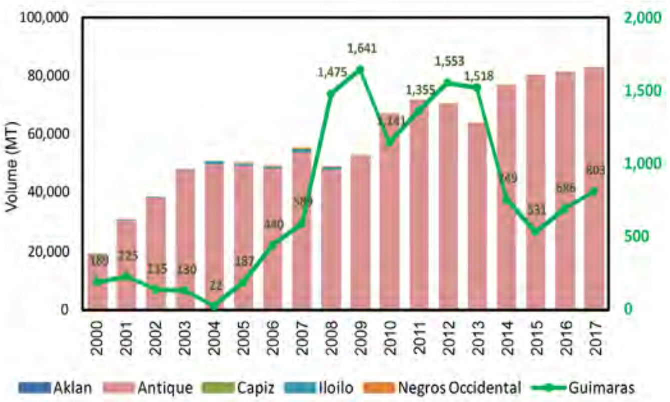

Figure 4. Seaweed production in the provinces of Region VI, Philippines from 2000 to 2017 (MT): Highlighting Guimaras, the numbers above the points of line graph indicate the volume of production

Source: Philippine Statistics Authority (2018)

The declining trends of production deterred the growing seaweed industry of the Province from investing more threatening the sustainability of this emerging major livelihood of the coastal communities, exacerbated by the variability of the climate and occurrence of natural calamities. It is known that the Philippines is frequently visited by typhoons every year. The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) Western Visayas Station reported that 71 tropical cyclones have crossed Region VI from 1950 to 2016. In 2017, a notable increase of 22 tropical cyclones passed by the Western Visayas Region, especially in Guimaras where intense rainfall occurred causing the Sibunag River – approximately 3.5 km away from the seaweed farming area in Panobolon Island – to overflow. Such phenomenon contributed to the sudden drop in the water salinity of the farming area to 20 ppt. Moreover, the summer season from March to May also remains a challenge to seaweed growers. Extreme sea surface temperatures (from 28 °C to 35 °C) and high salinities (35-36 ppt) could cause diseases and slow growth performance. In fact, the sudden fluctuations of temperatures and salinities stress the seaweeds resulting in the whitening or depigmentation of the thalli (branches) which eventually lead to breakage, and subsequently in mortalities as a consequence and hence, crop losses.

In addition, the incidence of "ice-ice" outbreak, *Neosiphonia* sp. epiphytic infestation, and attachment of the little wing pearl shells to the thalli have been the most prevalent problems observed (**Figure 5**) in the site. Apart from the environmental shifts, the occurrence of natural calamities such as tropical storms, intense monsoon rains, strong currents and winds, normally, from June to November, could also cause total damage to seaweed farms. Confronted by these seasonal outbreaks and calamities, growers practice immediate harvest of crops regardless of the current low market price of dried produce to refrain from incurring extensive production losses while securing healthy, non-infested seaweed cultivars to be used in the next cropping. Growers have acknowledged that over time, their seaweed farming practices have changed and at the same time, they have learned to adopt the climate-resilient practical approaches.

Figure 5. Infestations in seaweeds farms in Panobolon Island, Guimaras, Philippines, prevalent from March to May. *Left-right:* "ice-ice" disease, *Neosiphonia* sp. epiphytes, and little wing pearl shells

Way Forward

Extreme weather conditions, such as frequent and intense rainfall that cause fluctuation of sea surface temperature and salinity, pose threat to fisheries, fishery-dependent communities, and the aquaculture sector. A range of protocols are available for seaweed farming that have been successfully carried-out, yet there are still significant gaps in its biology, physiology and reproduction (Buschmann *et al*., 2017) that impede the better understanding on the effects of global climate change. The current study presented valuable indications that any aquaculture-related livelihood is likely vulnerable to climate change.

The findings of this study is expected to contribute to the creation of relevant policies and implementation strategies in seaweeds farming that adapt to climate change such as providing diverse livelihoods and other fishing-related activities, and conducting trainings for small-scale growers in Panobolon Island to develop their working skills in the other sectors (*e.g.* marketing, vocational endeavors) during the lean or off-season of seaweeds farming.

Aside from the Philippines, the other Southeast Asian countries such as Indonesia, Malaysia, and Viet Nam are also among the major farmed seaweed producers in the world (**Table 1**). Seaweed farmers in these other countries of Southeast Asia with similar climatic conditions could also benefit from the outputs of this study. In so doing, small-scale seaweed growers would not only be taking actions on responding to climatic change but also moving towards climate-resilient communities.

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