

Seaweed aquaculture through the lens of gender: Participation, roles, pay and empowerment in Bantayan, Philippines

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ABSTRACT

Aquaculture is one of the fastest growing food-producing sectors worldwide. Of particular importance is the cultivation of seaweed, particularly in East and Southeast Asia where seaweeds dominate the production market, and are key for coastal communities both as main livelihood source and as alternative or supplementary income to fisheries. Women play a crucial role in various segments of the seaweed aquaculture value chain; yet few researchers have empirically examined the gendered impacts of women's participation in aquaculture. Using the case study of Bantayan Island, in the Philippines, the objective of this study is to deepen our understanding of the impact of women's participation in aquaculture by specifically investigating their roles, remuneration and empowerment related to the production node of seaweed aquaculture. Adopting a novel research approach, which combines the outcomes of a focus group discussion and the data collected through two questionnaires, we provide a comprehensive and robust understanding of gender issues in aquaculture. Results of the economic analysis of labour costs indicate that women constitute most of the workforce but are paid less than men; the average gender pay gap is 55.4%. Moreover, our study finds that there is a well-established gendered division of labour in seaweed aquaculture. Greater female participation is not mirrored by more women in leadership roles and decision-making power in the workplace, although participation may have a positive impact on female intrahousehold empowerment. An important contribution of our analysis is to show that gender stereotypes in aquaculture production persist and they affect roles, wages and decision-making power. Acknowledging the fundamental contribution of women in aquaculture can inform the development of gender-sensitive indicators, supporting the measurement of progress towards relevant Targets of the fifth Sustainable Development Goal ("Achieve gender equality and empower all women and girls"), therefore mainstreaming gender into resource management, and poverty alleviation

1. Introduction

Aquaculture is one of the fastest growing food-producing sectors worldwide (Garlock et al., 2020; FAO, 2018 and 2020; Stentiford et al., 2020; Anderson et al., 2017). In 2018, it accounted for 46% of all the food coming from aquatic ecosystems (FAO, 2020).¹ Within the sector, aquaculture in marine waters has grown increasingly over the past sixty years mainly in coastal areas where production represented 55.2% of global aquaculture production (Chopin and Tacon, 2021; Costello et al.,

2020; Gentry et al., 2020). Of particular relevance is the cultivation of seaweed, which accounts for more than half (51.3%) of global marine and coastal aquaculture production (FAO live weight data as reported in Chopin and Tacon, 2021). East and Southeast Asia dominate the seaweed production market, accounting for 99.5% of world seaweed production (Chopin and Tacon, 2021). The sector is crucial for coastal communities since it represents an important source of income for numerous households and provides an alternative or supplementary income to capture fisheries (Suyo et al., 2020; Hurtado, 2013;

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¹ This figure does not account for aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants (Chopin and Tacon, 2021).

Valderrama et al., 2013; Sievanen et al., 2005).

Women participate in many segments of the aquaculture value chain but their contribution is under-recognized or, in worst cases, neglected (FAO, 2020; Bosma et al., 2019; Brugere and Williams, 2017). The economic benefits generated by the growing aquaculture sector are not uniformly distributed between men and women with the latter receiving lower salaries (Kruijssen et al., 2018). Notwithstanding, the income generated by the women engaging in aquaculture activities is important for meeting daily needs, improving financial security and supplementing the household income, and it also improves their decision-making status in the household (Weeratunge et al., 2012).

Women's invisibility in aquaculture is further exacerbated by the lack of data disaggregated by gender on participation rates and division of labour (Kruijssen et al., 2018; FAO, 2020; Wabnitz et al., 2021). Likewise, not much is known about the impact that women's involvement has on their empowerment and participation in decision making. Empowerment is a multifaceted concept; most definitions focus on issues of gaining power and control over decisions and resources that determine one's quality of life (Malapit et al., 2020; Akter et al., 2017; Mosedale, 2005). From a feminist's perspective, the most widely accepted definition is adapted from Kaber's (1999) which explains women's empowerment in terms of ability to exercise their agency, and make strategic life choices that have transformatory effects by challenging the existing gender relations, the gender division of labour, and how resources are distributed. Standard indicators to capture women's empowerment such as education, employment status and income levels are only proxies of empowerment as they do not capture other meaningful and context-specific dimensions of empowerment such as decision making on access to, and control over, productive assets as well as making choices within the household (Gopal et al., 2020; Kruijssen et al., 2018; Peterman et al., 2015; Quaye et al., 2016).

The assessment of gender division of labour, pay imbalances and advancement of empowerment metrics has been identified as a research priority to achieve the Sustainable Development Goal (SDG) n. 5 "Gender Equality and Women's Empowerment" (Malapit et al., 2019; Kruijssen et al., 2018; Richardson, 2018). Consensus has yet to be reached on which indicators should be used to measure progress towards relevant SDGs as well as how they should be weighted to construct a women's empowerment index (Yount et al., 2018; Richardson, 2018).

Few studies have addressed women empowerment and decision making in the aquaculture sector, and even less have specifically tackled the gender dimension of seaweed aquaculture. In this paper we aim, therefore, to provide novel insights and evidence regarding the gender roles and power dynamics in seaweed aquaculture. We achieve this by: 1) estimating gender differences in wages in seaweed aquaculture, 2) profiling gender participation and division of labour in the different phases of seaweed production, and by 3) examining the impact that participation in seaweed aquaculture has on different domains of women's empowerment. To this aim, we use the case study of Bantayan Island in the Philippines. The Philippines is the fourth largest producer of seaweed in the world (Chopin and Tacon, 2021) and have a long tradition of women participation in aquaculture activities (Weeratunge et al., 2012). We use observational information collected through two surveys developed and administered during 2017 and 2018 in the same geographical area, the municipality of Bantayan. To our knowledge this is the first in-depth, integrated analysis of salary gap, division of labour, and empowerment in the context of gender in seaweed aquaculture.

2. Women and seaweed aquaculture

Not much is known about how the participation in the seaweed supply value chain has transformed the economic and socio-cultural status of the women. Besta (2013) used a mixed method approach (household surveys, semi-structured interviews, focus group discussions, direct participant observations, key informant interviews and case studies) to examine how women's contributions to their households

from their seaweed income affected gender relations in Tanzania. Results demonstrated that seaweed farming contributed to improve women's status through income generation. Ramirez et al. (2020) also used a mixed method approach (semi-structured interviews and focus group discussions) to investigate female roles in the value chain of seaweed in the Philippines. Their findings show that women, despite being less visible than their male counterparts, have significant involvement in production, post-harvest and in marketing segments and contribute significantly to the household income. These findings support previous work by Kronen et al. (2010) which examined the impacts of gender on seaweed farming in Solomon Island using structured questionnaires. Results indicated, in fact, that seaweed farming is a non-gender biased activity that involves women in all production and marketing activities. The study also confirmed that women benefit from increases in seaweed farming production by providing access to an alternative source of income for the household. Suyo et al. (2020) targeted the same geographical area in the Philippines as Ramirez et al. (2020) to investigate, through data collected via questionnaire and analysed using Social Network Analysis, the gendered relations in seaweed farming production. They found that socio-cultural norms shaped farmer's perceptions of activities, thus influencing a gender stereotyped division of tasks in seaweed farming.

3. Materials and methods

3.1. Study area and seaweed aquaculture

The Municipality of Bantayan is located in the northern portion of the Province of Cebu in Central Visayas, Philippines (Fig. 1). It is one of three municipalities that make up Bantayan Island, in Northern Cebu Province. With a total land area of 79.3 km² and population of 86,247,² the Municipality of Bantayan is the largest of the three municipalities, accounting for 58% of the land area of the island. This includes 16 islands and islets with an estimated coastline of 44.5 km. It is a 1st class municipality, according to the income classification of municipalities.³ Fishing is the predominant economic activity of the inhabitants with land farming (poultry) as the second major source of income. Fish processing is also an important economic activity in the island which is a major supplier not only of fresh fish products but also of processed fish products for human consumption such as *ginamos* (salted fish) and *buwad* (dried fish) as well as of fish meal.

Seaweed is farmed at different locations in Bantayan and in the province of Cebu, mainly for production of carrageenan (a gelling, thickening agent adopted in food and non-food applications). The average volume of seaweed produced in the Province of Cebu in 2019 was 9873 metric tons - second only to Bohol - with a total sale value of 78,459 PHP (USD⁴ 1514) (Philippine Statistics Authority, 2020). Seaweed aquaculture is considered a regulated activity within municipal waters with technical support and extension services from national government agencies like the Department of Agriculture's Bureau of Fisheries and Aquatic Resources (BFAR).

The technology involved in seaweed farming for culturing the two main species - *Kappaphycus* and *Eucheuma* - is simple and consists of either fixed-off-bottom or single floating rafts (see Fig. 2) (Hayashi et al., 2017). Cuttings of seaweed (seedlings) are attached to a cultivation line

² As of 1st of May 2021.

³ Municipalities in the Philippines are divided into six main classes according to the average annual income measured during the last four calendar years immediately preceding the general classification, as stated in the Executive Order No. 249, s. 1987 of the Official Gazette of the Republic of the Philippines. The 1st Class is placed highest in the ranking with an average annual income of at least 55 million PHP, while the 6th Class is the lowest placed in the ranking with an average annual income below 15 million PHP.

⁴ Average exchange rate in 2019: 1 PHP = 0.0193 USD.

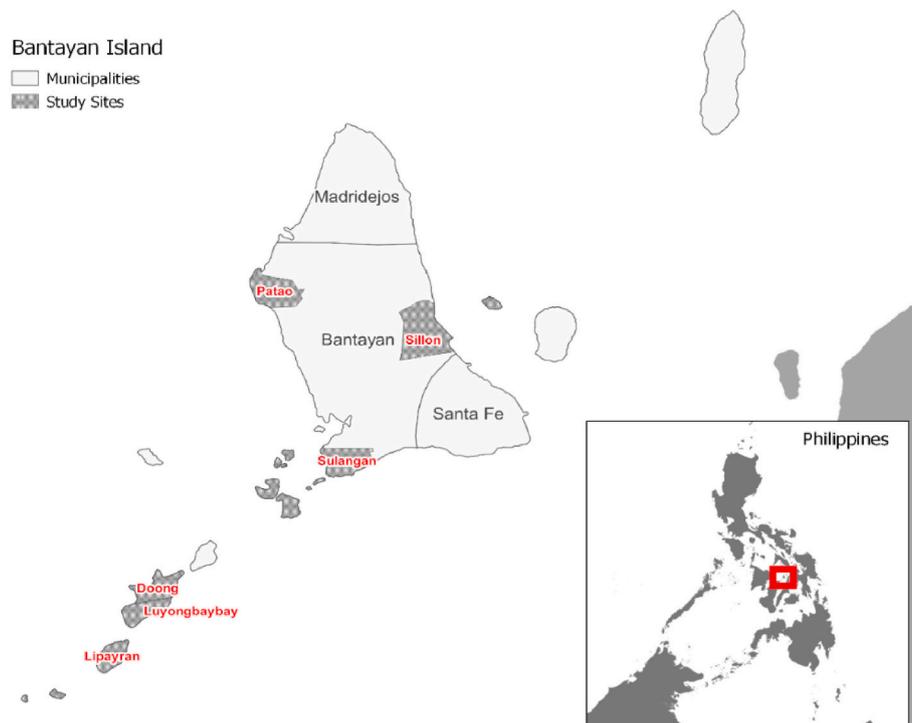


Fig. 1. Map showing the three municipalities of Bantayan Island, and the study sites (barangays) within Bantayan Municipality highlighted in dark grey and red font. Inset map shows location within the Philippines. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)



Fig. 2. Cultivation of *Kappaphycus* sp. ('cottonii') in Bantayan.

(e.g., polyethylene rope) with soft plastic strips (tie-tie), at approximately 30–40 cm apart along the line (Yap, 1999). The line is then stretched across two wooden stakes (inserted in the sea floor) or suspended in the water column by using polystyrene foam floats. The first harvest can be obtained in 2–3 months from when the line was deployed (Yap, 1999). In deeper waters, during high tide, the farmers use a paddle or non-motorised boat to reach and tend the farm, as well as to bring the seaweed ashore once harvested. The post-harvesting stage (seaweed treatment and management of supply chain) is a key phase in determining the quantity and quality of the carrageenan in the seaweed biomass. Most farmers are still adopting traditional methods such as platform drying and hanging of harvested seaweed to reduce their moisture content before selling the harvested biomass (Ali et al., 2017).

3.2. Survey description, data, and empirical approach

As part of a Newton Institutional Links project running between 2016 and 2019, two survey questionnaires were administered in Bantayan. The first questionnaire - *Questionnaire 1* - was administered during October and November 2017 and aimed at collecting information on

seaweed aquaculture production focusing on seaweed farm owners. Data were collected through face-to-face interviews in six barangays⁵ (Doong, Luyongbaybay, Lipayran, Patao, Sillon, and Sulangan) within the Bantayan municipality (Fig. 1). The sampling frame obtained through the seaweed farming associations' member lists comprised a total of 711 farm owners. A stratified random sampling design was used to select a representative sample of 300 farm owners. A total of 262 farm owners were interviewed, with a response rate of 87.3%. The sample was stratified based on farm owners' gender and farms' location (Table 1). After checking for inconsistencies, 19 observations were removed from the dataset, thus the final sample consisted of 243 observations.

The questionnaire focused on collecting data on farm structure and

⁵ A barangay is the smallest political subdivision in the country, several of which comprise one city or municipality.

Table 1
Sample characteristics – *Questionnaire 1* - by Bantayan Island barangay and farm owners' gender.

	Sampling frame		Sample	
	Male	Female	Male	Female
Doong	202	40	84	16
Luyongbaybay	81	14	35	6
Lipayran	23	41	10	17
Patao	28	28	12	12
Sillon	47	20	20	8
Sulangan	131	56	56	24
Total	512	199	217	83

size, farming techniques, main species cultivated during the high season,⁶ employment type, costs of seaweed production including employment costs by gender, and revenues from seaweed farming during a typical high season farming cycle. The data collected in *Questionnaire 1* are used in this research to explore gender differences in seaweed farming participation and wages.

The second questionnaire - *Questionnaire 2* - was specifically designed to explore more in-depth gender roles and power dynamics in seaweed aquaculture. The development of a gender focused research stream to explore the factors shaping gender relations and empowerment in aquaculture was prompted by the analysis of the data collected through the first questionnaire (see Section 3.1) as well as the information collected through a focus group discussion (FGD) which was organised during a field visit in one of the six study sites. The FGD took place in Lipayran in September 2017 to capture views and perceptions of women involved in seaweed farming in Lipayran regarding barriers, limitations and challenges of working in seaweed cultivation, and whether this activity has impacted their decision-making power within the household as well as in their daily activities related to seaweed production. *Questionnaire 2* was administered in September 2018 face to face to a sample of 310 seaweed farmers in three of the six locations surveyed in *Questionnaire 1* (Doong, Luyongbaybay and Lipayran) (Fig. 1). The sample is made up of farmers that were recruited by the research team based on their willingness to take part to our research. Observations in *Questionnaire 2* are not linked to observations in *Questionnaire 1* since, in the case of the former, the target audience was not restricted to seaweed farm owners, but we aimed at collecting responses from seaweed farms employees as well. The three sites surveyed were chosen due to the higher density of seaweed farms according to the farm associations member lists.

In *Questionnaire 2*, men and women's empowerment was measured using five decision-making power indicators linked to the workplace and the household (Fig. 3).

For the working domain, we adapted three indicators of instrumental agency from the Women's Empowerment in Agriculture Index (WEAI) (Alkire et al., 2013) describing respondents' ability to make decisions regarding production and control over use of income (Malapit et al., 2019). Specifically, the indicators we were interested in included influence over seaweed farm preparation and inputs or materials to buy and influence over use of income generated through seaweed production. The advantage of the WEAI is that it can be tailored around country specific productive activities which are important to gender and agriculture (e.g., seaweed culture) to inform policymakers, development organizations, and researchers on progress in gender equality (Alkire et al., 2013; Sraboni et al., 2014). For the household domain, we adapted two indicators from the Women's Empowerment section of the Demographic Health Survey (DHS) (Kishor and Subaiya, 2008). The DHS collects nationally representative data on healthcare and nutrition in

⁶ High season is considered the six-month period that starts in March and ends in August, whereas the low season is considered the six-month period that starts in September and ends in February.

low- and middle-income countries since 1985 and uses decision-making power at the household level to measure women's empowerment (Jones et al., 2020). The indicators used in this research associated with household decisions aim at capture respondents' ability to make health care decisions and ability to purchase items for the household. *Questionnaire 2* also included socio-demographic and farming activities-related questions.

Indicators of decision-making power were measured on a 5-point Likert scale to which a sixth option "Don't know" was also added. Respondents were asked to firstly rate their "actual/real" level of influence (No influence, Influence in very few decisions, Influence in some decisions, Influence in most decisions, Influence in all decisions) on each of the items related to inputs in productive decisions and control over income in the working domain. Then, respondents were asked to rate their experience on each of the items associated with intra-household decision making power in terms of frequency (Never, Rarely, Sometimes, Often, Always) of input in decisions related to healthcare and domestic expenditures. Our aim is to examine if and how socio-demographic and farming related factors impact the level of decision-making power, with a particular interest to gender differences. Because decision-making indicators are likely to be interdependent on the individual characteristics within respondents and to account for the ordinal nature of those indicators, our empirical approach to the analysis of *Questionnaire 2* information relies on the estimation of a seemingly unrelated ordered probit model.⁷ Our model consists of five simultaneous equations, one for each decision-making indicator, with multivariate normally distributed and correlated error terms at the individual respondent level:

$$y_{ki}^* = \beta_k x_{ki} + \varepsilon_{ki}$$

$$E(\varepsilon_{ki}) = 0, \text{Var}(\varepsilon_{ki}) = 1, \text{Corr}(\varepsilon_{ki}, \varepsilon_{vi}) = \rho_{kv}$$

where y_{ki}^* are unobserved latent variables of decision-making power that are observed for respondent i as the five ordered indicators (for $k = 1, \dots, 5$), β_k are the model parameters to be estimated and measuring the corresponding effect of socio-demographic and farming-related characteristics x_{ki} on decision-making power, and ε_{ki} are the correlated error terms. The x_{ki} independent variables included the main variables of interest, that is socio-demographic characteristics such as gender, age, education, income, and farm-related characteristics such as farm ownership, female farm ownership, group membership and years of experience (Table 2). The choice of this set of independent variables was guided by the research objective and a review of previous studies. The main socio-demographic variable of interest for our analysis was the gender of seaweed farmers in terms of the potential differences in decision making empowerment between females and males. The other farm-related and socio-demographic independent variables were used both as influencing empowerment and as control variables. We tested the inclusion of additional socio-demographic characteristics (marital status, household members, children in the household), but their addition did not provide improved statistical fit or enhanced results interpretation.

4. Findings

4.1. Nature of employment and wages in seaweed farming

Table 3 shows employment and wages in the seaweed farming sector in the areas under investigation as sampled in *Questionnaire 1* (2017). Each farm operator employed an average of 4.2 workers (male and female) with an average salary of 192.2 PHP (USD⁸ 3.82) per hour.

⁷ The models were estimated using the command `cmp` (Roodman, 2011) in Stata 16.1 (StataCorp., 2019).

⁸ Average exchange rate in 2017: 1 PHP = 0.0199 USD.



Fig. 3. Sources used in this work to investigate empowerment in aquaculture.

Table 2
Independent variables included in our model accompanied by a short description.

Independent variable	Description
Female	Gender of respondent and main parameter of interest. Dichotomous, coded as 1 if gender of respondent was female and 0 if gender of respondent was male.
Age	Age of respondent in years.
Education	A dichotomous variable was used to control for two status types: low education level (elementary school) coded as 0, and higher education level (secondary school or higher) coded as 1.
Income	The income effects are captured through a dichotomous variable for status type: low income coded as 0, and high income coded as 1.
Farm ownership	The farm ownership variable is accounted for using a dichotomous variable for two status types: employee coded as 0, and owner coded as 1.
Female farm ownership	The interaction between female respondents and ownership of the farm (Female X Farm ownership) was considered to examine if ownership of the asset has a positive effect on shaping power relations.
Group Membership	Membership to either a seaweed or fishing organisation. A dichotomous variable was used and coded as 1 if the respondent stated to be a member of a farming or fishing cooperative, and 0 otherwise.
Farming experience	Experience of respondent in seaweed farming in years.

Table 3
Average hourly pay and average number of workers in the seaweed farming sector in the areas under investigation in *Questionnaire 1* by gender and for the total (female & male) workers.

	Average pay per worker (PHP/h)	Average number of workers
Females	135.8 (110.3)	3.4 (3.8)
Males	304.3 (287.0)	1.9 (1.0)
Total (female & male)	192.2 (167.3)	4.2 (3.9)

Note: Standard deviations in parentheses.
Note: Calculations are based on employment data provided by farm owners.

Gender-disaggregated data show women employed in day-by-day activities constituted the majority of workforce. Regardless, the average pay that women received from working in the farm, 135.8 PHP (USD 2.70) per hour, was considerably and significantly lower than the average pay of male workers, 304.3 PHP (USD 6.00) per hour ($t(51) = 4.18, p < 0.01$). This translates into an average gender pay gap - expressed in hourly pay as a percentage of men's pay - as across the six barangays equal to 55.4%. In other words, men earned more than twice the average hourly pay of women.

Most farm owners interviewed (68%) relied only on informal family labour, indicating that seaweed farming is a family venture. Seaweed farming was indeed commonly reported to be a family affair (Ramirez et al., 2020; Msuya and Hurtado, 2017; Kronen et al., 2010). Further analysis, presented in Table 4, was carried out to compare family only versus non only family labour input into seaweed production, by gender

Table 4
Comparison between employment and hourly wages in farms solely using family input versus farms not solely using family input, derived from *Questionnaire 1*. Data are shown by gender and by total (female & male) workers.

	Only family		Not only family	
	Average pay per worker (PHP/h)	Number of workers	Average pay per worker (PHP/h)	Number of workers
Females	136.8 (118.7)	3.6 (4.0)	132.5 (78.0)	2.9 (3.2)
Males	254.3 (207.0)	1.9 (1.0)	397.9 (383.4)	1.9 (1.0)
Total (female & male)	160.3 (145.8)	4.6 (4.1)	262.7 (191.5)	3.7 (3.4)

Note: Standard deviations in parentheses.

of the labour force.

Results show that the average number of women engaged in seaweed production was higher than the average number of men, either in farms which relied entirely on family labour or in farms which did not solely rely on family workers. However, female input was slightly higher - 3.6 female workers, on average, per farm - in farm operations with only family workers, than in farms where labour was also supplied by workers outside the family circle - 2.9 female workers, on average, per farm. This may not be surprising given that employment in aquaculture, and in particular female employment, tends to be informal (ILO, 2021; Kruijssen et al., 2018; Elson, 1999). Notwithstanding, data show that female workers were always and significantly paid less than male workers both in those seaweed farm operations relying solely on family contributions ($t(37) = 3.58, p < 0.001$) and in farms with owners also employing workforce outside the family circle ($t(37) = 2.67, p < 0.01$). In case of family-only supplied labour men earned 45.4% more than women, while in case of salaried work in seaweed farms which used family as well as non-family inputs men were paid 66.7% more than women.

These findings show that female participation in seaweed production is considerable, but women and men do not receive equal remuneration; women earn less than men on average irrespective of working in a family business context or working outside a family-owned business. This suggests that women contribution is overlooked and that gender power relations are unbalanced in the context of seaweed farming activities.

Power dynamics, at work and in the household, are not solely shaped by economic returns; there are other interconnected factors at play (i.e. access to or control over productive resources and/or personal decisions, different occupations, social context, geographic locations, cultural norms, etc.) (Kruijssen et al., 2018; Richardson, 2018) which may prevent women from benefiting equitably from their participation in seaweed production. These factors were investigated through the administration of a second questionnaire and results are presented in the next sections.

4.2. Profiling gender participation in aquaculture and impact on empowerment

Table 5 reports socio-demographic characteristics of the sample from *Questionnaire 2*. The mean age of the farmers interviewed was 40 years.

Table 5
Socio-demographic and farm related characteristics of the sample, by gender, from Questionnaire 2.

Variables		Total (N = 310)	Male (N = 124, 40%)	Female (N = 186, 60%)
Age group (over 18) (%)	30 years old or less	29.7	33.9	26.9
	Between 31 and 50 years old	46.4	42	49.5
	51 years old or more	23.9	24.2	23.7
Education (%)	Primary	50.7	47.6	52.7
	Secondary/post-secondary	49.3	52.4	47.3
Monthly Income (%)	Low: PHP 2000–7889	74.5	66.9	79.6
	High: PHP 7890 – 15,780	25.5	33.1	20.4
Marital Status(%)	Single, widowed, annulled, separated	16.1	16.1	16.1
	Married, common law	83.9	83.9	83.9
Household number (%)	1 to 3	20.9	21	20.6
	4 or 5	44.1	46.8	42.4
	6 or more	35	32.2	37.0
Person(s) in household under 18 (%)	None	15.1	17.7	13.4
	1 to 3	61	62.1	60.2
Group Membership (%)	Yes	56.8	54.8	58.1
	No	43.2	45.2	41.9
Farming experience (mean years)		12.5	11.7	13.0

Half of female respondents fell in the “middle” age range of 31–50 years; slightly fewer male respondents (42%) fell under this age range. Results indicate no substantial gender differences in educational achievements; among female and male respondents, 47% and 52% were educated at secondary level (or higher). Similarly, the great majority of respondents, both males or females, were either married or in a common law partnership and lived in a household composed of 4–5 people with the number of children under 18 years of age falling between 1 and 3. Notably, more women (80%) than men (67%) were in the lower-income household class.

The average number of years of farming experience (Table 5) was very similar across the female and male sample (13 years and almost 12 years, respectively), with the observed difference not being statistically significant. It can be observed from Table 5 that, in terms of social capital, the percentage of women who stated to be member of farming or fishing organizations was marginally higher (58.1%) than in the case of men (54.8%), although this difference was also not statistically significant ($p > 0.05$). Concerning the asset ownership, there was a statistically significant association between gender and job type ($\chi^2 = 44.3$; $d. f. = 1$; $p < 0.01$). Fig. 4 shows that half of the men interviewed were farm owners; by contrast, a significantly lower number of female respondents, 14.8%, were owners of the asset. On the contrary, a considerably higher number of women, 85.2%, were workers in the seaweed farms.

Despite similarities in terms of years of farming experience, significant differences emerged between male-female distribution of hours allocated to different activities during the preparation phase. Fig. 5 shows that women spent overall more time (9 h on average) during the preparation phase of the farm ($t(307) = -1.73$, $p < 0.1$) than during either the growing or harvesting phases. Generally speaking, when looking at how respondents spread their effort across production phases in Fig. 5, it appears that both men and women distribute their time quite homogeneously but, on average, men worked more hours than women. The great and statistically significant majority of women (83%; Fig. 6) identified their co-workers to be of the same sex ($\chi^2 = 4.6$; $d. f. = 1$; $p < 0.05$). Greater and statistically significant differences associated with contribution of women in preparing the farm is confirmed as well by the male interviewees ($\chi^2 = 9.1$; $d. f. = 1$; $p < 0.01$), who elicited in fact that

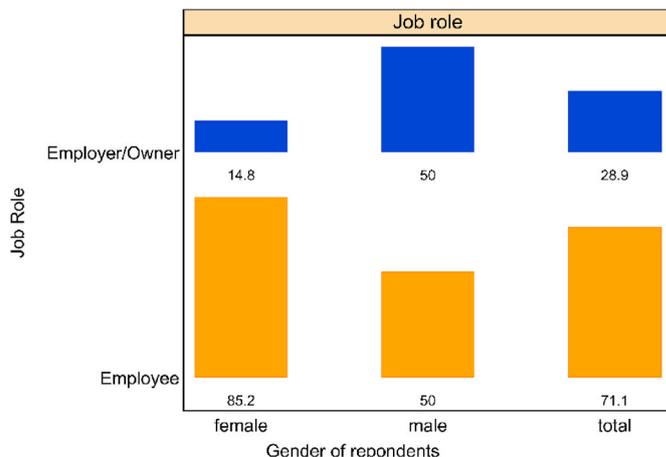


Fig. 4. Gender division of labour by job role (%).

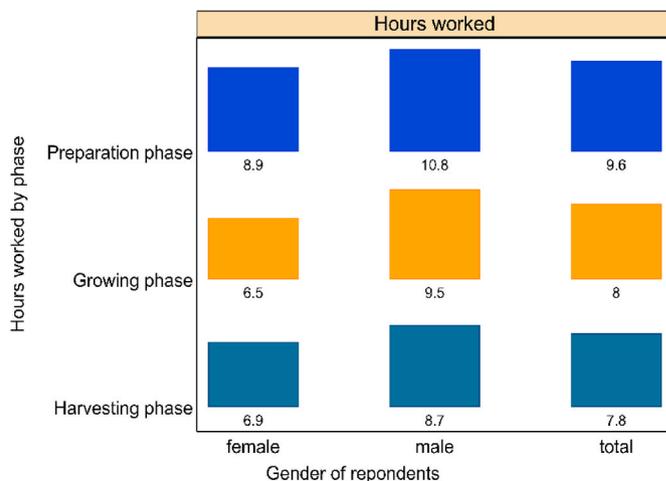


Fig. 5. Mean hours worked by phase (preparation, growing and harvesting) for females, males, and both genders combined.

they work mostly with women at the initial stages of the seaweed farming production cycle (Fig. 6). Conversely, the great majority of both male and female respondents in our sample stated to work mainly with male co-workers during the maintenance and harvesting phases of the farming production cycle than during the preparation phase (Fig. 6). However, in this case there is no statistically significant association between gender and the distribution of co-workers during the maintenance and harvesting phases of seaweed production cycle.

Table 6 reports the model coefficients estimated from the seemingly unrelated ordered probit model. The coefficients capture the effect of the independent variables on the likelihood of holding higher decision-making power in both the working domain (columns 1 to 3) and household domain (columns 4 and 5).

The statistically significant correlations between the error terms support the choice of a seemingly unrelated estimation approach. Correlations are found to be significant both within and between the decision-making spheres explored. Gender was a significant determinant of female workers’ empowerment, and also the variable of key importance in our model, having a statistically significant effect on all 5 indicators (sub-domains) of decision-making power, within both the working and household domains. Importantly, the contrast between the signs of the coefficients of the sub-domains under consideration for the working and household domains should be noted. The negative sign on the coefficients associated with decision making power at work in relation to the gender of the respondent indicates that women were less

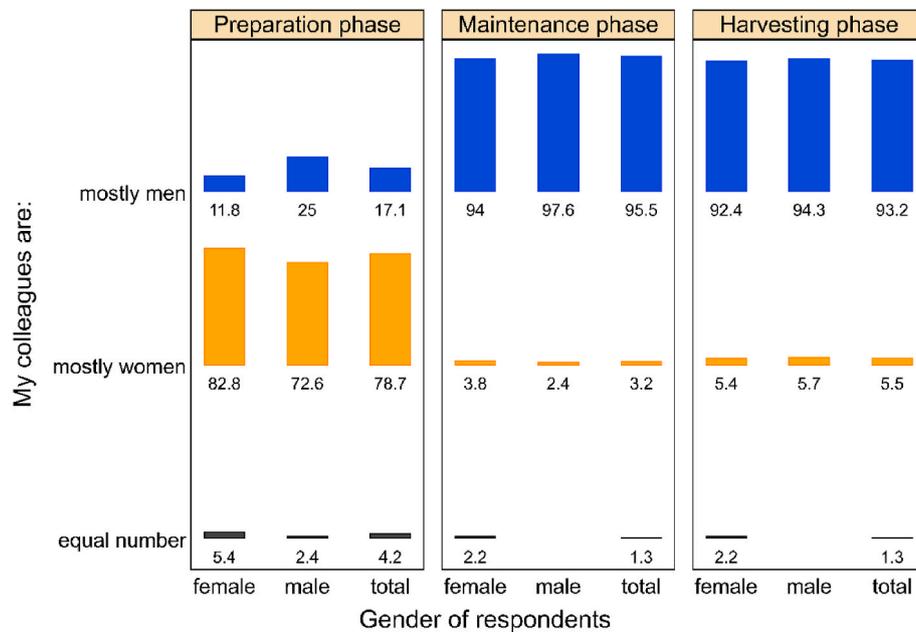


Fig. 6. Gender of co-workers (%) during different stages of seaweed production (preparation, growing and harvesting) for females, males, and both genders combined.

Table 6

Model coefficients estimated from the seemingly unrelated ordered probit model describing the effects of 8 independent variables on 5 correlated indicators for decision-making power: (1) preparation, (2) materials purchase, (3) income from seaweed farming, (4) healthcare, (5) household expenditures.

	(1) Preparation	(2) Materials purchase	(3) Income seaweed farming	(4) Healthcare	(5) Household expenditures
Female	-0.546*** (0.170)	-0.335* (0.172)	-0.304* (0.172)	0.521** (0.174)	0.653*** (0.172)
Age	-0.001 (0.005)	0.003 (0.005)	-0.006 (0.005)	0.005 (0.005)	0.009 (0.005)
Higher education	0.054 (0.138)	0.215 (0.140)	0.045 (0.138)	-0.118 (0.141)	-0.071 (0.139)
Income level	0.150 (0.148)	0.048 (0.149)	-0.131 (0.148)	0.192 (0.156)	0.094 (0.154)
Farm ownership	0.851*** (0.208)	1.176*** (0.213)	0.709*** (0.206)	-0.029 (0.207)	-0.378* (0.204)
Female farm ownership	-0.309 (0.300)	-0.712** (0.303)	-0.141 (0.299)	-0.191 (0.310)	0.261 (0.311)
Years of experience	0.024** (0.009)	0.019** (0.009)	0.026** (0.009)	-0.019** (0.009)	-0.012 (0.009)
Group membership	0.442*** (0.134)	0.355*** (0.136)	0.340*** (0.135)	0.288** (0.137)	0.255* (0.136)
Error terms correlations					
P ₁₂	0.87*** (0.02)				
P ₁₃	0.76*** (0.03)				
P ₁₄	-0.06 (0.07)				
P ₁₅	0.06 (0.07)				
P ₂₃	0.79*** (0.03)				
P ₂₄	-0.09 (0.07)				
P ₂₅	0.07 (0.02)				
P ₃₄	-0.08 (0.07)				
P ₃₅	0.20*** (0.07)				
P ₄₅	0.59*** (0.05)				
Seemingly unrelated model					
Observations	305				
Log-likelihood	-1689.37				
Single ordered probit equations					
Observations	300	299	299	305	303
Log-likelihood	-412.41	-394.99	-424.69	-361.70	-378.77

Note: Standard errors in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels respectively.

likely than men to make decisions regarding seaweed aquaculture production, from preparation to materials to buy (e.g., tools, equipment, raw materials) as well as how to use seaweed farming income. Conversely, the sign of both coefficients linked to intra-household decision making power in relation to gender was positive, suggesting that women were more likely to have greater influence over household decisions than men. Our results might also support the idea that female engagement in seaweed farming, whether formal or informal, can have a positive impact on women' autonomy regarding healthcare decisions and household expenditures. Findings from a study published by

Rahman and Naoroze (2007) suggest that empowerment status of women, including family decision making, is positively associated with participation in aquaculture activities. On the other hand, this result is likely to be explained by the persistence, in the context of the family, of stereotyped role models assigned to men and women, where the latter are perceived to be decision makers for domestic life matters such as budgeting and health and wellbeing of family members.

It was assumed that asset ownership is a key element impacting decision-making and, unsurprisingly, ownership of the seaweed farm was significantly and positively associated with the authority over

business production decisions. On the contrary, farm ownership was mildly but negatively associated with control over household expenditures patterns. We found, however, a negative association between being a female seaweed farm owner and all sub-domains of decision-making power associated with seaweed production, although it was statistically significant and negative only in the case of the ability of female owners to make decisions over the materials to purchase for the seaweed farm, such as ropes, nets, strings etc. Hence, the ownership of the productive asset did not directly translate in higher female capacity to make business related decision, as it could be assumed. The coefficients associated with the effect of years of farming experience of respondents on decision making power were, as expected, positive and statistically significant in relation to farm production related decisions. On the contrary, years of work experience was an indicator strongly, but negatively, associated with autonomy in healthcare decisions making (Table 6). Membership in local organizations, either seaweed farming or fisheries associations, was positive and significant in influencing decisions related to farming activities. Similarly, membership was significantly (but less strongly) associated with intra-household decision making power (Table 6). In the context of our study, the findings in Table 5 suggest that sociodemographic variables (income, age and education) were not significant predictors of decision-making power, either in seaweed production or within the family.

5. Discussion

Marine aquaculture provides an alternative livelihood source for many small coastal rural areas which have historically relied on fisheries as an important source of both food and income (FAO, 2020). In the developing countries of East and Southeast Asia, seaweed aquaculture has proved to be an activity which not only has substantially contributed to uplift the socio-economic status of coastal communities but has also provided an opportunity for women to be active in the labour force and contribute to the household earnings (Malapit et al., 2020; Kruijssen et al., 2018). With the present work our objectives were multiple. We firstly aimed to assess gendered impacts of aquaculture participation on wages. Secondly, we profiled gender participation in seaweed aquaculture production, and finally we investigated the impact this sector has on empowerment dynamics at farm operations level and within the household using primary data collected in the Philippines, our case study area.

The seaweed production analysis carried out through *Questionnaire 1* indicates, similarly with what was claimed by Ramirez et al. (2020) and Msuya and Hurtado (2017), that seaweed farming in the Philippines is predominantly a small scale and family business. From the gender analysis of the employment it emerged that, on average, female participation into seaweed aquaculture production is larger than male participation, especially in case of family-operated farms. Our findings show that when women labourers are salaried they receive smaller returns from aquaculture than men, which substantiates previous findings (Kruijssen et al., 2018). The comparison between *family-only* versus *non-family-only* paid work in seaweed aquaculture production indicates that salaried family-only male workers earn 1.8 times more than female workers, whereas in farms where salaried labour inputs are not provided solely by family members, men's retribution is three times higher than that of female workers.

These findings prompted further investigation into what factors other than wages can help to better understand gender power dynamics at work and within the household in the context of the seaweed aquaculture production in the Philippines. The analysis of the data collected through *Questionnaire 2* highlighted that farms are mostly men-managed whilst women engaged in seaweed farming are predominantly employees. Predominance of male ownership is corroborated by the results of similar studies carried out in other countries in South-East Asia. In Vietnam, for instance, only 2–3% of farms are owned by women (Velu et al., 2009). This could explain the negative relationship between male

ownership and their ability to influence intra-household expenditures decisions. Men may in fact spend more time in economic activities away from home, which translates in having less influence within the household (Weeratunge et al., 2010). Previous findings from literature (Weeratunge et al., 2012) highlight that in the Philippines less rigid socio-cultural norms favoured a more flexible gender division of labour. Our results show, on the contrary, that aquaculture male workers in Bantayan distribute their time across the different stages more homogeneously as opposed to women, which allocate their time prevalently to the preparatory phase of the seaweed farm (sorting, cutting, and tying seaweed planting materials to the rope lines), echoing the findings of Hurtado (2013). Much less time on average is spent by women working during the plants' growing and harvesting phases. Such results are coherent with Ramirez et al. (2020) and Malapit et al. (2020) who argue that the preparatory tasks of a seaweed farm are home based and hence leave the time for the domestic chores and childcare. It can also be hypothesised, in agreement with Hurtado (2013), Roxas et al. (2017), Malapit et al. (2020) and Suyo et al. (2020), that certain tasks demand for more straining physical work (e.g., diving to attach seaweed lines to stakes) and hence are considered more suited for men whereas activities carried out during the preparation phase require more patience and meticulous attention and hence are perceived to be more suitable for women. As claimed by Malapit et al. (2020) this is due to gender stereotypes about appropriate work, founded on perceptions about different physical abilities.

Our model estimates of the determinants of empowerment indicate that women involved in seaweed farming in the Philippines are empowered in decision making regarding healthcare and household expenditures, which is also substantiated by previous findings in literature (Aker et al., 2017). We find indeed that the coefficients of both dependent variables associated with intra-household decision making power—autonomy in deciding on healthcare and expenditures (i.e., food, clothing and leisure) are statistically significant and positive. It could be inferred that participation in aquaculture production (either formally or informally) contributes to strengthen women's agency in household decision-making processes. However, our sample did not include a non-working women group (control group) since it was outside the scope of this study, thus it is not possible to directly associate work and decision-making agency. As above, this result is likely to be linked to rooted gender sociocultural stereotypes that have traditionally portrayed men as breadwinner and women as homemakers (Rudman et al., 2012). Conversely, women's participation in farming activities does not translate in increased empowerment regarding the productive asset and the income it generates. Greater female participation during the farm preparation stage does not appear sufficient to enable women in our sample to exert authority over decisions regarding the preparation of the farm. According to Hurtado (2013) women participation in the decision-making processes regarding farming activities is mostly of consultative type.

Asset ownership as a means to accumulate wealth, can lead to increased empowerment and wellbeing (Deere and Doss, 2006). Our results suggest, conversely, that female farm ownership does not enable women to decide on resources to buy for the farm. The negative coefficient associated with female ownership of the asset and all spheres related to decision making power in the farm may be explained by the findings of Nagothu and Ortiz (2006) who observe that in some farms in the Philippines licenses were registered in the name of women, but they were in reality operated and managed by men. This is also consistent with the negative and statistically significant coefficient associated with the gender variable and the power to make decisions regarding the income generated through seaweed farming. It is nonetheless important to note that since a considerable number of seaweed farms are operated as a family business, as emerged through the findings from *Questionnaire 1*, it is plausible to assume that production related decisions may arise from intra-household processes and thus, decision-making power in the working and household domains can conflate.

The current study was limited by the impossibility to merge the employment and wages data collected in *Questionnaire 1* and *Questionnaire 2*. The first phase of data collection – *Questionnaire 1* – covered six study areas on Bantayan and the target population consisted only of farm owners which were sampled based on the seaweed farming associations members lists. The second phase of data collection – *Questionnaire 2* – covered three out of six areas investigated in the first round of data collection and the subjects interviewed included both farm owners (not necessarily the same individuals previously approached) and farm workers. Thus, it was not possible to bring together data collected in areas which could only be partially overlapped and with different respondents. In addition, results on gendered impacts of participation in aquaculture from *Questionnaire 2* are not representative of the entire seaweed production segment in the areas investigated because male and female respondents (either farm owners or farm workers) were not selected using a probability-based sampling approach.

6. Concluding remarks and way forward

Gender inequalities in participation, division of labour as well as pay gap and power distribution are persisting issues worldwide (Khitari, 2016; Elson, 1999). The aquaculture sector, particularly in developing countries, is no exception. A small number of studies have attempted to investigate empirically the multiple and diverse factors which impact participation, roles, economic and decision-making power in aquaculture production and value chain activities. Yet, indicators to measure progress made towards gender equality and women's empowerment specifically tailored to the aquaculture sector are still lacking.

Reducing gender disparities and empowering women are now an integral part of international commitments and frameworks; the Sustainable Development Goals (SDG) (United Nations, 2015), for example, mainstream explicitly gender equality and empowerment through its 5th goal “Achieve gender equality and empower all women and girls”. To achieve relevant SDG n. 5 targets in the aquaculture sector, such as Target 5. A: *Equal rights to economic resources, property ownership and financial services* and Target 5.6: *Universal access to reproductive rights and health*, the current gaps in knowledge regarding women participation, pay imbalances and empowerment must be filled.

Our findings contribute to increased knowledge in areas recognized as research priorities by enhancing understanding of division of labour and wage differences in coastal aquaculture, quantifying women's participation in seaweed production, and showing how participation in seaweed farming affects power relations in the work and household dimensions. If regularly collected, this information can help to measure progress towards meeting the targets of the SDG n.5 (Malapit et al., 2019) and, consequently, guide the formulation of gender sensitive policies and programmes, ultimately strengthening women's empowerment in aquaculture.

Our work confirms that women make a significant contribution to seaweed aquaculture production, but largely during the preparatory stage of the seaweed farms as the tasks can be carried out near the household and scheduled flexibly around domestic chores, childcare and family duties (Malapit et al., 2020; Bosma et al., 2019). It demonstrates the persistence of gendered stereotypes affecting women's and men's participation and roles in aquaculture production, remuneration and decision-making power (Malapit et al., 2020). Additional barriers faced specifically by women include lack of access to leadership positions and lack of involvement in decision-making in the workspace. Conversely, participation in the labour force may have a positive effect on women's autonomy and power to make decisions within the household. Given the important role played by women, appropriate measures and interventions should support women's empowerment and their social and economic wellbeing through, for example, the creation of targeted training programmes for sustainable seaweed production, from farm preparation to harvest and post-harvest operations, and build female

capacity to assume more leadership roles (see Msuya and Hurtado, 2017). Recognising the crucial contribution of women in aquaculture by promoting regular collection of gender-disaggregated data has profound implications for mainstreaming gender into natural resource management, poverty alleviation and sustainable development, and may foster their participation in decision making and more equitable access to aquaculture benefits.

For future research, we recommend repeating the study to include coastal communities producing seaweed in other key areas of the Philippines and other Asian countries to see if similar results are obtained, thus validating the findings of this work, or if gendered impacts of seaweed production vary across geographical regions. Furthermore, we also recommend expanding the assessment of division of labour, wages and decision-making power to include all nodes of the seaweed aquaculture value chain rather than production activities only, for a more comprehensive picture of the relationship between female empowerment and participation in seaweed aquaculture.

Future studies could further expand the approach used in this work to explore more exhaustively the relationship between aquaculture and the multidimensional components of female empowerment and develop one single index of women's empowerment in aquaculture by improving, adapting and combining not only indicators relative to the working and the household dimensions as used in this research, but also exploring other relevant dimensions and indicators of empowerment. Participation in decision making in small coastal communities is also linked, for example, to various forms of social capital. We therefore recommend including indicators relative to the social dimension, informed by coastal communities' contextual factors, for a more complete investigation of the associations with women's ability to influence farm and household decision-making. Finally, it is advisable to complement quantitative techniques with qualitative data collection methods (see Kruijssen and Newton, 2022) to both inform the construction and adaptability of the index to the local context and to enable a more in-depth understanding and interpretation of the findings of the women's empowerment in aquaculture index.

Author contributions

Elena Mengo: Conceptualization, Writing- Original draft preparation, Formal Analysis, Writing – original draft, Writing – review & editing, **Gaetano Grilli:** Conceptualization, Methodology, Formal Analysis, Writing- Reviewing and Editing, Data curation, **Joanna M. Murray:** Writing- Reviewing and Editing, Supervision, **Elisa Capuzzo:** Writing- Reviewing and Editing, **Rose-Liza Eisma-Osorio:** Writing- Reviewing and Editing, **Lenka Fronkova:** Writing- Reviewing and Editing, Data curation, **Jonathan O. Etcuban:** Investigation, **Judy Ann Ferrater-Gimena:** Investigation **Annie Tan:** Investigation.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jrurstud.2023.103025>.

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