
KNOWLEDGE, ATTITUDE, AND PRACTICES (KAP) ON BIOSECURITY AMONG SEAWEED FARMERS IN SELECTED COASTAL BARANGAYS OF BAIS CITY, NEGROS ORIENTAL

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Abstract

Over the years, the significant increase in seaweed production in the Philippines has been driven by numerous labor forces and stakeholders, primarily in *Kappaphycus* and *Eucheuma* farming. However, this growth has been hindered by various disease and epiphytic outbreaks, with no biosecurity approach in place. Previous studies suggest that using the Knowledge, Attitude, and Practices (K.A.P.) survey method can help develop effective management measures and policy strategies to minimize disease risks in culture farms. This study assessed the biosecurity-related knowledge, attitudes, and practices (K.A.P.) of 253 seaweed farmers in the top-producing coastal barangays of Bais City, Negros Oriental. The analysis revealed that while respondents have sufficient knowledge of common diseases and pests, they are uncertain about how these factors are introduced. Their attitudes and practices towards external, internal, and general biosecurity showed a positive response, indicating a good perception and strategic implementation of possible solutions. However, government intervention and support were found to be minimal. The study recommends necessary training for farmers, collaborative efforts between fisherfolk and the government, and further research to introduce both short-term improvements and long-term goals for sustainable seaweed production. This could lead to biosecurity interventions that support policy formulation, fostering scientifically sound solutions to prevent the future introduction and spread of pests and diseases.

Keywords: Biosecurity, Disease management, K.A.P. (Knowledge, Attitude, and Practices), Seaweed farming, Sustainable production

INTRODUCTION

Background of The Study

Seaweed farming production, particularly *Kappaphycus* and *Eucheuma* species, has a long history in tropical and subtropical countries (Hayashi *et al.* 2017), providing significant economic benefits and livelihoods to tens of thousands of seaweed farmers in developing countries (Hurtado 2013 as cited in Mateo *et al.*, 2021).

The Philippines, in particular, is among the world's top commodity producers, and numerous labor forces and stakeholders are involved in this fast-growing industry. Next to tuna, seaweed comes second in export value with 22% of the total country's export earnings in 2019 due to the demand for carrageenan production, according to BFAR 2020 Fisheries Profile.

Data from the Philippine Statistics Authority (P.S.A., 2016 to 2018) shows that seaweed farming is consequently regarded as one of the most important sources of income for coastal communities, especially in the Bangsamoro Autonomous Region in Muslim Mindanao (BARMM), Mindoro-Marinduque-Romblon and Palawan region (MIMAROPA), Zamboanga Peninsula, and

Central Visayas regions as they reflect significant production through the years compared to other regions.

In 2020, according to PSA VII, seaweed became the major contributor to the increase of fisheries production in the region as it topped the fisheries production in Central Visayas, accounting for 49 915 MT.

In the Province of Negros Oriental, aquaculture production had an increase of 24.1 percent in 2018, significantly contributed by seaweeds (11.1 percent) at 490.4 metric tons, next to big-eyed scad (12.8 percent) at 564.3 metric tons (Philippine Statistics Authority, 2018). Despite the significant increase in production and establishment of the industry, mainly from *Kappaphycus* and *Eucheuma* from the early 1970s, it began to decline for various reasons, including disease and epiphyte outbreaks in the mid-2000s.

Ward *et al.* (2021) explained that multiple problems play a vital role in reducing production capacities, such as the proliferation of epiphytic pests and continued incidence of ice-ice disease, which exacerbated the economic losses in top seaweed-producing countries, including the Philippines, Indonesia, Malaysia, and Tanzania, due to the absence or lack of biosecurity measure implementation from the point of origin to final out-planting sites (Mateo *et al.*, 2020).

Thus, applying the biosecurity concept in aquaculture has become essential for controlling pathogens, such as illnesses and pests, which can negatively affect farm productivity and output. Biosecurity may also positively impact the agricultural sector by enhancing the health and quality of farmed animals and plants (Moss *et al.*, 2012; Rodgers *et al.*, 2019; Campbell *et al.*, 2020).

Understanding and internalizing how biosecurity policies are conveyed to farmers, how biosecurity measures are implemented on farms, and how supporting policies impact farmers' behavior and awareness is crucial. However, according to the study of Campbell *et al.* (2020), the integration of biosecurity-related operations in the seaweed aquaculture industry is lacking. Most seaweed-producing nations have paid relatively little attention to implementing rules and policies concerning on-farm biosecurity techniques to date (Kembay *et al.*, 2020; Mateo *et al.*, 2020; Rusekwa *et al.*, 2020).

The Knowledge, Attitude, Practices (K.A.P.) survey technique was utilized in the Philippines to determine the biosecurity capacity of farmers involved in seaweed cultivation (Mateo *et al.*, 2021) and to identify knowledge and viewpoint gaps in aquaculture health management among farmers (Jia *et al.*, 2017). In regards to this matter, Bais City, Negros Oriental, was endowed with the abundance of this commodity, particularly *Eucheuma cottoni* and *Eucheuma spinosum*, but possessed various on-farm biosecurity risks and a multitude of issues caused by pest infestation, disease occurrence, and other environmental problems.

Therefore, this study is realized to evaluate the current biosecurity-related knowledge, attitude, and practices among seaweed farmers in the selected top-producing coastal barangays in the City of Bais. Previous studies believed using the K.A.P. survey method can help develop effective management measures and formulation of policy strategies to eliminate or minimize the potential risk of diseases in the culture farms.

Consequently, the study can provide biosecurity interventions for a possible policy formulation that will enable the development of scientifically robust solutions to minimize the future introduction and spread of pests and diseases.

Statement of The Problem

The present study aims to evaluate the Knowledge, Attitude, and Practices (K.A.P.) of Seaweed Farmers towards Biosecurity in Bais City, Negros Oriental. Specifically, this study sought to answer the following research questions:

1. What is the socio-demographic profile of the seaweed farmers in terms of:
 - 1.1. Age;
 - 1.2. Sex;
 - 1.3. Highest Educational Attainment;
 - 1.4. Seaweed farming experience; and
 - 1.5 Training experience?
2. What is the knowledge of seaweed farmers in terms of:
 - 2.1. Type of pests and diseases on the culture farm; and
 - 2.2. Introduction of pests and diseases on the culture farm?
3. What is the attitude of seaweed farmers in terms of:
 - 3.1. External Biosecurity Practices (E.B.P.);
 - 3.2. Internal Biosecurity Practices (I.B.P.); and
 - 3.3. General Farm Biosecurity Control Practices (GBCP)?
4. What are the practices observed/ implemented by seaweed farmers in terms of:
 - 4.1. External Biosecurity Practices (E.B.P.);
 - 4.2. Internal Biosecurity Practices (I.B.P.);
 - 4.3. General Farm Biosecurity Control Practices (GBCP)?
5. What are the additional on-farm biosecurity approaches by seaweed farmers in the coastal barangays of Bais City, Negros Oriental?
 - 5.1. General operational procedure?

Theoretical Framework of The Study

The study is primarily anchored on the Knowledge, Attitude, and Practice (K.A.P.) Theory. It divides human behavior change into three steps: acquiring knowledge, generating attitudes/beliefs, and forming practice/behaviors, during which human behaviors can also be effectively changed.

The seaweed industry has been subjected to various related studies on biosecurity measures because of the multitude of issues and continuing occurrence of disease-related problems that are persistent in eucheumatoid aquaculture.

This theory has been used as a backbone for significant research in the study of Mateo et al. (2020), which identified the gaps in the knowledge, attitude, and practice of seaweed farmers toward pest and disease outbreaks in the Philippines. Similarly, the study of Kambey *et al.* (2021) in Malaysia stated that K.A.P. analysis might help to inform the development of policy strategies and effective management measures for on-farm biosecurity risk elsewhere in the eucheumatoid industry.

Thus, using the K.A.P. survey instrument will be an essential tool to assess and highlight how biosecurity challenges are currently addressed by seaweed farmers in Negros Oriental, particularly in Bais City, and suggests how the K.A.P. survey could be used as a tool by policymakers and researchers to address gaps in biosecurity management practices.

Conceptual Framework of The Study

The Philippines, one of the top producers of seaweed globally, has a record of 22% export value of country's total export earnings in 2019 due to the demand for carrageenan production, according to BFAR 2020 Fisheries Profile.

Central Visayas, one of the country's key areas of seaweed production, has topped the fisheries yield of this commodity, accounting for 49 915 MT (PSA VII, 2020). It includes the yield of the province of Negros Oriental where aquaculture production is significantly contributed by seaweeds (Philippine Statistics Authority, 2018).

But through the years, the industry has faced multiple issues caused by disease infestations and other environmental problems. A study by Mateo *et al.* (2020) identified that the problem is due to the absence or lack of biosecurity measures implemented in the industry, which resulted in a decline in production over the years.

Therefore, this study aimed to evaluate the socio-demographic profile, Knowledge, Attitude, and Practices (K.A.P.) index, and other approaches of seaweed farmers in Bais City, Negros Oriental towards biosecurity. This method could address possible solutions and interventions to the gaps and challenges that the industry is currently facing. Also, this could be used as a tool for crafting short-term improvements and long-term goals for policymakers and stakeholders involved in the sector.

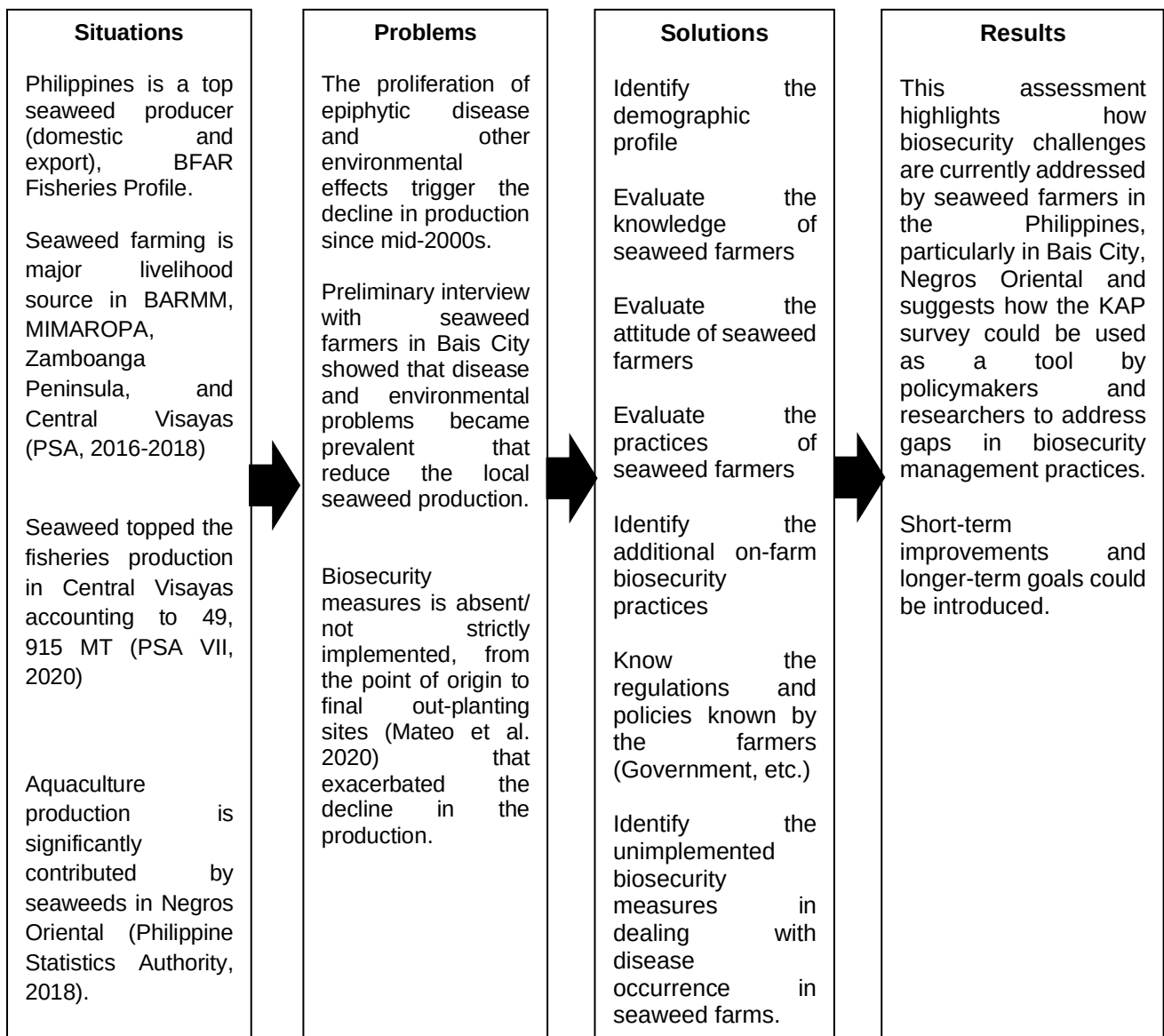


Figure 1. Conceptual framework of the study

Significance of The Study

The findings of this study will redound to the benefit of the community, considering that this fast-growing industry has huge opportunities and economic benefits to offer for the following:

For the Seaweed Farmers, this study will help them strengthen production and address the issues and concerns regarding the risk of biosecurity in the seaweed industry.

For the Bureau of Fisheries and Aquatic Resources (BFAR) and Local Government Unit (L.G.U.), this study will guide further policy formulation to effectively implement biosecurity measures in this fast-growing fisheries sector.

For the key officials, local community leaders, and stakeholders in the barangay, this study will serve as awareness of the current issues and status of the seaweed industry in the locality and how to put up possible interventions and solutions to the problem.

For academic institutions, faculty researchers, and students, this study will provide more information that will serve as baseline data for relevant research in the future.

For future researchers, this research will serve as a basis for conducting future studies relevant to this field.

Scope and Limitations of The Study

This study was conducted to assess the Knowledge, Attitude, and Practices (K.A.P.) of Seaweed Farmers toward Biosecurity Policy Implementation in the selected barangays of Bais City, Negros Oriental.

Several localities were identified and suggested by the City Agriculture Office (C.A.O.) following the data available in their office. These seaweed-rich producing barangays are Okiot, Olympia, and Tangcologan in Bais City, Negros Oriental.

The researcher interviewed the respondents from September until the first week of December 2022 until it reached the target number of respondents for this study.

LITERATURE REVIEW

Review of Related Literature

Seaweed cultivation is becoming an increasingly competitive choice for food-related biomass production. However, only eight Asian nations produced 99 percent of it, while most of the world's 150 coastal states and territories had not yet begun seaweed farming (Radulovichet *et al.*, 2015).

Despite the significant increase in production and establishment of the industry, mainly from *Kappaphycus* and *Eucheuma* from the early 1970s, it began to decline for various reasons, including disease and epiphyte outbreaks in the mid-2000s.

Ward *et al.* (2021) explained that multiple problems play a vital role in reducing production capacities, such as the proliferation of epiphytic pests and continued incidence of ice-ice disease, which exacerbated the economic losses in top seaweed-producing countries, including the Philippines, Indonesia, Malaysia, and Tanzania. It is due to the absence or lack of biosecurity measure implementation from the point of origin to the final out-planting sites (Mateo *et al.* 2020).

Hence, this chapter discusses the principles of seaweed farming, harvest and post-harvest processes, ecological and economic issues, and a perspective on prospects and challenges. The purpose is to provide both an overview of the current state of seaweed farming and a contribution to the sustainable growth of the business. Consequently, the following topics are given considerable consideration to assist and answer the research questions.

Socio-Demographics of Seaweed Farmers

The Philippine seaweed industry is subject to various connected dangers (Suyo, 2021). Environment-related risks (such as disease and insect infestations) were farmers' greatest threat of production failure. The instability of seaweed availability and the poor quality of raw materials were viewed as precursors to other dangers, such as greater competition among local dealers and processors.

As positions grew more homogeneous along the value chain, gender disparities in risk awareness and knowledge were more pronounced among seaweed producers than among dealers and processors. The rise of informal and market-driven solutions to prevent or minimize losses was precipitated by poor governance. However, prevented farmers from engaging in higher-revenue

trading and processing operations and contributed to market inefficiency. Lack of government backing has also hindered the ability of merchants and processors to engage in product development and diversification. Gender and community experiences influence and shape individuals' perception of their situations and environments, including their coping and adaptive methods for sustaining livelihoods in the face of recurrent risk events. To promote a resilient and sustainable seaweed industry, it is crucial to include informal structures and the diverse requirements of stakeholders in the institutional framework at the national level.

Labayo (2019) investigated 401 randomly selected families from 83 covered barangays facing Albay Gulf. The findings found that most fishing households (58 percent) were living below the poverty line. A large proportion of households (43 percent) were also reported to be below the subsistence level, indicating that their income is insufficient to fulfill even the most basic dietary requirements.

Even though most visited homes had access to power and owned a dwelling unit and physical possessions, access to safe and treated drinking water remained an issue. Community participation in Coastal Resources Management (CRM) is similarly minimal, as indicated by the small number of families that belong to people's groups, such as fisherfolk associations. To improve fishing households' living level and enhance their engagement in CRM, it is possible to empower them economically, socially, and environmentally through livelihood interventions, conditional cash transfers, and capability-building programs.

Dumilag (2022) highlighted that the significant diversity of cultivars maintained by Filipino farmers has contributed to the success of seaweed farming in the country for over 50 years. Although many eucheumatoid cultivars are currently (and consistently) recognized by Filipino farmers, no attempt has been made to summarize the current state of the local traditional knowledge regarding the diversity of this seaweed group, particularly in terms of taxonomy, cultivar designation, and distribution.

In addition, factors based on current local knowledge of eucheumatoid cultivars and genetic identification in the Philippines were reviewed. A total of 66 cultivars were identified over 58 provinces in the Philippines. The bulk of these cultivars were visually classified as either *K. alvarezii* or *K. striatus*, but their genetic identities remained unknown. *K. alvarezii* and *K. striatus* were more frequently farmed than *E. denticulatum* in the Philippines due, in part, to the greater demand for kappa-carrageenan extract compared to iota type. Currently, only in the southern Philippines is *K. malesianus* cultivated. This study's identification of numerous cultivars suggests that Filipino farmers hold valuable traditional knowledge that can be applied to future crop selection and breeding. Therefore, it is advised that an additional study be conducted by evaluating additional socio-demographic and economic features of traditional fish producers to identify their effects on the adoption rate of biosecurity policies.

Knowledge of Seaweed Farmers

Ward (2019) reported that losses of eucheumatoid stocks due to illnesses and pests in the Philippines have led to a 15 percent drop in output yields, equivalent to nearly \$100 million annually. Over 200,000 families in the Philippines are engaged in seaweed aquaculture; however, problems caused by epiphyte infestations and ice-ice disease have resulted in diminishing culture stocks and reduced carrageenan quality, which in turn leads to low market value, loss of income, and loss of employment opportunities, especially for marginal seaweed farmers.

As knowledge of seaweed diseases and the diversity of microorganisms linked with them grows, it becomes imperative to abandon the one-disease-one-pathogen paradigm in favor of the pathobionts notion (Bass, 2019). Pathobiotic systems are interactions between several host-associated organisms (including prokaryotes, eukaryotes, and viruses) and the host, as well as environmental factors, resulting in poor host health status.

Even when a main agent may be identified, other symbionts frequently mitigate its action. In seaweeds, which are known to be associated with a wide variety of microbial symbionts that influence their development, ecology, and evolution, the potential for invasion by opportunistic pathogens, environmentally induced pathogenesis, and microbial dysbioses to initiate or aggravate disease is diverse and pervasive. In addition, a given collection of clinical disease indications that may suggest a single etiology by a primary pathogen may have several similar etiologies.

The application of biosecurity in seaweed aquaculture is crucial in decreasing the impact of disease and pest outbreaks, according to Kambey et al. On Kappaphycus farms, the persistent presence of seaweed pests such as macroalgal epiphytes, epi-endophytic filamentous algae, and biofilms may further contribute to the prevalence of ice-ice sickness. The inquiry centered on preventative control techniques, such as the early detection of ice-ice syndrome and pests through propagule health checks, routine cleaning of crop thallus and accompanying long-line ropes, and environmental monitoring.

Using the Hazard Analysis and Critical Control Point (HACCP) methodology, farm operations and practices were also evaluated for potential biosecurity "risk." Observations were repeated in two distinct farm management systems, one of which implemented routine biosecurity precautions and the other which did not. Ice-ice syndrome and pest epidemic were dramatically reduced by 60–75 percent for *K. malesianus* and 29–71 percent for *K. alvarezii* at the farm that implemented routine biosecurity measures, compared to the farm that did not implement biosecurity measures. The biosecurity measures dramatically enhanced both the growth rate and quality of seaweed. The epi-endophyte *Melanothamnus* sp. infection levels contributed to the ice-ice syndrome in *K. malesianus*, whereas the epiphyte coverage corresponded with the occurrence of the disease in *K. alvarezii*. Faisan et al (Zamboanga City, Davao del Norte, and Tawi-Tawi). Individual seaweed plants, constituting 5% of the total number of seaweed plants on each farm, were evaluated in situ to determine the prevalence of pests and diseases. This survey indicated the presence of ice-ice illness (IID) at all sites, but at low prevalence rates of less than 25 percent, except in one site where prevalence was 100 percent. The incidence of IID was not significantly different between farms in shallow (0.5 m at low tide) and deep-water sites (depths exceeding 4 m at low tide) ($p>0.05$). On Luzon, the prevalence of the macrophyte pests *Sargassum* and *Ulva* ranged from 26 to 50 percent.

In addition, numerous farms with a low prevalence of epiphytic filamentous algae (E.F.A.), black blotches, and evidence of grazing were observed (0.2–11.2 percent). The severity of cover on the thallus of infected plants was determined on the three farms with the highest prevalence of IID and E.F.A. On the secondary and major branches, IID severity ranged from 76 to 100 percent coverage, whereas E.F.A. severity was below 25 percent in all thallus regions. Our findings indicate that yield-limiting illnesses and pests are prevalent on eucheumatoid farms in the Philippines. The important aquaculture sector in the Philippines requires strategies for diagnosing, surveillance, and managing yield-limiting pests and diseases to enable its maintenance and sustainable expansion.

Attitude of Seaweed Farmers

Tanquilut *et al.* (2020) found that exterior and internal biosecurity scores for layer farms in Central Luzon were widely dispersed, indicating that farm-to-farm compliance with various biosecurity measures varied. Layer farms in the region have an overall biosecurity score of 65.9 percent, while the total regional values for external and internal biosecurity are 63.3% and 71.9 percent, respectively. The province with the highest overall biosecurity was Bulacan, followed by Bataan. The two subcategories with the highest mean external biosecurity scores were the supply of materials (mean = 87.1) and procurement of pullets (mean = 83.7), while transport of animals had the lowest (mean = 50.6). Materials and measures between compartments received the highest average score within the internal biosecurity category.

Except for the region of Tarlac, layer farms exhibited weak to non-existent connections between internal and exterior biosecurity. This implies that a farm with a low exterior biosecurity score also had a low, and a high external biosecurity score had a high internal biosecurity score. The analysis also revealed that the biosecurity ratings of large commercial farms were 6.84 points higher than those of small commercial farms. The findings of this study may assist farmers in implementing the necessary changes to promote biosecurity compliance. Additionally, policies to impose, administer, and monitor compliance may be implemented. Regarding the execution of biosecurity measures, the current research reveals that the industry needs additional improvements.

According to Kambey *et al.* (2020), applying the biosecurity concept in aquaculture has become essential for managing pathogens, such as diseases and pests, which can negatively influence farm productivity and production. The concept of biosecurity can also have a positive impact on the industry by enhancing the health and quality of domesticated animals and plants. Although farmer biosecurity knowledge and attitude ratings ranged from 55.7% to 64.1%, implementation of procedures was low, according to the study (36.1–40.6 percent). The survey data revealed that a low level of education and transient employment in the seaweed industry lead to lower K.A.P. scores. Despite having a positive attitude toward biosecurity, extension personnel cannot assist farmers in implementing appropriate policies due to their poor understanding (57.9 percent) (76.9 percent). Due to the low understanding and capacity of the stakeholders to manage agricultural hazards, the implementation of national seaweed regulations, including biosecurity prevention and mitigation measures, remains weak. This paper demonstrates where short-term improvements and long-term goals could be implemented by identifying immediate gaps. This study also emphasizes the significance of translating biosecurity policies into on-the-ground knowledge and the necessity for economic support to enable a greater impact in the upstream sector of the seaweed aquaculture industry.

History has repeatedly demonstrated that heavy agriculture and domestication have severe and frequently irreversible effects on biodiversity (Loureiro *et al.*, 2015). To ensure the viability of algae production, a concerted effort in fundamental research is required to assess genetic resources and implement genetic conservation strategies, which are almost non-existent. In addition to immediate localized effects such as decreased light, changes in seawater temperature, and nutrient availability, it is vital to begin studying the long-term environmental impacts of algae farming. This is especially true for seaweed agriculture in coastal habitats, where posterior containment and disease management approaches are significantly more difficult, expensive, and ineffective than the deployment of good practices governed by science-based preventive policies. Improper management or constraints over seedling production, such as the use of inbred stocks or repeated vegetative propagation, can result in trait degeneration and the loss of agronomic value of a farmed

type16 as a result of, among other things, reduced growth, decreased quality and increased susceptibility to disease. The introduction of non-native seaweed species or genotypes, which pose threats to biodiversity and biosecurity, could be prompted by the import of seedlings of poor or declining quality.

Existing frameworks had the following deficiencies: inconsistent nomenclature for including farmed seaweeds, imprecise identification of implementation responsibility, insufficient empirical evidence, and poor alignment of biosecurity hazards and risks (Campbell *et al.*, 2020). Given the global importance of the cultivation of various seaweeds in alleviating poverty in low- and middle-income countries, it is crucial that the relatively low-unit value of the industry (relative to other aquatic animal sectors) not be confused with a perceived low risk of disease or pest transfer, nor with the subsequent economic and environmental consequences that disease transfer may have on receiving nations (well beyond their seaweed operations). A clear basis for developing robust international biosecurity policies related to the trade in seaweeds from the global aquaculture industry by first addressing the gaps highlighted in this study will be essential for limiting the impacts of pests and diseases on this valuable industry and natural capital in seaweed-farming locations. Despite the well-documented lessons learned from the oyster and crustacean sectors, these cases and subsequent analyses demonstrate a comparative lack of biosecurity understanding and implementation in the international and domestic seaweed industry. Given its global and expanding nature, scaled risk assessments and the identification of appropriate biosecurity measures should be conducted to safeguard the future of seaweed cultivation and wild algal populations and to bring biosecurity standards in line with those of other major aquaculture industries.

Practices of Seaweed Farmers

Rimmer *et al.* (2021) find that seaweed farming can sometimes, but not always, raise rural households in Indonesia over the poverty line. In addition to the obvious cash rewards, seaweed farming also contributes to the human and social capital of the households and communities involved in seaweed farming. Achieving continued economic and social benefits from seaweed farming will require additional policy development, research, and development to support improved and more consistent seaweed productivity and improved product quality at the farm level, provision of effective extension and technical support services, and diversification of existing value chains to reduce the impacts of price fluctuations associated with limited global commodity supplies. This worry is mostly attributable to the seaweed farmers' utilization of sustainable practices.

In subsequent years, according to Trono & Largo (2019), the Philippines recorded a steady decline in production due to epiphytes, loss of genetic diversity due to cultivation methods (i.e., vegetative propagation), political unrest in the main farming areas of the southern Philippines, and the occurrence of typhoons. More than 200,000 hectares of farmable land along the coastlines must be explored and examined to identify which regions are appropriate for seaweed cultivation. The random harvesting of *Sargassum* resulted in the issuance of Fisheries Order No. 250, which restricts the harvesting of *Sargassum*. The exploitation of *Gelidiella acerosa* remains a worry because no culture technology is currently available for the species. The absence of complete records on Philippine seaweed production must be remedied, and the country's unique algal resources must be studied.

Indonesia is the world's greatest producer of the red seaweeds *Kappaphycus* and *Eucheuma*, according to Kambey *et al.* (2020). 's research; yet, this country faces severe obstacles such as disease outbreaks, epiphyte infestations and a decline in seedling quality. Other aquaculture sectors

have widely implemented biosecurity techniques, which, when enforced, can help prevent the introduction and spread of diseases and pests. A comprehensive review of policy frameworks, including legislation, regulatory instruments, and national standards, was conducted to examine the present capacity for biosecurity in seaweed aquaculture in Indonesia. Biosecurity themes and threats were utilized to evaluate the current biosecurity content at the national level.

The results indicated the industry's greatest obstacles to implementing biosecurity rules. Barriers to implementation included vague references to the seaweed aquaculture sector, a restricted variety of biosecurity techniques, limited use of current scientific information, insufficient direction for the application of precaution, and inadequate inclusion of specific biosecurity threats. While national regulations are changing, current policies reveal a lack of clarity regarding biosecurity. Six recommendations are made to incorporate proactive biosecurity measures into existing frameworks to improve the health and sustainability of the Indonesian seaweed aquaculture industry.

The seaweed industries of Europe, Canada, and Latin America rely on the sustainable collection of natural resources. Rebours *et al.* (2014). In light of the number of nations seeking to grow their activities, the harvest should be administered in accordance with participatory and integrated governance regimes to assure long-term output.

To ensure environmental, social, and economic values in the world's coastal regions, the development of legislation and directives that permit the sustainable exploitation of natural resources must be placed on national and international political agendas. Portugal requires an evaluation of seaweed management plans in Europe, whereas Norway and Canada have created and implemented coastal management plans that include well-established and sustainable seaweed resource use. While numerous scenarios of seaweed exploitation can be observed throughout Latin America, each country needs long-term, ecosystem-based management plans to ensure that exploitation is sustainable. Peru and Brazil require these plans the most, but Chile has established a sustainable seaweed harvesting plan for most economically significant seaweeds. Moreover, seaweed aquaculture is in its infancy in Europe and Latin America, and its development will need to overcome several obstacles on multiple levels (i.e., technology, biology, policy).

Therefore, laws and the formation of "best practices" are required for the harvesting, management, and cultivation of seaweed. To enable seaweed use to become a lucrative business and improve income prospects for coastal communities, trained human resources will be necessary to provide knowledge and instruction to the concerned populations.

Disease Outbreaks in Seaweeds

In 1989, commercial cultivation of *Eucheuma denticulatum*, *Kappaphycus alvarezii*, and *Kappaphycus striatum* was initiated in Tanzania (Rusekwa *et al.*, 2020). The effects of pests and illnesses on the local seaweed business were detrimental to the environment, society, local culture, and human health. This article analyses existing biosecurity frameworks in Tanzanian legislation and policies to evaluate their substance concerning controlling pests and illnesses in the seaweed sector. Recommendations are presented to aid regulators in implementing biosecurity regulations that either expressly includes or are built with the Tanzanian seaweed sector in mind.

Several variables influence the continuous and sustainable spread of seaweed aquaculture. Perhaps most essential is the need for a deeper comprehension of pathogenic and physiological illness causes (Ward *et al.*, 2020). Improving pathogen characterization techniques, such as the routine application of histopathological and molecular diagnostic techniques in other aquaculture sectors, will create quick and reliable diagnostic tools. These will enable the early identification of

pathogen (and pest) outbreaks and, when combined with disease surveillance programs and environmental monitoring, will lead to a clearer knowledge of the abiotic and biotic variables driving disease and pest outbreaks. In addition to gaining a better understanding of disease-causing agents, it is essential to evaluate the role of the host in disease and pest susceptibility.

According to Tahiluddin & Terzi (2021), *Kappaphycus* spp. and *Eucheuma* spp. are two commercially significant seaweed species farmed worldwide owing to their high carrageenan content and diverse commercial uses. The prevalence of ice-ice sickness is one of the most significant obstacles to seaweed cultivation. In this paper, we conduct a literature review on the ice-ice disease of two commercially cultivated seaweed species (*Kappaphycus* spp. and *Eucheuma* spp.), concentrating on the illness' etiology, incidence, and control techniques. Ice-ice illness is produced by abiotic and biotic causes, as evidenced by white and soft tissue in afflicted seaweeds.

Campbell, Vergés, and Steinberg (2014) found that illnesses affecting natural ecosystems are rising in frequency and intensity, yet the repercussions of disease outbreaks are frequently underestimated compared to other ecological processes until they are blatantly disastrous (e.g., predation, competition). The disease may have enormous consequences on people and relationships between afflicted hosts and their natural predators.

Implementing biosecurity in seaweed aquaculture has an essential role in limiting the effect of disease and pest outbreaks, according to Kambey, Campbell, Cottier-Cook *et al.* (2020). On *Kappaphycus* farms, the persistent presence of seaweed pests such as macroalgal epiphytes, epi-endophytic filamentous algae, and biofilms may further contribute to the prevalence of ice-ice sickness. During the peak season of ice-ice disease in Gallam-Gallam Village, Sabah, Malaysia, biosecurity control strategies were evaluated on commercially farmed *Kappaphycus malesianus* and *Kappaphycus alvarezii* seaweeds. The inquiry centered on preventative management techniques, such as the early detection of ice-ice syndrome and pests through propagule health checks, routine cleaning of crop thallus and accompanying long-line ropes, and environmental monitoring. Using the hazard analysis and critical control point (HACCP) methodology, farm operations and practices were also evaluated for potential biosecurity "risk." Observations were repeated in two distinct farm management systems, one of which used routine biosecurity precautions and the other which did not. Ice-ice syndrome and pest epidemic were considerably reduced by 60–75% for *K. malesianus* and 29–71% for *K. alvarezii* at the farm that implemented routine biosecurity measures, compared to the farm that did not implement biosecurity measures. The biosecurity measures dramatically enhanced both the growth rate and quality of seaweed. The epi-endophyte *Melanothamnus* sp. infection levels contributed to the ice-ice syndrome in *K. malesianus*, whereas the epiphyte coverage corresponded with the occurrence of the disease in *K. alvarezii*. This method is the first research demonstrating that biosecurity management strategies reduce the frequency of ice-ice sickness and pests on a commercial seaweed farm.

Indonesia is the world's greatest producer of the red seaweeds *Kappaphycus* and *Eucheuma*, yet, this nation faces severe obstacles such as disease outbreaks, epiphyte infestations, and a decline in seedling quality (Kambey, Campbell, Sondak, *et al.*, 2020). Other aquaculture industries have largely implemented biosecurity techniques, which, when enforced, may help prevent the introduction and spread of diseases and pests. A comprehensive review of policy frameworks, including legislation, regulatory instruments, and national standards, was undertaken to examine the present capacity for biosecurity in seaweed aquaculture in Indonesia. Biosecurity themes and threats were utilized to evaluate the present biosecurity content at the national level. The results indicated the industry's greatest obstacles to implementing biosecurity rules. Barriers to implementation

included vague references to the seaweed aquaculture industry, a restricted range of biosecurity techniques, limited use of current scientific information, insufficient direction for the use of precaution, and inadequate inclusion of particular biosecurity threats. While national rules are changing, present policies need more clarity regarding biosecurity. Six recommendations are made to incorporate proactive biosecurity measures into existing frameworks to improve the health and sustainability of the Indonesian seaweed aquaculture industry.

In the past 25 years, the global demand for seaweed and its products has expanded dramatically (Msuya, Bolton, Pascal, *et al.*, 2022). Equally, the continent of Africa and its outlying islands have a substantial capacity to contribute to the global need for seaweed. Africa needs to catch up with China and the rest of Asia regarding seaweed production and utilization. Africa is the third-largest producer of red eucheumatoid seaweeds, generating around 120,000 t (F.W.) yearly. Thirteen African nations are cultivating and collecting seaweed for export or internal use, either commercially or experimentally. Tanzania's *Eucheuma* spp. and *Kappaphycus* spp. Contribute 92% of continental output, Madagascar's 4,7%, while South Africa's *Ulva* spp. and *Gracilaria* spp. Represent 1.5%. Over 2,000 species of seaweed have been identified in Africa, some of which are successfully grown in other regions. The climatic conditions of the continent range from warm, tropical waters to colder, nutrient-rich waters in the southwest, allowing for the production of seaweeds ranging from tropical eucheumatoids that produce carrageenan to temperate kelp species. The primarily female-run seaweed aquaculture industry in Africa has enhanced the standard of living of its coastal residents. The emergence of diseases and pests due to climate change and the low prices provided to farmers are cited as significant obstacles to the growth of this business. Africa can join China and Southeast Asia as a worldwide leader in producing, processing, and consuming a range of seaweeds if it scales up and expands its existing seaweed production and use efforts.

Bacterial infections cause high mortality in the wild and farmed fish (Maheswaran, Padmavathy, and Gunalan, 2013). Typically, farm issues are resolved by avoiding disease outbreaks or treating the existing sickness with pharmaceuticals or chemicals. In aquaculture, the usage of antimicrobial drugs has expanded dramatically. In the present investigation, seaweed samples were evaluated against a broad spectrum of freshwater fish infections. It is widely established that all five samples of seaweed exhibited anti-fish pathogen activity. It is noted that the present study aims to investigate the bioactive potential of prominent seaweeds found around the Gulf of Mannar as a prospective source of marine bioprospecting. This research intends to open the path for discovering novel bioactive substances to treat horrible diseases, consequently reducing multidrug-resistant organisms.

Each year, a considerable part of global food production is lost to pests and diseases, with the government and industry focusing on implementing effective biosecurity policies to prevent their establishment and spread (Campbell, Kambey, Mateo, *et al.*, 2020). The output of seaweeds in aquaculture is second only to farmed fish, and red algal carrageenophytes presently account for around 42% of the global production of all seaweeds. Despite its significance, the expansion of the seaweed industry is increasingly constrained by the prevalence of recalcitrant diseases, and epiphytic pests with the potential to emerge and the demonstrated propensity to spread, especially in the absence of effective national and international biosecurity policies. Urgent development of biosecurity policy and regulation to address biosecurity risk in seaweed aquaculture is essential to mitigate these negative effects. Existing legal frameworks were analyzed quantitatively for the substance of biosecurity measures, application to the seaweed business, and inclusion of dangers

posed by diseases, pests, and non-native species to comprehend current worldwide biosecurity frameworks and their efficacy. Existing framework deficiencies included inconsistent nomenclature for the inclusion of farmed seaweeds, imprecise assignment of implementation duty, inadequate evidence-based information, and weak alignment of biosecurity hazards and risks. Given the global importance of the cultivation of various seaweeds in alleviating poverty in low and middle-income countries, it is crucial that the relatively low-unit value of the industry (relative to other aquatic animal sectors) not be confused with a perceived low risk of disease or pest transfer, nor with the subsequent economic and environmental consequences that disease transfer may have on receiving nations (well beyond their seaweed operations). A clear basis for developing robust international biosecurity policies related to the trade in seaweeds from the global aquaculture industry by first addressing the gaps highlighted in this study will be essential for limiting the impacts of pests and diseases on this valuable industry and natural capital in seaweed-farming locations.

Biag *et al.* (2022) investigated the incidence of ice-ice diseases (IID) and epiphyte infestation (E.I.) in farmed seaweeds (*Kappaphycus* spp.), proposing a feasible technique to avoid early development and outbreaks. A prevalence evaluation of IID and E.I. was conducted on 29 seaweed farms, noting the cultivation stage and current farming practices. The data demonstrated that the beginning of IID and E.I. occurred in the early phases of out-planting due to stresses accumulated during the transplantation process. Newly planted seaweeds are exposed to the surface and direct sunlight for an extended duration during wave action, resulting in a high incidence of E.I. and IID. Therefore, it is recommended to integrate a bamboo spacer (B.S.) into floaters to avoid the early development of IID and E.I. in freshly planted seaweeds. B.S. may help maintain optimum depth, enhance seaweed line movement, reduce entanglement, and prevent seaweed from being exposed to the surface and direct sunlight.

The seaweed sector in the Philippines is a major contributor to national and worldwide aquaculture output (Mateo, Campbell, Cottier-Cook, *et al.*, 2020). It produces more than the capture fisheries industry and the majority of worldwide producers, except China and Indonesia. Since the early 1970s, seaweed species, notably *Kappaphycus* and *Eucheuma* spp., have been cultivated nationwide. In 2017, the Philippines produced 1.4 million tonnes of seaweed and carrageenan and exported 35,490 tonnes for US\$174 million. However, since the middle of the 2000s, a declining trend in seaweed output has been noticed due to pest and disease outbreaks, among other reasons, which have been worsened by climate change. This idea is the first article to evaluate biosecurity-related national laws and legislation (collectively referred to as "frameworks") pertinent to the Philippine seaweed sector. To evaluate how seaweed biosecurity is implemented into national policy, 12 frameworks were found, and seven were evaluated using established biosecurity themes, threats, and management mechanisms. It was discovered that the inclusion of biosecurity-related activities in national frameworks was confined to aquatic animal products or crops. Only the Code of Good Aquaculture Practices for seaweed includes seaweed farming but no biosecurity measures. The results revealed an obvious vacuum in the Philippines' present biosecurity legislation and policy, which, if addressed, can lessen the burden of endemic and emerging diseases and pests and promote the sustainable expansion of this key industry.

According to Faisan, Luhan, Sibonga *et al.* (2021), farmed eucheumatoids are the most important aquaculture commodity in the Philippines, accounting for more than 60 percent of the country's overall volume of aquaculture output. Despite severe production losses attributable to pests and illnesses in recent years, there is a need for more information regarding the temporal and geographical geographic distribution, seasonality, prevalence, and genesis of these key issues at

the farm level. Here, we investigated the incidence of pests and illnesses at 16 farm sites in three of the Philippines' most important seaweed-growing regions: Luzon (Palawan), Visayas (Bohol), and Mindanao (Zamboanga City, Davao del Norte, and Tawi-Tawi). Individual seaweed plants, constituting 5% of the total number of seaweed plants on each farm, were evaluated in situ to determine the prevalence of pests and diseases. This survey indicated the presence of ice-ice illness (IID) at all sites, but at prevalence rates below 25%, except in one site where prevalence was 100%. The incidence of IID was not significantly different between farms in shallow (0.5 m at low tide) and deep-water locations (depths exceeding 4 m at low tide) ($p>0.05$). On Luzon, there was a moderate prevalence (26–50%) of the macrophyte pests *Sargassum* and *Ulva*. In addition, the incidence of epiphytic filamentous algae (E.F.A.), black patches, and indications of grazing were modest (0.2%–11.2%) in different fields. The degree of cover on the thallus of infected plants was determined on the three farms with the highest prevalence of IID and E.F.A. On the secondary and primary branches, the severity of IID was quite severe (76–100% coverage), but the severity of E.F.A. was low (25% coverage) in all thallus areas. Our findings indicate that yield-limiting illnesses and pests are prevalent on eucheumatoid farms in the Philippines. The important aquaculture sector in the Philippines requires strategies for diagnosing, surveillance, and controlling yield-limiting pests and diseases to enable its maintenance and sustainable development.

Biosecurity Policy Implementation

Zamroni (2021) analyzed the characteristics of seaweed farming, the restrictions and opportunities, and the marketing channels of seaweed farming. As a qualitative method, this study employed structured and semi-structured questionnaires, and interviews were conducted with 294 respondents in South Sulawesi and West Nusa Tenggara Provinces. The data were evaluated using descriptive statistics, supply chain analysis, and SWOT. The findings indicate that small-scale seaweed farming is a primary source of household support (2-4 plots in each). Disease, post-harvest issues, farm ownership, monsoon season adjustments, marketing limits, quality of seaweed seeds, farm ownership, and post-harvest flaws are some of the obstacles to the development of this activity. Through the efforts of intermediaries with an exclusive relationship, the seaweed supply chain has offered benefits, such as the rapid provision of investment and daily operations funds, at no cost. In conclusion, traditional seaweed farming methods can be a vital driver for sustainable farming and coastal community livelihoods.

Campbell *et al.* (2022) utilized the Knowledge, Attitude, and Practice (K.A.P.) survey instrument to measure and compare biosecurity across cultures in the Philippines and Tanzania, two major red seaweed-producing nations. The political frameworks of the two nations are vastly distinct, and the seaweed industry operates within two very distinct value chains. However, seaweed-based products from these nations join the same international market as carrageenan, a global thickening ingredient used in various products. This study employs the K.A.P. survey instrument to evaluate currently accepted biosecurity control measures and to comprehend how potential international policy initiatives could be developed. Farmers from both producing nations are knowledgeable about biosecurity. In Tanzania, 64 percent of farmers rated Good or Fair, while 95 percent did so in the Philippines. The lower rankings for practices, 85 percent Poor in Tanzania and 88 percent Fair in the Philippines, indicating that farmers lack the resources to implement extra measures. In the context of the global seaweed business, the information acquired using the K.A.P. tool can be utilized to support a compromise between research, policy, and practice while considering regional issues. Given the similarities between the results of the seaweed industry and those of smallholder

agricultural sectors, it is suggested that government programs designed to encourage biosecurity in smallholder rural agriculture could be adopted for the seaweed industry. This study also highlights the potential use of the K.A.P. survey as a tool for correctly comparing the biosecurity issues faced by farmers in various aquaculture sectors around the world and for encouraging international alignment in approaches to aquaculture biosecurity regulations.

Similarly, Rimmer *et al.* (2021) stated that seaweed farming is appealing to farmers in rural coastal communities because capital and operating costs are low, farming techniques are not technically demanding, and labor requirements are relatively low (allowing farmers to engage in other livelihoods), and production cycles are short, resulting in regular income. Using reported seaweed farming revenue figures, we find that seaweed farming can, but does not always, raise rural households in Indonesia above the poverty line. In addition to the obvious cash rewards, seaweed farming also contributes to the human and social capital of the households and communities involved in seaweed farming. Achieving continued economic and social benefits from seaweed farming will require additional policy development, as well as research and development to support improved and more consistent seaweed productivity and improved product quality at the farm level, effective extension, and technical support services, and diversification of existing value chains to reduce the effects of price fluctuations associated with limited global commodity chains.

Songwe *et al.* (2016) used a structured questionnaire design. Before the training of enumerators, questions and variables were tested through interviews with a small sample of farmers. Using Slovan's calculations ($n = N / (1 + Ne2)$), a minimum sample size of 400 responders was selected from 23,000 farmers. However, interviews were conducted with 592 farmers from 48 seaweed-producing villages. Random sampling was employed to identify communities, and farmers were randomly chosen for interviews. Due to most of their production being below the breakeven mark, most farmers were not achieving economic returns, according to the study (1,439 kgs of dry seaweed per cycle). This is due to several factors: small farm size, lack of technology, low innovation upscaling, and lack of entrepreneurial abilities. Due to farmers' reliance on exporters for the seaweed market, the industry lacks support from other sectors because it is not connected to several stakeholders (such as Financial Institutions, Research, and Science and Technology) (Farmer-Exporter Model). Compared to other seaweed-producing nations such as the Philippines, Indonesia, and the Solomon Islands, seaweed-farming value-added industries lack scalability mechanisms. Despite the challenges, there is still potential for commercializing Zanzibar seaweed farming, and the sector is essential for competitive economic growth if the following conditions are met: development of seaweed policy and strategic plan; promotion of entrepreneurship, research, technology, and innovative upscaling system; enhancement of multistakeholder business model; engagement of youth and men in seaweed farming; and increased access to seaweed market information and financing.

Despite the vast potential of aquaculture as a source of food and income, only seaweed farming has reached commercial-scale production. This occupation is dominated by women and became prevalent as a tiny but consistent source of income in the early 1990s. However, economic and administrative constraints, as well as the occurrence of frequent seaweed die-offs, impede its expansion. Other types of aquaculture, such as fish farming, mud crab fattening, half-pearl farming, sea cucumber farming, and sponge and coral cultivation, are in the developmental or experimental stages with little yield. These operations are constrained by economic limits, lack of technological infrastructure and expertise, tiny and irregular production, and restricted trade and market access. In addition, there are insufficient management and monitoring mechanisms and no official

regulations or clear strategies for advancing aquaculture on a national scale. In addition, donor-driven projects dominate new aquaculture endeavors rather than local entrepreneurship. This circumstance discourages participation in aquaculture, and as a result, these operations are outcompeted by other established industries (e.g., agriculture and fisheries). We believe that the potential for the evolution of aquaculture is substantial due to its high environmental capacity. For sustainable mariculture growth in Zanzibar, obtaining profitable production and a stronger commitment from local populations, as well as developing efficient mariculture governance through support mechanisms and defined strategies to strengthen the industry at the national level, are important.

RESEARCH METHOD

This chapter dealt with the research design, research locale, respondents of the study, sampling technique, research instrument, data gathering procedures, and data analysis that will be utilized in the study.

Research Design

A quantitative method was employed to evaluate and assess farmers' scores following the main objectives of this study. It emphasized the responses in the standardized survey tool through statistical approaches and computational techniques.

At the same time, the systematic analysis measured the implementation of on-farm practices and included both analyses to clarify and identify the problems and to provide a comprehensive study concerning the seaweed biosecurity issues in Bais City, Negros Oriental.

Research Locale

This study was conducted in the seaweed-rich producing coastal barangays of Bais City, Negros Oriental which were identified and suggested by the City Agriculture Office. The areas were determined by selecting the top three localities with the high number of seaweed farmers in their respective barangay.

These neighboring barangays are Okiot (9.593037,123.150476), Olympia (9.617687,123.144699), and Tangculogan (9.613954, 123.102348), which pose a wide seaweed culture area in the city that is reflected on Figure 2.



Figure 2. Geographical map of Bais City, Negros Oriental pointing out the selected coastal barangays and seaweed culture farms as the research locale of the study.

Source: <http://mapnall.com/gntxmbaszost.html/map/Esri.WorldImagery/Map-Bais-City1132709.html>

Respondents of The Study

The primary respondents of the study were the seaweed farmers in the identified coastal barangays in Bais City, Negros Oriental. The population of the seaweed farmers in each research locale was determined through their respective Fisherfolks Organizations primarily involved in the industry.

These are Okiot Fish Organization, with 66 members; Olympia Fisherfolk Organization (OFFO), having 85 registered members; and Kapulungan sa Gagmay Mananagat sa Tangcologan (KAGAMATA), with 102 members, respectively. To sum up, a total of 253 local seaweed farmers were interviewed as respondents in the study.

Sampling Technique

The researcher employed a complete enumeration sampling method since there is a given number of seaweed farmers identified in each research locale. It allowed the researcher and his research assistants to interview all the respondents in each fisherfolk organization in the three coastal barangays of Bais City, Negros Oriental to avoid sampling error during data analysis.

Research Instrument

In data gathering, the researcher utilized the K.A.P. survey instrument. All respondents were interviewed with a structured questionnaire assessing their knowledge, attitude, and practices regarding on-farm biosecurity measures.

The questions reflected on the K.A.P. survey instrument were adapted from the aquatic animal survey conducted by Jia et al. (2017), while the biosecurity application applied in seaweed aquaculture was modified based on the F.A.O. Biosecurity tool kit.

Consequently, a systematic analysis was utilized to evaluate the execution of farm practices, and both analyses were done to clarify and identify the difficulties and assess a thorough research of the seaweed biosecurity issues in Bais City, Negros Oriental.

Each question component was carefully translated into the local dialect (Bisaya) of the study site to have a more precise understanding and concrete responses from the interviewees.

The questionnaire is mainly divided into various sections. The first part covers the demographical profile of the respondents (age, sex, highest educational attainment, seaweed farming experience, and training experience). The second part primarily includes assessing K.A.P. biosecurity measures of the respondents towards seaweed farming. And for the last part is composed of additional biosecurity approaches and a few open-ended questions regarding specific information on crop management practices.

Data Gathering Procedure

Before the data gathering procedure, the researcher sent a communication letter to the City Agriculture Office of Bais City, Negros Oriental to ask for approval to conduct the study and acquire relevant information about the city's seaweed industry.

After the approval and recommendation of the concerned office, the researcher sought the assistance of each Barangay Captain of the identified seaweed-rich producing coastal barangays to determine the possible respondents for the study.

After thoroughly coordinating with the concerned personnel, the researcher identified the fisherfolk organizations in each barangay. The data were gathered by administering survey

questionnaires through personal interviews with the seaweed farmers as respondents in each study site.

Data Analysis

The results of the study were subjected to various statistical computations. The data obtained from the quantitative approach were analyzed statistically using the SPSS program. Each K.A.P. score was tallied and computed to acquire its frequency distribution and identify each parameter's highest and lowest responses in various categories.

In answering S.O.P. #1, the respondents' demographic information was summarized proportionally based on the three identified research locales. The responses to each component question were tallied for the frequency distribution.

In the aspect of K.A.P. categories covering SOPs 2,3, and 4, frequency distribution was also used to get the most sought and lowest responses in each component question.

To answer the S.O.P. 5, the researcher tallied the frequently answered responses of the seaweed farmers in terms of their approaches that weren't asked in the previous sections of the questionnaire. The results were translated into percentage count to fully realize the most common techniques and interventions employed in the farms.

RESULTS AND DISCUSSION

Presentation, Analysis, and Interpretation of Data

The Socio-demographic Profile

The summarized data on the socio-demographic profile of the respondents from the three coastal barangays are indicated in Table 1.

Table 1. *Socio-demographic Information of the Seaweed Farmers.*

Demographic Profile	Okiot (66)		Olympia (85)		Tangculogan (102)		TOTAL (253)	
Age	Freq.	%	Freq.	%	Freq.	%	Freq.	%
<25	5	7.58	2	2.35	7	6.87	14	5.53
25-50	43	65.15	47	55.29	57	55.88	147	58.10
>50	18	27.27	36	42.36	38	37.25	92	36.37
Sex								
Male	30	45.45	54	63.53	66	64.71	150	59.29
Female	36	45.45	54	63.53	66	35.29	103	59.29
Highest Educational Attainment								
Tertiary	7	10.61	10	11.76	23	22.55	40	15.81
Secondary	29	43.94	15	17.65	30	29.41	74	29.25
Elementary	30	45.45	60	70.59	49	48.04	139	54.94
Less than Primary	–	–	–	–	–	–	–	–
Seaweed Farming Experience								
<1 years	21	31.82	–	–	4	3.92	25	9.88
1-5 years	11	16.67	20	23.53	14	13.73	45	17.79
6-10 years	8	12.12	44	51.76	57	55.88	109	43.08
>10 years	26	39.39	21	24.71	27	26.47	74	29.25
Training Experience								
With Experience	–	–	–	–	–	–	–	–
Without Experience	66	100	85	100	102	100	253	100

Table 1 reveals that most of the seaweed farmers surveyed (58.10%) were aged 25-50 and were male-dominated. It is much higher than those who are more than 50 years old (36.37%) and below 25 years old at 5.53%. It can also be noted that the oldest and youngest respondents interviewed in this study were 72 and 9 years old, respectively.

The sex ratio of seaweed farmers indicated that 59.29% are male and 40.71 % are female, and in terms of their educational attainment, 54.94 % had completed primary school, and 15.81 % had completed college. Only 9.88% of farmers have less than a year of experience, while 43.08% have six to ten years of experience.

It can also be noted that, despite their years of experience, they lack proper training in the management and implementation of seaweed farming. They acquired their skills and necessary knowledge in dealing with this aspect through direct conduct and observation from their families and peers involved in the industry. However, prevented farmers from engaging in more lucrative trading and processing activities and contributed to market inefficiency (Labayo et al. 2019). The minimal support from the government also hampered merchants' and processors' ability to engage in product development and diversification.

In addition, gender and community experiences influence and shape an individual's perception of their circumstances and environments, including their coping and adaptive strategies for sustainable livelihoods in the face of recurrent risk events in the seaweed industry.

It is essential to promote a resilient and sustainable seaweed industry to incorporate informal structures and the diverse needs of stakeholders into the government institutional framework.

Biosecurity Knowledge, Attitude, Practices (K.A.P.) Assessment

Knowledge

The following figures demonstrate the knowledge of seaweed farmers about the types of diseases and pests and how these factors were introduced in the seaweed farms.

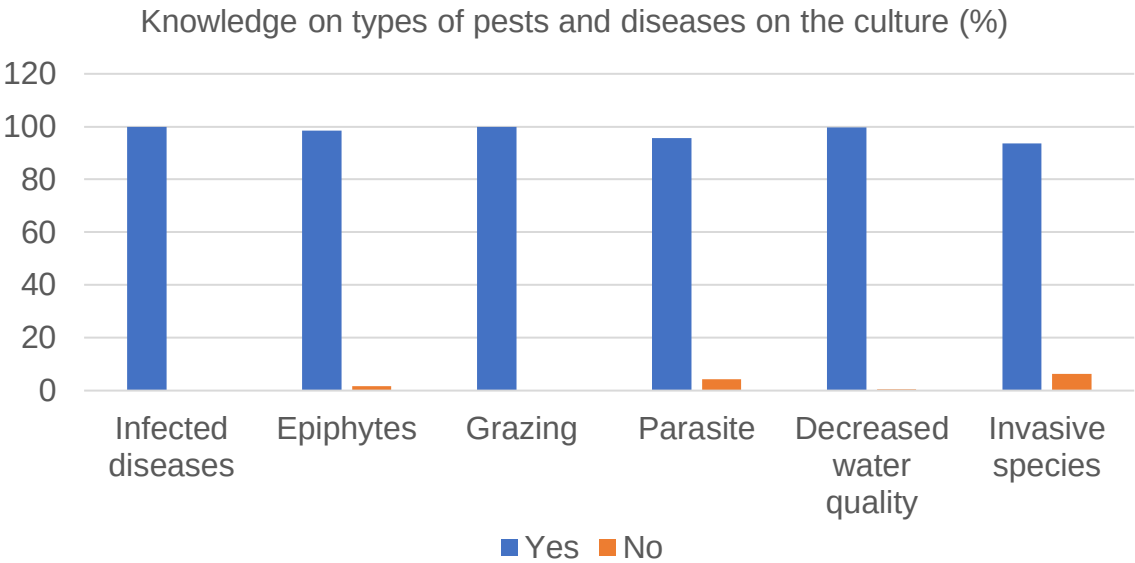


Figure 3. Knowledge of respondents about the types of pests and diseases that affect the seaweed farms in Bais City, Negros Oriental.

Figure 3 shows that the majority of the respondents are well aware of what type of pests or diseases affect their seaweed farms, which may include disease infection (100%), presence of epiphytic (98.42%), grazing (100%), parasitic (95.65%), and presence of invasive species (93.68 %), as well as environmental factor like decreased water quality (99.60%).

It can be noted in these results that ice-ice disease (IID) was the primary disease that infected the cultured commodity. The IID is characterized by bleaching of the thallus, followed by the disintegration of affected tissues, leading to a loss of biomass and reduced carrageenan yield. It has been associated with unfavorable changes in environmental conditions, particularly an increase in seawater temperature and a decrease in salinity, and infection by opportunistic or pathogenic bacteria (Ward *et al.*, 2021). The presence of biofouling organisms like eggs of finfishes and shellfishes are also factors that infest the production.

Consequently, siganid (*Siganus* sp.) fingerlings or locally known as "ketong" is the main organism that grazes the culture area since this species is characterized as being primarily herbivorous fishes that feed on seagrass and the majority of available algae (Hamza *et al.*, 2000). Grazing seaweed tissues by herbivores cause inconsistent crop yields, making commercial seaweed farming less economically viable (Meenakshisundaram *et al.*, 2006).

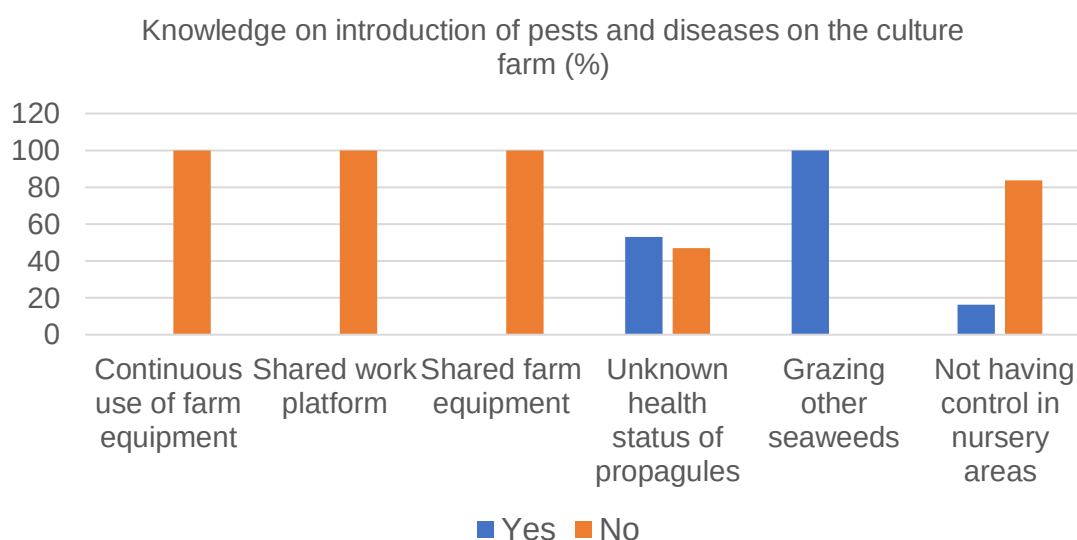


Figure 4. Knowledge on the introduction of pests and diseases on the culture farm.

It was found in Figure 4 that a higher proportion of respondents have inadequate knowledge of how those pests and diseases are introduced in their culture farms. All respondents have zero knowledge of the continuous use of farm equipment, shared work platform, and shared farm equipment can be an avenue for these risks to be introduced on the farm.

Mixed results were noted if the use of the unknown health status of propagules can be an introductory pathway in the farm since 52.96% of the respondents said yes while 47.04% disagreed on this aspect. All of them also responded that the presence of grazers could facilitate these problems, while 83.97% are not aware of the absence of control in nursery areas can be a risk to their respective farm.

The data presented indicate that despite the seaweed farmers' awareness of what type of pests and diseases are affecting their production during culture, they are unaware of how these factors are being introduced to their farms.

Knowledge about implementing biosecurity practices in seaweed aquaculture is a must because it will possibly reduce the impact of disease and pest outbreaks in the cultured commodity.

Attitude

The data below indicate the respondents' responses regarding their attitude toward External Biosecurity Practices (E.B.P.), Internal Biosecurity Practices (I.B.P.), and General Biosecurity Control Practices (GBCP) on their seaweed farms.

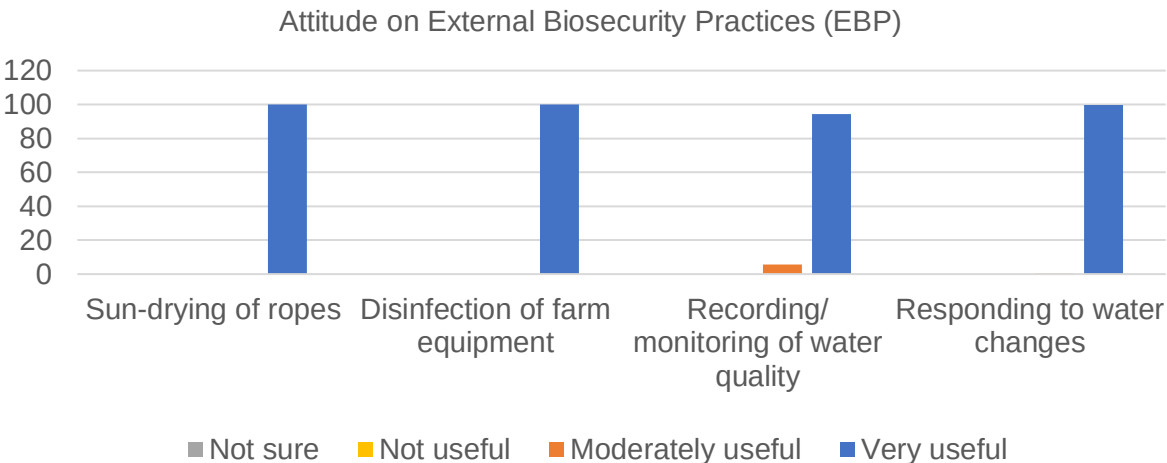


Figure 5. Attitude of respondents on External Biosecurity Practices (E.B.P.) in seaweed farming.

Results on the attitude of respondents towards external biosecurity practices became relevant as the majority of the total population in Figure 5 indicated that sun-drying of ropes (100%) used in the cultivation, disinfection of farm equipment (100%) through washing and cleaning, monitoring of water quality (94.47%), and responding to water changes (99.60%) are essential in eliminating the possible risk of pest and disease outbreaks in the farm.

These results contrasted with the related study of Kambey (2021) regarding the evaluation of biosecurity policy implementation in Malaysia, where it noted a poor attitude towards this mentioned category and its parameters.

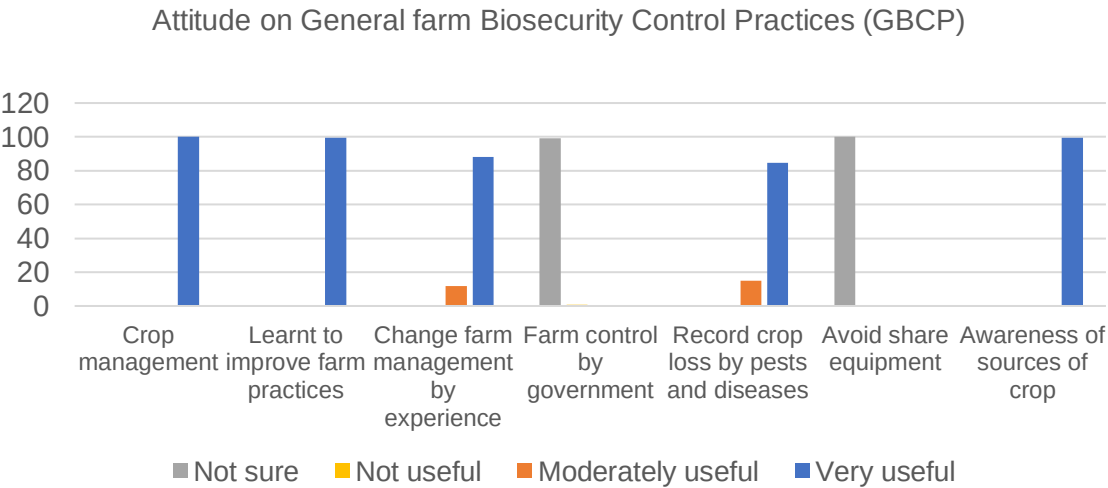


Figure 6. Attitude of respondents on Internal Biosecurity Practices (I.B.P.) in seaweed farming.

Parameters included in the attitude of respondents towards Internal Biosecurity Practices (I.B.P.) in Figure 6 showed a high level of acceptability that these factors are very useful interventions in minimizing the risk of biosecurity problems. These parameters include isolation and monitoring of new crops, prevention of disease through biosecurity, removing diseased crops, regular cleaning of farm equipment, and regular cleaning/ checking of crops that received significant remarks of 100%, 90.12%, 99.60%, 100%, and 100%, respectively.

However, 31.62% or 80 respondents said that they are not sure that reducing crop density during cultivation can reduce the risk because this is often practiced in the locality and is considered less significant.

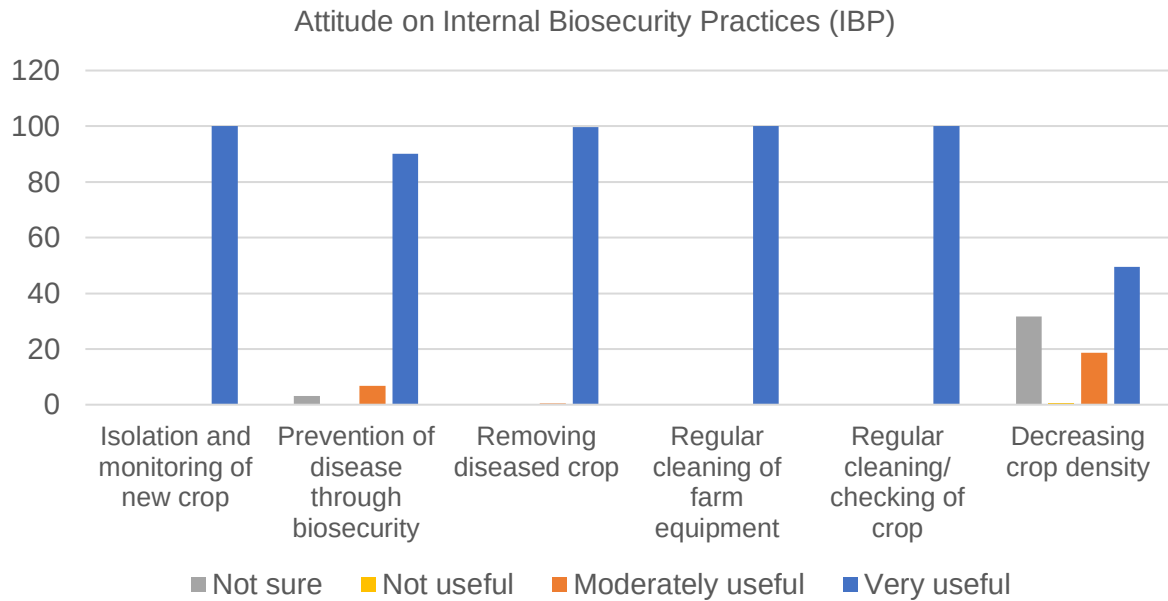


Figure 7. Responses on the Attitude of respondents on General farm Biosecurity Practices (GBCP) in seaweed farming.

General farm biosecurity control practices in various seaweed farms in Bais City, Negros Oriental indicated in Figure 7, posed a high level of Very Useful remark from the respondents that these parameters are relevant in mitigating biosecurity risks in the farm. It includes crop management (100%), improved farm practices (99.60%) and management by experience (88.14%), recording of crop loss (84.58%), and awareness of crop sources (99.60%).

However, farm control by the government and avoidance of sharing equipment constituted a high level of confusion, and respondents are not sure if these are relevant in the sector since this is generally non-existent in the locality.

With these results, the government's responsibility to assist farmers in this sector is not evident. The government should implement biosecurity measures to improve the health and quality of domesticated animals and plants, which will benefit the industry as a whole (Kambey et al., 2020). Planning and policy formulation should be included in these risk management activities, especially if they are intended to boost the seaweed industry's competitive advantage.

The implementation of national seaweed regulations, including biosecurity prevention and mitigation measures, remains weak due to the low understanding and capacity of the stakeholders

to manage agricultural hazards. Limiting the effects of pests and diseases on this valuable industry and natural capital in seaweed-farming locations will require a clear basis for developing robust international biosecurity policies related to the trade in seaweeds arising from the global aquaculture industry.

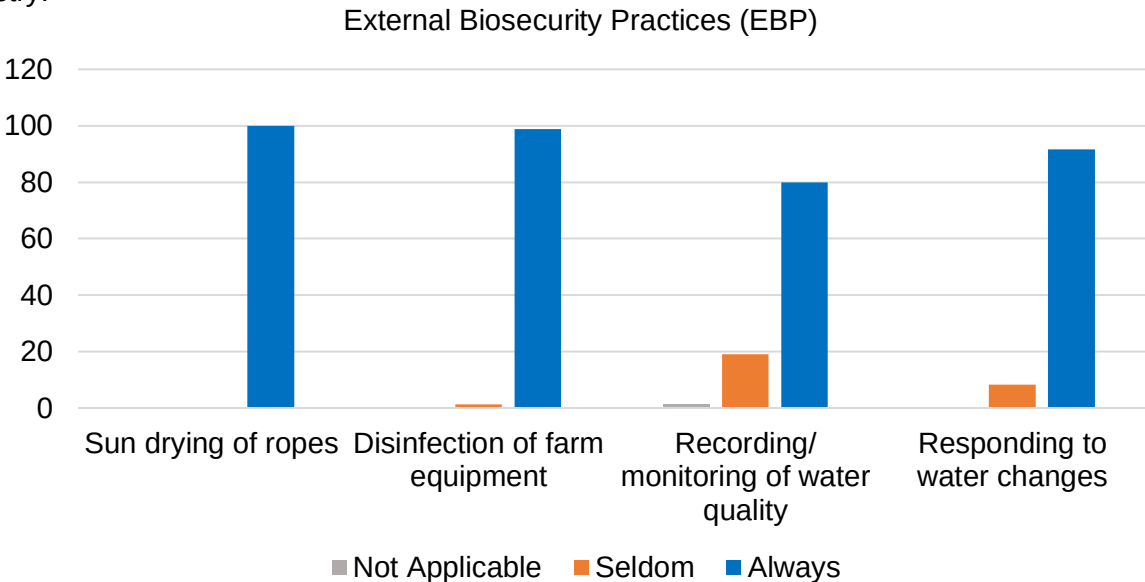


Figure 8. Responses of seaweed farmers on Practices towards External Biosecurity Practices (E.B.P.) in seaweed farming.

Practices

Seaweed farmers' responses towards External Biosecurity Practices (E.B.P.), Internal Biosecurity Practices (I.B.P.), and General Biosecurity Control Practices (GBCP) are shown in the given figures below

In the Practices category reflected in Figure 8, all of the respondents from three different coastal barangays in Bais City casually dried their used ropes after cultivation under the sun. This is done daily to eliminate all possible biofouling organisms attached to the surface and lengthen the materials' shelf-life.

Most respondents also practiced disinfection of farm equipment (98.81%) by washing it in a detergent soap, particularly the most conventional method applied in the locality. Monitoring (79.84%) and responding to water quality (91.70%) were done daily, but some of the respondents did it seldomly (18.97% and 8.30%, respectively) because their culture areas are located further in the intertidal zone where low tide is not a problem.

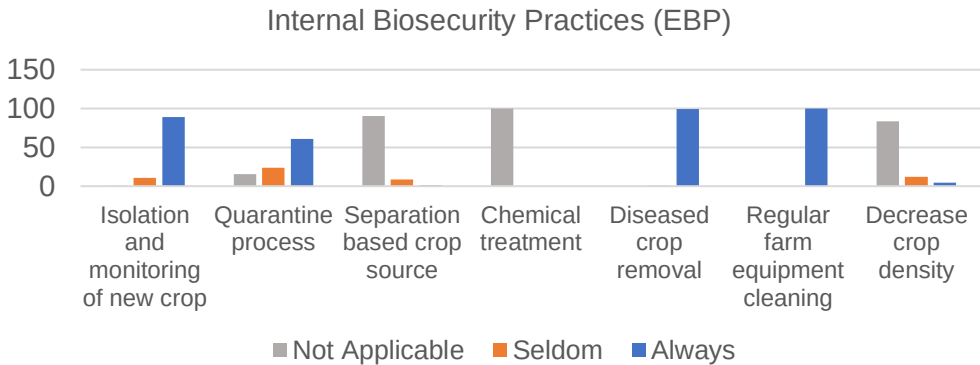


Figure 9. Responses of seaweed farmers on Practices towards Internal Biosecurity Practices (I.B.P.) in seaweed farming.

The various internal biosecurity practices in the seaweed farm are presented in Figure 9. It can be seen on the graph that isolation and monitoring of new crops are widely practiced by 88.93% of the respondents, while the quarantine process is applied daily by more than half of the respondents (60.86%) to reduce the seaweed biosecurity risk.

Conversely, the separation of crop source and chemical treatment is not applicable at 90.51% and 100%, respectively, to be applied in the culture farms because it can adversely affect the water quality and the commodity. Removal of the diseased crop (99.60%) by cutting the infected area and regular farm equipment cleaning (100%) are practiced regularly by the respondents.

Decreased crop density is not practiced by more than 80% of the farmers because it does not pose that much significance to the problem faced by the industry towards biosecurity. Because seaweed farmers tend to maximize the production in their cultivation area; hence, a crop density reduction is not necessary for the locality.

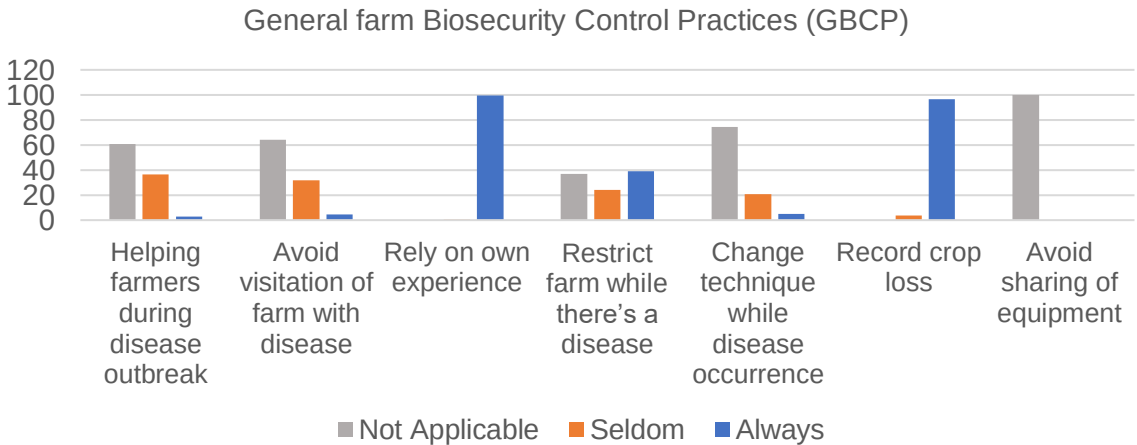


Figure 10. Responses of seaweed farmers on Practices towards General farm Biosecurity Control Practices (GBCP)

Figure 10 presents the last category of Practices regarding General farm biosecurity control practices on seaweed farms. More than half (60.87%) of the respondents revealed that they are not practicing (Not applicable) helping other farmers during disease outbreaks, while 36.36% and 2.77%

of them noted that they do it seldom and regularly. The result is comparable to the data reflected on the second parameter on avoidance in the visitation of the farm with disease showing 64.03% - Not applicable, 31.62% - Seldom, and 4.35% - Always.

Relying on their own experience (100%) and recording crop loss (96.44%) are practiced regularly by the seaweed farmers, while the majority of the respondents said that sharing of farm equipment (100%) isn't that applicable in the process since all of them have their resources for that particular venture. The rest of the parameters applied on the GBCP have constituted random results depending on the common practice implied in different barangays.

General Operational Procedure

This category shows the additional on-farm biosecurity approaches of the respondents on the general operational procedure practiced in their respective seaweed farms.

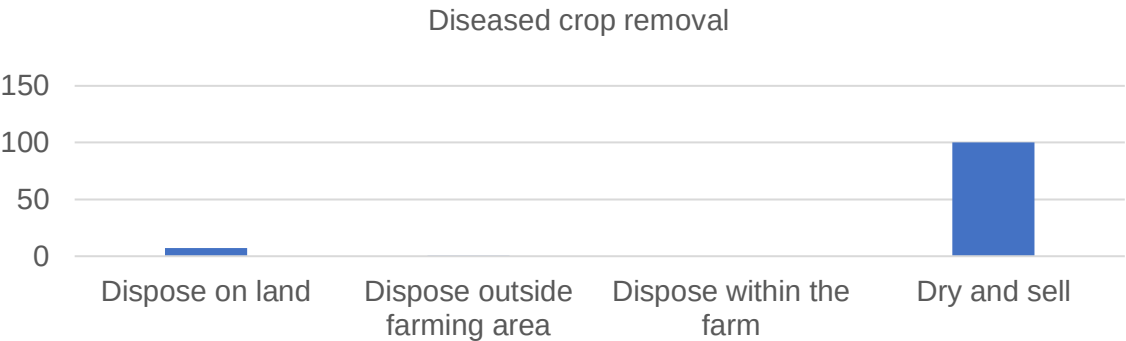


Figure 11. Seed sources of seaweed farmers in Bais City, Negros Oriental

The data presented in Table 11 reflect the different seaweed seed sources before the cultivation of the commodity.

Results showed that all of the respondents prefer to buy these resources from their fellow local farmers (100%) within the vicinity of the culture farms. A portion of them also uses their crop (26.88 %) to start the venture and is minimally applied in the area since the respondents prefer mostly the readily-available seed sources sold by other farmers. Apart from that, some of them procured their seeds provided by the government (26.48%) during calamities and other natural phenomena, but it is still minimal to address the gap in the industry.

In addition, there is no response that the respondents sourced their seeds from the trader because their presence is merely on the market chain aspect only after the commodities are harvested.

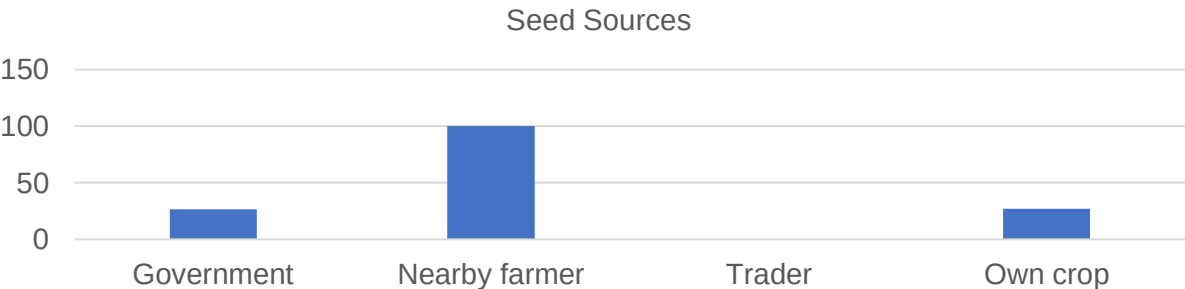


Figure 12. Different ways in the removal of diseased crop on the farm.

In practice, diseased crops are removed from the farms to minimize the spread of infection, and the parameters are reflected in Figure 12.

Most of the damaged crops caused by ice-ice disease and the presence of grazers are plucked from the plant's main stem and then dried and sold to the traders present in the locality to reduce post-harvest losses and operational costs for the farmers. It is the most common practice of all the respondents interviewed in this study. That is also practically done because if you compare the diseased crop with the ordinary one, there is no such big difference in its characteristics. The frequency of the tallied scores was much higher compared to the study by Kambey (2021).

Disposal on land and outside the farming area is seldom practiced at 7.11% and 0.40%, respectively.

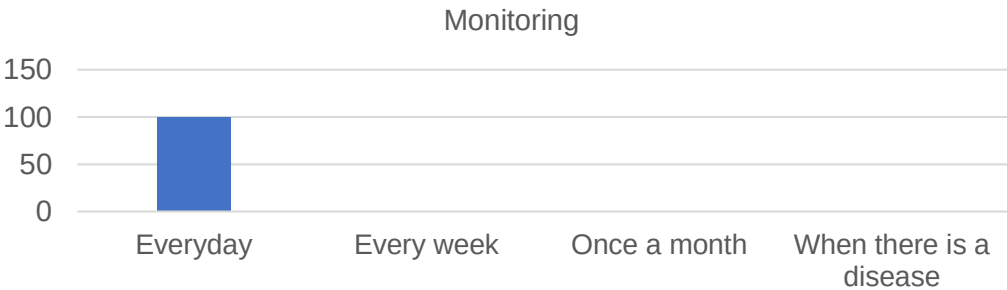


Figure 13. Different treatments applied on diseased crop on the farm.

New propagule seaweed next to old (100%), removal of old crop and use of new seeds (100%), and leaving the farm empty for quite some time (97.63) posed higher levels of respondents' response on how to treat farm after disease occurrence as shown in Figure 13.

These are the traditional techniques employed by all respondents in the study area and are comparable to the K.A.P. study conducted by Kambey in Malaysia last 2021.

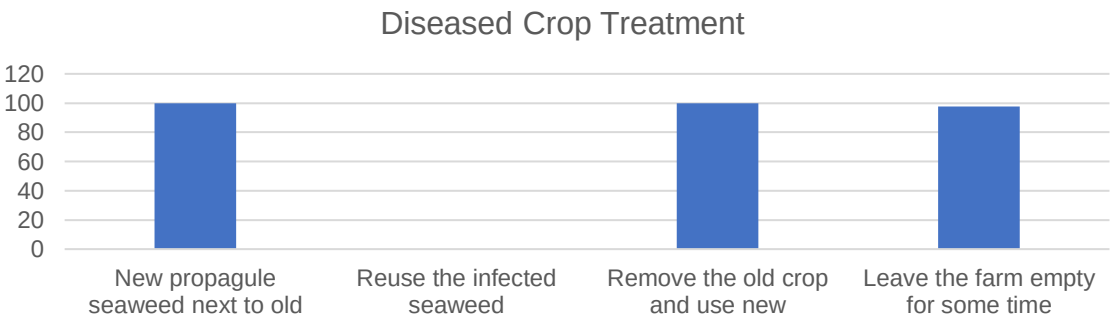


Figure 14. Monitoring frequency in seaweed farms.

Consequently, all the interviewed seaweed farmers in three locations monitor their commodities daily, as indicated in Figure 14. It is important to ensure that their cultured farms are well managed to avoid any problems or risks that may affect their production during the culture period. These include monitoring the condition of seaweed itself if there are infestations and diseases, as well as regular checking of water level to avoid overexposure of crops under the sun during low tide.

CONCLUSION

Summary

Biosecurity-related knowledge, attitude, and practices (K.A.P.) of the 253 seaweed farmers were assessed in this study to identify knowledge and viewpoint gaps of aquaculture health management among farmers in the selected top-producing coastal barangays of Bais City, Negros Oriental – Okiot, Olympia, and Tangculogan, respectively.

Analyses showed that respondents have adequate knowledge of what types of diseases and pests are present on the farm but are uncertain about how these factors are introduced. Attitude and Practices towards External, Internal, and General Biosecurity Practices showed a positive response as respondents have good perception and strategic implementation of possible solutions to biosecurity-related risks in their seaweed farms; however, government intervention and support in the industry were found to be minimal.

Conclusions

Evaluating the three seaweed-rich producing barangays in Bais City, Negros Oriental, it can be inferred that the majority of the small-scale individual farmers rely primarily on the cultivation of seaweeds, particularly the genus of *Eucheuma*, as their source of income and livelihood. Despite the thriving industry that offered many opportunities for the populace of the locale, numerous challenges like internal and external biosecurity risks still hinder its sustainable production during the cultivation process.

Assessing the Knowledge, Attitude, and Practices of farmers towards seaweed biosecurity indicates that there are still a lot of gaps to be filled to minimize the risk of unwanted diseases and pest infestations in the cultured commodity. Although most respondents have acquired the necessary knowledge on what type of diseases and pests affect their product, they are unaware of other external factors that contribute to the problem because no proper training and management measures are being introduced. It is due to less or minimal support from the government sector in providing seaweed farmers and stakeholders with necessary management intervention and policies for the industry. As a result, farmers practice traditional methods to reduce the biosecurity risks on seaweeds by relying on their own experiences observed and acquired from the farm.

Recommendations

Consequently, this study highlights in more detail the implementation gaps in policies concerning biosecurity measures at the farm level and indicates there are key areas for improvement that could help farmers and competent authorities to overcome the challenges in managing the seaweed aquaculture industry in the selected coastal barangays of Bais City, Negros Oriental.

Focus on clarity of specific instructions and procedures in policies to improve implementation of biosecurity through crop management by farmers (e.g., through programs of detection and mitigation). Conduct evidence-based experiments demonstrating the success of biosecurity measures in mitigating or minimizing biosecurity risks during farm production. Provide resource-poor farmers with incentivized programs to support consistent implementation for all small-scale individual farmers.

Support seaweed farmers by training government extension workers in seaweed-specific crop management and risks associated with the introduction of pathogens. Collaborate with local officials from the City and barangay level, down to the local fisherfolk organizations existing in every locality, to conduct an information drive so that farmers and the ordinary populace will be aware of what is

happening in the sector in scientific and research-based approaches. Cultivate other species that can be a biological control on the mentioned seaweed biosecurity risks.

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