

## IMPACT OF COVID-19 ON THE COASTAL ENVIRONMENT AND ACTIVITIES AT KO YO, SONGKHLA, THAILAND

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**Abstract.** The Thailand national lockdown caused by the coronavirus pandemic lasted for several months. Ko Yo is one of the tourist attractions in Songkhla province due to its unique culture, environment, and businesses. The lockdown has changed the local lifestyle together with its socioeconomic and environmental impacts. This study aimed to integrally investigate the impacts of the COVID-19 related societal responses on the coastal environment and activities and the adaptive capacity of businesses on Ko Yo Island in Songkhla province. The results showed negative impacts of the COVID-19 on restaurants, homestays, and aquaculture businesses due to the Governmental emergency decrees. Aquaculture was the most affected business. Despite the reduced number of customers and transportation problems, some restaurants and homestays have provided delivery services and fishing areas as novel services available to their customers. The decrease in coastal activities had positively affected some environmental parameters, e.g., total nitrogen, total phosphorus, dissolved oxygen, and biochemical oxygen demand in water. In conclusion, businesses in Ko Yo were vulnerable to the disruption and the COVID-19 related situation. The local government organizations should seek to support the local communities, active businesses, and people in need to increase their adaptive capacities by providing financial support, organizing career development workshops, and coordinating and counseling local people. Short and long terms of emergency measures should be set at upper levels of government.

**Keywords:** *global pandemic, socioeconomic effects, environmental effects, local Thailand*

### Introduction

The COVID-19 pandemic has rapidly spread worldwide, beginning from China, and has impacted several human societies and economics (Corlett et al., 2020; Wang et al., 2020). Lockdowns have been implemented both internationally and within many countries (Lim et al., 2020). In Thailand, transportation was restricted, while in southern Thailand, the borders of Songkhla Province were controlled since late March 2020. That command prohibited all entry in or out of Songkhla, except for some necessary/essential cases. Later on, restaurants, department stores, markets, hotels, and local services were ordered to shut down (Songkhla Provincial Government Center, 2020).

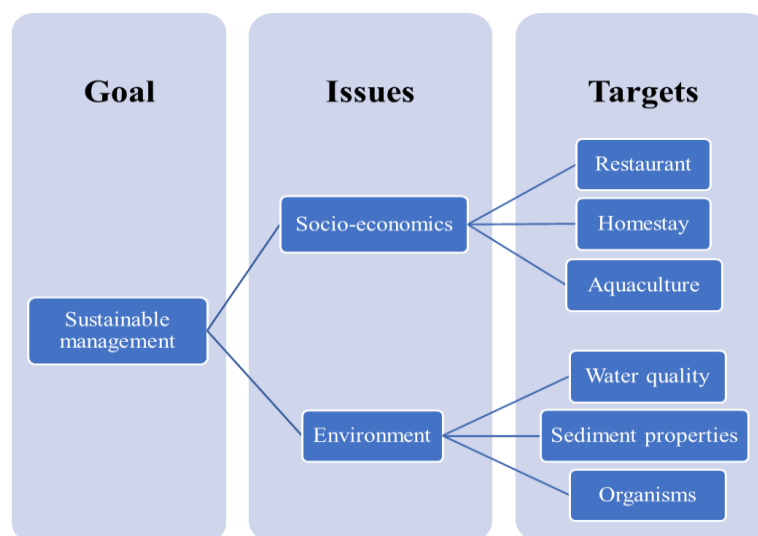
Ko Yo is an island in the lower Songkhla lagoon with a total area of 15 km<sup>2</sup>, divided into nine villages (Promprasit et al., 2013), and is an economical tourist attraction in the Songkhla province. Ko Yo has established an agricultural tourist club since 2000 (Thammachot, 2006) that has integrated occupations (more than 200 entrepreneurs)

from both large- and small-scale agricultural, fishery, and cottage industry businesses (Sutas Na-Ayuthaya, 2017). The coast of the peninsular is protected by hard constructions such as revetments, wave breakers where natural resources remain functional and essential for the local community. For example, the mangrove habitats and fisheries are highly important to Ko Yo's local community (Department of Marine and Coastal Resources, 2020).

Due to the Songkhla lockdown, most businesses have been closed for about two months, including those on Ko Yo. The local livelihoods were suddenly affected, with the loss of jobs and food security associated with this unique culture and environment. Hence, this study was conducted to examine the impacts of the COVID-19 pandemic on Ko Yo's coastal activities. The negative and/or positive consequences associated with the COVID-19 restrictions were assessed in relation to the vulnerability of the local communities to the disruption and the physical, chemical, and biological factors of the environment.

## Methodology

Both interview and environment surveys ended during 5-15 May 2020, Ko Yo, Songkla, Thailand. The conceptual framework (Fig. 1) involved both social and science aspects: 1) socioeconomic in the main types of local businesses around Ko Yo, i.e., restaurants, homestays, and aquaculture; and 2) environmental surveys at three main stations (Table A1 in the Appendix) with five sampling sites at varying distances from Ko Yo coast (Fig. 2).



**Figure 1.** Theoretical framework of this study for determining impacts of the COVID-19 situation on Ko Yo's coastal activities

### *Socio-economic observation*

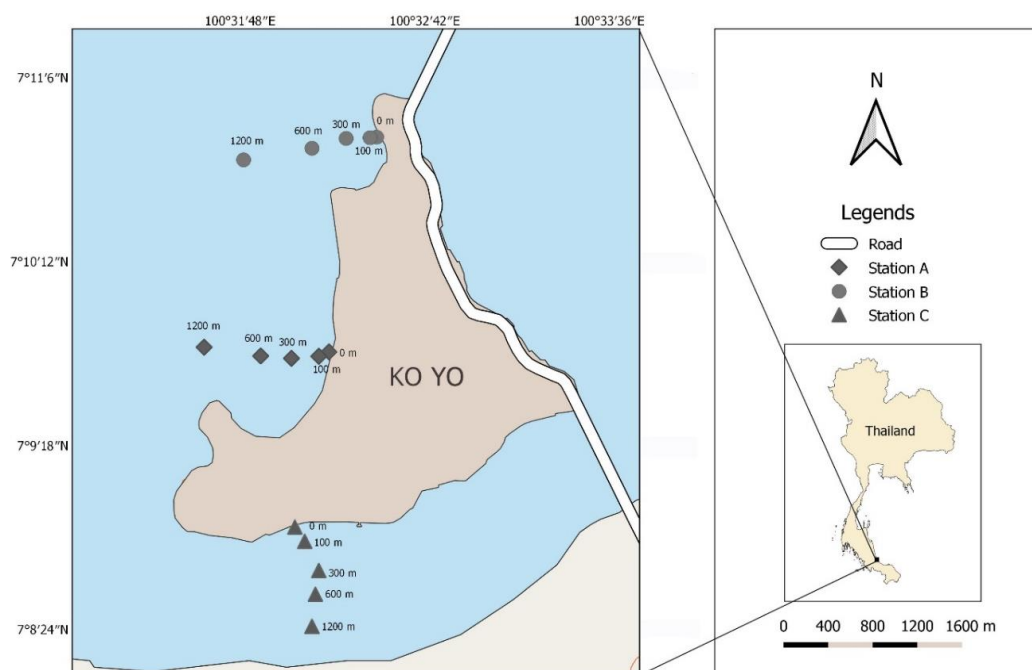
The representative sampling was calculated from a total of 133 local businesses; 66 restaurants, 40 homestays, and 27 aquaculture cages using Taro Yamane formula as follows:

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

in which “*n*” is the sample size, “*N*” is the population size, and “*e*” is the error of the allowable randomized sample. The samples ( $n = 33$ ) were randomly investigated from local entrepreneurs as key informants. Both structured and semi-structured interviews were done to deploy a questionnaire (Table A2) during May 2020, when the lockdown was still restrictive. The questionnaire was related to four main issues; 1) general information of respondents, 2) effects of the COVID-19 pandemic on income and employment, 3) entrepreneur’s adaptations to the COVID-19 crisis in terms of prevention of the spread of the epidemic, marketing/sale strategies, and new normal operations, 4) accessibility of aid measures from various agencies, (in)applicability of various government projects, and proposing aid measure requirements. Respondents provided all the economic data.

### Environmental survey

The water, sediment, and aquatic plants were sampled (Strickland and Parsons, 1972; Boyd, 1990; American Public Health Association, 1992) at three stations on 29-31 May 2019 and 5-7 May 2020 to compare the apparent impacts of the COVID-19 pandemic. For each coastal station, there were five sampling sites in the lake at different distances from each other (Fig. 2), and at each sampling site, three replicate samples were collected. The temperature and pH were *in-situ* measured using YSI Professional Plus Multiparameter (YSI Incorporated, USA). The Secchi Disk was used for transparency. Water samples were collected by Kemmerer Water Sampler (Wildlife Supply Company, USA) for further laboratory analyses of total nitrogen (TN), total phosphorus (TP), dissolved oxygen (DO), and biochemical oxygen demand (BOD). Sediment samples were collected using a Birge-Ekman grab (Wildlife Supply Company, USA). All collected sediment samples were kept at  $-20\text{ }^{\circ}\text{C}$  and afterward analyzed for organic matter and organic carbon. Organic carbon analysis was determined by analyzing elements C, H, and N (Carlo Erba, EA-1106 model) followed by Verardo et al. (1990).



**Figure 2.** The A, B, and C coastal stations on Ko Yo, Songkhla, Thailand with five sampling sites in the lake at different distances from each other

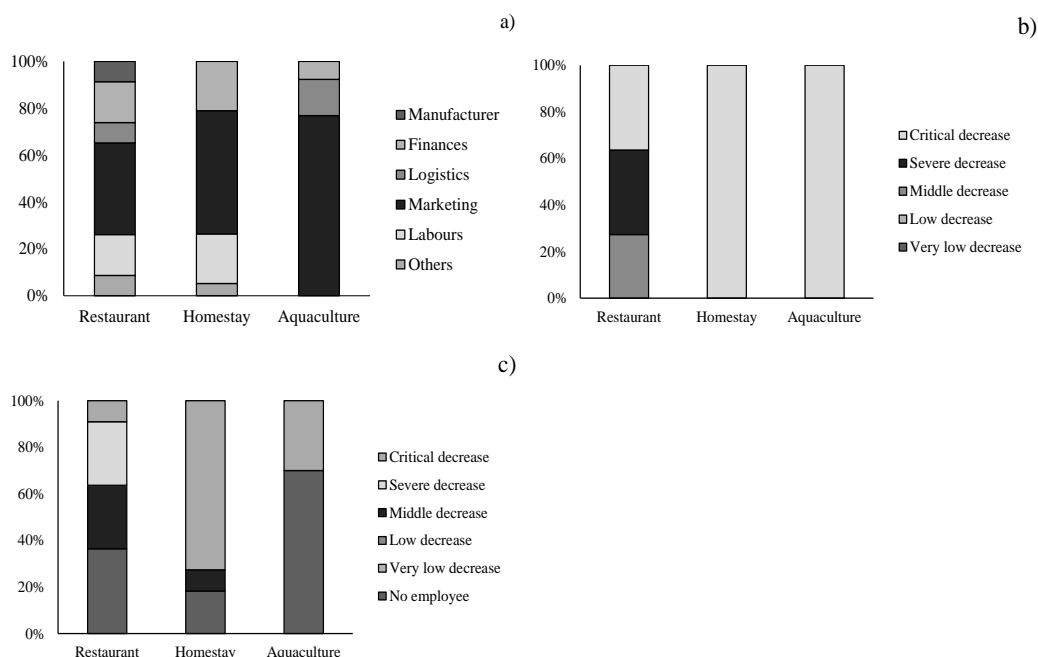
## Data analyses

The multiple-choice data from the questionnaire were analyzed for frequencies and percentages at nominal and ordinal scales to test the hypothesis in each variable. The environmental data were subjected to Levene's and Kolmogorov-Smirnov tests for homogeneity of variance and normality, respectively. The t-test was used at the confidence level of 95% to compare time changes in each environmental parameter.

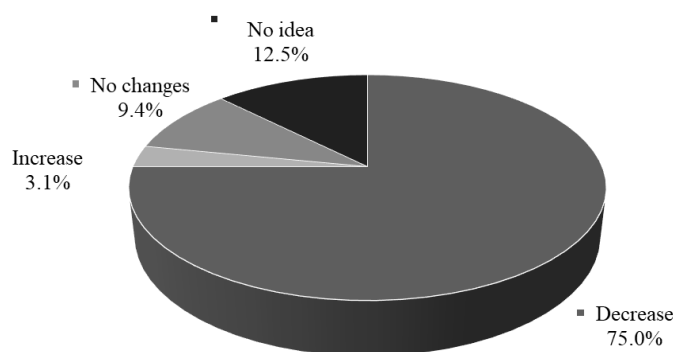
## Results

### Effects of the COVID-19 pandemic on local businesses

The COVID-19 pandemic mainly affected local businesses via marketing, such as order cancellations, customer loss, and absence of middleman, for 76.9%, 52.6%, and 39.1% of businesses operating aquaculture, homestays, and restaurants (*Fig. 3a*). The following obstacles were in finances and labor, whereas the lockdown impacted manufacturers, logistics, and other activity losses only caused minor trouble to the local businesses. In all cases, the questionnaire responses indicate a loss of income. A complete 100% of critical decreases were reported by homestays and aquaculture businesses, while restaurants showed more diverse and less extreme results: 36.4%, 36.4%, and 27.3% for critical, severe, and middle decreases, respectively (*Fig. 3b*). As a consequence of the COVID-19 pandemic effects, some owners needed to let some employees go this impacted the employment rate, mainly by homestays that represented 72.7% of the critical decrease cases. However, there were many local businesses without changes in employment, especially those without employees (*Fig. 3c*). Moreover, we investigated the interviewee's expectations of their income in the next six months. In total, 75% of all local business owners predicted a definite future decline (*Fig. 4*).



**Figure 3.** Frequency percentages among the local businesses ( $n = 33$ ) affected by the COVID-19 pandemic during May 2020; a) obstacles for business operation, b) income reduction, and c) employment



**Figure 4.** Percentages of future expectations regarding income in the next 6 months from May 2020 ( $n = 33$ )

### ***Adaptive strategies to the COVID-19 crisis***

With the outbreak prevention, 96.9% of all the local businesses have followed the standard procedures to protect themselves and customers from the COVID-19 virus. The primary methods were provided (Fig. 5a) as use of alcohol gel or spray (47.6%), surgery or fabric mask (39.7%), and other measures, such as controlling customer numbers and distancing by limited seating. Several owners have adapted to sustain their businesses (Fig. 5b). All business types generally pursued the reduced salary/workforce and productivity cost savings. Various strategies of additional services were also observed; the restaurants provided take-home or delivery (28.6%); the homestays provided customer attractions or promotions (21.4%); the aquacultures delivered their products to events (60%) instead of to walk-in customers and minor groups. Markedly, some restaurants (4.8%), homestays (50%), and aquacultures (30%) completely stopped operation. As seen in Figure 5c, a large proportion of entrepreneurs expect to operate later under a new normal situation, and some would improve their strategies, especially the homestays (27.3%). However, only a few aquaculture businesses would consider ceasing operations.

### ***Accessibility of aid measures***

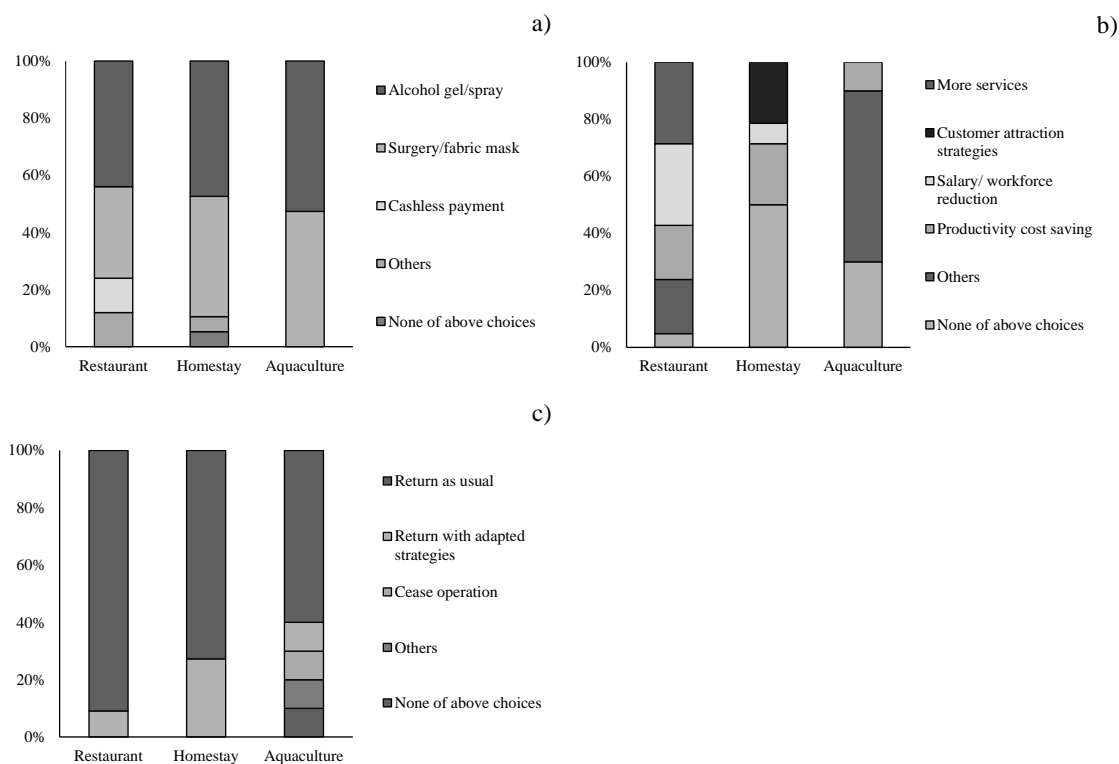
According to the “Kon Thai Mai Ting Kan” government aid measure, restaurants were the leading target group. Of them, 45% could register and get financial aid, but 18.2% could not successfully register. On the other hand, the local homestays and aquacultures were mainly not registered for aid (Fig. 6a). Additionally, there were other kinds of assistance, for instance, the retention or reduction of rental fee or deposit, materials for the COVID-19 prevention from various organizations. Nevertheless, more than half of the interviewees did not receive any assistance (Fig. 6b).

### ***Environmental parameters***

The physical, chemical, and biological parameters of the water observed at the study sites were significantly changed in one year (paired t-test,  $p < 0.05$ , Table 1). The temperature, total dissolved solids, dissolved oxygen, and chlorophyll-*a* increased, whereas salinity, total nitrogen, total phosphorus, and biological oxygen demand were lower than before the COVID 19 pandemic (Fig. 7). The water pH and transparency showed steady values. Similar to sediment quality, the organic matter and organic carbon appeared constant across the sampling times (Fig. 8).

**Table 1.** Statistical analysis by paired t-test comparing environmental parameters at two sampling times (2010 and 2020)

Parameter	Df	Mean	t	p-value
Temperature (°C)	14	-0.570	-2.563	0.023*
pH	14	-0.018	-0.405	0.692
Transparency (m)	14	0.050	0.660	0.520
Total nitrogen (mg-N/l)	14	2.291	14.984	< 0.001*
Total phosphorus (mg-P/l)	14	0.022	4.385	0.001*
Dissolved oxygen (mg/l)	14	-2.023	-5.698	< 0.001*
Biological oxygen demand (mg/l)	14	1.097	5.115	< 0.001*
Organic matter (%)	14	-0.754	-1.045	0.314
Organic carbon (%)	14	-0.196	-0.419	0.682

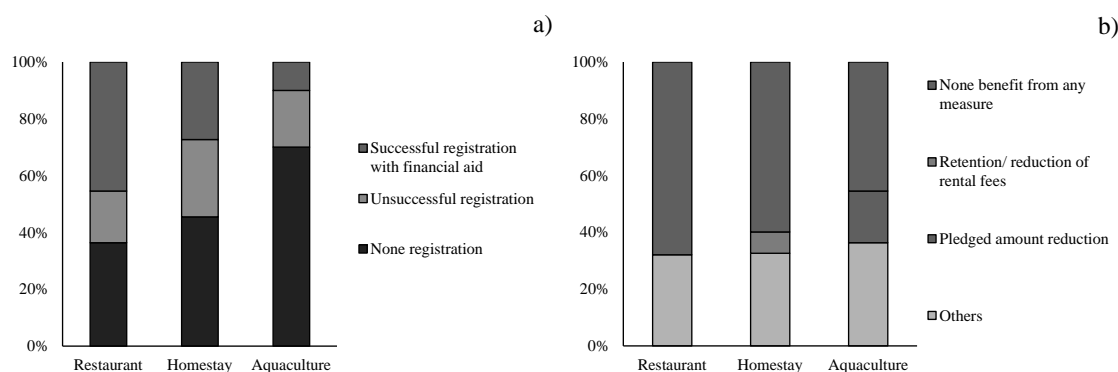


**Figure 5.** Frequencies (percentages) within each type of the local business ( $n = 33$ ) adapted to the COVID-19 pandemic during May 2020: a) outbreak prevention, b) adaptive process, and c) future expectation in new normal situation

## Discussion

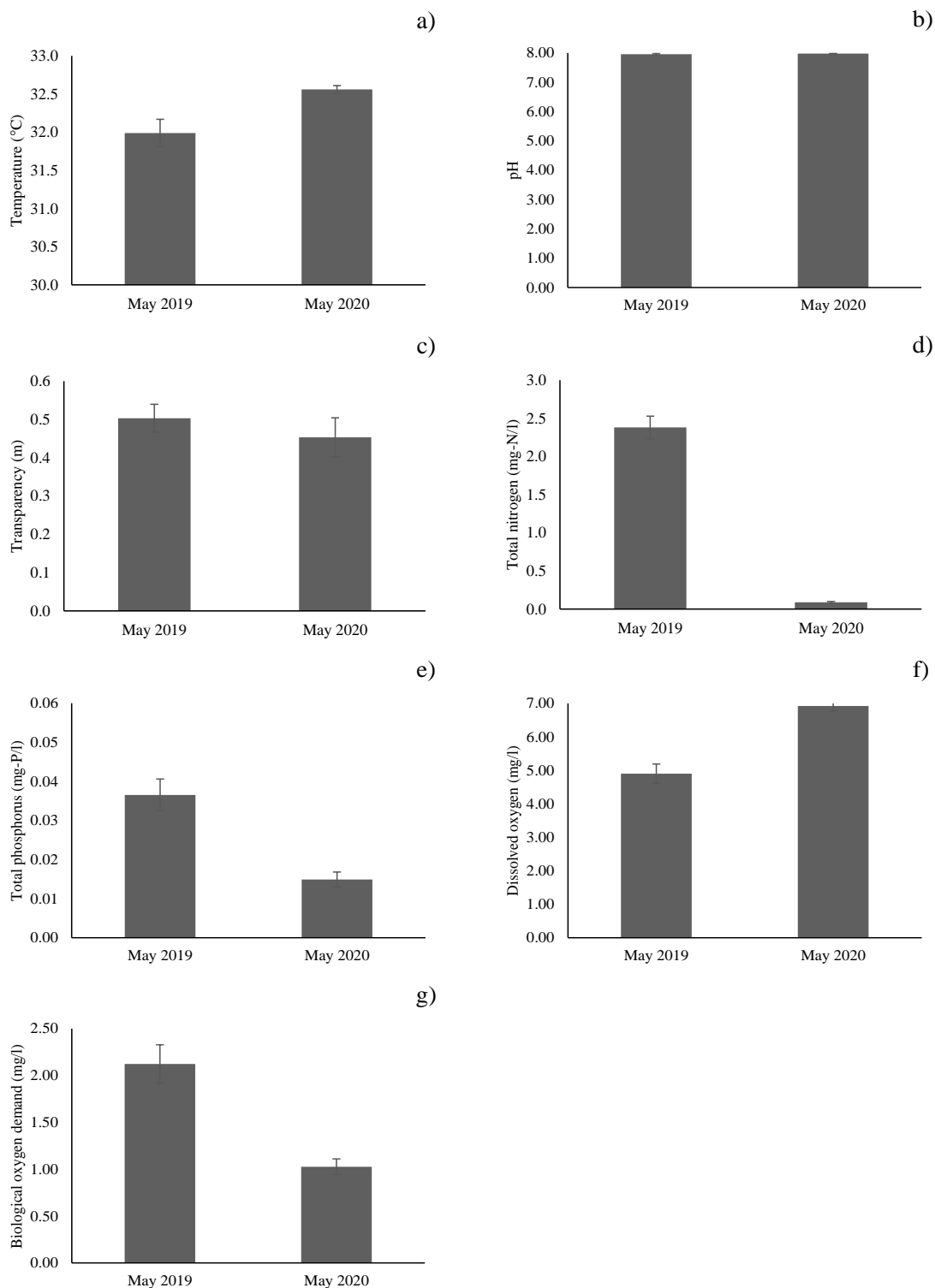
Undoubtedly, the local entrepreneurs on Ko Yo island were seriously affected by the COVID-19 pandemic (or the societal responses to it), primarily via marketing issues and loss of income. Since Ko Yo is relatively far from the main local population centers for delivery service, and the major customers used to be foreign tourists, the restaurants have previously operated for dine-in only. Losing foreign tourism had various domino effects. The aquaculture businesses were unable to continue operating mainly as suppliers

to the local restaurants. Moreover, the operations of physical markets and middlemen were disrupted as well. At the same time, homestays were temporarily closed due to the government's emergency measures. Another critical factor is that most local owners decided to temporarily lay employees off and cut their expenses rather than adapting to online platforms and digital marketing. Very few of the restaurants pursued their online marketing options. Overall, there was a severe impact on Ko Yo's local economy. Globally, the whole supply chain and production linkages have been disrupted by responses to the epidemic (Gregorioa and Ancog, 2020; Hasanat et al., 2020; McKibbin and Fernando, 2020; Ozili and Arun, 2020). Although it is difficult for the local people to master digital technology, they at least made an effort to create extra services, such as delivery. Long-term impacts are strongly expected, as our results on the business owners' expectations of income indicated potential recovery only after 1-2 years. There have also been several indirect effects of the COVID-19 lockdown, particularly in developing countries with high population densities: food shortages, psychological trauma, and reduced access to health care (Danylyshyn, 2020; Laborde et al., 2020; Loayza, 2020; McIntyre and Lee, 2020; Nochaiwong et al., 2020).



**Figure 6.** Frequencies (percentages) among each type of local business ( $n = 33$ ) concerning aid measures during the COVID-19 pandemic on May 2020: a) Kon Thai Mai Ting Kan project of the government aid measure, and b) other types of assistance

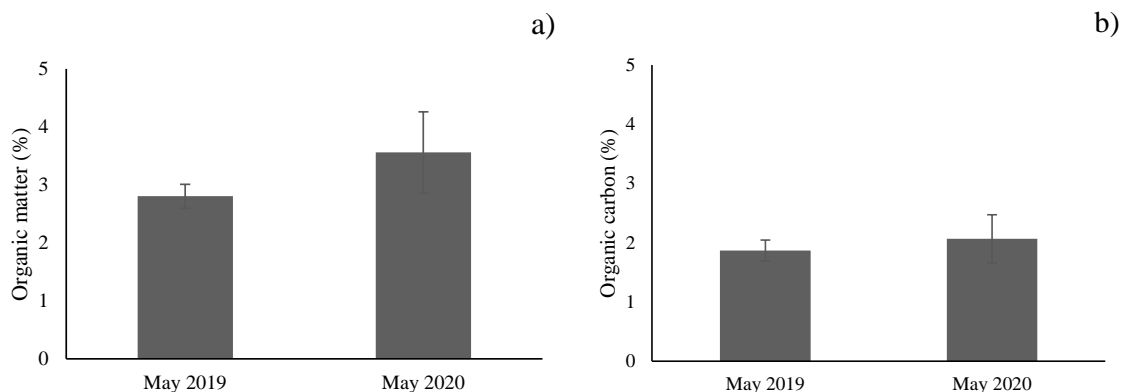
It was laudable that most people on Ko Yo demonstrated awareness and active prevention measures against the pandemic. The Thailand Public Health had rapid responses to COVID-19 tracing, daily reporting, quarantine restrictions, and public education (Doung-Ngern et al., 2020). Regarding the aid measures, less than half of Ko Yo entrepreneurs got any financial benefits. It should be noted that the government aid projects were implemented on digital platforms, and this could be a barrier to the locals or elderly people. Nevertheless, there were other forms of support, such as reduction or cancellation of electricity bill, water bill, waste disposal bill, along with a tax reduction. There was also a proposal from local entrepreneurs to request specific mitigations, markets, or channels for their export products and helping skills development or supporting alternative jobs.



**Figure 7.** Physical parameters of water (mean  $\pm$  SE); a) temperature, b) pH, and c) transparency, chemical and biological parameters; d) total nitrogen, e) total phosphorus, f) dissolved oxygen, and g) biological oxygen demand



Regarding environmental impacts, there were no significant differences ( $p > 0.05$ ) in transparency or pH of the water body around Ko Yo. In contrast, temperature, TN, TP, and BOD before the COVID-19 crisis (May 2019) were significantly higher ( $p > 0.05$ ) than during the pandemic (May 2020), while DO was significantly lower. However, an increase in temperature in May 2020 could not be related to human activities. TN and TP are water nutrients that play natural roles in nitrogen and phosphorus cycles. Another important source is sewage from the community, for example, wash waters and food residues (Regional Environment Office 16 (Songkhla), 2009; Pradit et al., 2010). Extremely high TN and TP will cause plankton bloom. BOD is the amount of oxygen used by microorganisms to decompose organic matter; too high BOD will spoil the water. In this study, TN, TP, and BOD in May 2020 were lower than in May 2019. This might be due to temporarily suspended or reduced anthropogenic activities, especially in businesses during COVID-19 (March-May 2020), and reduced sewage release. Nonetheless, TN in May 2019 and 2020 was still in the standard range of seawater quality for standard type 1 (0.020 mg-N/l) and types 3 and 6 (0.060 mg-N/l). TP in May of 2019 and of 2020 was also in the standard range of seawater quality standard type 1 (0.015 mg-P/l) and types 3 and 6 (0.045 mg-P/l). Furthermore, BOD in May of 2019 and of 2020 was in standard level for sewage control from the municipal wastewater treatment system and standards for wastewater discharge control from coastal aquaculture ponds, at less than 20 mg/l (Pollution Control Department, 2020). Dissolved oxygen at both these sampling times was still in the standard range of 5-8 mg/l. For wastewater, dissolved oxygen was less than 3 mg/l (Pollution Control Department, 2020).



**Figure 8.** Sediment quality (mean  $\pm$  SE); a) organic matter, and b) organic carbon (%) in sediment

Additionally, there were no significant differences in organic matter or organic carbon of sediments between May of 2019 and May of 2020 ( $P > 0.05$ ). The amount of organic matter arises from residues of plant, animal, and microbial cells, either alive or dead (Meksumpan, 2005), or even from waste discharge from the community sources such as homestays, houses built in seaward, and discharge of fecal waste or food waste into the seawater. There are sea perch cultures in cages, fed with fresh fish, and the food remains will settle down to the bottom. This contributes to organic matter content in the sediment. Therefore, during the COVID-19 outbreak affecting the trade of sea perch by prevented trading, the villagers needed to culture the sea perch continuously. Despite no activities during these two months, no change in organic matter or organic carbon was seen.

## Recommendations

The health tourism business will likely grow and will be a competitive advantage for the country. Based on this vision, we suggest management policies to appropriate authorities for the sustainable economic development of the community through local resources and benefit to the resource management by government organizations, according to the Thailand 4.0 policy. Furthermore, this policy suggestion conforms to the National Development Strategy following the 12th National Economic and Social Development Plan (2017-2020) in the eco-friendly growth strategy for sustainable development by preserving natural resources' preservation and restoration guidelines for proper conservation and utilization.

1. Relevant agencies should organize training to develop professional knowledge and skills in digital marketing, fishery and agricultural product processing, and other local production, emphasizing eco-friendly products and the management of health and eco-sustainable tourism.

2. Related departments should coordinate, assist, and advise people in various areas, such as in registration, to receive project funds; and serve as distribution centers to educate on adaptation and coping with the COVID-19 virus and distribute essential information equipment for disease prevention.

## Conclusion

The COVID-19 pandemic negatively impacted all three main types of business on Ko Yo island, namely restaurants, homestays, and aquaculture businesses. There was a butterfly effect with loss of customers, causing lack of income and emergency measures of the government disrupting operations. Meanwhile, employment suffered, and sea perch could no longer be sold to the nearby restaurants. Some entrepreneurs adapted to new services providing opportunities, but only in a few cases. The most affected by this crisis with no adaptation was aquaculture (mainly sea perch culture). This study suggests that Ko Yo businesses are vulnerable to this type of crisis, and there should be a risk management plan for coping with future crises or disasters. However, the reduced coastal activity on Ko Yo positively affected the water quality in terms of DO, BOD, TN, and TP that showed improvements from before the COVID-19 situation. Future studies on the indirect, long-term, and macro-level impacts of multiple waves of COVID-19 situation on socio-economy and environment and the adaptive capacity of local communities should be done.

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## APPENDIX

*Table A1. The study site locations of environmental sampling*

Station	Distance from coast (m)	Latitude	Longitude
A	0	7.180164	100.5412
	100	7.180104	100.5407
	300	7.180049	100.5388
	600	7.179247	100.5361
	1,200	7.178298	100.5305
B	0	7.162629	100.5374
	100	7.162275	100.5365
	300	7.162107	100.5342
	600	7.162297	100.5318
	1,200	7.164205	100.5273
C	0	7.148349	100.5347
	100	7.14762	100.5340
	300	7.144795	100.5365
	600	7.142855	100.5363
	1,200	7.140248	100.5360

**Table A2.** The questionnaire using for socio-economic data

Question	Answer	Remark
<b>Part I General information</b>		
<ul style="list-style-type: none"> <li>• Name of company</li> <li>• Type of business</li> <li>• The number of people in household</li> <li>• Annual income before COVID-19</li> <li>• Annual income during COVID-19 pandemic effect</li> </ul>		
<b>Part II Effects of the COVID-19 pandemic on income and employment</b>		
<ul style="list-style-type: none"> <li>• What obstacles have you encountered in your business after COVID-19? (can choose one or more than one)</li> </ul>	<input type="checkbox"/> Manufacturer Such as, the place origin cannot produce raw materials/raw materials cannot be delivered from the epidemic area <input type="checkbox"/> Finances Such as, there are still costs, and working capital can be insufficient in the next 3 to 6 months <input type="checkbox"/> Logistics Such as, transport must pass through the epidemic area <input type="checkbox"/> Marketing Such as, customer cancels the orders, the number of customers decreased, lack of middleman <input type="checkbox"/> Technology Such as, lack of technology or experience to adapt to an online system <input type="checkbox"/> Labor Such as, taking care of employees during the epidemic <input type="checkbox"/> Other, specific.....	
<ul style="list-style-type: none"> <li>• Income during COVID-19 pandemic compared to the same period last year</li> </ul>	<input type="checkbox"/> Decrease (answer next question) <input type="checkbox"/> Increase (jump next question) <input type="checkbox"/> No change (jump next question)	
<ul style="list-style-type: none"> <li>• Please estimate the percentage of reducing income. (The monthly income compared to the same period of last year)</li> </ul>	<input type="checkbox"/> 1% - 20% <input type="checkbox"/> 21% - 40% <input type="checkbox"/> 41% - 60% <input type="checkbox"/> 61% - 80% <input type="checkbox"/> 81% - 100%	
<ul style="list-style-type: none"> <li>• The number of employments in your business</li> </ul>	<input type="checkbox"/> Decrease (answer next question) <input type="checkbox"/> Increase (jump next question) <input type="checkbox"/> No change (jump next question)	
<ul style="list-style-type: none"> <li>• Please estimate the percentage of employment that being reduced</li> </ul>	<input type="checkbox"/> 1% - 20% <input type="checkbox"/> 21% - 40% <input type="checkbox"/> 41% - 60% <input type="checkbox"/> 61% - 80% <input type="checkbox"/> 81% - 100%	
<ul style="list-style-type: none"> <li>• What do you predict about the income in the next 6 months of your business?</li> </ul>	<input type="checkbox"/> Decrease <input type="checkbox"/> Increase <input type="checkbox"/> No change/very little change	
<b>Part III Adaptation to the COVID-19 crisis (can choose more than one)</b>		
<ul style="list-style-type: none"> <li>• Do you have any measures to prevent the COVID-19 spreading?</li> </ul>	<input type="checkbox"/> Yes <input type="checkbox"/> No (jump next question)	

Question	Answer	Remark
<ul style="list-style-type: none"> <li>If yes for last question, what methods you used?</li> </ul>	<input type="checkbox"/> Provide hand wash/alcohol gel <input type="checkbox"/> Provide mask for staff <input type="checkbox"/> Work from home <input type="checkbox"/> Provide quarantine place for staff <input type="checkbox"/> Modify payment to be cashless <input type="checkbox"/> Other, specific.....	
<ul style="list-style-type: none"> <li>Are there adaptation strategy in your business?</li> </ul>	<input type="checkbox"/> Increase selling opportunities/services/channels, such as, online, home delivery etc. <input type="checkbox"/> Temporary modification of products and services, such as selling masks, gels, alcohols, or hygiene businesses etc. <input type="checkbox"/> Change the type of business <input type="checkbox"/> Attract customers through various methods, such as, promotion, offer giveaways, free shipping etc. <input type="checkbox"/> Reduce salary of employees. <input type="checkbox"/> Reduce other expenses, such as, costs, production etc. <input type="checkbox"/> Sell some assets <input type="checkbox"/> Other, specific.....	
<ul style="list-style-type: none"> <li>What would you do after the situation back to normal?</li> </ul>	<input type="checkbox"/> Return as normal <input type="checkbox"/> Return as normal, and improve the business according to situation change/pattern/customer behavior/focus more on online services <input type="checkbox"/> Adjust the scale of operation <input type="checkbox"/> Switch to another business instead <input type="checkbox"/> Cease operation <input type="checkbox"/> Other, specific.....	
<b>Part IV Accessibility of aid measures</b>		
<ul style="list-style-type: none"> <li>Register in the aid project of government</li> </ul>	<input type="checkbox"/> Successfully registered and already received subsidies <input type="checkbox"/> Successfully registered, but was disqualified <input type="checkbox"/> Registration failed <input type="checkbox"/> Not register	
<ul style="list-style-type: none"> <li>Have you received assistance measures elsewhere apart from the aid project of government?</li> </ul>	<input type="checkbox"/> Yes, specific..... <input type="checkbox"/> No	
<ul style="list-style-type: none"> <li>Please specify what you want the government to help you mostly</li> </ul>		