Gendered-Value Chain Opportunities and Challenges in Seaweed Aquaculture: The Changing Gender and Socio-Economic Dynamics in Mwazaro and Kibuyuni Villages, South Coast Kenya

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Abstract

Globally, seaweed aquaculture is one of the key economic activity in coastal regions. It has emerged as a livelihood source in Kibuyuni and Mwazaro villages in south coast Kenya, fostering economic resilience and gender empowerment. This study examined gender-associated opportunities and challenges within the seaweed value chain, emphasizing labor distribution, economic contributions, and barriers to participation. A mixed-methods approach was employed, incorporating both qualitative and quantitative data from 155 respondents. The findings indicate that women dominate the activity engaging at different levels of the value chain, from farming to processing, while men largely control marketing. Seaweed farmers earn an average of USD 56 per 45-day production cycle. Seaweed farming, however, faces challenges such as a lack of technology, poor farming techniques, ineffective resource management, environmental factors, inadequate knowledge and skills, inadequate financial support, and inadequate farm inputs. Despite these challenges, the study established that the economic and social benefits outweigh the challenges. The findings suggest that targeted interventions addressing financial and market disparities can significantly enhance gender equity and sustainability. Additionally, these patterns highlight the gendered nature of labour division in the seaweed value chain. It is concluded that gender-based economic empowerment and sustainable development interventions are necessary to foster inclusive growth, resilience in coastal communities, and strengthen women's participation in the seaweed value chain. Seaweed aquaculture can contribute to inclusive economic growth in coastal communities especially in Kenya and the Western Indian Ocean at large.

Key Words: Seaweed, Value chain, Gender empowerment, South coast Kenya

Introduction

Globally, seaweed aquaculture is responsible for 51.3% of the total aquaculture production from marine and coastal aquaculture (Chopin and Tacon, 2021). It has been acknowledged that seaweed farming is gender-inclusive and nutrition-sensitive, offering a chance to support women and families (Obiero et al., 2021). Studies have shown that almost 90% of female fish workers worldwide engage in fish processing, which makes women's participation in seaweed

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aquaculture crucial for the various duties along the value chain (Monfort 2015; Siles et al., 2019). In addition, women's participation has been observed to be crucial at the various nodes of the value chain in other high-value industries, such as cosmetics and cooking among others (Buschamann et al, 2017). According to FAO (2018), aquaculture is acknowledged as one of the most dynamic food industries globally in response to the decline in fish stocks. The benefits of seaweed farming in Kenya have been rigorously examined (Mirera et al., 2020; Odhiambo et al., 2020). Seaweed cultivation contributes to the employment and economic development of coastal communities; hence, small-scale aquaculture is an important driver of this industry (Gallardo-Fen'andez & Saunders, 2018). Since seaweed farming targets the pro-poor, it has the potential to help fulfill Sustainable Development Goals (SDGs) like reducing hunger, improving water quality, mitigating climate change, protecting the ocean, and promoting gender equality, which emphasizes its ecological relevance (Garcia-Poza et al., 2022). As the seaweed industry expanded in Kenya (Obiero et al., 2021; Mirera et al., 2020), there is a need to have an in-depth understanding of its relevance to addressing underlying issues of gender equality that have been rarely addressed in studies from East Africa.

According to the Manifesto for the Marine Social Sciences, the current global development agenda and constantly changing political and economic conditions of coasts and oceans highlight the need for critical and constructive social science studies (Bavinck and Verrips, 2020). This involves highlighting the various realities small-scale aquaculture fishermen face, their gender dynamics, and their community (Bavinck et al., 2018). Interestingly, unlike their male counterparts, women have substantial contributions to make at different nodes of the agricultural and off-farm value chains, even though their efforts are sometimes undervalued or constrained due to societal norms (Quisumbing et al., 2021). Yet, while most research on aquaculture's problems, policies, and tactics raises serious questions about the industry's environmental sustainability (Krause et al. 2015), it does not address important aspects of social sustainability and gender relations, such as gendering resource access issues, inequitable distribution of benefits, benefits not being connected to local needs, and ecosystems being negatively impacted in ways that endanger livelihoods and conditions for resource production. Further, there is a clear gender gap in the industry regarding labour division, with fewer women engaged in harvest-related tasks (Monfort 2015; Nabuyanga et al., 2021). In particular, although seaweed farming is not lucrative, it gives women greater flexibility, autonomy, and independence—aspects of their jobs that are just as important to them as taking care of household chores due to their tidally dependent seaweed farming (Fernandez et al., 2018; Mirera et al., 2020). As a result, women have traditionally worked in the seaweed industry and may be considered an asset to the labour and money that male fishermen provide (Weeratunge-Starkloff & Pant 2011). Nonetheless, very little is known about the causes of gender inequalities, even though gender gaps have caused policymakers to become concerned and have become the focus of many development programmes (Ramirez et al., 2020). This paper examines seaweed production in the Kenyan coastal towns of Mawazaro and Kibuyuni to better understand the gendered socio-environmental dynamics and implications in small-scale seaweed aquaculture.

Materials and Methods

Study Area

Mwazaro and Kibuyuni villages are located in the south coast of Kenya (Figure 1) and the climate is generally tropical with two distinct rainy seasons: long rains (March to May) and short rains (October to December). The villages are located within reach of coral reefs, seagrass beds, and mangrove forests. These ecosystems support marine biodiversity and serve as important community livelihood resources through fishing, seaweed farming, and eco-tourism. The villages are close to the Kisite-Mpunguti Marine National Park, which protects the area from strong wave action and promotes biodiversity conservation. Conversely, it limits fishing practices in certain areas,

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calling for alternative livelihoods to support the communities.

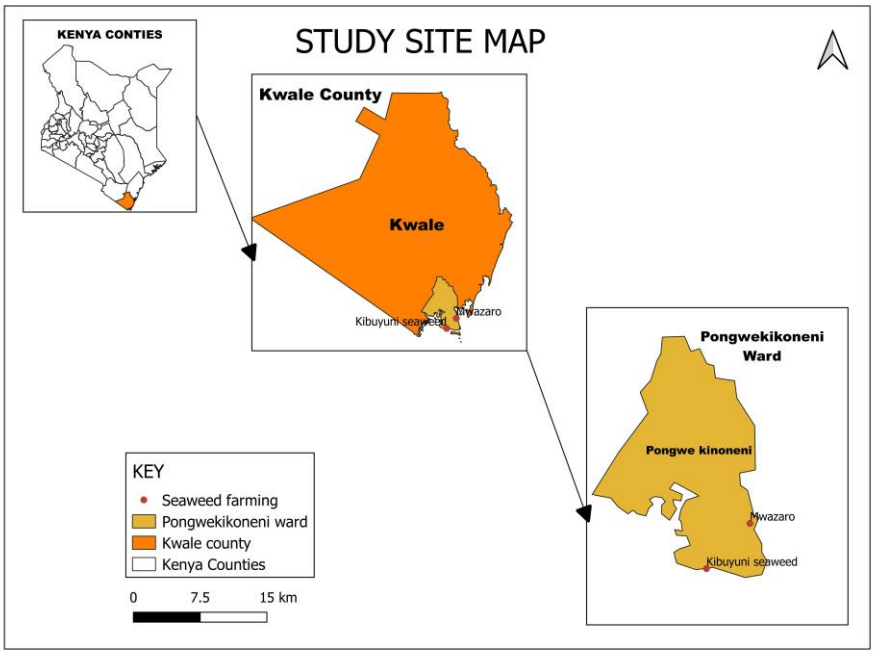

Figure 1. Map of Kenya showing Kwale County and the location of the two villages (Mwazaro and Kibuyuni)

A mixed research design was employed, which included both exploratory and explanatory methods. According to Bazeley (2024), mixed methods enable the researcher to produce statistically significant and contextually relevant findings that apply to real-world settings. The mixed designs provided flexibility and thus allowed for adjustments based on initial findings, i.e., when the exploratory segment revealed unexpected themes or insights, the explanatory segment was tailored to include additional variables or questions, providing adaptability to the research design. This flexibility helped refine the research focus based on empirical evidence rather than assumptions (Creswell & Plano Clark, 2017). The mixed research design further expanded the breadth and depth of the study by combining the strengths of qualitative and quantitative methods (Creswell et al., 2014). The findings were more valid and reliable because the mixed-methods design combined qualitative and quantitative approaches. According to Johnson and Onwuegbuzie (2004), integrating these two data types helps mitigate the weaknesses inherent in each method. Specifically, qualitative data added depth and context to the quantitative findings, while quantitative data offered generalizability to the qualitative insights. This complementary relationship enhanced the overall robustness and credibility of the research outcomes.

Sampling

The study targeted key stakeholders within the seaweed value chain as its population, including active seaweed farmers, chairpersons of the seaweed corporations/groups, and extension or research officers involved in seaweed farming activities. Stratified random sampling was employed, with respondents selected from a list of stakeholders provided by Kenya Marine and Fisheries Research Institute (KMFRI) field officers. This list was cross-verified against databases maintained by group leaders of seaweed farming communities in the respective villages to ensure accuracy and representation. To further enhance representativeness,

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particularly regarding gender, stakeholders in the seaweed value chain were stratified into gender sub-groups ("strata"). A random sample was drawn from each stratum (men and women) to reduce bias and improve control over the data collection process, thereby ensuring greater accuracy of the information obtained (Sharma, 2017; Acharya et al., 2013; Kelley et al., 2003). The method allowed each individual in the population to have an equal probability of being selected as a representative (Acharya et al., 2013). The sample size was determined with the assistance of presiding officers responsible for maintaining records of the seaweed farming groups. The target sample size "n" was computed using a simplified formula proposed according to Kuswanto et al. 2020, Israel 1992 and Yamane 1967 since the size of the population was known (Levy & Lemeshow, 2013).

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

N represents the population you are selecting from. This is the requirement for your sample to reflect.
e represents the allowable margin of mistake. The accepted norm is 5%; therefore, input 0.05. n represents the sample size necessary for conducting the surveys.

The Kibuyuni sampling frame was 137 active farmers; therefore n = N/ (1+N (e) 2
=137/ (1+137(0.05)2
=137/ (1+0.343)
=137/ (1.343)
=102

Mwazaro sampling frame was 70 active farmers, therefore n = N/(1+N(e)2
=70/ (1+70(0.05)2
=70/ (1+0.13)
=70/ (1.33)
=53

The snowball method was utilized to sample key informants in the seaweed stakeholder value chains. According to Parker & Geddes (2019), networking and referral aspects are essential in snowball sampling, a commonly used qualitative sampling technique. Initial contacts, or "seeds," who met the study's criteria were identified and invited to participate. The snowball sampling process continued until the desired sample size or saturation point (whereby information was repeating itself) was reached, at which point the sampling process was concluded.

Data Collection Instruments

A multi-faceted array of approaches was employed to elicit the primary data from the designated respondents (Creswell & Garrett, 2008) to enhance the comprehensive and profound comprehension of the phenomenon. The primary data was acquired through the implementation of (i) a semi-structured interview, (ii) a key informant interview, (iii) a checklist, and participant observation. In the semi-structured interview, participants were taken through a questionnaire on the seaweed value chain and gender, in addition to respondents' attitudes and perceptions (Fink, 2003). The questionnaires were distributed to active seaweed farmers. This enabled the collection of qualitative and quantitative data. Respondents were described in detail, including their demographics, access to resources, barriers, and potential in the seaweed value chain. The key informant interview technique was employed to gather in-depth information from stakeholder representatives with expert knowledge and insights on the topic (Lokot, 2021). This included the community leaders of the seaweed farming villages, seaweed management professionals/extension agents, community leaders, and identified individuals with indigenous knowledge of the connection between the seaweed value chain and gender issues. Participant observation technique is the most important and diverse research technique in the social sciences and it includes observation and documentation of interactions and relationships (Ciesielska et al., 2018) During the data collection period, a task checklist was created and used to track men's and women's tasks and responsibilities at the group level. Participation in this important activity helped build relationships with farmers. Additionally male and female interactions were also observed at the group level.

Procedure

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The present study utilized quantitative and qualitative methods through semi-structured interviews and key informant interviews. The fieldwork took place in three stages between 2022 and 2023. The first stage (October 2022 to May 2023) involved collecting data from the seaweed cultivators using semi-structured interviews. The semi-structured interview encompassed closed-ended and open-ended inquiries, supplemented by pivotal interviews. This process was conducted through face-to-face interviews. The respondents included 155 cultivators, representing nearly three-quarters of the total 207 granted concessions to individuals in the Mwazaro and Kibuyuni sites areas. The second stage involved three key interviews with participants from different backgrounds to ensure exposure to different perspectives. The final stage involved the observation grid that provided a detailed breakdown of gender participation across various stages of seaweed farming and its associated activities.

Data Analysis

Both quantitative and qualitative information were collected. Data was coded, compiled and cleaned in MS Excel for consistency. Two methods were used to analyse the data: (i) descriptive statistics and (ii) content analytical statistics. Descriptive statistics provided concise summaries of the sample and key observations (Cooksey and Cooksey, 2020). They were used to outline the characteristics of various variables, including the number and proportion of seaweed actors involved in the value chain per study site, demographic profiles, levels of experience, gender representation, estimated financial benefits, and the legislative and operational challenges encountered. Descriptive statistics also helped present recommendations for improving and promoting seaweed-based livelihoods. Data analysis was conducted using Excel 2016 and IBM SPSS Version 22. Analytical statistics were applied to systematically interpret qualitative data from interviews and open-ended responses. This method identified patterns, themes, and recurring issues related to stakeholders' experiences, perceptions, and suggestions. By coding and categorizing this information, content analysis enabled the researchers to derive meaningful insights that complemented the quantitative findings, thereby enriching the overall interpretation of the data.

Results

Participant response rate

A total of 155 active farmers from the villages of Mwazaro (53) and Kibuyuni (102) participated in the interviews, representing 75% of the total population. According to Babbie (2011), a response rate exceeding 60% is generally considered adequate for research purposes, underscoring the reliability of the data collected in this study. Similarly, Holtom et al. (2020) and Fincham (2008) emphasize that a 60% response rate is the benchmark often expected by journal editors and reviewers, further highlighting the significance of achieving such a rate in academic research. Therefore, the response rate attained in this study strengthens the credibility of the findings and meets widely accepted scholarly standards. As illustrated in Table 3.1 below, each key interview respondent was coded to preserve the privacy of the people whose quotes are included in this paper. The open-ended interviewing method allowed for gradually adding new questions derived from previous interviews. The subjects were informed before the upcoming interviews to maximize effective data collection. The process allowed participants to schedule their time and activities at their convenience. Face-to-face interviews were conducted with respondents at their homes or workplaces on the agreed-upon days and times.

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Table 1. Results of Key Informant, Respondent, and Response Rate

No.	Target population	Sample size	Occupation	Gender	Interview codes used in text
1			Chairlady Seaweed Group	Female	CSG
2			Coordinator KISEFA cooperation	Male	CKC
3			Sales Agent seaweed	Male	SAS
	5(100%)	3(60%)			

Demographic and socio-economic characteristics of respondents

This section presents the basic demographic characteristics of the study participants. These include gender, age, marital status, education level, household status, and religion. Out of the 155 surveyed cultivators, 29 were men (19%), and 126 were women (81%). This distribution reflected the gender proportion among concession holders, with almost 29 % of the original concessions granted to women as heads and breadwinners of families. In the current study, the majority of the population (68%) falls within the 18- to 47-year-old age group, comprising 55% of men and 71% of women. The second largest group consists of individuals aged between 48 and 77, accounting for 31% of the population, while only 1% is above 78 years old. The high proportion of younger individuals, especially women, indicates that the population is relatively youthful and economically active (Table 2).

Table 2. D emographic characteristics of the respondents by gender

Variable		Total N=155	Male N=29, 19%	Female N=126,81%
Marital status	Single	12%	31%	7%
	Married	70%	62%	72%
	Separated	4%	0%	4%
	Divorced	5%	3%	5%
	Widow/er	10%	3%	11%
Education Level	Low Education Level	95%	96%	94%
	Higher Education Level	5%	4%	6%
Position in the Household	Head Only	3%	7%	2%
	Head and Breadwinner	38%	72%	29%
	Breadwinner Only	9%	17%	7%
	Supportive Spouse	49%	0%	61%
	Dependant	1%	3%	1%
Main Occupation	Casual Jobs	6%	19%	3%
	Farming Crops	15%	7%	17%

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Fish Vendor	1%	0%	2%
Fishing	4%	19%	0%
Seaweed Farming	70%	56%	73%
Small Business	4%	0%	4%
Teacher	1%	0%	1%

Marital Status of the Respondents

Most of the seaweed farmers (70%) were married, with a higher proportion of females (72%) compared to males (62%). About 12% of the farmers were single, with a disproportionately high rate among males (31%) compared to females (7%). Widowhood was more prevalent among female farmers (11%) than their male counterparts (3%) (Table 2).

Education Level of the Respondents

As shown in Table 3.2, the vast majority of the population (95%) has a low education level, including individuals with no formal education or those who have only attended religious schools (madrassa) or primary school. There are minimal gender differences within this group. Only 5% of the population has attained higher education qualifications, such as secondary or tertiary education, with a slight gender disparity, 6% of women compared to 4% of men. Qualitative findings on the educational achievement of the seaweed community: -

> "*Men dominate the marketing and processing stages of the seaweed value chain because they are perceived to have more education and knowledge about business and society. Women are primarily involved in the earlier stages of production but lack representation in these higher-value activities." (CSG)*

The findings indicate that both educational and societal barriers contribute to the gender imbalance observed in the more financially rewarding stages of the seaweed value chain. This disparity underscores the need for targeted educational and capacity-building programs aimed at empowering women, thereby enhancing their participation in marketing, value addition, and business management activities.

Position in the Household of the Respondent

Only 3% of the total population are considered sole decision-makers within their households. In contrast, 38% serve as both the head of the family and the primary breadwinner, with men (72%) assuming this dual role far more frequently than women (29%). The supportive spouse category, where women dominate (61%), reflects traditional gender roles in which women are responsible for meeting household needs without being the primary breadwinner.

Main Occupation of the Respondents

Seaweed farming is the most common occupation (70%), particularly among women. In contrast, few men are engaged in the seaweed farming, though they predominantly focus on fishing and casual jobs, while women are more likely to work in agriculture and operate small-scale businesses.

Religion of the Respondents

The population is overwhelmingly Muslim (99%), with only 1% identifying as Christian. Religious homogeneity suggests a culturally unified population, which might reduce conflicts based on religious differences. The high Muslim majority in the population offers opportunities for cohesive, culturally respectful development programming. However, success depends on how well religious norms and institutions are integrated into policy, planning, and implementation frameworks. Inclusive, context-sensitive, and faith-informed approaches will be essential to ensure socioeconomic interventions' acceptance, sustainability, and effectiveness.

Income levels of seaweed farmers

Table 3 demonstrates the income levels of seaweed farmers in two coastal Kenya villages, Kibuyuni and Mwazaro. The analysis considers the number of farmers, average income, and the size of the income range.

Table 3. Average income of the respondents in seaweed production cycle of 45 days per village

Villages	Number	Average income(USD)	Maximum income (USD)	Minimum income (USD)
Kibuyuni	88	93	266	2.5
Mwazaro	53	48	266	4

The average income of Mwazaro seaweed farmers (93 USD) is almost double that of Kibuyi (48 USD). This suggests that seaweed cultivation of seaweed is more profitable in Mwazaro than in Kibuyuni. This could be due to better organization of farming groups, access to training, or supportive infrastructure like storage, drying facilities, or market access. The maximum income is the same in both villages (266 USD), suggesting that some farmers can achieve high yields, possibly because of larger holdings or more efficient farming practices. The minimum income in Mwazaro (4 USD) is higher than that in Kibuyuni (2.5 USD), indicating that even the poorest people in Mwazaro are better off than those in Kibuyuni.

Gender roles and empowerment on nodes of seaweed value chain

The objective was to document gender empowerment activities across the various nodes of the seaweed value chain. In presenting these findings from southern Kenya, it is essential to break down each node of the value chain and describe the specific tasks performed, the gender distribution within each task, and the forms of empowerment observed, such as equal participation or the nature of involvement in decision-making and execution. The analysis offers a detailed account of gender roles and empowerment dynamics throughout the value chain, as summarized in Table 4.

Table 4. Gender Empowerment Activities in the Seaweed Value Chain

Code	Nodes	Activity	Male= ♂ N=29	Female =♀ N=126	Both	How is the activity done? Indicate 'Mechanized' or 'Manual' as applicable) %
1	Production node	Seaweed plowing	100%	100%	♂♀	Manual
2		Sowing	100%	100%	♂♀	Manual
3		Weeding	100%	100%	♂♀	Manual
4	Harvesting node	Harvesting	100%	100%	♂♀	Manual
5		Transport by boat	100%	100%	♂♀	Manual 80%Mechanized 20%
6		Transportation of produce from the seaweed farm to	100%	100%	♂♀	Manual =70% and Mechanized=30 %

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		drying rack				
7	Marketing node	Transportation of produce from the drying rack to the market	100%	100%	♂♀	Manual= 80% and Mechanized= 20%
8		Preparation of storage facility	100%	100%	♂♀	Manual
9		Looking for buyers	5%	1%	KSW Cooperative, Agents	Mechanized
10		Negotiating for prices	5%	1%	KSW Cooperative, Agents	Mechanized

The findings of the study displayed in Table 4 illustrate the various gender empowerment activities in the seaweed value chain nodes: -

Production Node; The production node entails manual work consisting of the seaweed plowing, sowing, and weeding, which are 100% male and 100% female. This node demonstrates gender equality and participation. Men and women participate equally in manual plowing, indicating shared labor responsibilities at the outset of the production process. This is an important part of empowerment since it ensures that women can work in jobs that pay.

In the plowing activity, men and women are equally involved, with 100% participation in manual weeding. This effort highlights shared labor and reflects gender empowerment through equal access to income-generating opportunities. The weeding activity involves intensive manual labor. Men and women are fully engaged in the seeding process, with 100% participation. This equal involvement not only highlights gender inclusivity but also reflects empowerment, as women actively participate in the critical task of planting on an equal footing with men. This level of equality suggests that both men and women have equal access to labor responsibilities and shared community resources, such as seedlings. In the plowing activity, both men and women demonstrate full participation, with 100% involvement in the labor-intensive task of manual weeding. This shared responsibility reflects a balanced gender dynamic and highlights equal access to income-generating opportunities an important indicator of empowerment through inclusive participation in weeding initiatives.

Harvesting Node: The participation of men and women is 100% engaged in manual labour (Table 3.4). As regards to empowerment, equal participation in harvesting underlines the inclusive approach at one of the key stages in the seaweed value chain. This provides the farmers economic opportunities and enables them to become financially independent. Transport of seaweed from the farms to the ocean's shores is by using boats: participation by men and women is 80% manual and 20 % mechanical. As regards empowerment, while transport is somewhat mechanized, gender equality in participation ensures that neither gender is disproportionately burdened. Mechanical processes can increase efficiency and reduce physical demands on transport, indirectly empowering both genders through productivity gains.

Marketing Node; Gender participation in the transport of products from drying racks to the market is 100%, with both men and women taking part, and the process is 80% manual and 20% automated (Table 3.4). In the case of empowerment, both sexes are involved, providing shared opportunities to deliver the final product to the market. However, minimal mechanization means that labour is still very intensive, and mechanization could further empower both genders, especially women, by reducing manual labour.

With mechanized operationalization, Kibuyuni Seaweed Cooperative and agents dominate the market for buyers, with 5% of buyers being men and 1% being women. A stark gender gap in empowerment is evident at this node, where men are primarily responsible for sourcing buyers. The limited involvement of women in this critical aspect of decision-making highlights a serious lack of empowerment and control over market access. To address this imbalance, targeted gender empowerment interventions such as capacity-building, education, and support programs can be introduced to enable women to take on more active and influential roles in the commercial segments of the seaweed value chain.

Only 5% of men and a mere 1% of women primarily represented by KSW cooperative agents are involved in price negotiations through mechanized operational processes. Similar to the buyer-seeking stage, price negotiation is predominantly male-dominated, reflecting a continued gender imbalance in key decision-making roles. This limited involvement of women underscores their restricted influence over critical commercial aspects of the value chain. Empowering women to actively participate in price negotiations would not only enhance their control over income but could also lead to significant social and economic benefits for both individuals and the wider community.

Gender Roles and participation in seaweed value chain

This study emphasizes how men and women participate in different phases of seaweed production, highlighting areas where gender disparities occur, like marketing (dominated by men) and value addition (mostly done by women). The observation checklist provided (Table 5), a detailed breakdown of gender participation across various stages of seaweed farming and its associated activities. The following gender patterns emerge from the documentation.

Table 5. Gender participation observed in seaweed value chain

Site location: Estimated Age: Group: Seaweed Group Gender: Male and Female	Starting time-8:30 am End time-5:30 pm	Observed audience- individuals
Seaweed farming		Male and Female
Seaweed harvesting		Male and Female
Seaweed drying		Male and Female
Seaweed storage		Male and Female
Seaweed Value addition		Female
Seaweed marketing		Majority male with few women

The above checklist (Table 3.5) illustrates that seaweed farming activities within the production and harvesting nodes are generally shared equally between men and

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women. However, specific stages of the value chain show gendered patterns, with value addition being predominantly female-dominated, while men largely lead marketing activities. These patterns highlight the gendered nature of labor division within the sector, which could have crucial implications for economic empowerment, gender equality, and sustainable development interventions to foster inclusive growth in coastal communities. Gender-responsive policies that address these disparities, particularly by enhancing women's participation in marketing and other income-generating roles, could lead to more equitable outcomes.

Gendered-opportunities encountered in seaweed value chain

Table 6 presents findings on opportunities for gender empowerment in seaweed production, categorized by four main benefits: acquisition of skills and knowledge (34%), improvement of living standards (4%), enabling the catering of basic needs (26%), and serving as a source of livelihood (36%).

Table 6. Gender empowerment opportunities in seaweed value chain

		N	%
Main opportunities in seaweed production	Acquisition of skills and knowledge	51	34%
	Improvement of living standards	6	4%
	Enable catering of basic needs	39	26%
	Source of livelihood	59	36%
	Grand Total	155	100%

As shown in Table 6, the research findings are that more than a quarter, 34%, view seaweed production as a way to gain valuable skills and knowledge. This indicates that seaweed production is a platform for skill development, potentially boosting farmers' confidence and professional capacity in the value chain. Only 4% noted improved living standards, highlighting a potential gap in how the work translates to tangible quality-of-life improvements. The low percentage suggests that while seaweed production may empower farmers in various ways, it does not necessarily lead to substantial changes in income or overall economic status for many. However, the fact that 26% of respondents recognize seaweed farming as helping them meet their basic needs highlights the activity's practical and immediate economic benefits. This indicates that, although not transformative for all, seaweed farming provides a reliable source of livelihood for a portion of the community. However, this moderate percentage suggests that for a significant portion of both men and women involved, their earnings from seaweed production may only cover essential needs, with limited room for savings or additional expenses. The largest proportion (36%) views seaweed production as a source of livelihood.

Qualitative analysis with regard to opportunities in seaweed production from the document presents several key findings with supporting quotes:

> *"Economic Growth and Improved Incomes: Seaweed farming offers producers a stable and enhanced income. The finding highlights that "sale of 2kg of raw dry seaweed is 50 Ksh; USD, 0.4, after processing into powder it sells at 900 Ksh; USD 6.6" illustrating the potential for*

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significant profit through value addition (CKC)".

"Market Stability and Expansion: Establishing 'consistent markets' is noted as a vital opportunity, providing a dependable demand base for seaweed products. Entering 'new markets' further expands economic potential, positioning seaweed as a scalable industry (SAS)".

"*Diverse Livelihoods and Reduced Risk: Seaweed farming contributes to 'diverse livelihoods,' offering alternative income sources that reduce economic vulnerability. This diversity strengthens financial resilience for individuals and communities dependent on coastal resources (CSF)".*

Seaweed production presents promising opportunities for economic upliftment, market expansion, income diversification, and enhanced profitability through value addition. The industry's potential to create sustainable livelihoods and access new markets positions it as a valuable economic activity, particularly for coastal communities reliant on marine resources

Gendered-empowerment challenges in seaweed value chain

The study outlines challenges faced in the seaweed value chain production, focusing on issues related to gender empowerment (Table 7).

Table 3.6: Challenges encountered in seaweed farming

		N	%
Challenges encountered in seaweed value chain production	Inadequate knowledge and skills in seaweed farming	9	6%
	Lack financial support	9	6%
	Lack of farm inputs	7	5%
	Lose hope and quit farming	12	8%
	Low production	118	74%
	Grand Total	155	100%

As indicated in Table 7, an overwhelming statistic (74%) suggests that the seaweed farming industry is plagued by inefficiency or suboptimal conditions that significantly hinder productivity. Low production could result from multiple factors, including environmental challenges, lack of technology, poor farming techniques, or ineffective resource management. Losing hope and quitting farming (8%): Although this is a smaller percentage, it signals a concerning issue of sustainability within the workforce. If farmers lose hope due to ongoing challenges or lack of progress, it indicates a broader systemic issue where current strategies do not sufficiently address the needs of farmers. Inadequate knowledge and skills with 5%, lack of financial support, and lack of farm inputs with each (-6%). Qualitative findings indicated that farmers face significant challenges in scaling production due to market limitations and a lack of inputs and equipment. Addressing these constraints could improve production levels and profitability, encouraging more participation from men who traditionally engage in quicker-return activities. Women's participation is hindered by multiple factors, including other economic activities, household responsibilities, and cultural norms where husbands may not permit them to engage fully in seaweed farming.

."Production of raw and products is low due to low market, low price of raw material, insufficient equipment for products, lack of farm inputs, and lack of support."(SAS)

"*Climate change causes the shift to*

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venture in deep seaweed farming, less manpower, and no support in mobilization of communities and creating awareness on seaweed farming." (CSG)
"Quantity decreased in 2021 due to climate change, drought, and warm waters. Since 2023, quantities in the production supporters' value chain have improved.
"Women are involved in activities that are time-consuming like child upbringing and are not granted permission by their husbands." (CKG)

Discussion

The study explored the perceived opportunities and challenges in the Kibuyuni and Mwazaro seaweed value chain. The findings from the indicator that women predominate in the study sample, as evidenced by this notable gender disparity. The findings imply that women might participate in informal economic activities at a higher rate. Men's underrepresentation could also be a sign of migration brought on by other sociocultural or professional factors that affect the dynamics of the male population. This result aligns with Odhiambo et al., (2020), who discovered that women make up 90% of mariculture initiatives. Additionally, 75 % of seaweed farmers in Kenya are women (Mirera et al., 2020). The limited participation of men in seaweed farming is largely attributed to their preference for fishing, which offers daily income opportunities. In contrast, seaweed farming follows a 45-day cycle from planting to harvesting, delaying financial returns. This finding aligns with Juma et al., (2021), who observed that many individuals, particularly men, perceive aquaculture and small-scale farming as risky due to environmental variability and uncertain economic outcomes. In contrast, the higher participation of women in seaweed farming reflects their patience and resilience, shaped by limited alternative employment opportunities in coastal fishing communities. According to Ochiewo, (2004), the scarcity of diverse livelihood options has contributed to increased fishing pressure, threatening the sustainability of marine resources. Similarly, with few viable income alternatives, seaweed farming has emerged as a promising livelihood option that could help ease the strain on wild-caught coastal fisheries (Songwe et al., 2016).

Regarding the age distribution of seaweed farmers, the findings show that most are at their productive age, which may lead to a high demand for social services and jobs among young adults. It's crucial to note that older female farmers are also taking part, as is the growing proportion of men in a program initially intended for female farmers. This illustrates a livelihood that can be adjusted and used by people across ages and genders. Seaweed farming is often highlighted as a sustainable and profitable activity that can improve household income and provide a steady source of income for farmers, especially women. This is supported by Fitriana, (2016), who emphasizes that seaweed cultivation is a beneficial process for household businesses as it allows farmers to generate sufficient income to meet their daily family needs. The study reveals low levels of education, indicating limited access to educational resources/services or that immediate economic activities take precedence over formal education. This could hinder social mobility and contribute to persistent poverty, particularly among women with slightly higher education levels. Enduring poverty may still face structural barriers to equal opportunities in more formal sectors. This is because low literacy rates among residents of coastal areas are associated with greater dependence on predominantly locally accessible resources. This is consistent with a study by Robinson (2016), which observed similar results illustrating problematic scenarios, particularly among resource-dependent people who are disadvantaged when trying to obtain essential services such as education.

In the present study, men are typically viewed as the primary breadwinners, while women tend to assume supporting roles within the household. This distribution reinforces traditional gender norms to which men are more likely to conform to assuming the role of primary breadwinner and

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head of the household. Women's economic empowerment programs could help address this imbalance, enabling them to become more independent and less reliant on male household heads. This finding is consistent with Gideon's (2023) study, which states that the traditional patriarchal structure in Kenya views men not only as heads of families and community decision-makers but also as the sole arbiters of power. However, women are excluded from managing fisheries resources because of the long-standing assumption that men should direct and control all operations. This belief affects the management status of fishing communities and denies women equal opportunities. The findings found that although seaweed growing is a source of income in Kibuyuni and Mwazaro, there are significant income inequalities. Addressing structural and market problems could help farmers maximize their potential income and improve their livelihoods, given the high income variability. Farmers in both villages are exposed to economic insecurity. However, the higher average income in Mwazaro suggests that farmers there may be more resilient to market fluctuations. Previous studies of seaweed farming in Kenya have highlighted the importance of improved farming practices, government support and cooperative marketing strategies for increasing income stability (Msuya et al., 2013; Wakibia et al., 2011).

The study shows that the economy relies heavily on seaweed farming, which are more accessible to women. However, male-dominated fishing and casual labor roles may indicate gender differences in economic activities. To improve economic resilience, focus on diversifying income sources for both men and women and creating opportunities in sectors beyond agriculture and fishing. Similar findings from Larson et al., 2021 suggest that men acquire the majority of their money undertaking traditional fishing activities; however, in seaweed cultivation, women can benefit economically by participating in activities along the entire chain, from harvest to sale. A similar study by Obura et al. (2017) reported that many coastal communities are involved in seaweed farming which improves food security in local households and creates livelihoods for thousands of men and women. This is due to the relatively simple cultivation methods, low capital, locally available material inputs, and fast production cycles (Cai et al., 2021). In addition, the results of this study were supported by previous studies, such as a study conducted by Cuaton (2019) that showed that women can support their families and themselves through active participation in seaweed production.

In the seaweed value chain along Kenya's south coast, men and women are equally engaged in physically demanding tasks such as plowing, sowing, weeding, and harvesting, with each gender contributing 100% of the workforce. However, the few men participating in seaweed farming predominantly occupy market-facing roles, such as finding buyers and negotiating prices. Notably, 5% of men are involved in these activities, compared to only 1% of women, highlighting a gender imbalance in access to key commercial functions within the value chain. Women are significantly underrepresented in decision-making roles, particularly in activities directly impacting income, such as seeking buyers and negotiating prices (Suyo et al., 2020). Addressing this gender imbalance through training, education, or cooperative-based empowerment programs could provide substantial economic benefits to women. Women are significantly underrepresented in decision-making roles within the seaweed value chain, particularly in activities directly impacting income, such as seeking buyers and negotiating prices. Addressing this gender imbalance through training, education, or cooperative-based empowerment programs could provide substantial economic benefits to women (Suyo et al., 2021).

The opportunities presented by seaweed farming as an empowerment venture suggest that it is a reliable source of income for many participants, making it a vital component of their economic survival. This indicates a strong dependency on the sector for financial stability, particularly among women, who often have limited access to alternative employment opportunities in coastal communities (Larson et al., 2021). The outcomes are consistent with those of Obura et al., who claimed in 2017 that seaweed farming has been

practiced by numerous coastal communities, which could improve food security and provide income for many women and men. The study's results also align with research conducted by Mirera et al. (2020) and Odhiambo et al. (2020) which has demonstrated that seaweed farming has socioeconomic benefits for the local communities and that more stakeholders are becoming interested in the practice Seaweed farming is important for coastal communities because it gives many families a substantial income and can supplement or replace fishing earnings (Suyo et al., 2020). Growing seaweed is considered a sustainable small-scale aquaculture method. Furthermore, Rimmer et al. (2021) highlight that it is economical for families to earn money and sustain their way of life. Furthermore, Larson et al., (2021) highlight that seaweed farming offers a range of social benefits, including strengthened community ties, enhanced teamwork, preservation of cultural heritage, and increased awareness of health and wellness.

The findings indicate that climate change is a major constraint on seaweed farming, adversely affecting growth conditions, productivity, and sustainability (Msuya & Porter 2014). Additionally, herbicides and "ice-ice" diseases negatively impact production. Additionally, the findings reveal challenges related to limited capacity building, inadequate access to funding, and insufficient resources, all of which are critical for effective seaweed farming. The absence of these essential inputs suggests that marginalized groups, particularly women, may lack the necessary tools, training, and support to fully benefit from opportunities in the sector. The findings align with previous studies by Msuya and Hurtado (2017) and Kronen et al. (2010), which also identified several challenges that disadvantage seaweed farmers in the industry. These include financial constraints, limited management capacity, and environmental challenges, compounded by the multiple roles women often balance, such as caregiving and responsibilities as mothers and early childhood educators.

Conclusion

The study concludes that while seaweed farming presents clear economic benefits, several setbacks hinder full gender participation, particularly limiting women's involvement in higher-value activities such as marketing and processing. Social norms and practical barriers, such as the lack of childcare support, restrict women's ability to engage fully in the value chain. Empowerment programs that address these structural and societal challenges are crucial to promoting inclusive participation. Seaweed farming offers promising opportunities for gender empowerment, as evidenced by the study's findings. Key benefits include skill acquisition, income generation, and improved living standards, with women having the potential to fulfill basic needs and achieve economic security. However, targeted interventions are needed to maximize these benefits for women, especially regarding long-term economic stability and resilience. Training, improving access to credit, and enhancing market opportunities are vital to further empower women, allowing them to take on more profitable roles in the industry. The primary challenges in the seaweed value chain include low productivity, limited training, and resource constraints. Addressing technical and psychological challenges, such as inadequate knowledge, financial support, and persistent structural inequalities, is critical. Doing so will enhance women's empowerment and strengthen production outcomes and retention rates across the seaweed farming communities.

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