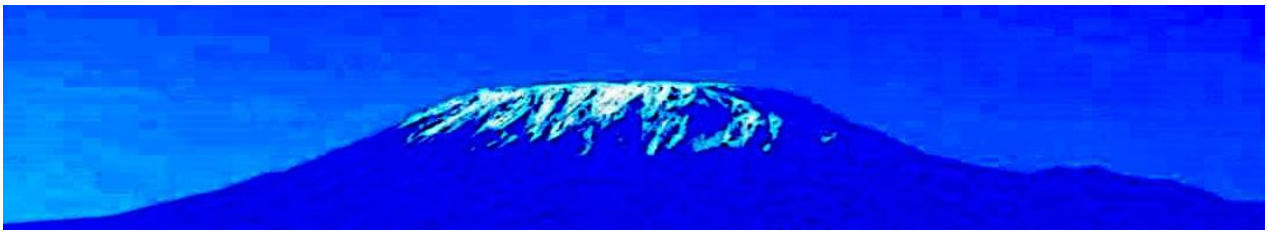
Volume 4 Number 1
2025

Tanzania Journal of Community Development (TAJOCODE)



Online: ISSN 2773-675X

A leading international Journal that advances the profession and practice of Community Development in the world

JOURNAL INFORMATION

TAJOCODE maintains an affiliation with the Community Development Professional Association of Tanzania (CODEPATA) and may, on occasion, be connected with other professional international organizations and research entities including universities. However, all editorial decisions are guided strictly by the quality of submissions and a rigorous peer-review process, ensuring independence from any political, financial, or personal influences from individuals and organizations. The journal adheres to the Committee on Publication Ethics (COPE) guidelines, which govern its peer-review procedures (visit www.publicationethics.org for details). Authors are encouraged to submit complaints or appeals regarding editorial decisions and can reach out to the Chief Editors for any inquiries. The journal is indexed in African Journals OnLine (AJOL @ www.ajol.info), google scholar, and RePEC EconPapers (https://ideas.repec.org/).

Information on submission

TAJOCODE is a peer reviewed journal. Visit journal's website for details https://www.ajol.info/index.php/tajocode/about/submissions

DISCLAIMER

The Editorial Board, TAJOCODE, and our publishers (referred to as the organs of the journal) make every effort to ensure the accuracy of all the information (the "content") contained in our publication. However, the mentioned organs, our agents, and our licensors make no representation or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the content. Any views and opinions expressed in this publication are the opinion and views of the authors, and are not the views of or endorsed by the organs of the journal. The accuracy of the contents should not be relied upon and should be independently verified with primary sources of information. The organs of the journal should not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, or other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the content.

Seaweed Farming and the Blue Economy in Transition: Livelihoods, Gender, and Governance in Tanga, Tanzania

Sixbert Joachim Msambichaka[1]

Article history
Received: 29/06/25
Revised: 27/07/25
Accepted:09/10/25
Published on line: 17/10/2025

Keywords: Seaweed Farming, Blue Economy, Sustainable Livelihoods, Gender Inequality, Climate Adaptation, Tanzania, Coastal Governance

Abstract

Seaweed farming is a cornerstone of Tanzania's blue economy, supporting livelihoods, women's employment, and climate adaptation. This study examined the socioeconomic, ecological, and governance dimensions of seaweed farming in the Tanga Region using a mixed-methods approach combining household surveys (n = 352), ten (10) key informant interviews, and three (3) focus group discussions. Quantitative data were analyzed with SPSS (version 25) using descriptive statistics, correlation, ANOVA, and regression, while qualitative data underwent thematic content analysis within the Sustainable Livelihoods Approach (SLA) and Gender and Development (GAD) frameworks. Results show that 82% of households depend primarily on seaweed for income, with women comprising 67% of producers. However, production is limited by ice-ice disease (73%), heat stress (65%), and market dependence on middlemen (87.8%), while only 3.1% of farmers engage in value addition. Education, household income, and access to extension services significantly predict adaptive capacity, revealing an adaptation gap that disadvantages low-income and less-educated farmers, particularly women. The study concludes that despite its economic importance, seaweed farming reinforces structural inequalities. Strengthening gender-responsive governance, promoting climate-resilient technologies, and enhancing local value addition are vital for transforming the sector into a driver of inclusive and sustainable coastal development.

[1] **Author**: The Mwalimu Nyerere Memorial Academy (MNMA) Phone: +255756288529 or +255714805672,

Corresponding author's Email: msambichakasix@gmail.com

Suggested citation: Msambichaka, S. J. (2025). Seaweed Farming and the Blue Economy in Transition: Livelihoods, Gender, and Governance in Tanga, Tanzania, *Tanzania Journal of Community Development* 4(1): 124-143

Introduction

Marine resources have long sustained coastal livelihoods worldwide, forming a foundation for food security, cultural identity, and economic exchange. In recent decades, the role of seaweed has expanded from a traditional subsistence product to a globally traded commodity used in pharmaceuticals, cosmetics, biofuels, and fertilisers (Jagtap and Meena, 2022; Johnson et al., 2023). With growing pressure on capture fisheries and mounting climate risks, seaweed aquaculture has emerged as a sustainable alternative livelihood that contributes to the Blue Economy and advances global sustainability goals (Saravanan et al., 2023; Brakel et al., 2021).

In Tanzania, seaweed farming aligns closely with the government's Blue Economy Agenda, formally incorporated into the National Fisheries and Aquaculture Policy (2020) and the Blue Economy Development Framework (2021). These policies prioritise marine-based livelihoods as vehicles for poverty reduction, women's empowerment, and environmental conservation key components of the country's Tanzania Development Vision 2025. Seaweed farming, dominated by small-scale coastal producers, is positioned as a strategic sector for achieving these ambitions by diversifying rural incomes, enhancing food security, and promoting climate resilience (Mwaijande, 2021; Ulega et al., 2022).

This national vision is consistent with the United Nations Sustainable Development Goals (SDGs). Seaweed aquaculture offers a vital source of income and employment to low-income coastal households, contributing to SDG 1 (No Poverty) (Shimba et al., 2021). As the sector is largely driven by women, it presents opportunities to enhance women's economic empowerment and participation in resource governance, aligning with SDG 5 (Gender Equality) (de la Torre-Castro et al., 2022). Furthermore, seaweed cultivation contributes to marine ecosystem services such as nutrient cycling, carbon sequestration, and habitat protection, thereby supporting SDG 14 (Life Below Water) (Saravanan et al., 2023). Despite these synergies, Tanzania's blue economy faces deep structural challenges unequal market relations, climate-induced stressors, and limited institutional coordination which threaten to undermine its transformative potential (Ana et al., 2024; Kweka et al., 2022; Turpie et al., 2022).

Globally, seaweed aquaculture has been celebrated as a "triple-win" solution that generates economic, ecological, and social benefits (Rimmer et al., 2021; Brakel et al., 2021). Yet, critical scholars caution that this optimism often overlooks local inequalities, ecological fragility, and governance failures (Langford et al., 2023; Vance et al., 2023). In East Africa, research has shown that while seaweed farming increases household income and women's participation in marine economies (Mirera et al., 2020; Shimba et al., 2021), it also perpetuates low-value dependence on export intermediaries and donor-led initiatives (Burra and Ushadevi, 2022; Evans et al., 2023).

Within Tanzania, most studies have concentrated on Zanzibar, leaving Tanga Region a rapidly emerging aquaculture zone underexplored (Charisiadou et al., 2022). The few existing analyses emphasise production trends but rarely interrogate the intersecting ecological, gender, and governance dimensions that determine sustainability. Moreover, policy discourse often presents seaweed farming as inherently empowering and sustainable, yet empirical evidence suggests persistent gender disparities, market dependency, and weak institutional integration (de la Torre-Castro et al., 2022; Ngajilo et al., 2023).

Problem Statement and Justification

While seaweed farming is central to Tanzania's blue economy narrative, its current organisation may actually reinforce vulnerability rather than reduce it. Farmers face declining productivity due to ice-ice disease and warming seas (Largo et al., 2020; Langford et al., 2023), are locked into low-value export chains (Burra and Ushadevi, 2022), and experience entrenched gender inequalities in control over income and decision-making (de la Torre-

Castro et al., 2022). Weak governance structures, insufficient extension services, and fragmented institutional coordination exacerbate these issues (Kweka et al., 2022; Turpie et al., 2022)

Addressing these challenges is vital not only for improving household livelihoods but also for achieving Tanzania's commitments to the SDGs and its national development agenda. The Tanga Region offers an ideal context for examining these interconnections, given its ecological diversity, growing role in aquaculture, and socioeconomic dependence on marine resources. This paper therefore investigates how seaweed farming contributes to livelihoods, gender equity, and environmental sustainability within Tanzania's blue economy framework.

Literature Review and Theoretical Framework

Global Discourses on Seaweed Farming and Sustainability

Seaweed aquaculture has become one of the fastest-growing forms of marine farming worldwide, with global production increasing more than tenfold over the past half-century (Jagtap & Meena, 2022). It is often celebrated as a "triple-win" solution that supports economic livelihoods, fosters environmental sustainability, and contributes to climate adaptation (Saravanan et al., 2023; Johnson et al., 2023). Globally, seaweed cultivation has been integrated into blue carbon and green growth agendas, offering ecosystem services such as carbon sequestration, nutrient cycling, and coastal protection (Brakel et al., 2021).

However, this optimism has been met with growing skepticism in recent scholarship. Critics argue that sustainability narratives often obscure deep inequalities within the sector, particularly regarding gendered labor, power relations, and access to value chains (Fernández et al., 2024; Langford et al., 2023; Adam et al., 2024). For instance, while seaweed aquaculture has created new income opportunities for women in Southeast Asia and Latin America, it has also reinforced gender hierarchies by confining women to low-paying, labor-intensive tasks with limited decision-making power (Anderson et al., 2023; Suyo-Diala & Hurtado, 2024).

Similarly, environmental claims of sustainability are contested. Large-scale aquaculture has sometimes contributed to habitat loss and biodiversity decline (Vance et al., 2023), while climate-induced threats such as ice-ice disease, bleaching, and ocean acidification challenge the long-term resilience of seaweed production systems (Largo et al., 2020; Matovu et al., 2022). These debates highlight that the sustainability of seaweed farming is not simply ecological or economic it is deeply social and political, shaped by governance, labor relations, and the distribution of benefits across gender and class lines (Adam et al., 2024; Rahaman et al., 2024).

Regional Debates: Seaweed Farming and Coastal Livelihoods in the Western Indian Ocean

In the Western Indian Ocean (WIO) region, seaweed farming has been widely promoted as an alternative to declining fisheries and as a pathway to climate-resilient livelihoods (Mirera et al., 2020; Evans et al., 2023). Yet, emerging evidence reveals a paradox: while seaweed farming diversifies income sources, it also reproduces vulnerabilities due to market dependence, environmental fragility, and gender inequalities (Turpie et al., 2022; Kweka et al., 2022).

Studies from Kenya, Madagascar, and Mozambique show that donor-led seaweed projects often overlook local ecological and cultural contexts, leading to inconsistent outcomes (Hussein et al., 2019; Henderson, 2024). In Kenya's Mwazaro and Kibuyuni villages, Kimanga et al. (2025) found that women's increasing participation in seaweed farming improved household income but not decision-making power, echoing findings across the region that empowerment remains partial and conditional (Matovu et al., 2024; Pena et al., 2023).

In Tanzania, seaweed aquaculture has become central to the government's Blue Economy Framework (Mwaijande, 2021; Ulega et al., 2022). Yet despite its prominence, the sector is characterized by low local value addition (Burra & Ushadevi, 2022), limited access to technology and credit (de la Torre-Castro et al., 2022), and exposure to environmental shocks (Langford et al., 2023). In Zanzibar, Dogeje et al. (2025) demonstrated that women's participation in seaweed aquaculture significantly raises household income but does not necessarily translate into structural empowerment without institutional and market reforms. The Tanga Region, while increasingly recognized as a new hub for marine aquaculture, remains underexplored despite facing similar ecological and governance constraints (Charisiadou et al., 2022; Turpie et al., 2022).

Empowerment, Gender, and Intersectionality in Marine Economies

Gendered analyses of marine livelihoods have expanded significantly in recent years, challenging traditional assumptions of women as passive beneficiaries and highlighting their central role in sustaining aquatic food systems (Matovu et al., 2024; Pike et al., 2024). In the context of seaweed farming, empowerment is often portrayed through women's numerical participation, yet this narrow view neglects deeper power relations in value chains and governance (Baker et al., 2024; Anderson et al., 2023).

Scholars such as de la Torre-Castro et al. (2022) and Adam et al. (2024) emphasize that true empowerment in aquatic food systems must involve control over income, decision-making authority, and access to knowledge and resources. In Zanzibar, women dominate production but remain excluded from marketing and value addition, where profits are concentrated (Ngajilo et al., 2023; Pike, 2025). Similarly, in Chile, women's growing participation in seaweed cooperatives has improved visibility but not necessarily equity, as cultural norms and institutional biases continue to limit their agency (Fernández et al., 2024; Salazar et al., 2023).

Intersectional research now argues for a shift from participation-based empowerment to transformative empowerment, where structural inequalities such as gender norms, class, and access to technology are actively challenged (Adam et al., 2024; Rahaman et al., 2024). This framing is particularly relevant for Tanzania, where the blue economy is evolving rapidly but remains constrained by unequal labor structures, limited institutional coordination, and minimal gender mainstreaming (Mwaijande, 2021; Kweka et al., 2022).

Governance, Climate Resilience, and Sustainability

Governance systems strongly shape the outcomes of seaweed aquaculture. Evidence from the WIO and other regions indicates that fragmented, donor-driven interventions often fail to build local ownership or institutional stability (Kweka et al., 2022). Conversely, participatory governance models that integrate local ecological knowledge with scientific management show promise for building resilience and inclusivity (Ali & Rashid, 2025; Matoju et al., 2022).

Sustainability, in this sense, extends beyond ecological health, it encompasses institutional continuity, equitable access, and adaptive capacity (Evans et al., 2023). As climate change intensifies, achieving resilience in coastal livelihoods requires not only technological innovation (such as floating raft systems or Integrated Multi-Trophic Aquaculture) but also the social and institutional capacity to absorb shocks (Fabiani et al., 2023; Adam et al., 2024). Without these structural foundations, sustainability remains a rhetorical goal rather than a lived reality.

Conceptual and Theoretical Framework

This study is guided by two complementary frameworks the Sustainable Livelihoods Approach (SLA) and Gender and Development (GAD) theory adapted for the blue economy context. The Sustainable Livelihoods Approach (Scoones, 1998; Evans et al., 2023) emphasizes how households combine assets (natural, financial, social, human, and institutional) to sustain their wellbeing under dynamic environmental and economic pressures. It helps explain how ecological shocks, market dependence, and governance systems interact to shape vulnerability or resilience in coastal communities. The Gender and

Development framework extends this by situating gender not as a standalone variable but as a structure of power and access (Rahaman et al., 2024; Pike, 2025). It focuses on how gendered roles and decision-making processes determine control over resources and benefits within the blue economy (Anderson et al., 2023; de la Torre-Castro et al., 2022).

Integrating SLA and GAD allows this study to move beyond economic metrics to explore how sustainability and empowerment are co-produced through social relations, governance arrangements, and ecological adaptation. This combined framework underpins the analytical lens applied to the Tanga Region where seaweed farming sits at the intersection of livelihood necessity, gendered labor, and environmental change.

Identified gaps

Existing scholarship on seaweed farming across East Africa has provided valuable insights into its economic potential, gender dynamics, and environmental implications. However, several critical knowledge and practice gaps remain, particularly in the Tanzanian mainland context.

First, most studies have concentrated on Zanzibar, leaving Tanga Region a rapidly expanding seaweed farming zone largely underexplored. Research in Zanzibar (de la Torre-Castro et al., 2022; Ngajilo et al., 2023) has highlighted women's central role in production but their exclusion from the more profitable segments of the value chain such as marketing, processing, and export. Yet, there is limited empirical evidence examining whether these gendered patterns persist or manifest differently in emerging mainland farming areas like Tanga. This represents a significant gap in understanding how gendered labor and market relations shape empowerment outcomes within Tanzania's broader Blue Economy framework.

Second, previous literature often presents seaweed farming as an inherently sustainable livelihood, emphasizing its economic and ecological benefits (Mirera et al., 2020; Johnson et al., 2023). However, this optimistic narrative frequently overlooks the social and institutional dimensions of sustainability particularly how governance structures, access to information, and power relations affect farmers' capacity to adapt to environmental and market shocks. Scholars such as Kweka et al. (2022) and Sabai (2021) note that governance in Tanzania's coastal sector remains fragmented, donor-driven, and poorly aligned with local realities. Consequently, little is known about how these governance gaps influence everyday decision-making and long-term livelihood resilience among seaweed farmers.

Third, while climate-related challenges such as ice-ice disease and sea temperature rise have been well documented (Largo et al., 2020; Langford et al., 2023), there is insufficient analysis of how these ecological stressors interact with socioeconomic vulnerabilities including income inequality, gender disparities, and limited access to adaptation resources. Most studies treat environmental and social risks separately rather than as interconnected pressures shaping livelihood security. This separation limits our understanding of the multidimensional vulnerability that defines seaweed farming households.

Lastly, there is a notable theoretical and methodological gap. Many existing assessments rely on descriptive approaches that fail to integrate conceptual frameworks capable of explaining how economic, environmental, and social factors interact. The Sustainable Livelihoods Approach (SLA) provides a useful lens for analyzing how households combine natural, financial, and institutional assets to sustain their wellbeing amid ecological change. Likewise, the Gender and Development (GAD) framework reveals how gendered power structures determine access to these assets and influence adaptive capacity. Yet few studies apply these frameworks jointly to the Tanzanian seaweed sector, leaving the intersection of livelihood sustainability, gender equity, and governance largely unexplored.

This study therefore addresses these gaps by focusing on Tanga Region a neglected but critical node in Tanzania's Blue Economy landscape. It employs a mixed-methods approach grounded in SLA and GAD frameworks to (i) analyze how seaweed farming contributes to household livelihoods, (ii) assess how gender and governance shape participation and benefits, and (iii) evaluate how environmental challenges interact with social structures to influence adaptation and resilience. Through this integrated analysis, the study contributes new empirical and theoretical insights into how small-scale aquaculture can be made both socially equitable and environmentally sustainable within Tanzania's evolving blue economy.

Methodology

Research design

This study adopted a convergent parallel mixed-methods design, enabling the simultaneous collection and analysis of both quantitative and qualitative data. This approach was selected to effectively capture the complex interactions between the ecological, socioeconomic, and gender dimensions of seaweed farming in the Tanga Region. The research process was informed by the Sustainable Livelihoods Approach (SLA) and the Gender and Development (GAD) framework. The SLA guided the assessment of how natural, social, financial, and institutional assets shape household resilience and adaptation to environmental and market stressors. Concurrently, the GAD framework provided an analytical lens for examining how gendered power relations influence participation, decision-making, and control over income within seaweed farming communities. The integration of these two frameworks ensured that the data collection and analysis captured both the structural and experiential dimensions of sustainability, elucidating how external systems such as markets, governance, and climate interact with internal household and gendered dynamics.

Study area

The study was conducted in the Tanga Region, located in the north-eastern coastal part of Tanzania along the Western Indian Ocean, between 4°0'S - 6°0'S latitude and 38°0'E – 39°0'E longitude as it is shown in Figure 1. The region is ecologically diverse, with marine ecosystems comprising coral reefs, mangrove forests, and seagrass beds, which are closely interlinked with artisanal fisheries and aquaculture activities. Historically, the area has relied heavily on capture fisheries, but in recent years seaweed farming has gained prominence as an alternative livelihood, promoted under Tanzania's national blue economy framework (Mwaijande, 2021).

Three districts were selected as the study sites, Pangani (5°25'S, 38°58'E), Tanga City (5°04'S, 39°06'E), and Muheza (5°10'S, 38°39'E) to capture varied ecological and socio-economic contexts. Pangani represents a hotspot of artisanal fishing and aquaculture, highly exposed to ecological stressors yet actively engaged in adaptive innovations. Tanga City, being more urbanised, offers better access to markets but faces competition from other coastal land uses. Muheza, on the other hand, is more rural, where communities depend strongly on natural resources and traditional knowledge systems. This diverse selection ensured a comprehensive assessment of seaweed farming in the region, considering variations in ecological exposure, governance support, and market accessibility.

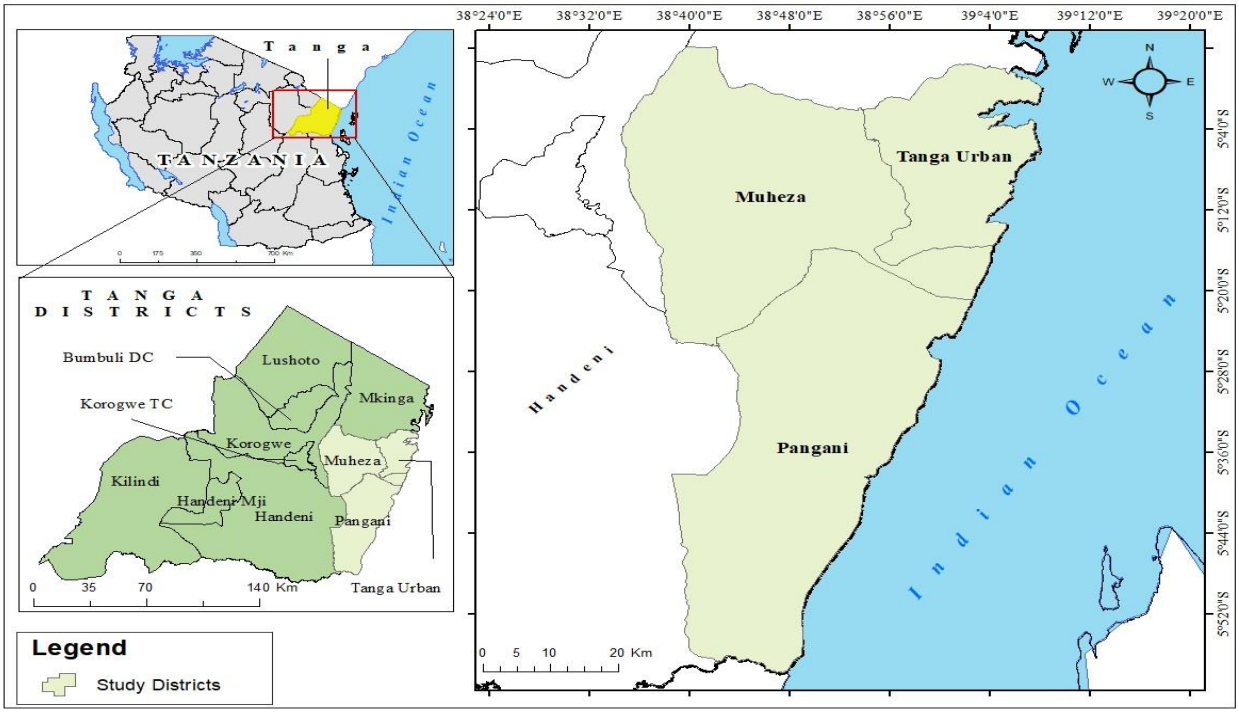


Figure 1: Location of the Study Areas
Source: UDSM, Department of Geography (2025)

Study population and sampling

The target population comprised households directly involved in seaweed farming within a five-kilometre coastal zone. According to district administrative records, there were approximately 4,200 active farming households across the three districts. A sample size of 365 was determined using the Yamane (1967) formula at a 95% confidence level and a 5% margin of error. Stratified random sampling ensured proportional representation by district, with Pangani constituting 40%, Tanga City 35%, and Muheza 25% of the sample. In total, 352 complete surveys were returned, yielding a 95.6% response rate. Qualitative sampling followed a purposive approach, selecting respondents based on gender, experience, and role within the seaweed value chain. This included ten (10) key informant interviews with district fisheries officers, farmers' cooperative leaders, and NGO representatives, as well as three (3) focus group discussions with women and men to capture gendered experiences and perceptions. This design ensured inclusivity and reflected the diversity of seaweed farmers' experiences.

Data collection methods

A combination of quantitative and qualitative tools was employed to ensure methodological triangulation and enhance the validity of the findings. Structured household surveys gathered data on demographics, farming practices, production systems, income levels, value chain participation, ecological stressors, and institutional access. Semi-structured key informant interviews with local leaders and officials provided insights into policy frameworks, extension services, and institutional challenges. Focus group discussions explored gender roles, income control, occupational health, and adaptation strategies, with women-only discussions ensuring a safe space for gender-specific dialogue. Furthermore, direct field observations complemented the interviews by documenting farming practices, infrastructure, and environmental conditions at the farm sites.

Data analysis

Quantitative data were analysed using SPSS (version 25). Descriptive statistics were used to summarise demographic and livelihood characteristics, while inferential analyses tested relationships between variables. A Pearson correlation examined associations between income, production, and environmental challenges; ANOVA compared production yields and

income differences across the three districts; and multiple regression analysis identified predictors of adaptation strategies and income variability. Qualitative data were subjected to thematic content analysis. Transcripts from interviews and FGDs were systematically coded according to emergent themes such as governance, gender relations, and ecological challenges. Triangulation was achieved by comparing quantitative patterns with qualitative narratives to identify points of convergence and divergence.

Ethical considerations

Ethical approval for the study was granted by the Tanga Regional Administrative Secretary. All participants provided informed consent after being briefed on the study's purpose and their right to withdraw at any time. No personal identifiers were used in the reporting of data. Gender sensitivity was ensured by conducting separate FGDs for women, allowing for free discussion of gendered barriers, and by recruiting trained local research assistants familiar with community norms and languages to enhance trust and accuracy. The research adhered to established ethical principles for community-based marine research, emphasising respect, reciprocity, and cultural sensitivity.

Methodological Rigour and Limitations

Methodological rigour was strengthened through triangulation across different methods, which enhanced internal validity. The integration of the SLA and GAD frameworks provided conceptual coherence, effectively linking household-level findings to broader institutional and policy contexts. However, several limitations are acknowledged. Firstly, the regional scope of the study limits the generalisability of the results to other coastal areas in Tanzania. Secondly, seasonal variability and a reliance on self-reported income data may have introduced some reporting bias. Nonetheless, these limitations were mitigated by the combination of multiple data sources and a strong emphasis on cross-verification during the analysis phase.

Findings and Discussion

This section presents and discusses the empirical findings of the study, integrating quantitative and qualitative data to provide a comprehensive analysis of the socioeconomic, ecological, and governance dimensions of seaweed farming in the Tanga Region. The presentation begins with a descriptive profile of the farming households, followed by inferential analyses examining the relationships between key variables, and concludes with a thematic discussion enriched by participants' narratives.

Socioeconomic and Livelihood Profile of Seaweed Farming Households

Across the three districts of Pangani, Tanga City, and Muheza, the study surveyed 352 seaweed-farming households. Results show that women constitute a striking 67% of primary farmers, reaffirming the sector's gendered structure and reflecting patterns seen across the Western Indian Ocean (de la Torre-Castro et al., 2022; Mengo et al., 2023). The average household had 5.4 members, and farmers reported roughly seven years of experience, indicating that seaweed farming is an entrenched livelihood rather than a short-term coping activity.

Economically, seaweed farming served as the main income source for 82.1% of households, yet most families pursued multiple income streams 54.3% engaged in artisanal fishing, 38.1% in crop farming, and 27% in petty trade. This diversification, while enhancing income security, also hints at the fragility of the seaweed economy itself. It aligns with the Sustainable Livelihoods Approach (SLA), where households balance diverse assets natural, human, and financial to manage vulnerability. In this case, seaweed provides the financial backbone, but the reliance on multiple small-scale activities underscores limited resilience to shocks such as disease outbreaks or market fluctuations (Evans et al., 2023).

Women's strong presence in production mirrors trends observed in Zanzibar and Southeast Asia, where female labor sustains seaweed value chains but rarely translates into economic

empowerment (Anderson et al., 2023; Ngajilo et al., 2023). Within the Gender and Development (GAD**)** framework, this imbalance points to structural inequality women contribute the bulk of labor but remain peripheral in decision-making and control over profits. As one participant noted in a focus group, "*We are in the water all day, but when the money comes, men decide what to do with it* ($MFDG_1$, 2025)." Such experiences highlight how gender roles, rather than purely economic forces, shape livelihood outcomes. Table 1 summarizes the household characteristics and livelihood activities, illustrating the sector's demographic and occupational contours.

Table 1: Household Characteristics and Livelihood Profiles (n = 352)

Characteristic	Frequency (n)	Percentage (%)	95% CI
Gender of Primary Farmer			
Female	236	67.0	[61.8-72.2]
Male	116	33.0	[27.8-38.2]
Seaweed as Primary Income	289	82.1	[77.8-86.4]
Additional Livelihoods			
Artisanal fishing	191	54.3	[49.0-59.6]
Crop farming	134	38.1	[32.9-43.3]
Petty trade	95	27.0	[22.3-31.7]

Note: CI = Confidence Interval

This socioeconomic profile portrays seaweed farming as both a livelihood anchor and a livelihood risk. The dependence on the sea for both income and food security exposes farmers to ecological vulnerabilities such as rising temperatures and ice-ice disease. As one farmer cooperative leader put it, "*When the sea changes, everything we depend on changes* (FCL_1, 2025)." These sentiments illustrate how environmental shifts translate directly into economic precarity a dynamic central to the SLA's concept of vulnerability context.

Moreover, gendered participation within this system is not merely descriptive but deeply political. Women's centrality in production yet marginality in governance structures reflects what de la Torre-Castro et al. (2022) term "participation without power." This reinforces the review's critique that earlier drafts were overly descriptive; here, gender is analyzed not as a demographic variable but as a social relation shaping access to and control over livelihood assets.

The livelihood diversity also underscores the informal, adaptive nature of coastal economies. Rather than static, seaweed farming households continuously adjust their activities to cope with fluctuating tides, prices, and policies. This fluidity exemplifies resilience-in-practice a form of everyday adaptation often overlooked in formal blue economy planning (Turpie et al., 2022).

Generally, seaweed farming in Tanga provides essential income and employment, particularly for women, yet remains embedded within precarious ecological and social systems. The findings suggest that strengthening livelihood sustainability will require more than technological interventions; it calls for policies that address structural inequities, enhance women's economic agency, and integrate smallholder voices into coastal governance. Only then can seaweed farming evolve from a survival strategy into a truly transformative pillar of Tanzania's blue economy.

Relationships between Income, Production, and Environmental Challenges

The study explored how household income from seaweed farming relates to production yields and environmental challenges, integrating statistical and qualitative evidence to unpack the dynamics of livelihood sustainability as shown in Table 2.

Table 2: Pearson Correlation Matrix of Key Variables (n=352)

Variable	Income	Production Yield	Environmental Challenges
Income	1		
Production Yield	.681**	1	
Environmental Challenges	-.447**	-.523**	1

p < 0.01

The data reveal a strong and predictable relationship between production yield and household income (r = .681, p < .01). This reinforces the centrality of seaweed productivity to coastal livelihoods in Tanga, confirming patterns observed across the Western Indian Ocean (Mirera et al., 2020; Evans et al., 2023). Simply put, when yields rise, incomes follow yet this dependency also exposes the fragility of household economies. The same marine environment that sustains income also renders farmers vulnerable to external shocks.

Environmental stressors such as *ice-ice disease* and heat-induced bleaching were negatively correlated with both production (r = –.523, p < .01) and income (r = –.447, p < .01). This empirically validates farmers' experiences that climate-driven ecological degradation directly undermines household stability. As one farmer cooperative leader explained, *"When the sea gets hotter, our farms die. We can't plan our lives anymore* (FCL_2, 2025)*."*

From the perspective of the Sustainable Livelihoods Approach (SLA), this pattern illustrates a classic "vulnerability trap" households heavily reliant on a single natural resource are the most affected by its decline. This interdependence reflects broader findings across coastal Tanzania, where marine-based livelihoods remain highly sensitive to climate and disease dynamics (Turpie et al., 2022; Ana et al., 2024).

Policy frameworks such as the Tanzania Blue Economy Development Framework (2021) and National Fisheries and Aquaculture Policy (2020) recognize the need for diversification and climate resilience, yet the Tanga data suggest that adaptation measures have not fully reached grassroots levels. Farmers continue to operate within ecologically precarious conditions, without sufficient institutional buffers or technological support.

In this context, the correlation results are not merely statistical they signal a structural failure of blue economy implementation. Environmental degradation translates directly into poverty, illustrating how weak governance and inadequate climate adaptation planning perpetuate vulnerability within the very communities that blue economy policies aim to empower.

District-Level Variations in Production and Income

Production and income outcomes varied markedly across the three districts, reflecting spatial inequalities in ecological exposure, market access, and institutional support as shown in Table 3.

Table 3: ANOVA Results for Production Yield and Income by District

Dependent Variable	District	Mean	Std. Deviation	F-statistic	p-value
Production Yield (tons)	Pangani	4.5	1.5	18.75	.000
	Tanga City	3.9	1.3		
	Muheza	3.1	1.1		
Monthly Income (TZS)	Pangani	92,000	28,500	16.89	.000
	Tanga City	81,200	26,100		
	Muheza	61,500	22,800		

Production and income levels differed significantly across districts (p < .001), with Pangani outperforming both Tanga City and Muheza. Pangani's higher average yield (4.5 tons) and

income (TZS 92,000/month) likely reflect its longer history of seaweed farming, stronger cooperative presence, and NGO support. In contrast, Muheza where yields averaged 3.1 tons and income just TZS 61,500 suffers from weak infrastructure, limited extension services, and higher exposure to disease outbreaks.

This spatial disparity reveals more than ecological variation; it underscores uneven governance and market access. As one officer put it, *"The buyers come to Pangani first. By the time they reach us, the prices are already lower* (DFO_1, 2025)*."* Within the SLA framework, such disparities indicate unequal access to institutional and social assets. While Pangani farmers benefit from stronger collective organization and periodic donor projects, other districts remain marginal to both state and private support systems. This reflects a broader trend in Tanzanian coastal development, where interventions are geographically concentrated and short-term (Kweka et al., 2022).

The tension here lies between policy aspiration and local reality. While national blue economy strategies emphasize inclusivity and equitable growth, their implementation often reinforces center–periphery divides. District-level inequality in seaweed productivity thus mirrors the uneven rollout of institutional capacity, a governance gap that risks entrenching localized poverty even within a growth-oriented sector

Predictors of Adaptation Strategy Adoption

A multiple regression analysis was performed to identify factors predicting the number of adaptation strategies adopted by farmers to cope with environmental and market challenges. The independent variables were education level, household income, farming experience, and access to extension services as shown in Table 4.

Table 4: Multiple Regression Predicting Adoption of Adaptation Strategies

Predictor Variable	Unstandardized B	Std. Error	Standardized Beta (β)	t-value	p-value
(Constant)	0.85	0.21		4.05	.000
Education Level	0.28	0.06	0.29	4.67	.000
Household Income	2.15E-05	0.00	0.21	3.45	.001
Access to Extension	0.31	0.09	0.19	3.44	.001
Farming Experience	0.02	0.01	0.09	1.52	.130

Regression analysis in Table 4 identified three significant predictors of adaptation - education ($\beta = .29$, $p < .001$), household income ($\beta = .21$, $p = .001$), and access to extension services ($\beta = .19$, $p = .001$) accounting for 32.5% of the variance in adaptive behavior. These results highlight that adaptation is a function of social privilege, not merely individual effort.

Better-educated and economically secure farmers are more capable of experimenting with new methods like floating rafts or changing planting schedules. Those with access to extension services mainly in Pangani are more informed and proactive. Conversely, low-income, less-educated farmers, who are predominantly women, remain least able to adapt. As one female farmer cooperative leader said, *"We hear about new techniques, but without money and training, how can we start?* (FCL_3, 2025)*"*

This "adaptation gap" exposes a profound equity issue within the blue economy. The Gender and Development (GAD) perspective helps clarify that adaptive capacity is socially constructed: men and wealthier households often monopolize the flow of information, credit, and technology. Women's exclusion from leadership roles and cooperatives compounds this

disadvantage, leaving them disproportionately exposed to environmental risks (de la Torre-Castro et al., 2022; Rahaman et al., 2024).

The findings echo global debates that resilience policies often neglect gendered power relations, resulting in what Evans et al. (2023) describe as "adaptation for some, vulnerability for others." In Tanzania's policy context, this suggests the need for gender-responsive extension models ones that integrate literacy, financial access, and participatory decision-making to ensure all farmers can benefit from innovation.

Thematic Integration of Qualitative Findings

The qualitative component of this study deepens understanding of the socioeconomic patterns revealed in the quantitative analysis. Through interviews and focus group discussions, three interrelated themes emerged governance and institutional support, gender relations, and ecological challenges each shaping the sustainability and equity of seaweed farming in Tanga. These narratives illustrate that seaweed farming is not only an economic activity but also a social and political process mediated by access, power, and policy.

Governance and Institutional Support

Project dependency and short-lived interventions

Across all districts, participants emphasized the transient nature of government and NGO support. Farmers described a familiar pattern: short-term projects that provide inputs or training but lack continuity. As one community leader in Pangani noted, *"They bring materials and training, but after a few months, the project ends. We go back to the old ways* (FCL_4, 2025)*."* This points to a "projectization" of governance a system where interventions are episodic rather than institutionalized (Kweka et al., 2022). The absence of sustained extension services undermines knowledge retention and limits the scaling of innovations like floating rafts or improved drying systems. Within the Sustainable Livelihoods Approach (SLA), this represents a failure to strengthen the institutional assets that enable adaptation and resilience.

The findings also resonate with Tanzania's Blue Economy Development Framework (2021), which envisions integrated coastal management but, in practice, remains fragmented. Weak coordination between local government, cooperatives, and research institutions perpetuates inefficiency and dependency. As Turpie et al. (2022) observe, such fragmentation prevents seaweed farming from evolving into a fully structured industry capable of generating sustainable income and environmental stability.

Market asymmetry and the "middlemen dilemma"

Participants repeatedly highlighted exploitative market relations. Middlemen who control access to exporters and urban buyers dictate prices and timing. A focus group in Tanga City captured this frustration: *"They tell us the price; we can't negotiate. If we refuse, they move to another village* ($TFGD_2$, 2025)*."* This dependence on intermediaries illustrates what Burra and Ushadevi (2022) call "value chain captivity," where producers remain trapped in low-value roles. It also reveals a gap in the Blue Economy policy framework, which emphasizes export growth but gives little attention to local value addition or market transparency. The result is an economic paradox: a sector that sustains thousands of livelihoods yet captures minimal value locally.

Empowering cooperatives, improving access to credit, and establishing transparent price information systems could counteract this asymmetry. Without these measures, farmers will remain price takers in a global value chain that thrives on their vulnerability.

Delayed and uneven resource allocation

Farmers also voiced frustration with bureaucratic inefficiencies. Delays in disbursing loans or equipment often mean missing planting seasons. As one cooperative official lamented, *"Support comes after the harvest. It helps no one* (FCL_5, 2025)*."* Such delays not only

undermine productivity but erode trust in public institutions. This tension reflects a deeper issue: while blue economy policies articulate ambitious goals, institutional inertia and resource misalignment at the local level hinder effective implementation. Addressing this requires decentralization and consistent financing mechanisms that reach smallholder farmers directly.

Gender Relations

Women's labor, men's control

Across all study sites, women dominate seaweed production (67%) but remain marginalized in decision-making and income control. Female participants described working long hours under harsh conditions soaking in seawater, drying and sorting harvests while men handle sales and financial decisions. One woman summarized it starkly: *"We work the farms, but the money goes through their hands* ($PFDG_3$, 2025)*."* This dynamic exemplifies what de la Torre-Castro et al. (2022) term "empowerment without control." It challenges the common narrative that women's participation automatically equates to empowerment. Under the Gender and Development (GAD) framework, true empowerment entails not only participation but also authority over income, resources, and collective decision-making (Anderson et al., 2023; Rahaman et al., 2024).

Despite national policy commitments such as SDG 5 (Gender Equality) and Tanzania's National Gender Policy (2022) implementation gaps persist. Women's exclusion from cooperatives and leadership positions limits their influence over pricing, access to credit, and adaptation technologies. This perpetuates what Pike (2025) describes as a "gendered governance vacuum" within marine economies.

Multiple burdens and health risks

One NGO representative narratives also reveal the physical and emotional toll of balancing seaweed farming with domestic duties. *"…most of women work like donkeys - farming and taking care of children and husbands, in between such tasks they sometimes get stressed* (NGO_1, 2025)." Many reported chronic back pain, skin irritation, and exhaustion from long days at sea followed by unpaid household labor. These accounts align with occupational health studies highlighting women's disproportionate exposure to ergonomic and dermatological hazards in seaweed farming (Ngajilo et al., 2023).

Yet policy frameworks remain largely silent on occupational safety in the aquaculture sector. Integrating health and safety training into extension services and promoting ergonomic farming technologies could mitigate these gendered risks, translating participation into genuine well-being rather than exploitation.

Barriers to leadership and collective voice

In both mixed and women-only focus groups, participants expressed frustration at their limited representation in cooperatives and local associations. Leadership remains predominantly male, even in sectors where women form the majority workforce. As one woman from Muheza put it, *"They say we don't understand business, but they never teach us or let us lead* (FCL_6, 2025)."

This absence of female leadership not only limits advocacy but perpetuates a cycle where gender-sensitive priorities such as childcare, credit access, and flexible training schedules are rarely institutionalized. From a GAD perspective, transforming this dynamic requires not just inclusion but structural reform: women must be positioned as decision-makers within cooperative boards and local governance bodies.

Ecological Challenges

The rising cost of environmental change

Seaweed farmers vividly described how shifting climatic patterns; warmer waters, stronger currents, and erratic rainfall are reshaping their environment. Many connected these changes

to global warming, revealing a nuanced local understanding of climate science. As one district officer noted, *"The sea is not the same. It's hotter now, and the wind confuses us. The mwani [seaweed] gets sick more often* (DFO_2, 2025)*."* Such accounts demonstrate lived climate literacy and highlight the SLA's "vulnerability context": environmental shocks directly translate into livelihood insecurity. The widespread occurrence of *ice-ice disease* and coastal erosion exemplifies how climate change undermines both ecological and financial sustainability (Largo et al., 2020; Langford et al., 2023).

Despite these realities, adaptive technologies such as floating rafts or Integrated Multi-Trophic Aquaculture (IMTA) remain out of reach for most smallholders due to cost, limited training, and inadequate institutional support (Fabiani et al., 2023). This creates an adaptation divide, where a few better-connected farmers can innovate while the majority remain trapped in declining productivity cycles.

Loss of coastal buffers and habitat degradation

Fisheries officer in Tanga City described the disappearance of mangroves and beaches once used for drying seaweed. "*Climate is very harsh, mangroves and beaches once used for drying seaweed are no longer available* (DFO_3, 2025)*."* The encroachment of urban development and the weakening of coastal ecosystems amplify exposure to storms and erosion. This finding aligns with Turpie et al. (2022), who warn that coastal habitat loss reduces the natural resilience of Tanzania's marine economies.

Rehabilitation of mangroves and the inclusion of community-managed marine areas in local spatial plans could help restore these protective ecosystems an approach consistent with the Blue Economy Development Framework's call for integrated ecosystem management.

Synthesis: Intersecting Vulnerabilities and Policy Implications

The qualitative narratives collectively portray seaweed farming in Tanga as a system of intersecting vulnerabilities economic, ecological, and gendered. Weak institutional continuity, gendered inequities, and climate stressors interact to constrain household resilience.

The tension between empowerment rhetoric and lived inequality is particularly stark. While policies celebrate women as "pillars of the blue economy," the everyday realities of exploitation, exclusion, and environmental uncertainty tell a different story. Similarly, while the sector is positioned as a vehicle for sustainable development, its dependence on middlemen and foreign markets sustains dependency rather than autonomy.

For Tanzania's blue economy to realize its transformative promise, policy must go beyond productivity targets. It must invest in long-term institutional support, ensure gender-equitable access to finance and decision-making, and embed ecological restoration at the core of marine livelihood planning. In short, resilience in seaweed farming will not emerge from technology alone it will require justice-oriented governance that values both people and the ecosystems they depend on

Conclusion and Policy Recommendations

Seaweed farming in the Tanga Region represents both a story of opportunity and one of constraint a livelihood that anchors thousands of coastal households but remains caught in structural and ecological fragility. The findings demonstrate that while seaweed farming contributes significantly to income diversification and women's employment, its long-term sustainability is undermined by environmental degradation, gendered inequality, and weak institutional support systems.

Revisiting the Livelihood Dynamics

At the household level, seaweed farming is indispensable: over 80% of surveyed families depend on it for their primary income. Yet the sector's vulnerability mirrors the delicate balance of the marine ecosystem it relies on. The Sustainable Livelihoods Approach (SLA)

helps clarify this tension: farmers possess rich natural and human assets but limited financial and institutional capital. When ice-ice disease, bleaching, or storms strike, livelihoods collapse rapidly because support systems extension services, cooperatives, and credit are either absent or inconsistent.

This imbalance exposes the paradox of Tanzania's Blue Economy Agenda: while the policy promises inclusive growth through marine-based livelihoods, the practical reality on the ground remains exclusionary. Wealth and knowledge circulate unevenly, and benefits tend to accrue to intermediaries and exporters rather than producers. The sector's structure thus sustains dependency rather than empowerment.

Gendered Dimensions of Vulnerability

The dominance of women in seaweed production (67%) challenges the traditional gendered division of labor in coastal economies, yet participation does not equate to empowerment. Women perform the most labor-intensive and health-risking tasks but remain largely excluded from leadership, credit, and decision-making. Within the Gender and Development (GAD) framework, this inequality underscores the need to shift from participation-based inclusion to transformative empowerment, where women not only contribute labor but shape strategy, negotiate markets, and access profits.

Tanzania's National Gender Policy (2022) and commitments to SDG 5 (Gender Equality) provide the normative foundation for such change. However, achieving it will require institutional redesign ensuring that cooperatives, training programs, and market structures are gender-responsive in both form and function.

Environmental Pressures and the Adaptation Gap

Ecological instability remains the greatest existential threat to the seaweed sector. The strong negative correlations between environmental stress and both yield and income confirm that climate change directly erodes household resilience.

The study's regression results show that education, income, and access to extension services are the strongest predictors of adaptation, revealing a widening adaptation gap. Better-off farmers innovate, while the poorest often women lack both resources and institutional contact to do so. Without targeted interventions, climate change will deepen inequality within coastal communities rather than unify them under the banner of sustainability.

Governance and Institutional Weakness

Perhaps the most persistent thread across all findings is the weakness of governance. Seaweed farming in Tanga is managed less as a structured economic sector and more as a sequence of donor-driven projects. This "projectization" produces bursts of activity followed by institutional silence, leaving farmers stranded between training sessions and unfulfilled promises.

The Blue Economy Development Framework (2021) envisions multi-level coordination between government, private sector, and communities, yet the lived experience of farmers tells a different story of uncoordinated agencies, delayed resource flows, and a lack of accountability. Bridging this gap demands not just new programs but a rethinking of governance culture itself: one centered on continuity, participation, and local agency.

Key Policy Recommendations

i. Institutionalize Inclusive and Decentralized Governance Support: Establish permanent district-level seaweed coordination units to replace short-term project cycles. These units should link farmers, cooperatives, and research institutions, ensuring continuous training, disease monitoring, and market data dissemination.

This aligns with Tanzania's Blue Economy Development Framework (2021) and addresses the study's finding on institutional fragmentation.

ii. Scale Up Climate-Resilient and Gender-Responsive Technologies: Subsidize and provide training for floating raft and Integrated Multi-Trophic Aquaculture (IMTA) systems, targeting women and low-income farmers. Integrating gender-responsive design into technology dissemination will close the adaptation gap identified in the regression analysis, supporting SDGs 5 and 13 on gender equality and climate action.

iii. Promote Local Value Addition and Market Transparency: Develop community-based seaweed processing and value-addition enterprises to reduce dependence on middlemen and enhance local income retention. Policies should ensure transparent pricing mechanisms and cooperative bargaining platforms, addressing the study's evidence of exploitative market structures and low-value capture.

References

Adam, R., Amani, A., Kuijpers, R., Danielsen, K., Smits, E., Kruijssen, F., & Farnworth, C.R. (2024). Climate-resilient aquatic food systems require transformative change to address gender and intersectional inequalities. *PLOS Climate*, 3(7), e0000309.

Ali, H.R. and Rashid, Z.A. (2025). Integrating local and modern knowledge for climate change adaptation in sustainable seaweed farming in Zanzibar. *Open Access Library Journal*, 12(1), pp.1-21.

Ana, Q.M., Elizabeth, T., Msuya, F., Kuguru, B., Jiddawi, N., Mahongo, S. … and Popova, E. (2024). A sustainable blue economy may not be possible in Tanzania without cutting emissions. *Science of the Total Environment*, p.174623.

Anderson, C., Tiitii, U., Madar, L., Tanielu, E., Larson, S. and Swanepoel, L. (2023). Unpacking gendered roles across the seaweed value chain in Samoa using photo elicitation methods. *Ocean & Coastal Management*, 232, p.106420.

Baker, M., Isaac, L., Alkoyak-Yildiz, M. and Rao, B.R. (2024). Examining the major barriers to women's participation and employment in coastal activities of India's blue economy: a systematic literature review. *Environment, Development and Sustainability*, pp.1-45.

Brakel, J., Sibonga, R.C., Dumilag, R.V., Montalescot, V., Campbell, I., Cottier-Cook, E.J. and Gachon, C.M. (2021). Exploring, harnessing and conserving marine genetic resources towards a sustainable seaweed aquaculture. *Plants, People, Planet*, 3(4), pp.337-349.

Burra, N.J. and Ushadevi, K.N. (2022). Porter's five forces analysis of Zanzibar's seaweed industry. *Asian Journal of Agricultural Extension, Economics & Sociology*, 40(11), 185-196.

Charisiadou, S., Halling, C., Jiddawi, N., von Schreeb, K., Gullström, M., Larsson, T. and Nordlund, L.M. (2022). Coastal aquaculture in Zanzibar, Tanzania. *Aquaculture*, 546, p.737331.

de la Torre-Castro, M., Lindström, L., Jiddawi, N.S., Pike, F. and Max, A. (2022). Women and adaptive capacity to climate change in East African seascapes: Zanzibar as an example. *Frontiers in Marine Science*, 9, p.931883

Dogeje, F., Msuya, F.E., Ngaruko, D. and Mohamed, A.S. (2025). Blue economy dynamics: does women's participation in seaweed aquaculture influence their income levels? Empirical evidence from Zanzibar. *Aquaculture International*, 33(1), pp.27-52

Evans, L.S., Buchan, P.M., Fortnam, M., Honig, M. and Heaps, L. (2023). Putting coastal communities at the center of a sustainable blue economy: a review of risks, opportunities, and strategies. *Frontiers in Political Science*, 4, p.1032204

Fabiani, G., Namukose, M., Katikiro, R.E., Yussuf, Y.S., Steinmann, N.M. and Msuya, F.E. (2023). Tanzania case study: potential and challenges of integrated multi-trophic aquaculture (IMTA) system of seaweed and sea cucumber. In: *Challenges in Tropical Coastal Zone Management: Experiences and Lessons Learned*. Cham: Springer, pp.133-148.

Fernández, G.L.G., Avila, M., Saunders, F., Riquelme, R., Rodriguez, D., Aroca, G. and Gutierrez, J. (2024). Prospects of equitable and sustainable seaweed aquaculture: a case

study of changing gender and socio-economic relations in Maullín, Chile. *Maritime Studies*, 23(1), p.7

Henderson, J 2024, *Rising from the depths: utilising marine cultural heritage to create social, cultural and economic benefits in Kenya, Tanzania, Mozambique and Madagascar: emergent findings*. The University of Edinburgh, Edinburgh. https://doi.org/10.2218/ED.9781836450696

Jagtap, A.S. and Meena, S.N. (2022). Seaweed farming: a perspective of sustainable agriculture and socio-economic development. In: *Natural Resources Conservation and Advances for Sustainability*. Elsevier, pp.493-501

Johnson, B., Divu, D., Mojjada, S.K., Koya, M., Tamilmani, G., Megarajan, S. … and Gopalakrishnan, A. (2023). Economic prosperity and environmental sustainability through seaweed culture. *Marine Fisheries Information Service, Technical and Extension Series*, 257, pp.30-40

Kimanga, F., Ladan, L., Mirera, D., Maundu, A., Moyoni, H., Bironga, C. and Onyango, J. (2025). Gendered-value chain opportunities and challenges in seaweed aquaculture: the changing gender and socio economic dynamics in Mwazaro and Kibuyuni Villages, South Coast Kenya. *Multidisciplinary Journal of Technical University of Mombasa*, 4(1), pp.1-17.

Kweka, O., Katikiro, R.E., Daniel, F., Namkesa, R.A.M. and Ponte, S. (2022). Sustainability partnerships in the coastal resources sector in South-east Tanzania. *Journal of Sustainable Development*, 15(4), pp.162–177

Langford, Z., Ruhon, R., Walyandra, Z.Z., Lapong, I. and Armis, R.A. (2023). Environmental and socio-economic constraints to marine seaweed farming. In: *Globalisation and livelihood transformations in the Indonesian seaweed industry*. Routledge, pp.150–176

Largo, D.B., Msuya, F.E. and Menezes, A. (2020). *Understanding diseases and control in seaweed farming in Zanzibar*. FAO Fisheries and Aquaculture Technical Paper No. 662. Rome: FAO

Matoju, I., Le Masson, V., Montalescot, V., Ndawala, M.A. and Msuya, F.E. (2022). A resilience lens to explore seaweed farmers' responses to the impacts of climate change in Tanzania. *Applied Phycology*, 3(1), pp.132-148

Matovu, B., Bleischwitz, R., Alkoyak-Yildiz, M. and Arlikatti, S. (2024). Invigorating women's empowerment in marine fishing to promote transformative cultures and narratives for sustainability in the blue economy: a scoping literature review from the Global South. *Mitigation and Adaptation Strategies for Global Change*, 29(8), p.83

Mengo, E., Grilli, G., Murray, J.M., Capuzzo, E., Eisma-Osorio, R.L., Fronkova, L., ... & Tan, A. (2023). Seaweed aquaculture through the lens of gender: participation, roles, pay and empowerment in Bantayan, Philippines. *Journal of Rural Studies*, 100, p.103025

Mirera, D.O., Kimathi, A., Ngarari, M.M., Magondu, E.W., Wainaina, M. and Ototo, A. (2020). Societal and environmental impacts of seaweed farming in relation to rural development: the case of Kibuyuni village, south coast, Kenya. *Ocean & Coastal Management*, 194, p.105253

Mosha, S.S. and Daudi, J.M. (2020). A review of aquaculture production in Tanzania: recent status, challenges and opportunities, and its impact in poverty alleviation. *Sumerianz Journal of Agriculture and Veterinary*, 3(8), pp.2617–3131

Mwaijande, F. (2021). Managing the blue economy: a case study of Tanzania. In: *The blue economy in Sub-Saharan Africa*. Routledge, pp.158-179

Ngajilo, D., Adams, S., Kincl, L., Guernsey, J. and Jeebhay, M.F. (2023). Occupational health and safety in Tanzanian aquaculture: emerging issues. *Journal of Agromedicine*, 28(2), pp.321–333

Pena, M., McConney, P., Simmons, B. and Blackman, K. (2023). The challenging climate for women in caribbean fisheries-from seaweed to seafood, and practice to policy. In: *The impact of climate change on vulnerable populations*. Praeger, pp.126-143

Pike, F. (2025). *Gender in Marine Protected Areas: Implications for conservation and sustainability in a changing ocean*. Doctoral dissertation, Stockholm University

Pike, F., Lindström, L., Ekstedt, J., Jiddawi, N.S. and de la Torre-Castro, M. (2024). Dynamic livelihoods, gender and poverty in marine protected areas: case study from Zanzibar, Tanzania. *Ambio*, 53(8), pp.1218-1233

Rahaman, M.S., Dana, L.P. and Anjum, N. (2024). Empowering women in building a sustainable blue economy. In: *Handbook of sustainable blue economy*. Cham: Springer Nature Switzerland, pp.1-20

Rimmer, M.A., Larson, S., Lapong, I., Purnomo, A.H., Pong-Masak, P.R., Swanepoel, L. and Paul, N.A. (2021). Seaweed aquaculture in Indonesia contributes to social and economic aspects of livelihoods and community wellbeing. *Sustainability*, 13(19), p.10946

Salazar, C., Jaime, M., Retamal, R.C. and Baquedano, M. (2023). Women engagement, psychological traits, and gender gaps in the small-scale seaweed aquaculture in Chile. *Reviews in Aquaculture*, 15(4), pp.1540-1553

Saravanan, P., Chatterjee, A. and Bhowmick, G.D. (2023). Diverse roles of seaweed in the blue carbon economy and sustainable development: a comprehensive review. *Green and Low Carbon Economy*, 2(1), pp.1–17

Shimba, C., Magombola, D.A. and Ibrahim, S. (2021). Assessment of seaweed farming in sustaining household livelihood in East coast district, Zanzibar, Tanzania. *European Journal of Physical and Agricultural Sciences*, 9(1), pp.1-12

Suyo-Diala, J.G.B. and Hurtado, A.Q. (2024). Stakeholders' perspectives and gender relations as indicators of knowledge systems: empirical evidence from the Philippine seaweed industry. In: *Tropical phyconomy coalition development: focus on eucheumatoid seaweeds*. Cham: Springer International Publishing, pp.299-308

Turpie, J., Brühl, J. and Lokina, R. (2022). Incorporating poverty and gender considerations in marine spatial planning: a case study of the Tanga region in Tanzania. *Marine Policy*, 138, p.105024

Ulega, A., Mgaya, Y., Lokina, R. and Mushy, R. (2022). The contribution of marine fisheries to socio-economic development in Tanzania mainland: reflections on the blue economy concept from selected coastal villages. *Journal of the Geographical Association of Tanzania*, 42(2), pp.1-22

Vance, C., Pollard, P., Maguire, J., Sweeney, J. and Murphy, F. (2023). Sustainable scale-up of Irish seaweed production: quantifying potential environmental, economic, and social impacts of wild harvesting and cultivation pathways. *Algal Research*, 75, p.103294

Yahya, B., Yahya, S., Mmochi, A. and Jiddawi, N. (2020). Comparison of seaweed growth, fish abundance and diversity in deep water floating raft with tubular nets and shallow water off-bottom lines seaweed farms. *Tanzania Journal of Science*, 46(3), pp.840-850.

Policy Brief: Advancing Gender-Responsive Seaweed Farming in Tanzania's Blue Economy: Insights from Tanga Region

Author**: Sixbert Joachim Msambichaka, The Mwalimu Nyerere Memorial Academy (MNMA)**

Background

Seaweed farming has become a strategic livelihood in Tanzania's coastal regions, contributing to poverty reduction, women's employment, and climate resilience. It is central to the government's Blue Economy Development Framework (2021) and the National Fisheries and Aquaculture Policy (2020), and aligns with Tanzania's Development Vision 2025 and the Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty), SDG 5 (Gender Equality), and SDG 14 (Life Below Water). However, recent evidence from the Tanga Region reveals that the sector's transformative potential is constrained by ecological stressors, gendered labor hierarchies, and fragmented governance systems.

Key Findings

Drawing on a mixed-methods study involving 352 household surveys, 10 key informant interviews, and 3 focus group discussions, the research highlights several critical dynamics. Women constitute 67% of seaweed producers, yet remain excluded from value addition and decision-making processes. Seaweed farming is the primary income source for 82% of households, but productivity is increasingly threatened by ice-ice disease (73%) and heat stress (65%). Market dependence on middlemen is high (87.8%), and only 3.1% of farmers engage in value addition. Education, income, and access to extension services significantly predict adaptive capacity, revealing an adaptation gap that disproportionately affects low-income and less-educated farmers, particularly women.

Policy Implications

The findings underscore the need for a gender-responsive and climate-smart policy approach. First, women's empowerment must extend beyond participation to include control over income, access to technology, and decision-making authority. Second, climate-resilient technologies such as floating raft systems and disease-resistant seaweed strains should be scaled up, alongside training programs that build ecological literacy. Third, local value addition must be prioritized through investment in processing equipment, branding, and cooperative development. Finally, governance structures must be strengthened through participatory planning, improved extension services, and integration of local ecological knowledge into policy frameworks.

Recommendations

To unlock the full potential of seaweed farming as a driver of inclusive coastal development, the government should embed gender equity and climate resilience into the Blue Economy agenda. Development partners and NGOs must shift from donor-driven models to locally owned, context-sensitive interventions. Academic institutions should expand intersectional research beyond Zanzibar to mainland regions like Tanga, applying frameworks such as the Sustainable Livelihoods Approach (SLA) and Gender and Development (GAD) theory. These efforts will ensure that seaweed farming contributes not only to economic growth but also to social justice and environmental sustainability.

Muhtasari

Kilimo cha mwani ni nguzo kuu ya uchumi wa buluu wa Tanzania, kikichangia kuboresha maisha ya wakazi wa pwani, kuongeza ajira kwa wanawake, na kusaidia juhudi za kukabiliana na mabadiliko ya tabianchi. Utafiti huu umechunguza vipengele vya kijamii, kiuchumi, kiikolojia na utawala vinavyohusiana na kilimo cha mwani katika Mkoa wa Tanga kwa kutumia mbinu mchanganyiko (mixed methods) iliyojumuisha dodoso za kaya (n = 352), mahojiano kumi (10) ya wadau wakuu, na vikundi vitatu (3) vya majadiliano shirikishi. Takwimu za kiasi zilichambuliwa kwa kutumia SPSS (toleo la 25) kupitia takwimu elekezi, uchambuzi wa uhusiano (correlation), ANOVA, na regression, ilhali data za kimaelezo

zilichambuliwa kwa njia ya uchambuzi wa kimaudhui kulingana na mfumo wa Sustainable Livelihoods Approach (SLA) na Gender and Development (GAD). Matokeo yanaonyesha kuwa asilimia 82 ya kaya zinategemea kilimo cha mwani kama chanzo kikuu cha kipato, huku wanawake wakichangia asilimia 67 ya wazalishaji. Hata hivyo, uzalishaji unadhoofishwa na ugonjwa wa ice-ice (asilimia 73), mfadhaiko wa joto (asilimia 65), na utegemezi wa soko kupitia madalali (asilimia 87.8), huku asilimia 3.1 pekee ya wakulima wakijihusisha na kuongeza thamani. Kiwango cha elimu, kipato cha kaya, na upatikanaji wa huduma za ugani vinaathiri kwa kiasi kikubwa uwezo wa wakulima kujibadilisha, na hivyo kuibua pengo la uhimili (adaptation gap) linalowaathiri zaidi wakulima wenye kipato cha chini na wasio na elimu, hasa wanawake. Utafiti unahitimisha kuwa licha ya umuhimu wake wa kiuchumi, kilimo cha mwani bado kinaendeleza kutokuwepo kwa usawa wa kimfumo. Kuimarisha utawala unaojali usawa wa kijinsia, kukuza teknolojia himilivu kwa tabianchi, na kuendeleza shughuli za kuongeza thamani katika jamii ni hatua muhimu za kulibadilisha kuwa sekta endelevu na jumuishi katika maendeleo ya pwani.

Maneno Muhimu: *Kilimo cha Mwani, Uchumi wa Buluu, Maisha Endelevu, Usawa wa Kijinsia, Uhimili wa Tabianchi, Tanzania, Utawala wa Pwani*