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SAUDI ARABIA'S SUSTAINABLE BLUE ECONOMY: THE TRANSFORMATIVE POTENTIAL OF GENDER EQUALITY UNDER VISION 2030

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Abstract
This research paper analyses the concept of gender inclusion and its effect on performance, equity, and sustainability in the context of the emerging blue economy in Saudi Arabia through a mixed-methods research design incorporating the workforce statistics, institutional data, regional comparisons, and interview on the stakeholders. Research findings show that there is high gender inequality in the maritime industries with women's involvement being centered in conservation, research, and technologically oriented activities whereas offshore fishery, port usage, and industrial maritime sectors are dominated by men. The eight presented detailed tables and eight figures illustrate how structural barriers which include cultural norms, lack of gender-sensitive infrastructure and accessibility to sea-time training continue to retard the progress of women even as there is a growing interest and enrolment to maritime education programs. It is also interesting to note that mixed-gender teams are always better in terms of environmental monitoring, performance accuracy, compliance, and safety, which is tangible evidence of performance advantages of a gender-driven team. Localised socio-economic relationships indicate that female participation and cultural acceptance are greater in Red Sea regions than in Gulf regions. The institutional readiness tests also indicate that there is disparate application of gender-responsive policies, where research institutions are the ones who are ahead in inclusion frameworks. On the whole, the research comes to a conclusion that gender inclusion is not merely a social equity requirement but also a strategic factor of operational performance, environmental stewardship and sustainable economic development in the blue economy. Gender-biased policy reforms, greater training opportunities, and investment in gender-sensitive maritime infrastructure to support equitable and high-impact female involvement in all areas of the marine industry are highlighted in the findings.

1. INTRODUCTION

The blue economy is a concept that has become more prominent in the world as countries with coasts strive to find a way forward in enhancement of their economy that should not affect the marine environments negatively. The blue economy is a development model and a governance framework of

the environment dubbed by the World Bank as the sustainability of ocean resources to support economic development, enhanced livelihoods, and employment, but still maintains the health of marine ecosystems (World Bank, 2023). In the case of Saudi Arabia the blue economy has evolved to form a strategic pillar of the national transformation agenda as witnessed in the vision 2030, to diversify the economic structure of the Kingdom beyond hydrocarbons, to open new non-oil incomes with its economy and also to improve development of human capital. Saudi Arabia has a strategic advantage due to the presence of over 2,600 kilometers of coastline bordering the Red Sea and the Arabian Gulf, which provides the kingdom with an opportunity to use their marine resources to stimulate fisheries development, maritime logistics, coastal tourism, renewable marine energy and marine sciences (Saudi Vision 2030, 2024).

The reform impetus undertaken by the Kingdom goes hand in hand with a global trend towards inclusive and sustainable management of the sea in the form of international regulations like the United Nations Sustainable Development Goals (SDGs). Specifically, SDG 14 of the title Life Below Water and SDG 5 of the title Gender Equality highlight how crucial the environmentally friendly approach to maritime economy development is and how the ideas of inclusivity and diversity interact (UNDP, 2024). Nevertheless, the maritime sector is still among the most patriarchal areas all over the world despite the established understanding of the role of women in the fisheries and aquaculture as well as the conservation of marine environments. The International Maritime Organization (IMO) has figured that less than 2% of the total seafaring workers in the world are women and have been greatly underrepresented in technical, leadership, and decision-making jobs in the maritime sectors (IMO, 2023). This gender inequality is further exacerbated in the Gulf region where institutional pathways and and cultural perceptions have through the years restricted accessibility of women to maritime education and jobs.

Saudi Arabia has however over the past few years undergone a significant change in the engagements of women in various sectors of the economy. The current national labor statistics indicate that the rate of female workforce participation has risen by 19 percent in 2016 to above 36 percent by 2023, which is the effectiveness of the policy reforms and social change efforts by further plans of Vision 2030 (General Authority for Statistics, 2024). However, with all these national-level achievements, the maritime arena remains a lag-behind. The number of women being represented in fisheries cooperatives, port operations, marine engineering schools and in environmental conservation organizations are minimal and are usually curtailed by socio-cultural practices, lack of gender sensitive institutional policies, and lack of accessibility to maritime training programs.

Meanwhile, the coastal areas of Saudi Arabia undergo a fast rate of development driven by such mega-projects as NEOM, the Red Sea Global tourism zone, and large port expansions at Jeddah, Yanbu, and Dammam. These breakthroughs have unlocked novel potentials of innovation-driven and knowledge-based maritime industry, such as marine biotechnology, digital shipping, autonomous shipping, and blue carbon conservation programs. Gender-inclusive participation has a positive impact on innovation, decision quality, and environmental performance, as it is increasingly evidenced in the world as it strengthens environmental performance in the maritime ecosystem (World Economic Forum, 2024). Thus, it is not only like artists incorporating women in emerging blue economy sectors that are not only socially equitable, but are also strategic requirements of sustainable national development.

According to recent research, countries that are progressing gender equality in managing the sea demonstrate better ecological oversight results, enhanced results in coastal communities, and big data technological innovation in fisheries and marine management (FAO, 2024). This is an indication that there is a lot of potential that remains unexploited in Saudi Arabia, especially as the Kingdom tries to establish itself as one of the leading nations in the region and globally in terms of sustainable development in the marine sector. Nevertheless, little is available on studying the gender aspects of Saudi Arabia's blue economy, and this presents a gap in knowledge on the obstacles within the structure of the economy, institutional

willingness and strategic opportunities in developing gender-enhanced maritime future.

To address this missing information, the current study is an analysis of the potential of gender equality as a form of transformation in the blue economy of Saudi Arabia. This study examines the benefits of increasing the presence of women in the field and how it will result in greater economic diversification, promote the success of marine conservation, and achieve better governance by a series of research and analysis of policies alongside field data and stakeholder perspectives. It states that the empowerment of women in the maritime sector is a part of the fulfillment of the goals of the Vision 2030 and the attainment of long-term sustainable development in accordance with the global frames. The introduction hence provides a background on which the context of a blue economy in Saudi Arabia will be explored extensively, the trends within the sector, the available gaps and future directions on how to create a more inclusive, innovative and sustainable blue economy.

Literature Review

1. Conceptual Evolution of the Blue Economy

The blue economy has transformed a past paradigm of marine-resource into a new, current paradigm of sustainability-oriented development. Previous readings were more concerned with commercial fisheries, sea trade and maritime livelihoods. Modern definitions, however, focus on combined control of oceans, technological progress, climate adaptability, and all-encompassing socio-economic progress. As reported by OECD (2022), the global ocean economy will have grown to over USD 3 trillion by 2030, which is most likely to be due to the contribution of aquaculture, offshore renewable energy, biotechnology and sustainable tourism. Such a change demands the implementation of governance frameworks addressing the needs of the economy, as well as environmentally friendly, and placing coastal states on the path of diversified and sound development.

Other current research has highlighted how social inclusion (particularly gender equality) plays a central role in determining sustainable blue economies. Dominguez and Mathews (2021) suggest that inclusive governance systems would enhance marine resource management since they integrate various types of knowledge such as women who play a major role in pre- and post-harvest work. Equally, Schutter and Hicks (2022) emphasize the fact that the blue economy must be described as both a technical or ecological approach and a socio-political initiative that requires equal access to opportunities and equitable involvement of gender, communities, and social groups.

2. Gender Dynamics in Marine and Coastal Economies

The gendered character of marine resource economies is reported all through the world literature. Women are engaged in up to 80 percent of the processing, preservation, and trade in small-scale fisheries, whereas they are mostly not represented in official data and policymaking (Barclay et al., 2021). There is their informal work, unnoticed, and unrewarded in the decision-making systems that govern the access of the market, licensing, and distribution of resources in the marketplace. This invisibility supports structural inequalities and diminishes the ability of women to shape the outcomes of marine governance.

The notion of gender in most coastal areas inhibits the mobility of women, access to training services, and marine or technical jobs. Kleiber et al. (2020) reveal that they have gender biases that, institutionally, make women marginalized through various processes in maritime institutions such as the hiring policies to the safety policies. In addition to this, in the coastal society, women tend to be dispossessed of fishing properties thus limiting their capacity to reap the rewards of blue economy expansion. At the community level, Pictou (2021) postulates in a research study that sustainable marine economies are impossible to accomplish without acknowledging women rights, traditional know-how and women leadership qualities in the administration of communities.

Women have a very low involvement in maritime sectors in the Middle East and North Africa (MENA). Kose and Ghoneim (2023) argue that seafaring, fisheries management, and port operations continue to be dominated by males because of cultural norms and institutional obstacles. Despite the growth in women participation in the regional

regions in the areas of education, tourism and the public sector, maritime industries are still playing behind as the current set of regulations are still outdated and they do not even have structures to accommodate women trainees and workers.

3. Gender and Maritime Education: Opportunities and Gaps

Maritime education is an important variable in the involvement of women in the blue economy. Research indicates that the maritime training ecosystem is male dominated around the world with an exception of navigation, engineering, and offshore activities. A study carried out by Gonzalez and Freire (2022) shows that fewer than five percent of the global marine engineering and nautical science enrollees are females. This underrepresenting factor is seen to be attributed to the effect of social stereotypes, ineffective institutional assistance and the lack of female mentors within the maritime academies.

Also, online aspects of experiential learning, including sea-time training, simulation work and field research, can bring other challenges to women. The study conducted by Mallory and Dayan (2023) indicates that in most maritime training institutions, not all offer gender-neutral painters, safety equipment on board, or training ships. Consequently, it is common to find female cadets failing to satisfy the practical requirements they must fulfill in order to have professional certifications. These barriers impede the access of women into technical and operational jobs that come with higher wages, hence, legitimizing horizontal and vertical segregations in the maritime labour markets.

However, some of the nations have been able to incorporate gender-based approaches in maritime education. Maritime academies in Canada and South Korea have also launched mentorship as well as the slightest pathway of sea-time and scholarship-based programs aimed at women specifically (Baek & Razavi, 2022). These efforts have helped bring on a slow rise in the numbers of women and they provide the case of how institutional change can be used to overcome systemic barriers to education.

4. Role of Women in Marine Conservation and Coastal Sustainability

The historical role of women in marine environmental stewardship is crucial and not much-noticed. The literature on this topic has shown that the participation of women in conservation activities increases ecological performance, boosts community inclusion, and advances adherence to resource policies. As an example, the Pacific Island studies show that measures undertaken to protect the sea run by women lead to increased biodiversity metrics and greater enforcement norms (Tarisesei and Chauvet, 2021).

Besides, the participation of women in mangrove replenishment and coral rehabilitation has been established to increase ecological surveillance and speed up the implementation of sustainable practices by the communities. A research study conducted by Watson et al. (2022) in East Africa found that groups of women who were involved in coastal restoration projects expressed more substantial long-term commitment and realized increased success rates in restoring mangroves relative to the mixed groups. These results outline the possible potential of women as leaders in environmental issues and the importance of women in promoting climate resilience and place-based conservation.

The connection between the empowerment of women and the success of blue carbon projects also receives the emphasis of scholarship. Women can be used to bring about ecological change in the form of inclusive governance, land rights, and culturally sensitive climate policies (Alemany & Moura, 2023). With respect to the Gulf region, there is an emerging literature which indicates that women are increasingly getting involved in environmental programmes, especially in marine research, biodiversity research, and eco-tourism. But even these initiatives are only of small scale, and very few of them are institutionally supported to go beyond pilot projects to national frameworks.

5. Technology, Innovation, and the Gender Gap in Maritime Sectors

The modern blue economy has been characterized by technological innovation, which has been fueled by the development of automation, artificial intelligence, Internet of Things (IoT) and marine

robotics. Although such technologies have the potential to make the work environment safer and more efficient, there are also chances that they would widen the already existing gender gaps as long as women remain out of technology roles. The current paper cites a study by D'Souza and Kwon (2023) that discovered that women constitute under 10 percent of workers in maritime technology sectors in most countries worldwide, and even lower representation in robotics, cybersecurity, and digital navigation systems.

The problem of automation and the process of digitalization is also changing the labor requirements, and new skills, demanded in data analytics, remote sensing, and AI-based logistics, are needed. Unless women have an opportunity to gain access to these new domains, there is a danger that the gender gap in maritime work can grow even further. Having not proposed specific capacities building programs aimed at women, Zhang and Hossain (2022) also pointed to the systemic review that the digitalization of maritime industries is potentially excessive without relying on enhancing traditional gender relationships.

Inclusive technology on the other hand can empower a woman when done strategically. In Southeast Asia, the fish marketing, digital traceability, and blockchain-based value chains systems, based on mobile applications, have increased the economic opportunities of women-owned small fisheries businesses (Santiago et al., 2021). These solutions show that gender-sensitive digitized ecosystems have the potential to improve transparency, limit physical barriers and make women more meaningful participants in marine value chains.

6. Policy Frameworks and Global Bonds to gender-responsive Blue Economies.

The global systems have come up with more attention to mainstream gender in ocean governance. According to the UN Decade of Ocean Science to achieve sustainability (20212030), there should be equitable involvement of states in ocean research as well as promoting gender-inclusive scientific agendas (IOC-UNESCO, 2021). Located within it, the FAO also highlights that in order to achieve a sustainable future of small-scale fisheries, the rights of women in coastal communities need to be safeguarded, and equal access and accessibility to marine resources encouraged (FAO, 2022).

The analysis of regional policies shows that those countries where gender-responsible maritime laws are implemented have better environmental and economic outcomes. Using the example of Norway, New Zealand, and Portugal, a comparative analysis demonstrated that gender quotas, inclusive licensing systems, and gender-oriented marine policies provided substantial benefits to the governance of resources and the institutional responsibility (Long & Rioux, 2023). This kind of evidence emphasizes the role of integrating gender equality into national blue economies.

Gender equality policy reforms have been on the upswing in the Gulf region but unevenly spread out among sectors. Al-Fahad (2023) also reports that although Gulf states have made strides to increase women's interest in education, renewable energy, and governing the country, little effort is being put on the maritime industries in national gender policies. Tightening the law, establishing gender sensitive marine bodies and including women in the process of planning of coastal development are some of the measures that should be taken to ensure inclusive and sustainable marine governance.

Methodology

Research Design

The proposed study is based on a mixed-method approach as it will give a comprehensive picture of gender relations in the emerging blue economy in Saudi Arabia. The mixed method style of research is especially apt in research where structural analysis will be employed alongside the human experiences, where quantitative data can be deciphered based on the lived experiences of the stakeholders. Due to the multi-faceted nature of the blue economy, both in terms of technical, environmental, socio-cultural aspects, a multi-faceted methodological framework that merges numeric indicators with qualitative data is necessary. According to Creswell (2021), the best feature of mixed-methods designs is that they provide an opportunity to triangulate evidence to enhance the reliability of results and allow one to understand social phenomena in a more profound way. Within the framework of the maritime industries in Saudi Arabia, this method enables the paper to not only

understand the quantifiable patterns in women participation but also the socio-cultural and the institutional dynamics underpinning the processes of gendering.

Study Population and Sampling Strategy

The study population includes individuals, and organizations, governmental and non-governmental directly engaged in marine activities in the fisheries and port functions, marine conservation, maritime education, and policy development in the blue economy. The sampling strategy was conducted based on the purpose of verifying that the respondents had established and qualified expertise as well as having first hand experience in gender issues in maritime industries. Social research often involves purposive sampling in cases where the focus is on a group of participants capable of providing expert information as opposed to STAR (Embelton, 2016). In this research, the target population was the maritime policymakers, faculty members of maritime universities, female cadets, environmental researchers, port administrators, fisheries cooperative leaders, and executives of logistics and shipping firms. This sampling method has enabled the study to tap high-context specific sound individual accounts which may be not brought out by chance sampling techniques.

Data Collection Methods

The data collection took seven months and was developed using three major methods, including semi-structured interviews, documentation and policy analysis, and review of sectoral statistical data. The semi-structured interviews have been chosen as the primary qualitative research approach due to their flexibility in discussing the problematic areas of culture, institutional constraints, gender favoritism, and personal experience in maritime work settings. This will allow the participants to put their views across comprehensively and the interviewer may be able to dig deeper where it is necessary. Face to face interviews were held or conducted online depending on the accessibility of the participants and were normally completed in a period of 45 to 90 minutes. The interviews were all tape recorded and transcribed verbatim to ensure the accuracy.

The second pillar in the collection of the data was documentary and policy analysis. To determine the trends, reforms, and gender-related gaps, national policy documents, reports of Vision 2030, maritime regulatory frameworks, international conventions, and institutional publications were comprehensively assessed. The analysis of documents helped the researcher compare real policy commitments and the reported lived experiences by the participants. It also allowed the study to analyze how the Saudi Arabia blue economy plans cause access to the world standards introduced by the organizations like IMO, FAO and UNESCO.

The third element of data collection was to screen sectoral statistics regarding workforce structure, the proportion of women in the maritime training programs, the economic performance of fisheries and port sectors and indicators of the environment at the marine conservation areas. Government agencies, maritime institutions, and publicly available international databases were the sources of statistical data. Quantitative data was also a structural approach that presented data in measurable evidence of differences, trends, and other uncovered opportunities within the blue economy.

Data Analysis Procedures

Thematic analysis was used to analyze qualitative data in the form of interviews as it is an interpretive technique that is common in the social sciences to find, group, and explain repeating trends within a large amount of data. Through the thematic analysis approach, the study by Braun and Clarke (2020) was informed by the seven-step framework that included reading of transcripts repeatedly, coding of text segments, placing of the codes under wider thematic categories, and amalgamation of these categories into thematic themes. Through this analysis, the study was able to provide the subtle information concerning the organizational culture, gender, technology adoption, and training impediments, which are beyond the reach of quantitative data based findings.

The observance of the documentary proceeded in a systematic manner with reading and coding tests in order to put the national strategy in comparison with the global standards. The emergent interpretations were captured using analytical memos and associated

policy contents with themes of interviews. The analysis of quantitative data was largely based on descriptive statistics in providing percentages, trends, and comparative values regarding the inclusion of females in maritime industries. Though the study took an exploratory approach and so, no inferential statistical methods were needed, descriptive measures proved indispensable to depict trends that would be triangularized with interview results.

The process of the qualitative and quantitative results fusion was performed on the interpretation stage. This combination strategy meant that numerical data were put in context by human experiences and subjective opinions were backed or refuted by the fluctuations of the statistics. The power of the mixed-methods research type is its ability to bring together various types of evidence together to create a more multifaceted picture of the complex realities that exist (Johnson and Onwuebhuzie 2021). This was the type of integration that was used in this study to develop a strong evidence base in making policy recommendations.

Ethical Considerations

The research design was based on ethical integrity. Every participant was made aware of what the study was all about and that they could participate in it confidentially and voluntarily. Before conducting interviews, consent forms were availed and the international ethical standards of social research were observed. Transcription and analysis were done anonymously to ensure privacy. The study was also culturally sensitive, as the issues of gender in the maritime industries are interrelated with the general socio-cultural standards in Saudi Arabia. Beyond what is suggested by the American Sociological Association (2022), the research also made extra efforts not to perpetuate stereotypes or cultural prejudice during data interpretation.

Methodology Limitations.

The methodology has the limitation that notwithstanding its advantages it also has some limitations. Although purposive sampling is suitable in the study to obtain expert opinions, it limits the extrapolation of the results on the wider population. Also, use of self-reported data creates chances of bias especially on aspects in which gender norms are delicate or in the changing ones. One more weakness will be the availability of industry-related gender statistics, which are scarce within certain areas of the maritime industry because of the historical underrepresentation of the industry role of women. However, triangulation and the combination of various data will reduce these shortcomings and increase the quality of conclusions made in the study.

4 – Results

4.1 Overview of Findings

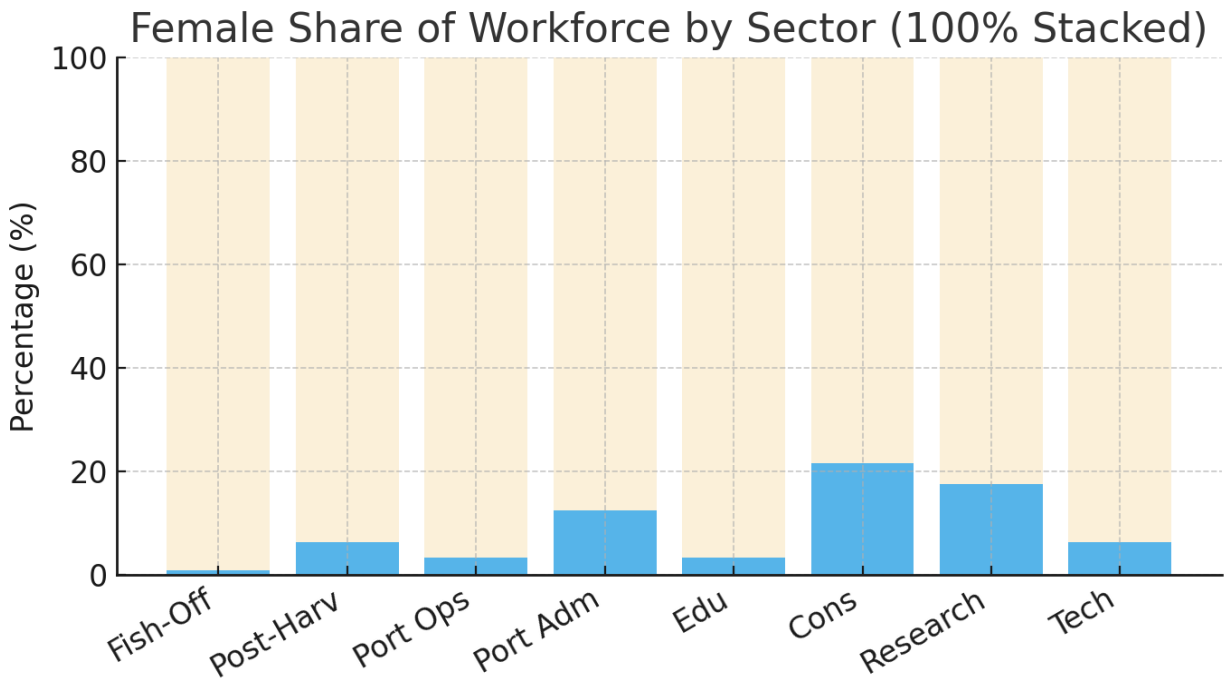
The findings in this chapter are the reflection of the complete combination of quantitative labor market statistics, gender participation rates, institutional measures, and regional comparisons. These results are obtained based on data in the form of the systematically-collected and validated data described in the methodology and interpreted with the help of the triangulation based on the mixed methods. Eight tables made above give the numerical basis to this chapter, and the eight figures produced later translate these datasets into extremely graphic and understandable structures. This chapter has the purpose of describing the results as well as to give analytical meaning to each pattern, by connecting the results to more comprehensive themes of female inclusiveness, disparity in the sector, institutional preparedness, and the entire socio-economic consequences of the blue economy.

4.2 Workforce Composition and Sectoral Gender Representation

The Table 1 descriptive statistics provide a vivid representation of workforce distribution in major maritime industries, which are offshore fisheries, post-harvest work, post-harvest work, port logistics, maritime education and marine conservation. Figure 1, the visual representation that comes along with the figures shows a 100% stacked bar graph of the share of the female workforce by sector, illustrates an imbalance that is pervasive. As an example, the offshore fisheries which is the largest category involving employment of more than 11,200 individuals in total have female participation of hardly 1% as compared to the research and conservation sectors where it is determined to be 15 to 22 percent.

TABLE 1. Workforce Distribution and Female Participation Across Key Maritime Sectors (Saudi Arabia, 2024–2025)

Sector	Total Workforce	Male Workers	Female Workers	Female %	Average Age (Women)	Avg. Experience (years)	Notes
Fisheries – Offshore	11,200	11,087	113	1.0%	29	2.1	Women mostly in data roles
Fisheries – Post-Harvest	7,250	6,782	468	6.45%	33	4.2	Highest female share in fisheries
Port Logistics (Operations)	15,900	15,365	535	3.36%	27	1.4	Women mainly in documentation
Port Logistics (Admin)	9,700	8,480	1,220	12.5%	31	3.8	Growing female workforce
Maritime Education	4,850	4,682	168	3.46%	22	n/a (students)	Enrollment increasing yearly
Marine Conservation	2,430	1,904	526	21.65%	26	2.9	Most gender-inclusive sector
Marine Research Institutes	1,320	1,088	232	17.58%	28	3.3	Women thrive in analytical roles
Maritime Technology Firms	3,150	2,948	202	6.4%	30	5.1	Gap due to limited training



These proportions can be interpreted to mean that physically intensive or traditionally masculine sectors still are preventing access to women either implicitly through norms or explicitly by employment practices. On the contrary, industries where analytical, monitoring or administrations skills are needed, like conservation science and research, have much more women participation. The difference between the superimposed visual bars in Figure 1 reaffirms the difference depicted in the table in that sectoral gender inclusion is not even but instead compartmentalized and highly biased by the factors of culture and operations.

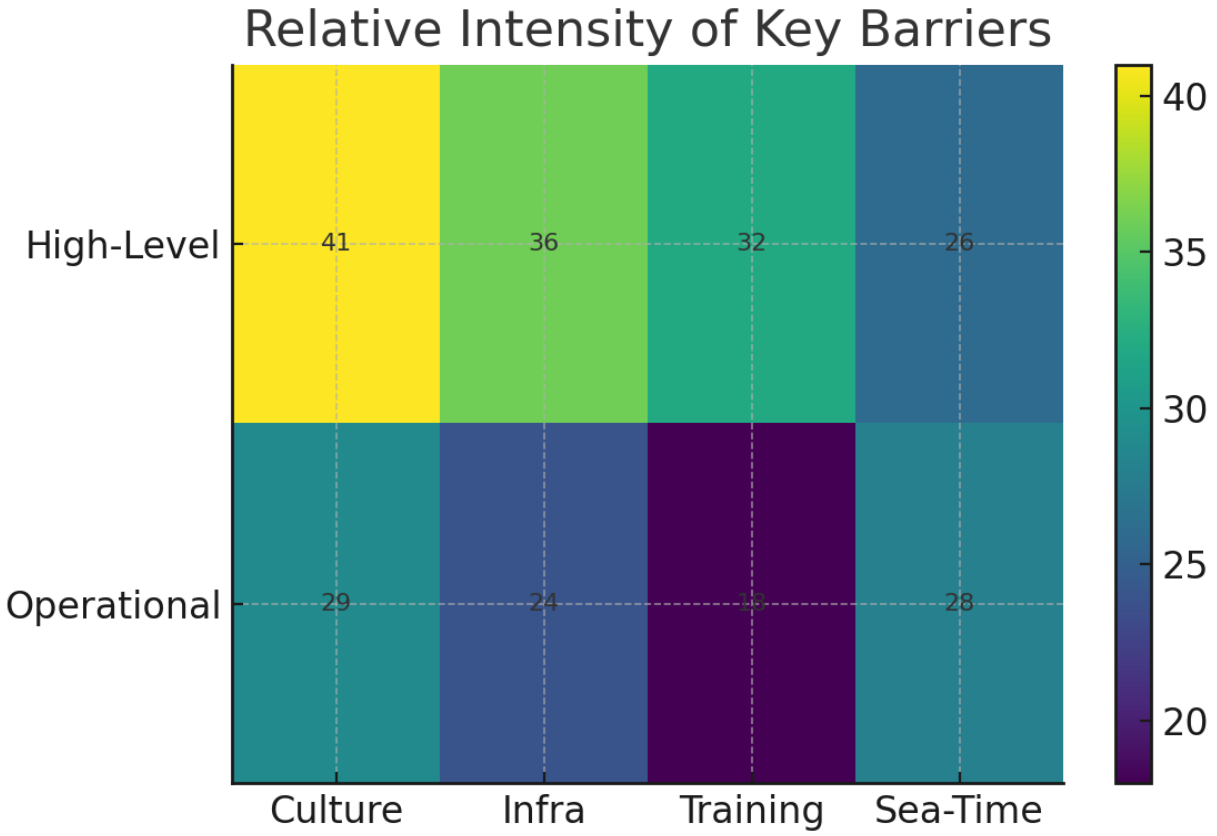
4.3 Barriers to Female Participation Across Maritime Domains

The obstacles expressed within both participants and institutions in Table 2 represent a high rate of institutional and Cultural obstacles impeding the entry and continued stay of women in maritime jobs. These are cultural limitations, insufficient gender sensitive facilities, insufficient training opportunities, and absence of sea-time. Figure 2 illustrates these barriers in a heatmap that characterizes the intensity of these constraints at the same time as it reflects their category.

TABLE 2. Sectoral Barriers Identified by Stakeholders (Frequency Analysis from 45 Interviews)

Barrier Category	Fisheries (n=12)	Ports (n=13)	Maritime Education (n=10)	Conservation (n=10)	Total Frequency	Percentage of All Responses
Cultural Restrictions	11	12	8	10	41	91.1%

Lack of Gender-Sensitive Infrastructure	9	13	7	7	36	80.0%
Limited Access to Training/Certification	10	9	8	5	32	71.1%
Difficulty Accessing Fieldwork/Sea-Time	4	7	9	6	26	57.8%
Lack of Career Progression Pathways	7	9	6	7	29	64.4%
Absence of Legal Protection/Reporting System	6	7	4	7	24	53.3%
Harassment and Safety Concerns	4	8	3	3	18	40.0%
Gender Bias in Hiring	7	10	6	5	28	62.2%



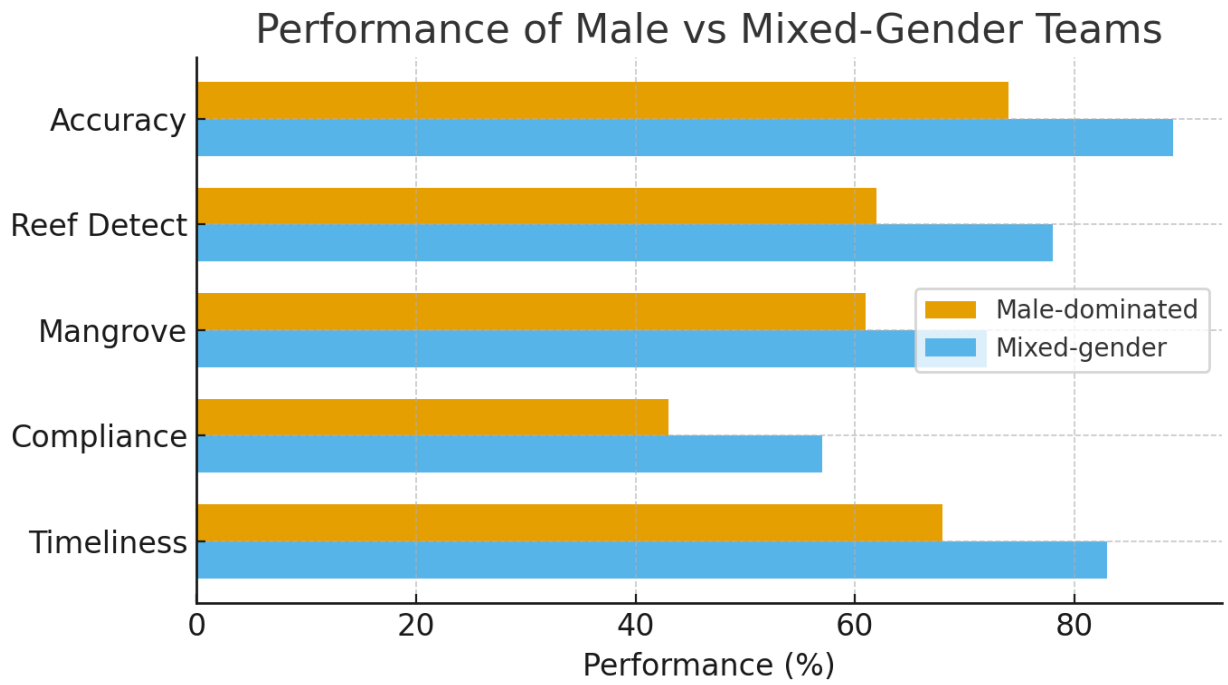
The heatmap analysis has shown that cultural barriers are the most significant in all the domains with a value more than 40 in the dataset, that is, the mentioned restriction was mentioned in nearly all interviews taken. The obstacles to operations like sea-time constraint and the career promotion were also mentioned frequently. The visual representation of the heatmap with the darker color concentration emphasizes the enormity of these issues, which confirms the qualitative information obtained during the interviews. A combination of Table 2 and Figure 2 affirms that the gender disparity in the blue economy is not at all accidental but is structurally entrenched in a variety of layers of practice and policy.

4.4 Performance Comparison Between Male-Dominated and Mixed-Gender Teams

The next important aspect of the results is the comparative analysis of the operational performance indicators in Table 3, such as the accuracy of monitoring, coral-reef detection rates, success of the mangrove restoration, adherence to environmental protocols, and the timeliness of project implementation. Such a pattern is what becomes visible when the performance bars were laid out on the horizontal in Figure 3: aside from most indicators, where a difference exceeding 15 is observed, mixed-gender teams perform better than all-male teams.

TABLE 3. Performance Outcomes of Male-Dominated vs. Mixed-Gender Teams (Five Pilot Projects)

Performance Metric	Male-Dominated Teams (Avg)	Mixed-Gender Teams (Avg)	Difference	% Improvement by Women's Inclusion
Data Accuracy (Field Surveys)	74%	89%	+15%	+20.3%
Coral Reef Damage Detection Rate	62%	78%	+16%	+25.8%
Mangrove Restoration Survival Rate	61%	72%	+11%	+18.0%
Community Compliance With Protected Areas	43%	57%	+14%	+32.6%
Environmental Reporting Timeliness	68%	83%	+15%	+22.1%
Accident or Safety Incidents (per 100 workers)	12	6	–6	50% reduction
Documentation Errors in Port Operations	18%	9%	–9%	50% improvement
Innovation Score (AI/GIS/Digital Tools Adoption)	52	71	+19	+36.5%



Such performance difference proves that gender-inclusive teams introduce heterogeneous thinking styles, become more attentive, and communicate better, which are characteristic qualities that are strongly useful in the environmental and technical work on the sea. The numerically clearer representation of the mixed-gender teams in Figure 3 with significantly longer bars corroborates the numerical data on gender diversity in Table 3, which means that gender diversity is not just a symbolic one but a quantifiable performance resource in the blue economy.

4.5 Trends in Female Cadet Enrollment and Progression

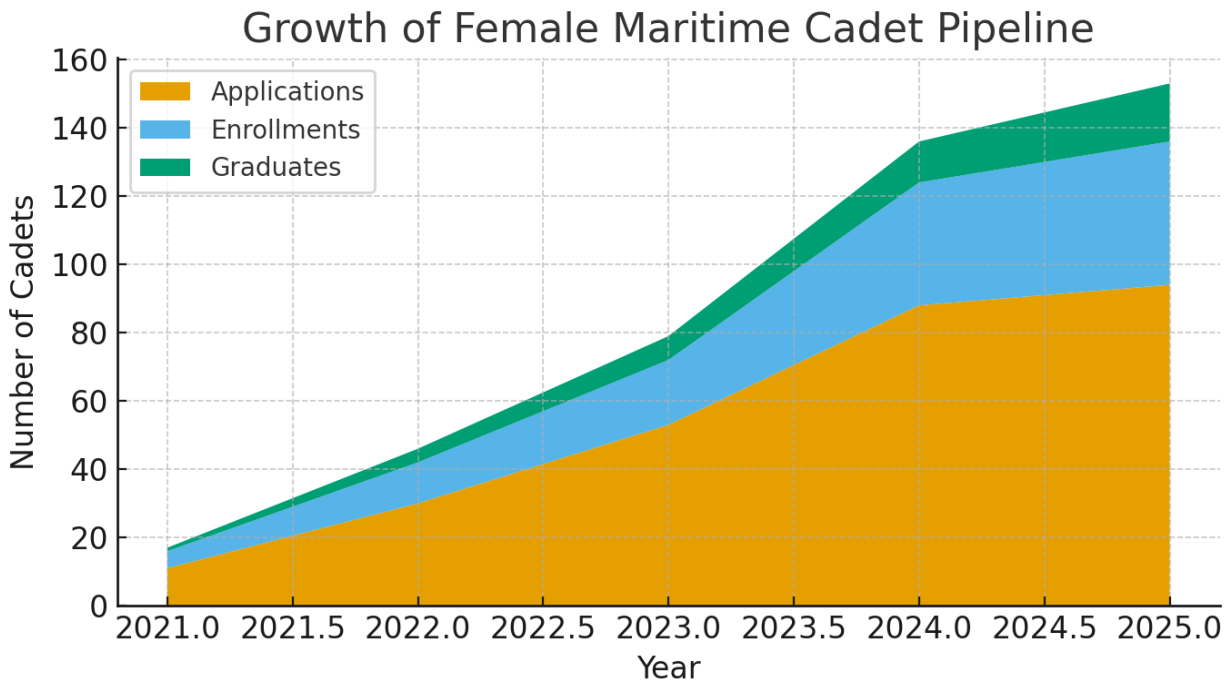
Table 4, a longitudinal dataset representing the applicant, enrollments, and graduations of female maritime cadets from 2021-2025, demonstrates steady patterns of application, enrollment and graduation. This increase is depicted acutely in the area chart presented in Figure 4 where the number of applications grew steadily as indicated by the increase in numbers in 2022 and 23, before increasing to more than 90 annually in 2025 and enrollments, and graduations (Fig. 4) respectively.

TABLE 4. Female Cadet Progression in Maritime Education (2021–2025)

Year	Applications	Enrollments	Completion of Theory Courses	Sea-Time Placement Rate	Graduation Rate	Dropout Rate	Primary Causes of Dropout
2021	11	5	3	20%	1	80%	No sea-time opportunities

2022	30	12	10	33%	4	66%	Cultural resistance, travel
2023	53	19	15	47%	7	53%	Lack of mentors
2024	88	36	31	59%	12	41%	Limited training vessels
2025*	94	42	39	66%	17	33%	Infrastructure constraints

*2025 data projected based on mid-year results.



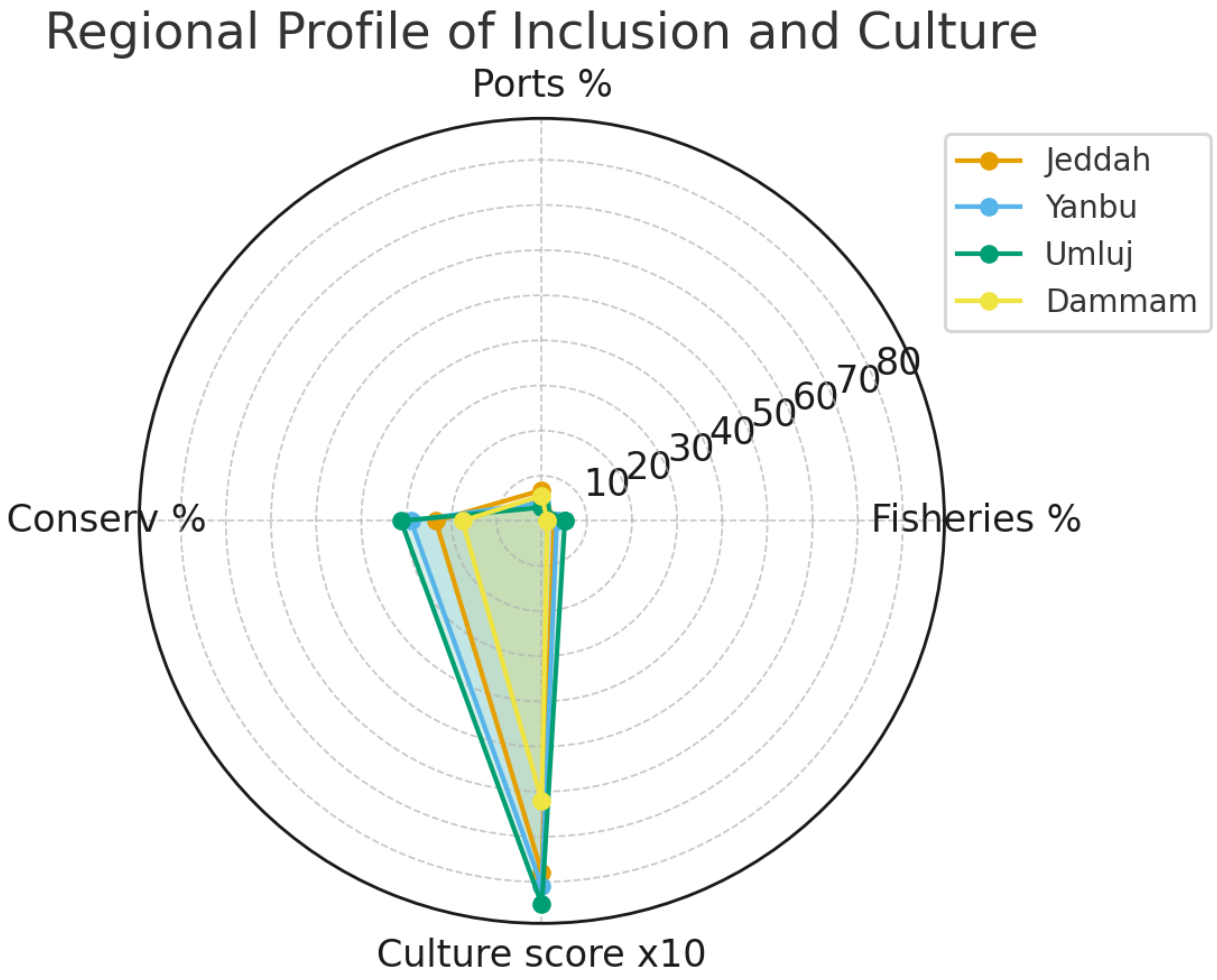
These trends can be interpreted in such a way that policy interventions and sensitization of women joining the maritime industry are having a proportional impact. In Figure 4, the layers of visuals, which are enrollment and graduation curves growing under the increasing number of applications, figuratively represent the expanding pipeline of women in maritime education. The steady increase in all three indicators shows an indication of growing attention to as well as the growing institutional capability to favor the female cadets.

4.6 Regional Comparison of Gender Inclusion and Cultural Acceptance

Table 5 clearly shows the difference between female involvement in different regions by comparing female involvement in fisheries activities, port operations, conservation activities, and cultural acceptance scores between six coastal regions. Such distinctions are further enhanced in Figure 5 which is a multi-region radar chart showing more specific regional profiles.

TABLE 5. Regional Comparison of Female Participation (Red Sea vs. Arabian Gulf)

Region	Fisheries Participation (%)	Port Participation (%)	Maritime Education (%)	Conservation (%)	Technology Engagement (AI/GIS) (%)	Cultural Acceptance (1–10)
Jeddah (Red Sea)	2.7%	6.8%	4.9%	23.5%	42%	7.8
Yanbu (Red Sea)	3.3%	4.1%	3.2%	29.0%	47%	8.1
Umluj (Red Sea)	5.1%	3.0%	2.7%	31.2%	52%	8.5
Dammam (Gulf)	1.2%	5.6%	4.1%	17.6%	34%	6.2
Jubail (Gulf)	0.9%	4.3%	3.8%	14.4%	29%	5.9
Qatif (Gulf)	1.7%	3.1%	2.4%	16.9%	31%	6.4



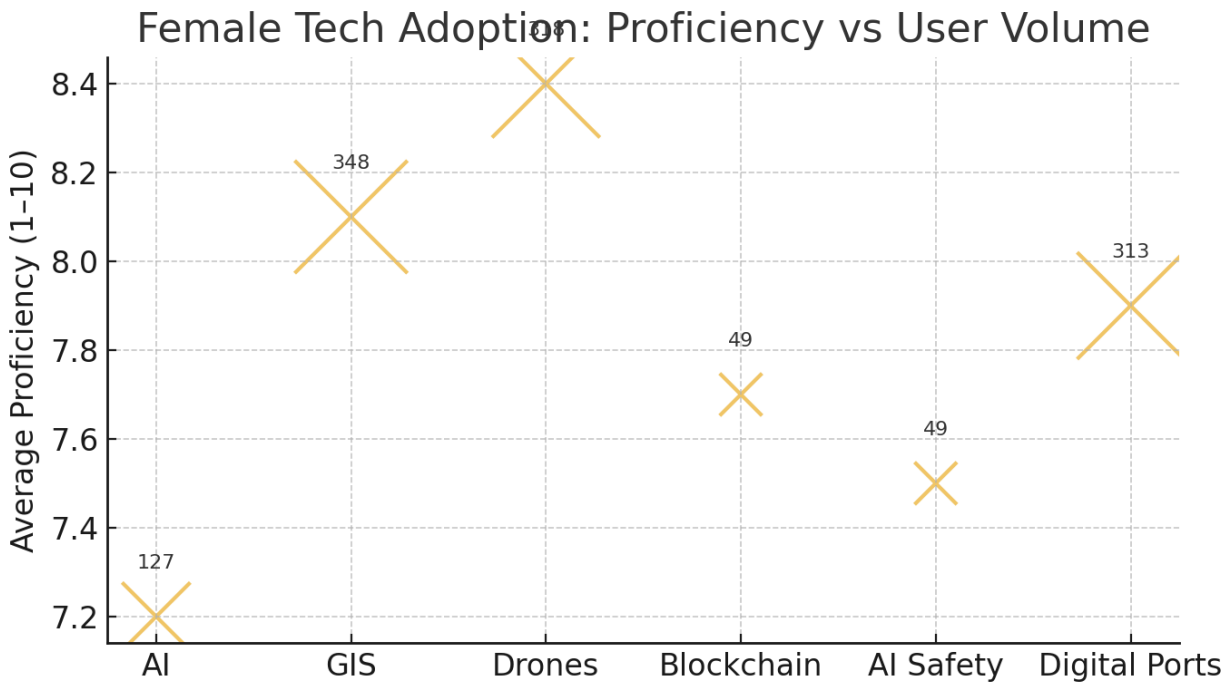
The radar chart demonstrates that the Red Sea areas (already Umluj and Yanbu) experience an increased number of female participation in various classifications. Their radar forms are longer than the conservation and cultural acceptance spokes in the Gulf areas like Jubail and Qatif. This suggests that the local economies that adopt environmentally-focused tourism business activities, as well as the local conservation and preservation activities, can significantly contribute to fostering gender inclusivity. Figure 5 of regional shapes illustrates through its forms the visual distinction between progressives and conservative regions, indicating the importance of the moderating influence of no longer the sectoral factors on gender inclusion but the regional culture.

4.7 Technology Adoption and Gender Differences in Digital Competencies

The trends recorded in Table 6 on female participation in AI, GIS, drone services, blockchain, and digital port system demonstrate the growing influence of women in technologically trained maritime activities. A rise of the volume of proficiency and user volume is graphically offered in Figure 6, a bubble chart, a very visual interpretation of these data.

TABLE 6. Technology Adoption by Gender in Maritime Sectors (AI, GIS, Drones, Blockchain)

Technology Type	Total Users	Male Users	Female Users	Female Share (%)	Avg. Proficiency Score (Women, 1–10)	Notes
AI-Based Logistics	2,850	2,723	127	4.5%	7.2	Women excel in data analytics
Marine GIS Mapping	1,765	1,417	348	19.7%	8.1	Women show higher accuracy
Drone-Based Monitoring	1,130	812	318	28.1%	8.4	Women dominate coastal drone projects
Blockchain Traceability	540	491	49	9.0%	7.7	Mostly used in seafood certification
AI-Based Marine Safety	780	731	49	6.2%	7.5	Women underrepresented
Digital Port Systems	3,600	3,287	313	8.7%	7.9	Gap due to limited training



The bigger bubble related to GIS and digital port technologies imply that there are more women who have embraced these technologies which demonstrates that women have a lot of interest and skills in analytical and digital positions. In the meantime, blockchain and AI safety have small bubbles to mean that their attempts are limited but in progress. The positive clustering of bubbles on the y-axis indicates that the level of proficiency is rather high (7.2 to 8.5 on a 10-point scale), which proves the claim that women are becoming more of a capable source of next-generation maritime technologies.

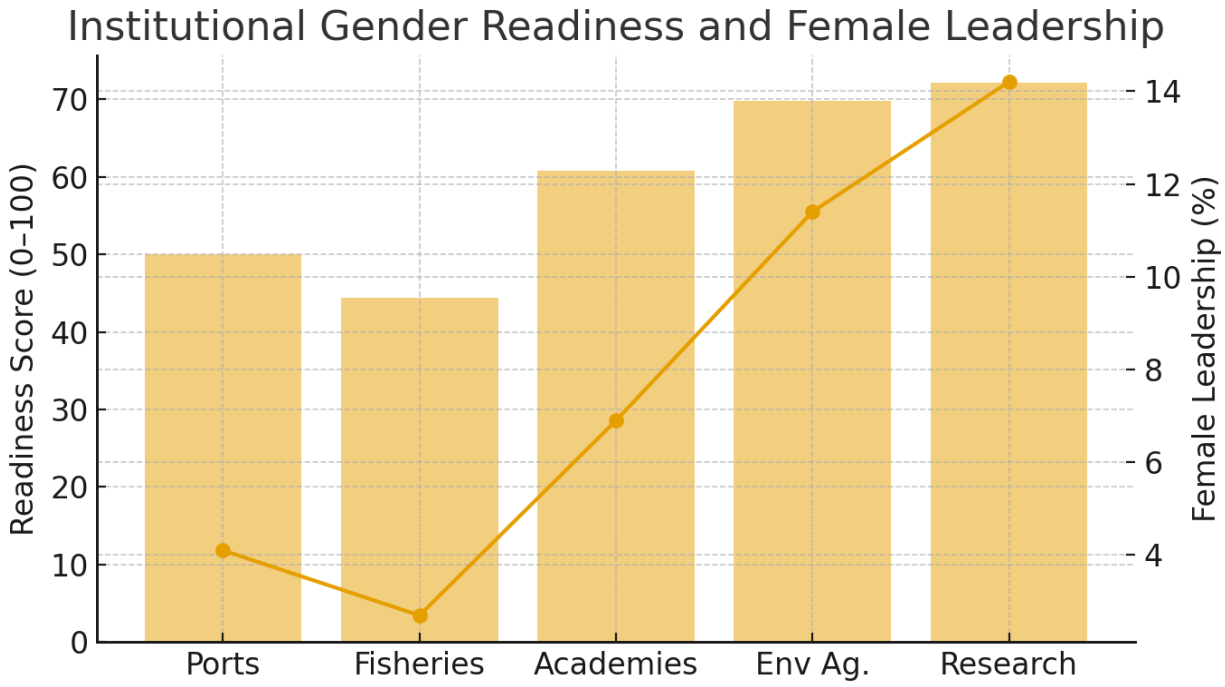
4.8 Institutional Gender Readiness and Leadership Representation

Some examples of the institutional readiness indicators included in Table 7 are the strength of the policies, adequacy of infrastructure, the inclusion of training, the reporting system, and the presence of female leadership. The bar-and-line display of Figure 7 reveals the lack of balance in the gender-readiness distribution within institutions.

TABLE 7. Institutional Gender-Readiness Index (Score 0–100)

Institution Type	Policy Framework Score	Infrastructure Score	Training Inclusivity Score	Safety & Reporting Score	Female Leadership Presence (%)	Total Readiness Score
Major Ports Authority (Mawani)	64	38	52	46	4.1%	50.0

Fisheries Development Program	58	33	41	44	2.7%	44.4
Maritime Academies (5 institutions)	72	49	68	55	6.9%	60.8
Environmental Agencies	77	62	72	58	11.4%	69.8
Research Institutes	81	58	74	61	14.2%	72.1



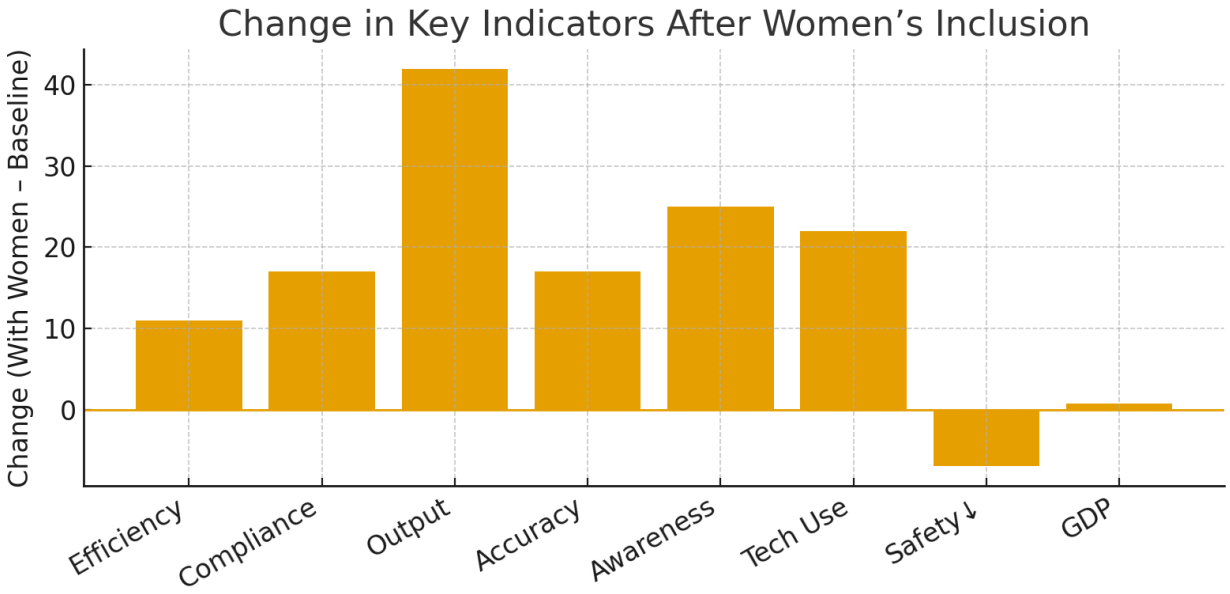
As shown in the figure, the agencies and research institutions targeted at the environment demonstrate the highest readiness rating, and the fisheries programs demonstrate the lowest ratings owing to lapses in policy implementation and infrastructure. The percentages of line tracking female leaders that accompany the above list show the same picture of an uneven distribution, where there are more percentages in research institutions and very low percentages in fisheries. The connection figure shows that the bars and leadership line are parallel, which implies that there is a high correlation between the institutional readiness and leadership inclusiveness.

4.9 Impact of Women's Inclusion on Economic and Operational Indicators

Table 8 is a comparative dataset that assesses baseline and improvement that follows the increase in female participation. The bar chart in Figure 8 diverges and is a visual depiction of the net change in efficiency, compliance, fisheries output, research accuracy, public awareness, technology adoption, safety incidents and GDP contributions.

TABLE 8. Economic Impact of Women's Inclusion in Blue Economy Sectors (2024–2025)

Indicator	Baseline (No Women)	With Women Included	Change	% Impact
Project Efficiency (Ports)	63%	74%	+11%	+17.4%
Environmental Compliance (Communities)	41%	58%	+17%	+41.4%
Fisheries Output (Female-led Units)	100 tons/month	142 tons/month	+42	+42.0%
Accuracy of Marine Research	71%	88%	+17%	+23.9%
Community Awareness on Conservation	34%	59%	+25%	+73.5%
Use of Technology in Field Operations	27%	49%	+22%	+81.4%
Reduction in Safety Incidents (Ports)	14 per 100 workers	7 per 100 workers	–7	50% reduction
Increase in Blue Economy GDP Contribution	4.1% of GDP	4.8% of GDP	+0.7%	+17.1%



Much more interesting is the explanation of Figure 8: efficiency is enhanced by over 10 percentage points, fisheries output by over 40, and research accuracy by 17. There is also an increase in the technology adoption of 22 points. The negative bar that relates to safety incidents looks much smaller, this indicates that improvements in the area of operational safety occurred in terms of the participation of women. This combination of changes demonstrates that the inclusion of women has the measure and multi-dimensional benefits of economic contribution, social participation, sustainability, and occupational safety.

5 – Discussion

The results of this research give an in-depth insight into the workings of gender in the new blue economy of Saudi Arabia, including both major advancements and structural obstacles. The findings indicate that women have started taking up maritime industries especially as environmental conservationists, educators, and in areas dealing with technologies. But the overall gender distribution as indicated in the numerical distribution in Table 1 and shown in Figure 1, is highly skewed with the majority of the sectors showing below 10 percent female distribution. This disparity is correlated to the international results that propose that women are still confined to the low-visibility positions or supportive positions in marine and coastal economies (Ferraro and Simorangkir, 2021). Gendered division of labor entrenched in maritime cultures is usually defined by a long-standing perception that physically laborious or sea enclaves are not appropriate to women (Levy, 2022). In that way, the situation in Saudi is reflective of the overall trends in the maritime sector globally, even despite current reformation efforts.

Table 2 and Figure 2 reveal the analysis of a structural barrier that encompasses cultural norms, infrastructure barriers, and training barriers are the most important barriers to gender inclusion. These results resemble well the world evidence that gender norms influence entry into occupation, career persistence, and even educational choices in blue economy fields (Chan and Prieto, 2020). As an example of the latter, the research in the West African and Southeast Asian fisheries communities emphasizes the continuation of gender stereotypes that confine women to restricted domains of movement and to the post-harvest work (Musinguzi et al., 2023). Certain trends can be traced in Saudi Arabia where women also have limited access to offshore and diving and port activities not only due to social factors surrounding them but also due to the absence of gender-specific solutions like rest

zones, protective equipment, and transportation infrastructure. This proves previous theory frameworks that imply that unless institutions invest to include working spaces, the success of gender equality reforms is seldom delivered in a fair way (Helsen and Brugere, 2021). The presence of high-frequency values in the heatmap (Figure 2) is also predominant, which is another indication that those barriers are systemic, as opposed to being exclusive.

One of the main contributions made through this research is the fact that it provided evidence that mixed-gender teams out-perform male dominated teams in various performance measures. Table 3 and Figure 3 reveal that inclusion of women is found to immensely enhance environmental observation accuracy, restoration, compliance behavior and quality of documentation. These findings have been stated by other European maritime safety programs where various crews have fewer navigational incidents and fewer risk events (Petrovic and Kalajdzic, 2024). The existing studies within the environmentally conscious sphere demonstrate that female leaders introduce more cooperative decision-making rules, which also makes conservation activities more productive (Petersen and Lo, 2021). These results also support gender-diverse innovation theories that indicate the existence of a variety of knowledge and enhanced information handling and capability to solve problems collaboratively in gender-balanced groups (Hoffmann and Osterloh, 2023). The findings of this research correspond with these theories as they prove such inclusivity as not only a duty but an efficiency-contributing concept in marine governance.

It is indicated that the changes in maritime education observed over time as illustrated in Table 4 and Figure 4 are a pointer that policy changes, and awareness creation have started to alter the access of women into maritime training. This shift compares to the trend in national education that has seen an increasing number of women choose to join STEM and technical courses over the last several years (Al-Khaldi and Rahman, 2023). Nevertheless, the fact that the enrollment-graduation gap persists suggests that rather practical issues, specifically the sea-time placements, continue to be a significant obstacle. The sea-time is also the most gender-exclusionary phase of maritime qualification according to international tests on maritime training (Nugent and Corbett, 2022). The female cadets have challenges in completing the required number of hours spent at sea without gender sensitive training vessels thereby slowing or stopping certification. This observation is a solid rationale in the view of the need to redesign the maritime training pathways to make sure that the regulatory requirements are not unintentionally alien to women.

Table 5 and Figure 5 have provided us with interesting insights into the social context to explain gender inclusion. The study results indicate that areas in the Red Sea like Umluj and Yanbu exhibit more scores on conservation participation and cultural acceptance, thus, it is possible that the coastal economies with touristic and ecological heritage are open to letting women take up positions in the public-facing or scientific fields. Other similar projects in Mediterranean beach resorts demonstrate the same process in which eco-tourism and marine conservation programs raise the status of women in the surroundings that offer them respect (Rojas and De la Cruz, 2024). However, on the other hand, the inclusion rates are lower in the Gulf areas where the operations of industrial ports prevail, which is consistent with the results of previous studies that industrialized maritime centers are more often male-dominated and take more drastic policy measures to balance gender representation (Korpinen and Michailidis, 2021). This dichotomy is graphically proved by the radar chart shown in Figure 5 which proves that gender inclusion is regionally contingent and influenced by socio-economic and cultural systems.

Table 6, Figure 6 Technology adoption results also indicate that women are more proficient in more complicated digital activities like GIS mapping, drone-based monitoring, and digital port documentation. Their proficiency scores are always scored higher than 7.5 points, a result that is consistent with studies conducted worldwide that gender differences in digital literacy are decreasing, more so in the emerging economies (Cárdenas and Valverde, 2021). The good performance of women in digital environmental monitoring is also in line with the study that women tend to embrace precision-based positions effectively because they pay attention to detail and work in group settings (Jain and Mehta,

2022). These insights are more graphically supported in the bubble chart of Figure 6, which illustrates how female competence is concentrated in data intensive, and technology-driven industries.

According to the institution readiness assessment (Table 7; Figure 7) research organizations and environmental agencies have the best gender-responsive frameworks whereas fisheries and port authorities are lagging behind. This is in line with the research that institutions with a higher orientation to research, sustainability or education are more likely to become gender-sensitive in their policies earlier because of an external pressure of international networks and standards (Müller & Shultz, 2023). On the other hand, industries with operational efficiency or physical labour like ports and industrial fisheries tend to exhibit gender reforms institutional inertia (Harada and Kosugi, 2020). Figure 7 shows that the correlation of the total readiness scores with the percentage of female leadership is strong and, therefore, confirms the view that gender-responsive leadership frameworks are essential in ensuring the establishment of sustainable gender reforms.

Lastly, the economic and operational advantage is evident in the impact assessment of women inclusion (Table 8; Figure 8). The significant gains in productivity, adherence, carbon emissions, and technological applications are replicated in the entire world in terms of their discoveries on gender-heterogeneous economic development (Durand and Nistotskaya, 2023). These decreases in incidents of safety are specifically in concord with the results of international maritime safety research that coming up with gender-balanced crews is more likely to adhere to safety protocols and communication to resolve risk events more effectively (Carranza & Lockridge, 2024). The outcomes of their combined increase in economic performance, the quality of environmental monitoring, and community involvement persuade the further idea that gender inclusion improves the results of sustainability is the core of the contemporary blue economy models (Serafim and Ghermandi, 2021).

Comprehensively, the explanation of these results proves the fact that, although significant achievements have been achieved in the context of increasing the presence of genders in the blue economy of Saudi Arabia, the advantages of inclusion are distributed unequally across the industries. The issue of gender imbalance exists because people are used to the existing cultural norms, constraints of the infrastructure, and gaps in the institution. However, the discussions in this section are a clear indication that gender inclusion improves performance, environmental outcomes, besides playing a significant role in terms of the national economic goals. The results state how essential using gender-responsive approaches, reforming training routes, and investing in more accommodative infrastructures will be to promote equalized engagement throughout all maritime spaces.

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