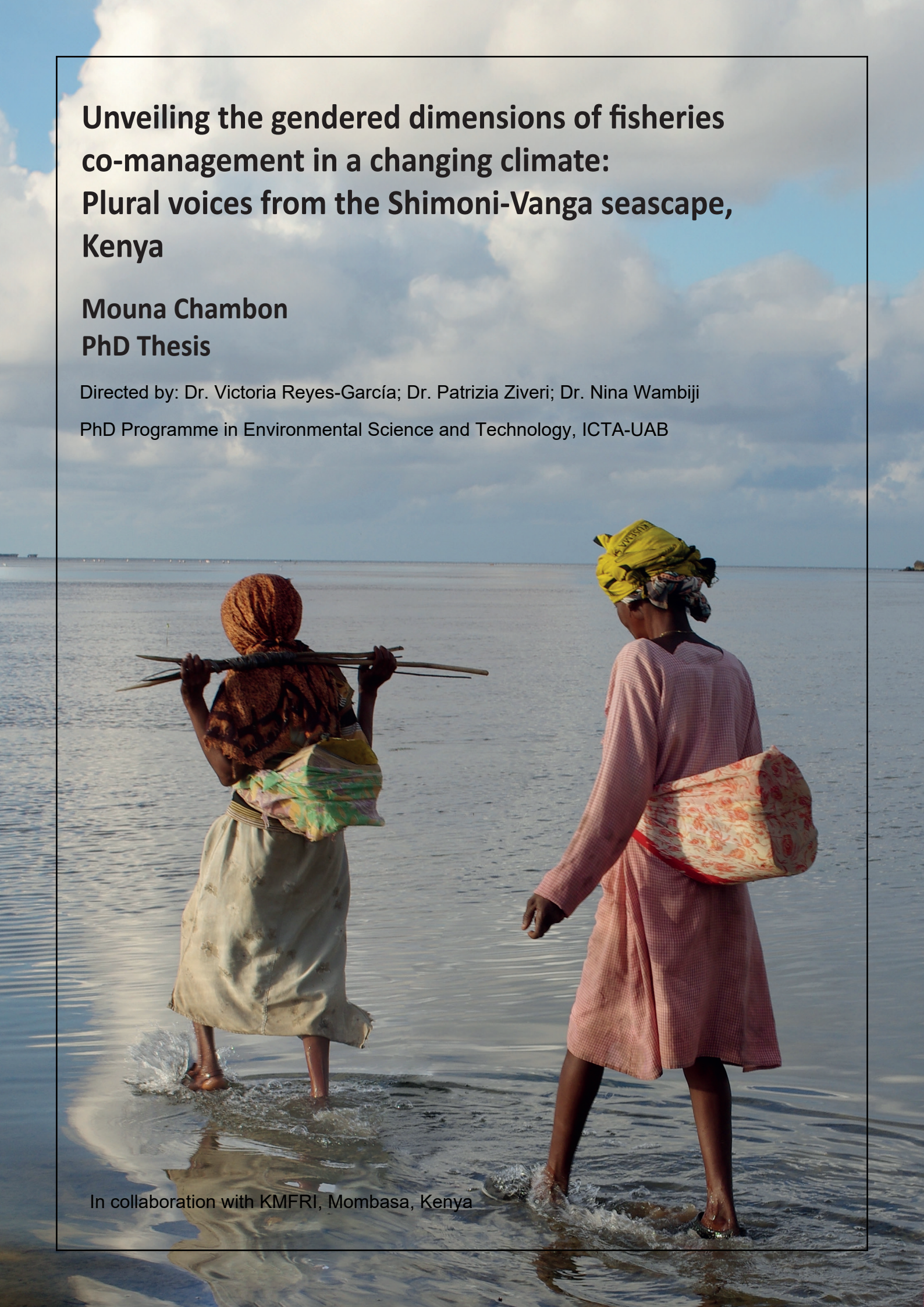
Unveiling the gendered dimensions of fisheries co-management in a changing climate: Plural voices from the Shimoni-Vanga seascape, Kenya

Mouna Chambon

PhD Thesis

Directed by: Dr. Victoria Reyes-García; Dr. Patrizia Ziveri; Dr. Nina Wambiji

PhD Programme in Environmental Science and Technology, ICTA-UAB



In collaboration with KMFRI, Mombasa, Kenya

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Icons of marine taxa within the chapters (by the Noun project). These taxa occur within the study site: **Chapter 1:** Triton's trumpet (*Charonia tritonis*) © Olga. **Chapter 2:** Billfish (Istiophoridae) © Arif fajar yulianto. **Chapter 3:** Red knobbed starfish (*Protoreaster lincki*) © Juicy Fish. **Chapter 4:** Cowrie shell (Cypraeidae) © Amos Kofi Commey. **Chapter 5:** Rabbitfish (*Siganus*) ©Vrijlansier. **Chapter 6:** Ray (Batoidea) ©iconixar. **Chapter 7:** Octopus (*Octopus cyanea* or *Octopus vulgaris*) © Dimitri Lupo.

All presented photographs are the outcome of this research and were taken in the study site with the agreement of the persons portrayed.

In all the document, the names of the villages where I worked are not mentioned and the names of the research participants have been modified for the purpose of confidentiality.

Contents

Summary

Climate change poses mounting challenges to small-scale fisheries (SSF) social-ecological systems globally. Given the socio-cultural, nutritional, and economic importance of SSF for many coastal communities around the world, understanding the impact of climate change and how to best adapt to these changes is critical. Researchers and development actors have emphasized the need to embrace new fisheries management approaches. In particular, fisheries co-management has been proposed as a successful enabler for climate change adaptation in SSF. However, to shift potential gender inequalities in SSF communities, further research is needed to address the gendered dimensions of fisheries co-management in the context of climate change. While women represent 40% of the SSF workforce, their role has been systematically overlooked, especially when it comes to management and decision-making processes. These gender bias in fisheries research could limit the development of effective gender transformative adaptation strategies.

To address the research gap on the gendered nature of SSF management, this doctoral thesis takes an interdisciplinary perspective to explore the role of gender in SSF co-management approaches where local communities play a leading role, also called community-based fisheries management (CBFM). Specifically, this work contributes to the understanding of 1) the role of gender in co-managed SSF and their governance and 2) how the gendered dimensions of CBFM may affect the potential of this approach for climate adaptation. This work is grounded in the case of co-managed SSF communities in the Shimoni-Vanga seascape, South Coast of Kenya. It relies on a mixed-method approach for data collection and analysis, combining qualitative and quantitative research methods and respecting a gender-balanced sampling. Data collection methods include semi-structured interviews (n=57), focus group discussions (n=8), individual survey (n=203), and pebble games (n=35). In addition, the relief map method (n=32) was adapted to SSF settings to explore the potential of intersectional perspectives on CBFM dynamics.

This doctoral thesis comprises two introductory chapters presenting the study subject (Chapter 1) and geographical area (Chapter 2). The core of the thesis consists of one chapter based on the review of the literature and three empirical chapters. The literature review chapter corresponds to a systematic review of women's participation in SSF management and related impacts at the global level (Chapter 3). The chapter allows to situate the main findings of this thesis in the context of the international scholarship on the topic. The three empirical chapters focus on co-managed SSF communities in coastal Kenya and address respectively a) the gendered dimensions of fishing (Chapter 4), b) the gendered nature of climate change impacts reported by SSF communities in relation to scientific evidence (Chapter 5), and c) gender-inclusiveness in CBFM using an intersectional perspective (Chapter 6).

The systematic literature review (Chapter 3) reveals an important research gap on gender and SSF. The peer-reviewed literature was obtained from the Web of Science Core Collection and Scopus (n= 124 case studies). Findings from this chapter suggest a dearth in gender-disaggregated data in the SSF literature, with 40% of the studies not providing information on women's participation in SSF management and decision-making. This gap is particularly significant in Africa and Asia, two regions where SSF is critical for local livelihoods and food security.

This thesis work also shows that gender is key for understanding the dynamics of co-managed SSF in coastal Kenya (Chapter 4 and 6). Gender influences social identities, fishing activities, fisheries production, and participation in SSF management. Specifically, this work shows that there is a marked contrast in fishing techniques used by fisherwomen, who specialize in gleaning in intertidal areas, and fishermen, who use a wider range of fishing techniques in areas beyond the reef.

Furthermore, women contribute significantly to SSF social-ecological systems in coastal Kenya (Chapter 4, 5 and 6). More specifically, women's fishing activities contribute substantially to local diets. Findings from this work indicate that women's catches represent about a third of the catch eaten at home in mixed-headed households, and up to 50% of the fisheries products consumed in fisherwomen-headed households (Chapter 4). Similarly, women hold specific environmental knowledge linked to their gender roles, a knowledge that illuminates the complexities of local climate change impacts (Chapter 5). For instance, more women than men perceived changes in rainfall patterns, which may be explained by the fact that women are primarily responsible for fetching water.

Despite women's important role in co-managed SSF, women's meaningful participation in CBFM is not achieved in coastal Kenya (Chapter 6), which resonates with the broader literature on gender and SSF management (Chapter 3). Women's participation levels in CBFM were systematically lower than those of men, ranging from passive to active participation levels. Moreover, other power structures, such as age or education level, interact with gender in mediating individual's participation in CBFM highlighting the need to apply an intersectional framework to research on SSF management and governance. Community-based fisheries management may ultimately reinforce social inequalities, thus challenging both the inclusiveness of such approach, and its effectiveness in enabling SSF adaptation to climate change.

Overall, this work shows that gender is a pivotal dimension of co-managed SSF in coastal Kenya, but women's participation in CBFM is limited, which raises issues regarding the development of inclusive and effective adaptation strategies in the context of climate change. Findings from this work contribute to the gender and fisheries literature, and more specifically to the growing discussion about SSF management in a climate change context. Suggested future research lines include investigating further gender equity in SSF management and governance, diversifying knowledge in ocean research, and expanding intersectional research on SSF. To enhance the adaptive capacity of SSF social-ecological systems in the face of climate change, there is a need to reconsider the inclusive dimension of CBFM and move towards gender-transformative approaches in every aspect of SSF, from data collection to management and governance.

Key words: Climate change; Co-management; Gender; Ocean sustainability; Small-scale fisheries; Western Indian Ocean

Muhtasari

Mabadiliko ya tabianchi huleta changamoto kubwa katika mifumo ya kijamii na ikolojia ya uvuvi wa kiwango kidogo (SSF) kimataifa. Kwa kuzingatia umuhimu wa kijamii, kiutamaduni, lishe na uchumi unaohusisha SSF kwa jamii nyingi za pwani kote ulimwenguni, kuelewa jinsi zinavyoathiriwa na mabadiliko ya tabianchi na jinsi ya kukabiliana na athari hizi ni muhimu. Kutokana na hali hii, watafiti na watendaji wa maendeleo wamesisitiza haja ya kukumbatia mbinu mpya za usimamizi wa uvuvi. Hasa, usimamizi wa ushirikiano wa uvuvi umependekezwa katika miaka ya hivi karibuni kama kuwezesha kwa mafanikio ya kukabiliana na mabadiliko ya tabianchi katika SSF. Hata hivyo, utafiti zaidi unahitajika ili kushughulikia vipimo vya kijinsia vya usimamizi shirikishi wa uvuvi katika muktadha wa mabadiliko ya tabianchi, kwa hivyo mbinu hii ya usimamizi inasaidia kutambua na kubadilisha uwezekano wa kukosekana kwa usawa wa kijinsia katika jumuiya za SSF. Ingawa wanawake wanajihusisha kwa kiasi kikubwa katika SSF, jukumu lao limepuuzwa kimfumo, haswa katika suala la usimamizi na michakato ya kufanya maamuzi. Upendeleo huu wa kijinsia katika utafiti wa uvuvi unaweza kupunguza uundaji wa mikakati madhubuti ya kukabiliana na mabadiliko ya kijinsia.

Ili kushughulikia pengo hili la utafiti, tasnifu hii ya udaktari inachukua mtazamo wa fani mbalimbali kuchunguza nafasi ya jinsia katika mbinu za usimamizi wa ushirikiano wa SSF ikiwa jumuiya za mitaa zilijihusisha na jukumu kuu, pia huitwa usimamizi wa uvuvi katika jamii (CBFM). Hasa, kazi hii inalenga kuelewa 1) jukumu la jinsia katika usimamizi wa SSF na utawala wake, na 2) jinsi inavyoathiri uwezekano wa CBFM wa kukabiliana na hali ya hewa. Kazi hii inatokana na jamii zinazosimamiwa na SSF katika mazingira ya bahari ya eneo la Shimoni-Vanga, pwani ya Kusini mwa Kenya. Inatokana na mbinu mseto za ukusanyaji na uchanganuzi wa takwimu, kuchanganya mbinu za utafiti wa ubora na kiasi na kuheshimu kimfumo sampuli ya uwiano wa kijinsia. Mbinu za kukusanya takwimu ni pamoja na usaili wa muundo nusu (n=57), majadiliano ya vikundi lengwa (n=8), uchunguzi wa mtu binafsi (n=203) na michezo ya kokoto (n=35). Zaidi ya hayo, mbinu ya ramani ya usaidizi (n=32) ilichukuliwa kwa mipangilio ya SSF ili kuchunguza uwezo wa mitazamo ya makutano juu ya mienendo ya CBFM ingawa jinsia ilikuwa kigezo kikuu cha uchanganuzi kilichotumika katika utafiti huu.

Tasnifu hii ya udaktari inajumuisha sura mbili za utangulizi zinazowasilisha somo husika (Sura ya 1) na eneo la kijiografia (Sura ya 2). Kiini cha Tasnifu kinajumuisha muundo mmoja na sura tatu za msingi Sura ya awali inalingana na uhakiki wa fasihi wa utaratibu wa ushiriki wa wanawake katika usimamizi wa SSF na athari zinazohusiana katika ngazi ya kimataifa (Sura ya 3). Hali hii ya awali ya ujuzi inaruhusu kuweka vizuri zaidi kitaaluma uchunguzi wa msingi wa tasnifu hii kupitia sura zake za kijaribio zinazozingatia jumuiya za SSF zinazosimamiwa pamoja katika pwani ya Kenya, ambazo zinashughulikia ifwatavyo mtawalia a) vipimo vya kijinsia vya uvuvi (Sura ya 4), b) asili ya kijinsia ya athari za mabadiliko ya tabianchi zilizowasilishwa na jumuiya za SSF kuhusiana na ushahidi wa kisayansi (Sura ya 5), na c) ushirikishwaji wa kijinsia katika CBFM kupitia mitazamo ya makutano (Sura ya 6).

Kazi hii inaibua pengo muhimu la utafiti katika fasihi iliyopo kuhusu jinsia na SSF (Sura ya 3). Pengo hili lilitambuliwa kupitia uhakiki wa utaratibu wa fasihi iliyopitiwa na rika kwa kutumia Mtandao wa Ukusanyaji wa Msingi wa Sayansi na mfumo wa Scopus (n= tafiti 124). Mapitio ya kimfumo yanabainisha upungufu katika takwimu zilizogawanywa kijinsia kulingana na fasihi ya SSF, mathalan 40% ya tafiti zilizonukuliwa ambazo hazikutoa habari kuhusu ushiriki wa wanawake katika usimamizi na uongozi wa maamuzi ya SSF. Pengo hili lilikuwa kubwa hasa katika Afrika na Asia, maeneo mawili ambamo SSF ni muhimu kwa maisha ya ndani na uhakika wa chakula.

Zaidi ya hayo, kazi hii ya tasnifu inaonyesha kwamba jinsia ni kipengele muhimu cha kuelewa mienendo ya SSF inayosimamiwa pamoja katika pwani ya Kenya (Sura za 4 na 6). Jinsia huathiri utambulisho wa kijamii, shughuli za uvuvi, uzalishaji wa uvuvi, na ushiriki katika usimamizi wa SSF. Hasa, kuna tofauti kubwa katika mbinu za uvuvi na maeneo kati ya wanawake wavuvi ambao wamebobea

katika kukusanya masalio katika maeneo ya katikati ya mawimbi na wavuvi wanaotumia mbinu mbalimbali za uvuvi katika maeneo yenye umbali zaidi ya mwamba.

Zaidi ya hayo, wanawake huchangia kwa kiasi kikubwa katika mifumo ya kijamii na kiikolojia ya SSF katika pwani ya Kenya (Sura ya 4, 5 na 6). Hasa zaidi, shughuli za uvuvi za wanawake huchangia kwa kiasi kikubwa mlo wa ndani, unaowakilisha hadi 50% ya bidhaa za uvuvi zinazotumiwa katika kaya zinazoongozwa na wavuvi (sura ya 4). Vile vile, wanawake wana ujuzi maalum wa kimazingira unaohusishwa na jukumu lao la kijinsia ambalo huangazia ugumu wa athari za mabadiliko ya tabianchi (sura ya 5). Kwa mfano, wanawake wengi zaidi kuliko wanaume waliona mabadiliko katika mifumo ya mvua, ambayo yanaweza kuelezewa na ukweli kwamba wanawake wanawajibika hasa kuchota maji.

Licha ya jukumu muhimu la wanawake katika usimamizi mwenza wa SSF, ushiriki wa maana wa wanawake katika CBFM haupatikani katika pwani ya Kenya (Sura ya 6), ambayo inaangazia fasihi pana kuhusu jinsia na usimamizi wa SSF (Sura ya 3). Viwango vya ushiriki wa wanawake katika CBFM vilikuwa chini kimfumo kuliko vile vya wanaume, kutoka kwa hali ya utulivu hadi amilifu. Zaidi ya hayo, miundo mingine ya mamlaka huingiliana na jinsia katika kupatanisha ushiriki wa mtu binafsi katika CBFM, kama vile umri au kiwango cha elimu, kusaidia hitaji la kutumia mfumo wa makutano kwa utafiti kuhusu usimamizi na utawala wa SSF. Usimamizi wa uvuvi wa kijamii unaweza hatimaye kuimarisha ukosefu wa usawa wa kijamii, na hivyo kutoa changamoto kwa ushirikishwaji wa mbinu hiyo, na ufanisi wake katika kuwezesha ukabilianaji wa SSF na mabadiliko ya tabianchi.

Kwa ujumla, kazi hii inaonyesha kwamba jinsia ni mwelekeo muhimu wa SSF inayosimamiwa pamoja katika pwani ya Kenya, lakini ushiriki wa wanawake katika CBFM ni mdogo, ambao unaibua masuala kuhusu maendeleo ya mikakati jumuishi na madhubuti ya kukabiliana na hali hiyo katika muktadha wa mabadiliko ya tabianchi. Matokeo haya yanachangia katika fasihi ya jinsia na uvuvi, na hasa zaidi katika mjadala unaoibuka kuhusu usimamizi wa SSF katika muktadha wa mabadiliko ya tabianchi. Njia za utafiti za siku zijazo zinazopendekezwa ni pamoja na kuchunguza usawa zaidi wa kijinsia katika usimamizi na utawala wa SSF, kubadilisha maarifa katika utafiti wa bahari au kupanua utafiti wa makutano kuhusu SSF. Kuhitimisha, ili kuongeza uwezo wa kukabiliana na hali ya mifumo ya kijamii na kiikolojia ya SSF katika kukabiliana na mabadiliko ya tabianchi, kuna haja ya kutazama upya mwelekeo jumuishi wa CBFM na kuelekea kwenye mbinu za kuleta mabadiliko ya kijinsia katika kila nyanja ya SSF, kutoka ukusanyaji wa takwimu hadi usimamizi. na utawala.

Maneno muhimu: Endeleza mazingira bora ya bahari; Jinsia; Magaribi mwa Bahari ya Hindi; Tabianchi; Usimamizi Mwenza; Uvuvi wa kiwango Kidogo

Resum

El canvi climàtic planteja constants desafiaments als sistemes socioecològics basats en la pesca artesanal a nivell mundial. Atesa la importància sociocultural, nutricional i econòmica d'aquesta activitat per a moltes comunitats costaneres d'arreu del món, entendre com es veuen afectades pel canvi climàtic i com respondre als seus impactes s'ha convertit en tema fonamental. Investigadors i actors del desenvolupament han posat èmfasi en la necessitat d'adoptar nous enfocaments a la gestió de la pesca. Específicament s'ha proposat la cogestió com a eina d'adaptació al canvi climàtic. No obstant, per tal d'evitar desigualtats de gènere dins de les comunitats pesqueres cal entendre el rol de gènere dins d'aquestes societats en el context de canvi climàtic. Tot i que el treball de les dones representa un 40% de l'esforç total de l'activitat pesquera i les que se'n deriven, la seva participació s'ha passat sistemàticament per alt, especialment quan es tracta de gestió i presa de decisions. Aquests biaixos de gènere també dins la recerca poden limitar el desenvolupament d'estratègies efectives d'adaptació al canvi climàtic.

Aquesta tesi doctoral integra una perspectiva interdisciplinària per a explorar els rols de gènere en la cogestió de la pesca artesanal on les comunitats locals tenen un paper protagonista. També anomenada gestió de la pesca basada en la comunitat o CBFM per les seves sigles en anglès (*community-based fisheries management*). Concretament, en aquest treball es pretén entendre el rol de gènere en la pesca artesanal, la seva governança i quin és el potencial de l'estratègia CBFM en l'adaptació al canvi climàtic. L'estudi es basa en el cas específic de les comunitats que habiten el territori Shimoni-Vanga, a la costa sud de Kenya. Amb un enfocament mixt per a la recollida i anàlisi de dades, combinant mètodes d'investigació qualitatius i quantitatius i respectant sistemàticament un mostreig equilibrat de gènere. La recol·lecció de dades inclou entrevistes semiestructurades (n=57), discussions en grups (n=8), enquestes individuals (n=203) i jocs de còdols (n=35). A més, es va adaptar un mapa de relleu (n = 32) a la configuració de la pesca artesanal per a explorar la perspectiva interseccional a la dinàmica de la comunitat, tot i que el gènere va ser la principal variable analítica utilitzada.

Consta de dos capítols introductoris que presenten el tema d'estudi (Capítol 1) i la zona d'estudi (Capítol 2), seguit d'una revisió de la literatura preexistent i tres capítols empírics. La revisió sistemàtica de la literatura se centra en el paper de les dones en la gestió de la pesca artesanal i les implicacions a escala global (Capítol 3). Els següents tres capítols empírics se centren en les comunitats pesqueres a la costa de Kenya i tracten respectivament a) de la dimensió de gènere en la pesca (Capítol 4), b) la naturalesa del gènere sobre els impactes del canvi climàtic que perceben els pescadors artesanals i en contrast amb l'evidència científica (Capítol 5) i c) la inclusió de gènere a través de perspectives interseccionals dins de les comunitats (Capítol 6).

La revisió bibliogràfica (Capítol 3) mostra la mancança de perspectiva de gènere en els estudis sobre comunitats basades en la pesca artesanal. Els estudis analitzats es van obtenir de les bases de dades de Web of Science i Scopus (n = 124 estudis). La revisió sistemàtica revela una manca de dades desagregades per gènere a la literatura sobre gènere i pesca artesanal, amb un 40% dels estudis documentats que no van proporcionar informació sobre la participació de les dones en la gestió i la presa de decisions. Especialment significativa a Àfrica i Àsia, que dues regions on la pesca artesanal és fonamental per a la subsistència de moltes comunitats locals.

En aquesta tesis també es demostra que el gènere és un factor clau per entendre la dinàmica de les comunitats pesqueres a la costa de Kenya (Capítol 4 i 6). El gènere influeix en les identitats socials, l'activitat pesquera i la participació en la gestió i presa de decisions. Es demostra que existeixen

diferències en les tècniques emprades per les pescadores, especialitzades en la pesca a la zona intermareal, i els pescadors, que centren la seva activitat mar endins, fora dels esculls.

A més a més, les dones contribueixen de manera significativa dins d'aquests sistemes socioecològics a la costa de Kenya (Capítol 4, 5 i 6). Els resultats d'aquest treball indiquen que les captures de les dones representen aproximadament un terç de les captures que es consumeixen a casa en les llars amb cap mixt, i fins al 50% dels productes pesquers consumits a les llars amb cap de pescadors (Capítol 4). De la mateixa manera, les dones tenen coneixements ambientals específics vinculats al seu paper de gènere que il·luminen les complexitats dels impactes locals del canvi climàtic (Capítol 5). Per exemple, més dones que homes van percebre canvis en els patrons de pluja, cosa que es pot explicar pel fet de que les dones són les principals responsables d'aconseguir aigua.

Malgrat la participació activa de les dones en aquestes comunitats basades ne la pesca artesanals, la seva participació en la gestió i presa de decisions es insignificant (Capítol 6), cosa que ressona amb la literatura més àmplia sobre gènere i gestió la pesca artesanal (Capítol 3). El nivell de participació de les dones en la gestió i presa de decisions es més baix que els dels homes, i altres estructures de poder interactuen amb el gènere en la mediació de la participació de l'individu, com ara l'edat o el nivell d'educació. Donant suport a la necessitat d'aplicar un marc interseccional en la investigació sobre la gestió de la pesca artesanal. La gestió de la pesca basada en la comunitat pot, en última instància, reforçar les desigualtats socials, posant en dubte tant la inclusió d'aquest enfocament com la seva eficàcia per permetre l'adaptació de la pesca artesanal al canvi climàtic.

En resum, aquest treball mostra el gènere com una dimensió fonamental en la gestió de la pesca artesanal a la costa de Kenya, on la participació de les dones a la CBFM és limitada i planteja problemes al desenvolupament d'estratègies d'adaptació inclusives i efectives en el context del canvi climàtic. Aquestes treball contribueixen a la literatura en termes de gènere i pesca i, més concretament, a la creixent discussió sobre com gestionar la pesca artesanal en un context de canvi climàtic. En un futur s'hauria de continuar incorporant la perspectiva de gènere en els estudis sobre gestió i presa de decisions dins de la pesca artesanal, diversificant el coneixement i expandint la interesccionalitat. Per tal de millorar la capacitat d'adaptació dels sistemes socioecològics basats en la pesca artesanal davant del canvi climàtic cal considerar la dimensió inclusiva a les CBFM i avançar cap a enfocaments transformadors de gènere en tots els aspectes, des de la recollida de dades fins a la gestió i governança.

Paraules clau: Canvi climàtic; Cogestió; Gènere; Oceà Índic occidental; Pesca artesanal; Sostenibilitat marina

Resumen

El cambio climático plantea desafíos crecientes en los sistemas socio-ecológicos pesqueros desde la pequeña escala (SSF, por sus siglas en inglés) hasta el nivel mundial. Dada la importancia sociocultural, nutricional y económica de la pesca artesanal para muchas comunidades costeras de todo el mundo, comprender cómo se ven afectadas por el cambio climático y cómo responder a estos impactos se ha vuelto fundamental. En este contexto, las/los investigadoras/es y las/los actoras/es del desarrollo han enfatizado la necesidad de adoptar nuevos enfoques de gestión pesquera. En particular, en los últimos años se ha propuesto la cogestión pesquera como un facilitador exitoso de la adaptación al cambio climático en la pesca artesanal. Sin embargo, se necesita más investigación para abordar las dimensiones de género de la cogestión pesquera en el contexto de cambio climático, de modo que este enfoque de gestión ayude a identificar y cambiar posibles desigualdades de género en las comunidades SSF. Si bien las mujeres representan el 40% de la fuerza laboral de la pesca artesanal, su papel se ha pasado por alto sistemáticamente, especialmente cuando se trata de procesos de gestión y toma de decisiones. Estos sesgos de género en la investigación pesquera podrían limitar el desarrollo de estrategias efectivas de adaptación transformadoras de género.

Para abordar esta brecha de investigación, esta tesis doctoral adopta una perspectiva interdisciplinar para explorar el papel del género en los enfoques de cogestión de la pesca artesanal, en los que las comunidades locales desempeñan un papel destacado, también llamado gestión pesquera comunitaria (CBFM, por sus siglas en inglés). Específicamente, este trabajo tiene como objetivo comprender 1) el papel del género en la SSF cogestionada y su gobernanza, y 2) cómo afecta el potencial del CBFM para la adaptación climática. Este trabajo se basa en el caso de comunidades SSF cogestionadas en el paisaje marino de Shimoni-Vanga, costa sur de Kenia. Surge de un enfoque de métodos mixtos para la recopilación y el análisis de datos, que combina métodos de investigación cualitativos y cuantitativos y respeta sistemáticamente un muestreo equilibrado en términos de género. Los métodos de recopilación de datos incluyen entrevistas semiestructuradas (n=57), discusiones en grupos focales (n=8), encuestas individuales (n=203) y juegos de guijarros (n=35). Además, el método del mapa en relieve (n=32) se adaptó a entornos SSF para explorar el potencial de las perspectivas interseccionales sobre la dinámica CBFM, aunque el género fue la principal variable analítica utilizada en este estudio.

Esta tesis doctoral consta de dos capítulos introductorios que presentan el tema de estudio (Capítulo 1) y el área geográfica (Capítulo 2). El núcleo de la tesis consta de una síntesis y tres capítulos empíricos. El capítulo de síntesis corresponde a una revisión sistemática de la literatura sobre la participación de las mujeres en la gestión de la SSF y los impactos relacionados a nivel global (Capítulo 3). Este estado preliminar de conocimiento permite situar mejor académicamente la investigación central de esta tesis a través de sus capítulos empíricos que se centran en las comunidades SSF cogestionadas en la costa de Kenia, que abordan respectivamente a) las dimensiones de género de la pesca (Capítulo 4), b) la naturaleza de género de los impactos del cambio climático reportados por las comunidades SSF en relación con la evidencia científica (Capítulo 5), y c) la inclusión de género de la CBFM a través de perspectivas interseccionales (Capítulo 6).

Este trabajo pone de manifiesto un importante vacío de investigación en la literatura existente sobre género y pesca artesanal (Capítulo 3). Esta brecha se identificó mediante una revisión sistemática de la literatura revisada por pares utilizando Web of Science Core Collection y Scopus (n = 124 estudios de caso). La revisión sistemática revela una escasez de datos desglosados por género en la literatura sobre género y SSF con un 40% de los estudios documentados que no proporcionaron información sobre la participación de las mujeres en la gestión y la toma de decisiones de la SSF. Esta brecha fue particularmente significativa en África y Asia, dos regiones donde la pesca artesanal es fundamental para los medios de vida locales y la seguridad alimentaria.

Además, este trabajo de tesis muestra que el género es un factor clave para comprender la dinámica de la SSF cogestionada en la costa de Kenia (Capítulo 4 y 6). El género influye en las identidades sociales, las actividades pesqueras, la producción pesquera y la participación en la gestión de la pesca artesanal. Especialmente, existe un marcado contraste en las técnicas y áreas de pesca entre las pescadoras que se especializan en la pesca en áreas intermareales y los pescadores que utilizan una gama más amplia de técnicas de pesca en áreas más allá del arrecife.

Además, las mujeres contribuyen significativamente a los sistemas socio-ecológicos de la pesca artesanal en la costa de Kenia (Capítulos 4, 5 y 6). Más concretamente, las actividades pesqueras de las mujeres contribuyen sustancialmente a las dietas locales. Los resultados de este trabajo indican que las capturas realizadas por mujeres representan alrededor de un tercio de las capturas consumidas en el hogar en hogares mixtos, y hasta el 50% de los productos pesqueros consumidos en hogares encabezados por mujeres pescadoras (Capítulo 4). De manera similar, las mujeres poseen conocimientos ambientales específicos vinculados a su rol de género que iluminan las complejidades de los impactos locales del cambio climático (Capítulo 5). Por ejemplo, más mujeres que hombres percibieron cambios en los patrones de lluvia, lo que puede explicarse por el hecho de que las mujeres son las principales responsables de ir a buscar agua.

A pesar del importante papel de las mujeres en la SSF cogestionada, no se logra una participación significativa de las mujeres en la CBFM en la costa de Kenia (Capítulo 6), lo que concuerda con la literatura más amplia sobre género y gestión de la SSF (Capítulo 3). Los niveles de participación de las mujeres en el CBFM son sistemáticamente más bajos que los de los hombres, oscilando entre pasivos y activos. Además, otras estructuras de poder interactúan con el género al mediar la participación individual en el CBFM, como la edad o el nivel educativo, lo que respalda la necesidad de aplicar un marco interseccional a la investigación sobre la gestión y la gobernanza de la SSF. La gestión pesquera comunitaria puede, en última instancia, reforzar las desigualdades sociales, desafiando así tanto la inclusividad de dicho enfoque como su eficacia para permitir la adaptación de la pesca artesanal al cambio climático.

En general, este trabajo muestra que el género es una dimensión fundamental de la SSF cogestionada en la costa de Kenia, pero la participación de las mujeres en el CBFM es limitada, lo que plantea cuestiones relacionadas con el desarrollo de estrategias de adaptación inclusivas y efectivas en el contexto del cambio climático. Estos hallazgos contribuyen a la literatura sobre género y pesca, y más específicamente al creciente debate sobre la gestión de la SSF en un contexto de cambio climático. Las líneas de investigación futuras sugeridas incluyen investigar una mayor equidad de género en la gestión y gobernanza de la SSF, diversificar el conocimiento en la investigación oceánica o ampliar la investigación interseccional sobre la SSF. En conclusión, para mejorar la capacidad de adaptación de los sistemas socioecológicos de la SSF frente al cambio climático, es necesario reconsiderar la dimensión inclusiva del CBFM y avanzar hacia enfoques transformadores de género en todos los aspectos de la SSF, desde la recopilación de datos hasta la gestión y gobernanza.

Palabras clave: Cambio climático; Cogestión; Género; Océano Índico occidental; Pesca en pequeña escala; Sostenibilidad del océano

Résumé

Le changement climatique pose des défis croissants aux socio-écosystèmes de la pêche artisanale au niveau mondial. Compte tenu de l'importance socioculturelle, nutritionnelle et économique de la pêche artisanale pour de nombreuses communautés côtières du monde entier, il est essentiel de comprendre l'impact du changement climatique et comment s'adapter au mieux à ces changements. Les chercheur.e.s et les acteur.rice.s du développement ont souligné le besoin de nouvelles approches en matière de gestion des pêches. En particulier, la cogestion des pêches a été mise en avant comme un catalyseur efficace de l'adaptation au changement climatique au sein des systèmes de pêche artisanale. Cependant, des recherches supplémentaires sont nécessaires pour comprendre les dimensions genrées de la cogestion des pêches dans le contexte du changement climatique, de sorte que cette approche de gestion puisse permettre de réduire les inégalités potentielles entre les genres au sein des communautés de pêche artisanale. Bien que les femmes représentent 40% de la force de travail dans le secteur de la pêche artisanale, leur rôle dans ce secteur a été systématiquement négligé, notamment en ce qui concerne les processus de gestion et de prise de décision. Ces biais genrés qui caractérisent la recherche halieutique sont susceptibles de limiter le développement de stratégies d'adaptation efficaces et transformatrices en matière de genre.

Pour combler cette lacune de recherche sur la nature genrée de la gestion de la pêche artisanale, ce travail de doctorat adopte une perspective interdisciplinaire pour examiner le rôle du genre dans la cogestion des pêches, particulièrement dans les approches où les communautés locales jouent un rôle de premier plan, également appelé gestion communautaire des pêches. Plus précisément, ce travail contribue à mieux comprendre 1) le rôle du genre dans les systèmes de pêche artisanale cogérés et leur gouvernance, et 2) comment cette dimension genrée affecte le potentiel des approches de gestion communautaire des pêches en termes d'adaptation climatique. Ce travail s'appuie sur le cas des communautés de pêche artisanale cogérées dans le paysage marin de Shimoni-Vanga, sur la côte sud du Kenya. Cette thèse adopte une approche mixte de collecte et d'analyse des données, combinant des méthodes de recherche qualitatives et quantitatives et respectant systématiquement un échantillonnage équilibré entre les genres. Les méthodes de collecte de données comprennent des entretiens semi-structurés (n=57), des discussions de groupe (n=8), des enquêtes individuelles (n=203) et des jeux de cailloux (n=35). De plus, la méthode de la carte en relief (n = 32) a été adaptée au contexte de la pêche artisanale pour explorer le potentiel des perspectives intersectionnelles sur les dynamiques de la gestion communautaire des pêches.

Cette thèse de doctorat comprend deux chapitres introductifs présentant le sujet d'étude (Chapitre 1) et la zone géographique (Chapitre 2). Le cœur de la thèse consiste en un chapitre de revue de littérature et trois chapitres empiriques. Le chapitre de revue de littérature correspond à une revue systématique de la participation des femmes à la gestion de la pêche artisanale et les impacts associés au niveau mondial (Chapitre 3). Ce chapitre permet de situer les principaux résultats de cette thèse dans le contexte de la littérature internationale sur le sujet. Les trois chapitres empiriques se basent sur l'étude de communautés de pêche artisanale cogérées sur la côte du Kenya et abordent respectivement a) les dimensions genrées de la pêche (Chapitre 4), b) la nature genrée des impacts du changement climatique reportés par les communautés locales et l'articulation de ces savoirs locaux avec les connaissance scientifiques (Chapitre 5), et c) l'inclusion du genre dans la gestion communautaire des pêches à travers une perspective intersectionnelle (Chapitre 6).

La revue systématique de littérature révèle une lacune importante dans la littérature existante sur le genre et la pêche artisanale (Chapitre 3). Cette revue systématique de la littérature évaluée par des pairs s'appuie sur l'utilisation de Web of Science Core Collection et Scopus (n = 124 études de cas). Les résultats de ce chapitre indiquent un manque de données ventilées par genre dans la littérature sur la pêche artisanale, avec 40 % des études documentées qui ne fournissaient pas d'informations sur la

participation des femmes à la gestion et à la prise de décision de la pêche artisanale. Ce manque de données est particulièrement important en Afrique et en Asie, deux régions où la pêche artisanale joue un rôle essentiel dans les moyens de subsistance locaux et la sécurité alimentaire.

Ce travail de thèse montre également que le genre est un facteur clé pour comprendre les dynamiques de gestion communautaire des pêches sur la côte du Kenya (Chapitres 4 et 6). Le genre influence les identités sociales, les activités de pêche, la production halieutique et la participation à la gestion des pêches. En particulier, il existe un contraste marqué dans les techniques et les zones de pêche des pêcheurs et pêcheuses : alors que les pêcheuses sont spécialisées dans le glanage d'invertébrés dans les zones intertidales, les pêcheurs utilisent une plus large gamme de techniques de pêche et ciblent les zones situées au-delà du récif.

En outre, les femmes contribuent de manière significative aux socio-écosystèmes de la pêche artisanale (Chapitres 4, 5 et 6). Plus précisément, les activités de pêche des femmes contribuent de manière substantielle à l'alimentation locale. Les résultats de ce travail indiquent que les captures des femmes représentent environ un tiers des captures consommées dans les ménages mixtes et jusqu'à 50 % des produits de la pêche consommés dans les ménages tenus par des pêcheuses (Chapitre 4). Par ailleurs, les femmes possèdent des connaissances environnementales spécifiques liées à leurs rôles genrés qui mettent en lumière la complexité des impacts locaux du changement climatique (Chapitre 5). Par exemple, plus de femmes que d'hommes ont reporté des changements dans les régimes de pluie, ce qui peut s'expliquer par le rôle déterminant des femmes dans la gestion des ressources en eau des ménages.

En dépit du rôle important des femmes dans les systèmes de pêche artisanale cogérés, elles ne participent pas de manière significative à la gestion des pêches sur la côte du Kenya (Chapitre 6), comme documenté dans la littérature existante sur le genre et la gestion de la pêche artisanale (Chapitre 3). Les niveaux de participation des femmes à la gestion communautaire des pêches étaient systématiquement inférieurs à ceux des hommes, allant d'une participation passive à active. De plus, d'autres structures de pouvoir interagissent avec le genre en façonnant la participation des individus à la gestion communautaire des pêches comme l'âge ou le niveau d'éducation, ce qui soutient la nécessité d'appliquer un cadre intersectionnel à la recherche sur la gestion et la gouvernance de la pêche artisanale. La gestion communautaire des pêches pourrait éventuellement renforcer les inégalités sociales, limitant alors à la fois le caractère inclusif d'une telle approche et son efficacité à permettre l'adaptation de la pêche artisanale au changement climatique.

Dans l'ensemble, ce travail montre que le genre est une dimension centrale de la gestion communautaire des pêches sur la côte du Kenya, mais que la participation des femmes à la prise de décision est limitée, ce qui représente une préoccupation majeure au regard du développement de stratégies d'adaptation inclusives et efficaces dans le contexte du changement climatique. Ces résultats contribuent à la littérature sur le genre et la pêche, et plus particulièrement au débat croissant sur la gestion de la pêche artisanale dans le contexte du changement climatique. De futurs axes de recherche prometteurs incluent l'étude des enjeux d'équité des genres dans la gestion et la gouvernance de la pêche artisanale, la diversification des connaissances en matière de recherche sur l'océan ou le développement de recherche intersectionnelle sur la pêche artisanale. Afin de renforcer la capacité d'adaptation des socio-écosystèmes de pêche artisanale face au changement climatique, il est nécessaire de reconsidérer la dimension inclusive de la gestion communautaire des pêches et d'évoluer vers des approches transformatrices en matière de genre dans tous les aspects de la pêche artisanale, de la collecte de données à sa gestion et gouvernance.

Mot clés : Changement climatique ; Cogestion ; Durabilité de l'océan ; Genre ; Océan Indien occidental ; Pêche artisanale

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Main acronyms and abbreviations

BMU: Beach Management Units

CBFM: Community-based fisheries management

CBNRM: Community-based natural resource management

CPUT: Catch per unit of time

EACC: East African Coastal Current

EC: Executive committee

ECC: Equatorial counter current

EEZ: Exclusive economic zone

FAO: Food and Agriculture Organization of the United Nations

FGD: Focus group discussions

FPE: Feminist political ecology

IPCC: Intergovernmental Panel on Climate Change

IP & LC: Indigenous Peoples and local communities

KMFRI: Kenya Marine and Fisheries Research Institute

LEK: Local ecological knowledge

LICCI: ERC-Funded project “Local Indicators of Climate Change Impacts”

LMMA: Locally Managed Marine Areas

MEB: Multiple Evidence Base approach

MPA: Marine protected areas

NEM: Northeast monsoon season (November-March)

SC: Somali Current

SDG: Sustainable development goals

SEC: Southern Equatorial Current

SEM: Southeast monsoon season (April-October)

SES: Social-ecological system

SSF: Small-scale fisheries

SSI: Semi-structured interviews

SST: Sea surface temperature

UN: United Nations

WIO: Western Indian Ocean

Foreword

“ La lune était sereine et jouait sur les flots.
La fenêtre enfin libre est ouverte à la brise,
La sultane regarde, et la mer qui se brise,
Là-bas, d'un flot d'argent brode les noirs îlots.“

From the poem “Clair de Lune“ by Victor Hugo (1829), l.1-4.[1]

Dear readers, I wish to confess that this doctoral work draws its inspiration from the important role played by the moon in my study site. It took me several months of living with the Swahili people from the Shimoni-Vanga seascape on the South Coast of Kenya to realize that a central - yet silent - protagonist of my study was missing. Since then, I considered it as a “seamark” that illuminated my sometimes-winding research journey. In the field, I had become so accustomed to its presence which defined my research timing, that coming back to Europe was particularly troubling at first. I continued looking for the moon at dusk…but the urban landscapes of Barcelona and Paris are quite different from that of Wasini Island. Soon I forgot my new friend, as well as the regular cadence and the poetry that it had brought me.

Owing to its regular cycles and its visibility, the moon has influenced the calendar of many societies, and in particular the Muslim calendar. In my study site, Islam is the dominant religion that shapes local socio-cultural systems. Therefore, during my ethnographic experience, I participated in many community events that were driven by the different phases of the moon such as the holy month of Ramadan, which corresponds to the ninth month of the Islamic calendar.

Furthermore, the moon strongly influences fishing activities within the Shimoni-Vanga seascape. Since it causes ocean tides, its different phases determine the season for foot fishing, a female-dominated activity. Foot fishers go at sea only during low tide periods locally called “*bamvua*” when the reef flats are exposed, thus allowing to catch invertebrates by hand or using pointed sticks. During the *bamvua* that last about two weeks per month, foot fishers tend to spend most of their day fishing to maximize their catch. Delving into my research topic, I thus needed to familiarize myself with the different moon phases to capture the gendered dimensions of fishing activities.

[11] Hugo, V. (1829). “Clair de Lune “. *Les Orientales.* (Ed 1868). Hachette Bnf. 52p.

The moon also epitomizes, in my opinion, the tension between sciences and the sensible. From the perspective of small-scale fishing communities from the Shimoni-Vanga seascape, changes in the climate system cause changes in the timing of tides, as expressed by Amina, an octopus fisher: "*Bamvua are less predictable than before. Tides might come earlier or later than expected*". Those local perspectives from SSF communities are somehow not found in the academic literature. Beyond these different viewpoints between scientific and local knowledge regarding tidal dynamics, the symbolic figure of the moon invites us to reconsider and value spiritual and intimate relationships with the ocean.

Like the moon, my thesis presents two faces as you will discover as you read. A visible face first, which aims to describe the studied small-scale fishing communities, their management and governance through the Beach Management Unit framework, and how they experience climate change impacts. A hidden side then, which intends to unravel gender power relationships in fisheries co-management and reveal the different power structures that intersect in shaping individuals' participation in fisheries decision-making processes. In line with the feminist scholarship, this thesis contributes to illuminating the invisible through the analysis of gender dynamics characterizing community-based fisheries management.

Finally, this moon inspiration resonates todays with the recognition of the end of an academic cycle... after four years of rigorous and sustained work, the time has come to share with you the results of my research on the gendered nature of co-managed fisheries in the face of climate change, drawing on my field experience in the Shimoni-Vanga seascape, South Coast of Kenya. This gives me the opportunity to reflect on the whole research process from its design to its implementation, the different challenges I faced and how I relate the outcomes of my research to the broader literature. As I today have to put a final dot on this document, it however does not sound like an end, rather a beginning. But before opening a new cycle, let me tell you this story….

Chapter 1
Introduction

Small-scale fishing boats in the twilight, Shimoni-Vanga seascape, South Coast of Kenya.

Introduction

1. Motivation and aim

"*We must protect the oceans, and the people whose lives and livelihoods depend on them, from the impacts of climate change.*" This statement by António Guterres, the United Nations (UN) Secretary-General, at the opening of the Second UN Ocean Conference in 2022 resonates with the myriad of challenges posed by climate change to coastal communities worldwide.

Anthropogenic climate change has caused substantial changes on coastal and marine ecosystems over the last century and these trends are likely to continue into the next decades at a pace that depends on current and future socio-economic and political choices at the global scale (Gattuso et al., 2015; Intergovernmental Panel on Climate Change [IPCC], 2021). As a result of increased atmospheric concentrations of greenhouse gases, the ocean is notably experiencing warming sea temperatures, deoxygenation, and acidification (Kwiatkowski et al., 2020; Turley et al., 2011). In turn, these physical changes are affecting marine life both directly and indirectly through changes in ecosystem productivity and composition (Blanchard et al., 2012; Pörtner, 2014). For instance, it is widely documented that climate change induces changes in fish species composition, abundance, and distribution, ultimately affecting the viability of marine fisheries globally (Cheung et al., 2018; Lotze et al., 2019).

Climate change impacts on marine biodiversity largely affect small-scale fisheries (SSF), which are identified as one of the most vulnerable food production systems to climate change impacts (Food and Agriculture Organization of the United Nations [FAO] et al., 2023). While there is no consensual and static definition of SSF, they commonly refer to multi-species, multi-gear, and labor-intensive fisheries (Smith & Basurto, 2019). Small-scale fisheries represent 40% of the global catch in capture fisheries and employ more than 60 million people globally. Furthermore, it is estimated that 53 million additional people engage in subsistence fishing, making SSF the largest employment sector within the blue economy (FAO et al., 2023). Beyond their economic contribution, SSF are vital for the livelihoods, nutritional needs, and cultural identities and resilience of coastal populations throughout the world (Kawarazuka & Béné, 2010). Overall, SSF contribute substantially to the UN sustainable development goals (SDG) (Bitoun et al., 2024; FAO, 2015). Given the importance of SSF for the coastal communities they sustain, addressing the challenges posed by climate change to SSF is critical. By interacting with climate change and exacerbating its effects, overfishing, pollution, habitat destruction, population growth, and urbanization are factors that combine to adversely influence the future of SSF (Ojea et al., 2020).

To better understand the complex challenges faced by SSF, scholars commonly apply a social-ecological system (SES) framework, based on the recognition that human and ecological systems are entangled (Cinner & Barnes, 2019; Ojea et al., 2020). While a considerable body of literature has examined the responses of SSF social-ecological systems to climate change through biological and ecological lenses (Green et al., 2014; Pörtner & Peck, 2010; Shultz et al., 2016), recent work has highlighted the important role of fisheries management and governance in adapting SSF to climate change impacts (Kyvelou et al., 2023). There has been a growing interest in discussing new fisheries management approaches that enhance SSF adaptive capacity and reduce their vulnerability in face of rapid environmental and climatic changes (Gaines et al., 2018; Lindegren & Brander, 2018; Pinsky & Mantua, 2014).

In particular, adaptive fisheries co-management (hereafter: co-management) holds the promise of favoring SSF adaptive capacity and increasing the overall system's resilience to climate change. Co-management is characterized by management processes that are flexible and emphasize collaborative and decentralized approaches, social learning, and the inclusion of diverse knowledge sources (Fabricius & Currie, 2015). Previous research has highlighted the contributions of co-

management to climate change adaptation by improving social capital (Quimby et al., 2023), fostering social-ecological resilience (Kushardanto et al., 2022; Nogué-Alguero et al., 2023), and providing flexibility to respond to climatic variability (McClenachan et al., 2015; Peiffer & Harte, 2022). While co-management is an auspicious adaptation tool in SSF social-ecological systems, it has developed in many guises, covering a large spectrum of power-sharing arrangements. Scholars have emphasized the need for greater involvement of SSF communities and recognition of their rooted knowledge within co-management schemes, through community-led initiatives, also known as community-based fisheries management (CBFM) (d'Armengol et al., 2018; Deepananda et al., 2015).

Despite women's significant contribution to the SSF sector, accounting for about 40% of the global workforce (FAO et al., 2023), the gendered dimensions of co-management are largely unaddressed, especially in the context of climate change (de la Torre-Castro et al., 2017; Rohe et al., 2018). Gender is an analytical lens that helps understand how social-cultural and institutional norms contribute to shaping and constructing gender identities associated with individuals of different sex and the resulting behaviors, roles, expectations, and opportunities across diverse societies and time periods. In this way, gender differs thus from sex, understood as the biological attributes assigned to individuals at birth. The few studies that have explored the role of gender in co-management suggest that, despite the potential of co-management for supporting gender equity in SSF owing to its participatory and inclusive principles, the outcome depends on its implementation on the ground (Kleiber et al., 2019; Smallhorn-West et al., 2022). In some cases, co-management may instead reinforce gender inequalities within SSF communities (Baker-Médard, 2016; Johnson et al., 2021). As an illustration, a study in Solomon Islands reveals that women's access to leadership roles in co-management was restricted despite their representation in local fisheries committees, suggesting that gender norms hampered their meaningful participation in fisheries decision-makings (Rabbitt et al., 2022). Since climate change is expected to accentuate existing social inequalities in the future, these gender biases observed in the context of co-managed fisheries may be strengthened by adverse climate change impacts (IPCC, 2023). However, a comprehensive analysis of the actual role of gender in co-management in the face of climate challenges is still missing from the academic literature, despite a growing call for gender equitable SSF at the international level (FAO, 2017).

Lack of research on the gendered aspects of co-management raises four main issues regarding fisheries research, management, and adaptation strategies in the context of climate change. First, although women's and men's roles in fisheries differ greatly around the world, they tend to engage in different parts of the value chain (Lentisco & Lee, 2015). Given these gendered patterns characterizing SSF, adopting a gendered perspective is fundamental for understanding the complex power relationships between women and men in SSF communities (FAO et al., 2023). Second, there is growing evidence that women are disproportionately affected by climate change impacts globally (Pearse, 2017). A gendered approach is thus required for analyzing climate vulnerabilities in SSF social-ecological systems. Third, women's knowledge and practices related to their fishing activities represent an untapped source of information with potential for climate change research (Kleiber et al., 2015). In that sense, a gendered analysis of co-management may contribute to gain a more holistic understanding of local climate change impacts (Kleiber et al., 2018). Finally, considering the reported benefits associated with women's participation in environmental management and governance (de la Torre-Castro, 2019; Leisher et al., 2017), it is necessary to better understand the gendered aspects of participation in co-management in order to improve fisheries management and climate adaptive strategies.

This PhD dissertation addresses some of the key knowledge gaps mentioned above related to the gendered aspects of co-management in a changing climate, focusing on CBFM approaches. Although I mostly focused my work on the gender variable through a binary lens (i.e., women and men), I recognize the wide diversity of gender identities and their intersection with other axes of social differentiation, hence I applied an intersectional framework in the last empirical chapter of this thesis (Chapter 6). I expect this study to greatly contribute to the literature at the interface of gender, SSF and climate change. This doctoral research is grounded in coastal Kenya, a region where SSF provide 80%

of the marine catch and contribute significantly to local livelihoods, while being recognized as highly vulnerable to climate change impacts (Kimani et al., 2018; Taylor et al., 2019). The overarching aim of this PhD dissertation is to explore the role of gender in CBFM as an adaptive response to climate change impacts in coastal communities on the South Coast of Kenya.

2. Climate change impacts on coastal and marine social-ecological systems

In this section, I outline the state of knowledge about climate change impacts on coastal and marine SES drawing upon both scientific and local knowledge and highlighting existing variability within each knowledge system. Recognizing their complementarity, I expose different approaches used to bring these two ways of knowing together, which may enrich the understanding of climate change impacts on SSF social-ecological systems.

2.1. Scientific knowledge

Since the industrial revolution, climate change has significantly altered coastal and marine ecosystems worldwide (IPCC, 2019a). One major climate-induced stressor in the ocean is warming, with an increase in global sea surface temperature (SST) by 0.7 °C over the last century (Bindoff et al., 2007). In addition, the ocean is also experiencing an increase in frequency, intensity, and duration of marine heatwaves (MHW) (Oliver et al., 2021). Those events refer to anomalous and punctual sea warming episodes lasting for five days or more. Besides warming, scientists have also reported a marked decrease in oxygen levels over the past century, referred to as ocean deoxygenation (Keeling et al., 2010; Oschlies et al., 2018). Over the period 1970-2000, dissolved oxygen in the global ocean has declined by −0.93 $mmolm^{-3}$ (Helm et al., 2011). This oxygen decrease has two causes. First, oxygen solubility is reduced in warmer water. Second, ocean warming contributes to increase ocean stratification and limits ocean mixing. Oxygen decrease limits the downward mixing of surface oxygen-rich water into the deeper ocean, a phenomenon called ventilation. This phenomenon is emphasized in coastal areas through land pollution, also called eutrophication (Gilbert et al., 2010). Regarding ocean productivity, some authors have reported a decrease in net primary production (NPP) since 1900 (Boyce et al., 2010), even though the attribution to climate change remains debated within the scientific community (Rykaczewski & Dunne, 2011). This decrease in productivity is thought to be related to the enhanced stratification, and the weaker vertical mixing that reduces the input of nutrients to the sunlit surface layer. Another major climate-related change in the ocean is the decline in sea surface pH, which causes an acidification of the ocean (Doney et al., 2009). It is estimated that sea surface pH dropped by 0.1 pH unit since 1850 (Bindoff et al., 2007).

These physical and biogeochemical changes cause accelerating negative impacts on coastal and marine biodiversity (Doney et al., 2012). Decline in ocean productivity is likely to affect the rest of the food chain (Kwiatkowski et al., 2018; Lotze et al., 2019). Marine organisms are also affected by rising temperatures which might challenge their thermal tolerance, and lead to distribution shift or species extinction (Cheung et al., 2009). Another important source of change for marine species is ocean acidification that alters the physiological and behavioral functioning of calcifying organisms in the ocean such as coccolithophores, a key player in the ocean carbon cycle (Pallacks et al., 2023; Ziveri et al., 2007). By adversely impacting marine biodiversity, climate change is ultimately posing significant challenges to food production systems and ocean-based economic sectors, including capture fisheries (IPCC, 2021). For instance, owing to climate-driven changes in species' spatial distribution and abundance, fisheries in many world regions have experienced significant reductions in catch, thus

challenging their management and economic returns (IPCC, 2019b). Over the coming decades, climate models predict that current trends in coastal and marine SES will continue to intensify, although the pace and magnitude of changes depend on climate scenarios (Bopp et al., 2013; Cocco et al., 2013). All these changes will also be modulated by natural climate variability and other anthropogenic stressors. Because of this cumulative and synergetic nature of climate change impacts, it is hard to draw a comprehensive and accurate analysis of social-ecological responses across scales.

Behind these global trends, climate projections on coastal and marine SES show high regional variability, thus calling for an analysis of climate change impacts on the ocean at a regional scale (Kwiatkowski et al., 2020). In particular, the Western Indian Ocean (WIO) (58°S–108°N, 50–65°E) is a singular case since it experiences a faster increase in SST than any other ocean basin (Roxy et al., 2014). Between 1901 and 2012, the WIO summer SST increased by +1.28°C against only 0.78 °C in the usually warmer central-eastern Indian Ocean, also known as the Indian Ocean warm pool. The WIO is therefore an ocean warming hotspot. In turn, this marked WIO warming trend may adversely alter the monsoon, rainfall patterns, and marine food webs. For instance, one study documents a 20% decline in phytoplankton biomass in the Arabian Sea since 1950, and attributes it to warmer SST, therefore suggesting that future warming will result in further decline in productivity (Roxy et al., 2016). In addition, coastal ecosystems in the WIO region are substantially impacted by climate change through major coral bleaching events, sea level rise and coastal sedimentation and erosion (UNEP-Nairobi Convention & WIOMSA, 2015). With 30% of its population living by the coast and relying on fisheries resources and coastal habitats for nutritional needs and income, the WIO is therefore highly vulnerable to climate change impacts on fisheries SES (Beal et al., 2020; Jacobs et al., 2021; Obura et al., 2017; Taylor et al., 2019). Overall, regional variability and uncertainties associated with climate projections call for expanding research on climate change impacts in regions that are identified as the most vulnerable to climate change such as the WIO.

Beyond climate sciences, there is a need to recognize and embrace a greater diversity of ways of knowing and worldviews on climate change impacts on coastal and marine SES. This is especially the case for knowledge systems owned and held by Indigenous Peoples and local communities (IP & LC) owing to their place-based and relational understanding of environmental changes and acknowledging that they have long been excluded from climate discussions (Orlove et al., 2023).

2.2. Local ecological knowledge

"*The word itself, "research", is probably one of the dirtiest words in the Indigenous world's vocabulary. When mentioned in many Indigenous contexts, it stirs up silence, it conjures up bad memories, it raises a smile that is knowing and distrustful*." (Smith, 1999, p.1)

The Intergovernmental Panel on Climate Change (IPCC) and part of the scientific community have called for greater inclusion of other knowledge forms in climate research, especially knowledge held by IP & LC on their environment, also referred to as Indigenous and local knowledge (ILK) or local ecological knowledge (LEK) in the literature (Cai et al., 2017; Reyes-García et al., 2016). Local ecological knowledge is a term that refers to complex knowledge systems embracing knowledge about biological and ecological dynamics, practices shaping environmental use and management, and their socio-cultural dimension (Berkes, 2008; Martin et al., 2009; Puri & Vogl, 2005). Above all, LEK must be understood as a way of life and a governance system for diverse IP & LC across the world. Dynamic and adaptive, LEK represents "embodied, relational and place-based systems" whose production cannot be uncoupled from the socio-environmental context (Latulippe & Klenk, 2020, p.8). Owing to their long-term and sensitive interactions with their environment, diverse IP & LC have expanded LEK in ways that relate to changes in their environment and climate patterns (Klein et al., 2014). In this context, recent efforts have sought to challenge the Western framing of climate change impacts and recognize LEK as

its own knowledge system, which is equally legitimate as climate sciences (IPCC, 2023; Rosenzweig & Neofotis, 2013).

In particular, recent research work has striven to illuminate and value knowledge on climate change held by fisherfolk (Alati et al., 2020; Deb, 2015; Gupta et al., 2023; Savo et al., 2017). Given their intimate relationship with the sea, fishers have developed a thorough and rooted understanding of local coastal and marine dynamics over time. This rich body of knowledge allows SSF communities to detect long-term changes in the weather or climate-induced changes in the ocean (Deb, 2015; Grant & Berkes, 2004). For example, fishers' forecasting skills increase their ability to notice fine changes in seasonal patterns shaping wind or current conditions. In their global review of fishers' knowledge spanning over 300 fishing communities, Savo et al. (2017) show that subsistence-oriented fishers are well aware of climate change impacts on coastal and marine ecosystems throughout the world. Half of fishers' climate-related observations in this study relate to changes in the weather and climate systems. For instance, fishers widely reported change in seasonality and in the frequency of extreme weather events. This evidence can be linked to their capacity to read and predict weather patterns for safety reasons, especially in the Artic region (Ford et al., 2008; Prno et al., 2011). Furthermore, according to the same review, fisherfolk reported changes in physical systems, such as sea level rise or coastal erosion, and in the biological system, such as changes in species range and behaviors, which have a direct effect on their livelihoods. This study also indicates that changes less commonly reported by fishers revolve around their cultural identity and well-being such as experiencing solastalgia, which refers to psychic distress caused by adverse impacts of climate change. Altogether, LEK held by small-scale fishers reflects a holistic and granular view of local experiences of climate change impacts and their regional variability. All these changes must be understood from a broader perspective since SSF communities – like other IP & LC – often conceptualize climate change in relation to other drivers of change, and in light of historical oppressive forces linked to colonialism, imperialism, racism, patriarchy and other sources of structural socio-environmental inequalities (Bee et al., 2015; Reyes-García et al., 2024).

However, LEK is not uniformly distributed across members of a given society, but rather influenced by various axes of social differentiation (Díaz-Reviriego et al., 2016; Gallois et al., 2017; Hitomi et al., 2018). In particular, gender is a key variable to consider when examining intracultural variability in LEK (Díaz-Reviriego et al., 2016; Torres-Avilez et al., 2016). Gender may mediate views and experiences perceived by individuals of diverse gender identities as well as the type of knowledge they may acquire over time through their different roles in society (Alston & Whittenbury, 2013). Most studies have used a binary view of gender to document how LEK differs between women and men in diverse fields such as fisheries resources (Silva et al., 2019), hunting strategies (Reyes-García et al., 2020) or wild edibles (Guimbo et al., 2011). For instance, Porcher et al. (2022) show how women's and men's knowledge on wild edible plants differ in Betsileo societies in Madagascar, with women's expertise directed towards herbaceous life forms and those of men towards endemic species. A growing body of literature has also explored how gender norms and roles shape the way that local people observe, relate to, cope with, or adapt to climate change impacts in many parts of the world (Bee, 2014; Dankelman, 2010; Lambrou & Nelson, 2010). Other social categories such as ethnicity or religion also influence people's relationship to their environment. That is why scholars are increasingly examining gender in connection with other power structures, known as intersectionality (Crenshaw, 1989).

2.3. Towards a dialogue between scientific and local knowledge

There is an expanding discussion about what is the best epistemological approach to apply when engaging with plural knowledge systems, or knowledge pluralism, in environmental and climate research (Löfmarck & Lidskog, 2017; Orlove et al., 2023; Tengö et al., 2014). Most of the existing studies that weave together scientific knowledge and LEK have often adopted an integrationist approach where elements of one knowledge system are integrated into another (White & Lidskog, 2023). This process relies on a validation exercise whereby knowledge of the former system is evaluated through the

criteria of the latter one. Such a process appears problematic in the light of power asymmetries that define the relationship between IP & LC and the scientific community owing to colonial history (Tengö et al., 2014). In their work, Roue & Nakashima (2018) proposed a historical analysis of the successive approaches adopted by the Western academic community to work with LEK. They showed how scientists have stopped denigrating LEK – a legacy of the Enlightenment age, which established a strong distinction between the rational and spiritual world – and have begun to gradually recognize and validate these knowledge systems. Yet, LEK validation through scientific methods may alter their integrity, while reinforcing the hegemony of scientific knowledge (Tengö et al., 2014). For example, assessing the validity of LEK from a metric and positivist standpoint, without considering their related cultural values, ethics, and spiritual dimension, may weaken and discredit their epistemological power. An alternative logic is the parallelist approach that explores potential connections between knowledge systems and highlights complementary views. Because this approach assumes that knowledge is situated and built within a specific system, the validation concept is not considered relevant. Instead, the parallelist approach promotes collaboration between knowledge systems, by recognizing the autonomy and distinctiveness of each system (Snively & Williams, 2016). This parallelist approach is increasingly being recognized in global discussions aiming to diversify and improve ocean knowledge, such as processes towards an Intergovernmental Panel for Ocean Sustainability (Gerhardinger et al., 2023).

Reflecting these two opposing approaches, there is a current divide in the literature on whether to use the term “local perceptions” (Fernández-Llamazares et al., 2017; Pyhälä et al., 2016) or “local indicators” (Reyes-García et al., 2016; Rosenzweig & Neofotis, 2013) when referring to environmental reports by IP & LC knowledge holders. In this work, we apply a parallelist approach and used the term “local indicators” to stress the equivalent roles that LEK and instrumental data-based scientific knowledge play in mutually enriching climate change evidence. We build on Berkes’s (2009) work to explore local indicators of climate change impacts, which are representing one component of a broader LEK system developed over time by IP & LC with a long history of interaction with their environment.

3. Analytical lenses

In this doctoral work, I examine the gendered dimensions of CBFM in a climate change context. To analyze the interplay between climate change impacts on SSF communities, CBFM dynamics and gendered power relationships, I mobilize three main lenses at the interface of SES resilience thinking, adaptive fisheries co-management, and feminist political ecology scholarship. This integrated conceptual framework provides an original perspective to reflect on overlaps and complementarities between these three approaches and identify potential research gaps (Figure 1.1).

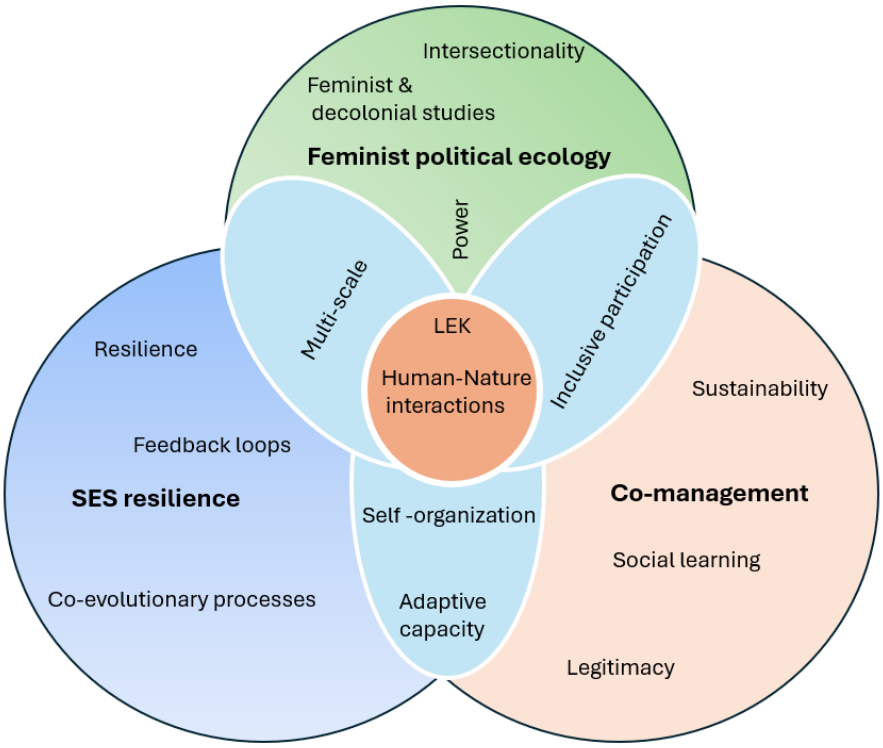

Figure 1.1: Diagram showing the three analytical lenses used in this PhD research, their overlaps, and complementarities.

3.1. Social-ecological system resilience

"The delineation between social and natural systems is artificial and arbitrary."
(Berkes & Folke, 1998, p.4)

Social-ecological system approach is a conceptual framework used to capture the complex relationships between societies and their environment (Berkes & Folke, 1998). For many decades, social and ecological processes have been studied in silo. Applied ecology research often overlooked people's interactions with their environment, whereas many social scientists focused on social issues without considering their ecological implications (Berkes et al., 1998). Against this background, the SES approach emerged as a powerful lens to analyze the two systems together, acknowledging the interdependence between people and nature (Ommer et al., 2012). Scholars from different disciplines have applied an SES approach to diverse topics and at multiple scales, from community-based to regional resource management (Boyd & Folke, 2012).

Over time, the SES approach has merged with resilience thinking to enrich the analysis of social-environmental changes (Biggs et al., 2015). Resilience was originally conceptualized in the ecology field regarding the capacity of a system to absorb disturbances (Holling, 1973). Viewing it from a social-ecological perspective, there is a large amount of research focusing on the ability of SES to address unexpected changes, while sustaining the functioning of the whole system (Brown, 2016). Adaptive capacity, which refers to the capacity of an SES to adapt to change, is commonly perceived as a driver of social-ecological resilience (Berkes et al., 1998; Boyd & Folke, 2012).

In the context of climate change, there has been a growing interest in assessing SES adaptive capacity and resilience (Cinner & Barnes, 2019; Salgueiro Otero & Ojea, 2020). Scholars have proposed different understandings of SES resilience in relation to climate change, either emphasizing connections between resilience, adaptation, and vulnerability concepts (Brown, 2016) or stressing their differences (Janssen, 2007). Brown (2016) identifies five main research gaps in adaptive approaches in SES, including i) the need to recognize the interactions between climate change and other environmental changes affecting SES, ii) the importance of inter-scalar and inter-sectoral analyses, iii) a lack of attention to feedback effects within SES, iv) uncertainty levels on modelling SES trajectories, and v) the influence of socio-cultural norms and values on SES. Knowledge pluralism is also recognized by scholars as a driver of SES adaptation to climate change (Pearce et al., 2015). Weaving scientific and local knowledge systems together through equitable processes whereby each knowledge holder is granted the same rights and agency in the research may result in knowledge co-production (Norström et al., 2020). Such process may play an important role in increasing the adaptive capacity of an SES, and ultimately its resilience, provided that Indigenous and local sovereignty is respected (Berkes et al., 2008; Latulippe & Klenk, 2020).

I apply an SES resilience lens (*sensu* Biggs et al., 2015) to understand the complexities linked to SSF social-ecological systems in the face of climate change. This SES resilience approach provides me with the tools to address the complex and intertwined relationships between SSF communities and their coastal environment. Scholars working on fisheries systems have emphasized the dynamic, uncertain, and non-linear character of SSF, which requires an SES analytical frame (Berkes & Ross, 2013; Boyd & Folke, 2012). Grounding my study on the South Coast of Kenya, I take as an entry point the intimate connection that SSF communities have developed over time with the sea, which permeates throughout their fishing practices, knowledge, and worldview. The SES resilience thinking allows me to capture this two-way relationship and contextualize these complex dynamics in the light of climate change.

Moreover, this approach represents a relevant analytical foundation to capture variability in SSF social-ecological systems across multiple spatial-temporal scales. In my study, I examine SSF management at different levels, from local management structures under the Beach Management Units (BMU) (Chapters 4, 5, 6) to national fisheries frameworks (Chapter 6). To address the complexities of climate change impacts on SSF, I also adopt a regional viewpoint by assessing its impacts at the WIO level (Chapter 5). Similarly, I consider the inherent temporal dynamics of SSF social-ecological systems by exploring reported climate induced change over three decades.

In addition, I mobilize the concept of adaptive capacity which lies at the core of the SES resilience approach (Boyd & Folke, 2012). In the context of climate change, investigating the conditions that favor SES adaptive capacity helps us reflect on how SSF communities can respond and adapt to climate change impacts (Adger et al., 2011). In line with other SES scholars, I conceptualize climate change as a systemic and relational driver of change that interacts with other anthropogenic and non-anthropogenic factors affecting SSF livelihoods (Pörtner et al., 2023).

3.2. Adaptive fisheries co-management

"We in the social sciences face as great a challenge in how to address the analysis of CPR [common- pool resources] *problems as do the communities of people who struggle with ways to avoid CPR problems in their day-to-day lives."* (Ostrom, 1990, p.216)

Originating from the collective action theory (*sensu* Ostrom, 1990), fisheries co-management is broadly understood as a formal governance arrangement whereby the authority to manage fisheries is shared between local users and the state (Berkes, 2009; Jentoft et al., 1989). In practice, fisheries co-management incorporates a broad spectrum of institutional configurations depending on various power-sharing levels. Co-management differs theoretically from CBFM approaches in which fisheries are entirely controlled by communities (Western & Wright, 1994). However, in reality, most community-based initiatives are embedded in national frameworks and legislation, which challenges this differentiation. In this PhD work, I use the generic term of fisheries co-management as a broad category that includes any specific community-based arrangements.

Since the 1990s, fisheries co-management has been largely promoted in fisheries management strategies and policies (Carlsson & Berkes, 2005; Gutiérrez et al., 2011; Rivera et al., 2016). Scholars have argued that, in contrast with a state-centered approach, fisheries co-management offers a more flexible and appropriate strategy to address the complex and diverse nature of fisheries (Jentoft, 1989; Khan & Neis, 2010). In addition, some researchers have claimed that this approach contributes significantly to increasing the legitimacy of management measures by involving local users in the decision-making, which often results in improving compliance, and thus management efficiency (Jentoft, 1989; Pinkerton, 2018).

The popularity of fisheries co-management resulted in an academic debate about its actual effectiveness for achieving sustainable fisheries (Rivera et al., 2021; Sen & Nielsen, 1996; Wilson et al., 2003). Fisheries co-management has been implemented in diverse fisheries settings with contrasting results, suggesting that its outcomes are highly context-specific (Berkes, 2009). A recent study by Smallhorn-West et al. (2022) assessed the contribution of SSF co-management to the 2030 Agenda for Sustainable Development. The study found limited evidence to support direct causal relationships between SSF co-management and most of the SDG because of the influence of local and external drivers. In particular, the authors suggest that SSF co-management has great potential for tackling gender inequalities in SSF communities (SDG N°5), but that the outcome depends on its implementation. In some instances, fisheries co-management can reinforce gender inequalities because of exclusionary approaches in decision-making (Rabbitt et al., 2022; Vunisea, 2008; Warren & Visser, 2016).

Through decades of practice, fisheries co-management has converged towards adaptive fisheries co-management (Fratsea et al., 2022). Folke et al. (2002) define this hybrid approach between adaptive and co-management as ''*a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of learning-by-doing*" (p. 20). Owing to its flexible nature, adaptive co-management contributes to building adaptive capacity. This approach is recognized for favoring collective sense-making, fostering dialogue between stakeholders, promoting equitable distribution of responsibilities, and supporting social learning (Berkes, 2009). By enhancing the adaptive capacity of SSF systems, adaptive co-management thus has an interesting potential for enabling SSF adaptation to climate change.

I use an adaptive fisheries co-management lens (*sensu* Berkes et al., 2007) to examine the linkages between CBFM and climate change adaptation through a gendered perspective. This lens allows us to delve into the specific challenges related to self-governance in the fisheries sector. Drawing on the concept of polycentricity, the scholarship on adaptive fisheries co-management has explored various factors influencing the capacity of SSF communities to jointly manage their fisheries with governments

and other stakeholders (Cinner & Huchery, 2014; Sen & Nielsen, 1996; Smallhorn-West et al., 2022). This analytical framework is useful to assess the potential of CBFM to enable climate change adaptation. My work addresses the lack of gender considerations in this literature by revisiting strengths and weaknesses associated with adaptive fisheries co-management through a gender and intersectional perspective.

There has been increasing interest in studying LEK in relation to adaptive fisheries co-management from different viewpoints (Armitage et al., 2007; Berkes & Armitage, 2010; Fache & Pauwels, 2020). Some scholars argue that adaptive fisheries co-management favors dialogue between local knowledge holders and governmental institutions through iterative processes, ultimately increasing the adaptive capacity of SSF communities (Berkes, 2007). However, other scholars have stressed that fisheries co-management in certain cases fails in recognizing and valuing LEK in its conceptualization and implementation (Fache & Pauwels, 2020; Smallhorn-West et al., 2022). In this work, I address this tension between LEK and adaptive fisheries co-management by exploring the role of LEK in co-managed SSF facing climate change through a gender lens, which may represent a relevant ground for further research on LEK in fisheries governance (Chapter 5).

An essential aspect of adaptive fisheries co-management thinking that underpins my research work lies in its sustainable ambition. Researchers in this field argue that the participation of local communities in the management of their fisheries is critical for ensuring fisheries' long-term sustainability, thus escaping the tragedy of the commons (Berkes, 2007). This perspective shaped my conceptualization of human-nature interactions within SSF social-ecological systems and responses to climate change impacts. I built on the concept of sustainability to understand the role of adaptive fisheries co-management in ensuring the viability of fisheries and enhancing the adaptive capacity of SSF social-ecological systems (Berkes, 2009; Evans et al., 2011; Rivera et al., 2016).

3.3. Feminist political ecology

> ""*Feminism" as used to capture women's engagement in demanding and creating an equitable society, is an English word that speaks different languages worldwide*."
> (Cornwall & International African Institute [IAI],2005, p.4)

Feminist political ecology (*sensu* Sultana, 2021) emerged in the 1990s to address the lack of attention in mainstream political ecology to alternative narratives, and especially those questioning gender power relationships. Feminist political ecology (henceforth FPE) scholars argue that gender is a key variable shaping – and being shaped by – the ways individuals experience and interact with their environment (Nightingale, 2006; Rocheleau & Nirmal, 2015). In particular, Rochelau et al. (1996) identify three main axes of gender differentiation in environmental and political processes related to environmental knowledge, rights and access to resources, and mobilization. They suggest that these gender variations are both a product of socio-cultural norms and a driver influencing the interactions between societies and their environment. Over the past three decades, FPE has greatly contributed to political ecology by providing more nuanced understandings of power issues in environmental settings.

However, there has been a growing call for expanding mainstream FPE scholarship to other dimensions of social difference. Some scholars, mostly from the Global South, have claimed that, at best, Western feminist views on gender (e.g., Butler, 1993 or Moore, 1994) are not appropriate to all cultural contexts. According to these scholars, these views, if not reinforcing the domination of Western ideologies, at least contribute to maintaining cultural colonization of minds (Cornwall & IAI, 2005; Hayman et al., 2015; Walsh, 2015). As suggested by Sultana (2021), engaging with alternative visions of feminism may generate a more comprehensive view of social dynamics, "*from margins to center*" (p.156). This call for decolonizing FPE has been particularly strong in Africa, a region where gender research has long been embedded in Eurocentric, imperialist, and colonial ideologies (Appendix 1 – Box 1), leading to a white feminist fatigue syndrome (Bhandar & Silva, 2013) among female African authors (Tamale, 2020).

Alternative framings of gender and feminism by African female authors offer powerful analytical lenses to better capture the intricacies of power relationships based on gender and other social categories in the African context. African womanism represents one of these major conceptual frameworks (Kolawole, 1997; Manyonganise, 2015; Ogunyemi, 1985). The term "womanism" was first coined by Alice Walker (1983) in the context of Black feminist struggles in the United States, and later reclaimed by African female figures. African womanism provides a relevant framework to understand African women's lived experiences, their identities, worldviews, and agency. At the core of this concept is the importance of African cultures in framing gender relationships. African womanism questions gender through the lens of cultural practices and calls for fostering those that support gender equity, understood as equal dialogue between individuals of diverse gender identities. Further, womanism is meant to be an umbrella concept, encompassing various social power structures such as gender and skin color, but also class or seniority.

To address these limitations, over time FPE analyses have shifted from their initial focus on gender relationships to integrate a greater diversity of gender identities and adopt an intersectional framework recognizing the intersection of gender with other axes of social differentiation (Mollett & Faria, 2013; Sultana, 2021). By expanding research on issues related to race, age or disability, and the ways they compound together, recent FPE scholarship provides a more comprehensive picture of complexities linked to power dynamics in the context of environmental issues. However, intersectional FPE research on the African continent remains scarce, especially in the context of climate change (Rice et al., 2024; Vercillo et al., 2022).

Feminist political ecology is a structural lens of my PhD work used to analyze gender dynamics related to CBFM and climate change impacts on SSF communities. Owing to my positionality, I acknowledge that I built on Western feminist perspectives but with a particular interest in complementary views on gender and other markers of social differentiation and recognizing the power of African womanism to contextualize gender issues in East Africa. I take accountability for statements expressed in this manuscript that may not reflect emic understandings of social power hierarchies in the study area, recognizing that this work does not claim to provide a unique and unequivocal narrative.

As pointed out by feminist scholars, FPE analyses seek to shed light on invisible and overlooked dynamics in human-nature relationships (Bee et al., 2019; Carey et al., 2016). This approach provides an enriched and in-depth picture of the political dimension of SES by making visible gender power hierarchies. I build on this illuminating power of the FPE lens to investigate the role of gender in co-managed SSF communities in the context of climate change. My work questions male dominance in the SSF sector by highlighting women's contribution within and outside the SSF value chain, addressing fishing practices (Chapter 4), reports of climate change (Chapter 5), and participation in SSF management and governance (Chapter 6). Furthermore, this work falls within FPE scholarship by exploring a counternarrative to the assumption of homogenous communities within SSF social-ecological systems (Rocheleau, 2008). In particular, I unravel intersectional power asymmetries in SSF communities, thus demonstrating the heterogenous – and potentially conflictual – nature of local communities (Chapter 6).

This research embraces knowledge pluralism and hopefully contributes to challenging Western epistemic hegemony. FPE scholars have long stressed power asymmetries involved in knowledge production, arguing that environmental research is situated and shaped by ideologies (Haraway, 1988; Rocheleau, 1996; Todd, 2015). To redress this imbalance, they support cooperative research practices that include diverse forms of knowledge and value self-reflexivity (Sultana, 2021). Building on this critical stance, I attempt to bridge scientific and local knowledge systems through a gendered perspective to address the complexities of climate change impacts on SSF communities in the WIO region (Chapter 5). However, I acknowledge that the research design and implementation was driven by my research team and was not co-built with local SSF communities owing to constraints of my PhD timeframe and requirements.

In addition, I engage with FPE scholarship through the mobilization of intersectional and emotion analyses. Within the FPE community, there has been growing interest in expanding gender analyses to other axes of social differentiation to better understand the nested relationships between different power structures (Mollett & Faria, 2013; Sultana, 2021). In the same vein, FPE authors give particular attention to emotions and affects in social-environmental processes suggesting that this subjective perspective provides a more comprehensive view of research subjects, as opposed to conventional positivist approaches (Gonzàlez-Hidalgo & Zografos, 2020). In my work, I combine intersectional and emotion studies by analyzing lived experiences related to CBFM places, thus highlighting the complex dialectic between intersecting social positions, subjective emotions, and participation in SSF management (Chapter 6).

Overall, this PhD work relates adaptation in SSF social-ecological systems to issues related to gender equity and inclusive participation, positing that gender-inclusive management strategies may enhance SES adaptive capacity in the face of climate change.

4. Research strategies and methodological approach

4.1. Context of the thesis

This doctoral work is part of a broader research project titled "*Local Indicators of Climate Change Impacts: The Contribution of Local Knowledge to Climate Change Research*" (LICCI) led by Dr. Victoria Reyes-García. This project received a five-year grant from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program as an ERC Consolidator Grant (No 771056 LICCI). The primary objective of the LICCI project is to advance our understanding of the complexities of climate change impacts at the local level by exploring and valuing LEK. The LICCI project results from a collaborative work through a research network across 40 different study sites, including scholars from an Indigenous background and in a way that respects Indigenous data sovereignty guidelines.

As part of the LICCI core team, I engaged in different project-related tasks during my PhD program such as LICCI data collection in coastal Kenya using the LICCI protocol (Reyes-García et al., 2023), data entry and cleaning, and contribution to writing articles based on LICCI data with other team members. Throughout my doctoral work, I was supported by the Kenya Marine and Fisheries Research Institute (KMFRI) for selecting my study site, designing my study, and organizing logistics in the field. In addition, during my time in Kenya I collaborated closely with researchers from the French Institute For Research in Africa (IFRA), the British Institute in Eastern Africa (BIEA), the French National Research Institute for Sustainable Development (IRD), Kenyatta University and the United States International University, Africa who provided valuable inputs to my work.

To collect data in my study site, I obtained the ethics approval of the Ethics Committee of the Universitat Autònoma de Barcelona (CEEAH CA01), an authorization from the Kenyan National Commission for Science, Technology and Innovation (License No: NACOSTI/P/22/15149), and the consent of local authorities from each studied village. Additionally, I compiled Free Prior and Informed Consent from each village and individual who participated in my PhD study. People whose photos I use for research or dissemination purpose, also provided oral agreements for the use of their images for those specific purposes.

My doctoral work stems from 14 months of fieldwork in Kenya, which were divided into two stays between September 2021 and January 2024. The first fieldwork period (September 2021- April 2022)

was conducted with three Kenyan research collaborators who, at that time, were interns at KMFRI in Mombasa. During this first period, I aimed to get introduced to local communities and familiarized with the study area through an ethnographic approach and to collect gender-disaggregated data on fisheries activities and production (Chapter 4), and on reports of climate change impacts by local communities using the LICCI protocol (Reyes-García et al., 2023) (Chapter 5). To do so, I used diverse data collection methods, including participant observation, photography, semi-structured interviews (SSI), focus group discussions (FGD), and an individual face-to-face survey. During this first period, I faced some challenges related to a certain reticence on the part of some villagers and a tendency from participants to expect money from my research team. Continuous dialogue and time spent living in the studied communities helped clarify my intentions and the purpose of my research and build trust with local people. At the end of this first stage, I presented preliminary results from my study to each village involved in the research project. This feedback activity took the form of 1) a formal workshop during which I presented to BMU members the main results and recommendations for fisheries management and 2) an itinerant photographic exhibition on the gendered dimensions of co-managed SSF, which moved from one studied village to another and was hosted in community places frequented by individual of diverse gender identities.

The second fieldwork period (July 2023- January 2024) was carried out with the support of my main Kenyan research collaborator, Joey Ngunu Wandiga. Since he also participated in the first period of fieldwork, he was familiar with the LICCI project and my PhD work. The objective of this second fieldwork period was to complete my initial dataset by collecting information on nutritional (Chapter 4) and governance (Chapter 6) aspects of the studied SSF communities using a gender lens. More specifically, I investigated fisherwomen's contribution to fish and seafood provision to households and the gendered dimensions of participation in local BMU using participant observation, photography, SSI, relief maps and pebble games. I did not face any major challenge this time since local people trusted me and welcomed this research enlargement. At the end of this fieldwork, I organized a discussion panel on my research findings in collaboration with KMFRI, the Alliance française in Mombasa and other stakeholders engaged in SSF co-management in the study site. On this occasion, I invited one fisherwomen representative to express the views of her community on my research work. This dissemination event was combined with a photographic exhibition hosted in the Alliance française of Mombasa for one month. In addition, during this period, I built bridges with other academic institutions working in Kenya such as IFRA and BIEA to help refine my data analysis and disseminate my research results.

4.2. Interdisciplinary framework

In this doctoral work, I adopt an interdisciplinary lens, crossing social and natural sciences, to explore CBFM in a climate change context through a gendered approach. More specifically, my PhD is situated at the intersection of two main research lines at ICTA-UAB: ethnoecology and marine sciences.

As a practice, interdisciplinarity has been widely studied from different perspectives (Barthel & Seidl, 2017; Jollivet, 1992). Scholars have notably explored the diversity of interdisciplinary methods (Li Vigni, 2021), implications of such an approach for academic disciplines (Vidal, 2011), and its limits (MacMynowsky, 2007; Schipper et al., 2021). Feedback from researchers who have engaged in interdisciplinary work contribute to highlighting its human dimensions in terms of interculturality (Lemay & Darbellay, 2014) and value exchanges (Lemay & Giugnatico, 2017). As a flexible and multidimensional approach, interdisciplinarity has potential for conceptualizing and addressing complex issues related to SES (Haider et al., 2018). For this reason, there has been growing interest over the past decades in the sustainability science literature in exploring solutions to human-environment challenges through interdisciplinary lenses (Brandt et al., 2013; Pereira et al., 2015; Ruppert-Winkel et al., 2015). On the climate crisis in particular, the scientific community and the IPCC have advocated for fostering interdisciplinary research, arguing that the interactions between different

disciplines – as well as across diverse knowledge forms – would advance our understanding of climate change intricacies (IPCC, 2023; Mooney et al., 2013; Olsen et al., 2013).

Drawing on a strong interdisciplinary background with a dual master's degree in tropical ecology and political sciences, I recognize myself in the emerging generation of early-career researchers who start working with an interdisciplinary profile, in contrast to senior scholars who tend to engage in interdisciplinary work in later stages of their career (Haider et al., 2018). In particular, I acutely relate to the notion of an "undisciplinary journey" experienced by most interdisciplinary early-career scholars, which refers simultaneously to i) a space characterized by blurred academic boundaries, ii) an iterative and self-reflexive process, and iii) a scientific orientation towards research applied to sustainable development challenges (Haider et al., 2018).

My doctoral work reflects this interdisciplinary dimension through its conceptual basis, methodological approaches, and institutional framework. On the theoretical front, this PhD dissertation contributes to bridging the gap between scholarship on climate change stemming from natural sciences (i.e., climatology, oceanography, physics, and biology) with literature that addresses climate change through social sciences perspectives, using theoretical frameworks such as SES resilience, collective action theory, or FPE. At the methodological level, I combined quantitative statistical methods to analyze fisheries and climate data with qualitative methods from social sciences, including participant observation, SSI, FGD, and intersectional tools such as relief maps. The complementarity of these methodological tools resulted in unique and comprehensive insights into my study topic. Finally, my academic work was enriched by my participation in two research groups at ICTA-UAB, the Laboratory for the Analysis of Social-Ecological Systems in a Globalized world (LASEG: http://www.laseg.cat/en) and the Marine and Environmental Biogeosciences Research Group (MERS: https://mers.uab.cat/). This academic experience facilitated my integration in an interdisciplinary and international research environment that was beneficial to the development of my research work.

Nonetheless, this interdisciplinary experience brought substantial challenges that I needed to consider and address throughout my PhD program. In their study, Haider et al. (2018) identify three main issues related to early interdisciplinary research. First, developing a specific scientific identity might be difficult for students and early-career scholars who address a wide range of research topics and perspectives. In my case, my geographical study area and research topic helped situate my work in the academic subfield of gender and fisheries related to global changes in tropical SES. Second, the lack of methodological groundness – or challenges related to the development of robust and specific methods – is a common issue faced by early interdisciplinary researchers. Against this background, in my PhD work, I developed specific methodological skills on statistical and qualitative methods. In addition, I gained interpersonal skills involving flexibility, the capacity to work in various cultural contexts, and research synthesis skills, which may apply across various disciplines and research topics. Finally, epistemological agility is required to be able to navigate between different disciplinary languages and epistemological communities. Through my three co-supervisors, each one from a different disciplinary background, I learned how to create a dialogue between different scientific approaches and respond to their specific academic requirements. Overall, I gained a holistic view on my research topic and an openness to other research fields.

Beyond these challenges, interdisciplinarity is a continuous process that has built and will continue to build my scientific identity and made me think more deeply about other lines of enquiry and research practices. An interdisciplinary approach has helped me take a broader and more critical look at issues at the intersection of climate change, gender, and fisheries, and has contributed to the originality of my work. My capacity to navigate through this "undisciplinary" process (Haider et al., 2018) – thanks to the support of my co-supervisors and research groups – is an additional outcome of my PhD work that deserves as much consideration as my actual research findings.

4.3. Methodological approaches

In this study I combine three main methodological approaches: i) ethnoecology methods, ii) the multiple evidence base (MEB) approach, and iii) feminist research methods. These three methodological perspectives correspond to the practical application of my analytical lenses. By bringing them together, I broadened the range of my methodological tools and deepened my conceptual thinking, while gaining a better understanding of the complexities of my research topic.

First, I applied an ethnoecological approach to study the interconnections between SSF communities and their coastal environment in the context of climate change. This broad and multidisciplinary field focuses on the complex relationships between human societies and their environment, with a particular interest in LEK (Anderson, 2011; D'Ambrosio, 2014). Since my PhD work revolves around marine SSF, I consider it falls under marine ethnoecology, a subfield of ethnoecology that seeks to understand the multidimensional relationships between peoples and their marine environment and consider the implications of such relations for management and governance (Ban et al., 2013; Morales et al., 2017; Narchi et al., 2014). Following this approach, I gathered both biological and anthropological information to illuminate the multifaceted nature of the relationships between Kenyan coastal communities and their fisheries. With the support of KMFRI, I was able to access local catch assessment data for 2005-2019, which provided fine information on commonly harvested fisheries taxa. In addition, through my ethnographic fieldwork I gained an in-depth understanding of the local SSF livelihoods and the gender-differentiated ways of fishing. These data were completed with first-hand information on the specific terminologies used by local people to refer to marine species. I checked the matching between local and scientific taxa names using fisheries identification materials provided by research collaborators (Anam & Mostarda, 2012).

Then, I drew on parallelist methodological approaches to build a dialogue between scientific and local knowledge systems on climate change impacts. Parallelist approaches – as opposed to integrationist ones – seek to achieve collaboration between knowledge systems (Snively & Williams, 2016). Collaboration can be illustrated by the Canadian aboriginal Mi'kmaw Nation "Two-Eyed Seeing" principle. This concept metaphorically highlights how the use of both Indigenous and scientific knowledge, like two eyes, may enrich our view of reality (Bartlett et al., 2012). Collaboration relies on the inclusion of diverse knowledge systems – or plural knowledge systems – recognizing their specificities in terms of worldviews, languages, practices, cosmologies, and ontologies. Each of these knowledge systems contributes to enrich the diverse ways of knowing (Orlove et al., 2023). Specifically, in my research methodology, I applied the MEB approach developed by Tengö et al. (2014). The MEB approach defends the equality and complementarity between knowledge systems and the value of plurality. The MEB acts as starting point for knowledge co-production based on principles of equality and transparency, while accepting the potential divergences between knowledge systems. In my doctoral work, the MEB approach provided a relevant analytical framework to connect perspectives from co-managed SSF communities on climate change impacts with scientific evidence reported in the WIO region as presented in chapter 5.

Finally, I built on feminist ethnographical methods to illuminate the gendered dimensions of my research topic. While there is not one single "feminist" method, approaches used by feminist ethnographers are usually characterized by four common features that resonate with my PhD work (Buch & Staller, 2007). First, by investigating the important – yet overlooked – contribution of women to SSF social-ecological systems, my methodological approach falls within feminist methods that seek to reveal (and redress) androcentric bias and explore alternative narratives in research as opposed to what has been called "malestream" research (Harding, 1987a). Second, I made sure that my methodological design and practical approach in the field were socially relevant for local communities, inclusive of emotional dimensions, and reflective of the valuing of other forms of knowledge than scientific knowledge. These perspectives converge with feminist ethnographic work that shifts away from positivism and critically questions knowledge production processes (Harding, 1987b).

Furthermore, my work aligns with feminist ethical considerations through a continuous self-reflexive attitude, and specific care given to my relationships with my collaborators and local people. Finally, feminist ethnographers have sought to give voices to a great diversity of oppressed experiences. In this study, I attempted to integrate an intersectional framework using relief maps to capture power dynamics in SSF settings, thus joining other feminist scholars in their quest to "ask the other question" by exploring intersecting forms of subordination (Davis, 2008, p. 70; Rodó-Zárate, 2014).

4.4. Overview of data collection methods

Building on these interdisciplinary and complementary methodologies, I used a mixed-method approach for data collection and analysis to address the gendered aspects of CBFM in climate change adaptation. I combined both qualitative and quantitative research methods and used different types of data sources, including primary and secondary data. The detailed descriptions of the research methods and sampling strategies used in this study are presented in the chapters of this thesis, whereas in this section I provide an overview of the data collected, my ethnographic experience, language-related issues, and research collaboration in the field.

Secondary data used in this study include environmental data on meteorological variables and ocean surface temperature (Chapter 5) and gender-disaggregated data on CBFM governance (Chapter 6). Furthermore, I used peer-reviewed publications to synthetize the state of knowledge on women's participation in SSF management (Chapter 3) and on climate change impacts on coastal SES in the WIO (Chapter 5). Primary data analyzed in the empirical chapters of this study comprise data derived from participant observation, photography, SSI, FGD, individual survey, relief maps, and pebble games (Table 1.1).

Table 1.1: Overview of the main data collection methods and primary data gathered with corresponding empirical chapter.

Period	Method	Type	Sample size	Main data collected	Chapter
Both periods	Participant observation	Qualitative	/	Gender roles, gendered fishing practices, and intersectional power dynamics in CBFM	4,6
	Photography	Qualitative	/	Gender roles and gendered fishing practices	4
First fieldwork period	Semi-structured interviews	Qualitative	n=11 individuals (six women and five men)	Gender identification, differences, and gaps	4
	Semi-structured interviews	Qualitative	n=28 individuals (14 women and 14 men)	Gender-disaggregated data on marine knowledge, fishing practices, and reports of changes in the coastal environment	4,5
	Semi-structured interviews	Qualitative	n=18 individuals (nine women and nine men)	Women's and men's participation in CBFM	6
	Focus group discussion	Qualitative	N=8 non-mixed FGD (4-9 individuals in each FGD)	Collective agreement on reports of changes in the coastal environment, and on women's and men's participation in CBFM	5,6
	Individual face-to-face survey	Quantitative	n=141 individuals (62 women and 79 men)	Gender-disaggregated data on fishing temporalities, locomotion, gears and techniques, target taxa and fishing catch, effort, and income	4
	Individual face-to-face survey	Quantitative	n=203 individuals (103 women and 100 men)	Gender-disaggregated data on reports of changes in the coastal environment	5
Second fieldwork period	Relief maps	Qualitative	n= 32 individuals (16 women and 16 men)	Intersectional dimensions of CBFM places	6
	Pebble games	Quantitative	n=35 households	Local diet composition; Source of fish/seafood at home	4

During my fieldwork, I lived with local families in studied villages or, alternatively, in a guesthouse. Through this proximity with local people, I gained in-depth and grounded understanding of their livelihoods, occupations, social organizations, and diets. I participated in daily activities such as fishing trips, domestic work, meals, time spent with kids, cultural celebrations, or fisheries-related meetings. Since my hosting families were strongly connected with local fisheries committees, I had easy access to information about community events, especially on fisheries matters. Being associated with specific hosts was an advantage since they introduced me to their friends and relatives, which facilitated my research work. However, I am aware that this connection may also have brought some methodological biases when engaging with other villagers who perceived me through their relationship with my hosts. In addition, living with local families helped me improve my Swahili and become more confident communicating with people.

Primary data were mostly collected in Swahili. Although English and Swahili are the two official languages in Kenya, owing to the specific history of the coastal region, coastal communities in Kenya are more conversant with Swahili. Through my fieldwork, I gained a basic level of Swahili that was sufficient for understanding simple topics of daily life. However, I needed the support of an interpreter to apply my research protocol and capture people's responses without any ambiguity. In the field, I worked mostly with Joey Ngunu Wandiga, but I decided to include two additional collaborators for

conducting the survey. My three collaborators were Kenyans from different cultural and socioeconomic backgrounds to coastal people. They were fluent in Swahili but needed to adjust to local languages such as Digo or Shirazi, which are related but slightly different. They all had training in fisheries sciences and held a bachelor's degree. They were very familiar with fisheries issues and specific vocabulary, including the local names of marine taxa. I consider our working relationship to have been mutually enriching since I provided them with resources on qualitative and quantitative research methods. In return, they helped me translate my research questions from English to Swahili, conduct interviews and surveys, and provided me with guidance on local cultural norms and expectations. Joey Ngunu Wandiga is co-author of all the articles I wrote based on the data we collected.

4.5. Research positionality

> "*It is critical to pay attention to positionality, reflexivity, the production of knowledge and the power relations that are inherent in research processes in order to undertake ethical research, especially in international field research contexts.*" Sultana (2015, p. 382).

No research work is value-free. Research is inevitably loaded with subjective views, for which reason researchers must reflect on, identify, and acknowledge this unconscious bias, also called positionality (Holmes, 2020). In this section, I disclose my own research positionality regarding this PhD project. Specifically, I seek to address the three following questions: Where do I come from? How did this background influence my research topic and process? And how did I attempt to address some of the biases linked to my positionality?

This PhD work is influenced by the multidimensional lenses that define my individuality as a person, and as a PhD student. I identify myself as a young woman, cis-gender and heterosexual, as a white person from France – a European and highly developed country characterized by a heavy colonial legacy in Africa –, but with Arab roots, and as a PhD student doing research in East Africa. I consider myself as atheist, left-oriented, politically engaged, with strong feminist values. Regarding my ontological and epistemological standpoints, I acknowledge that I received a privileged education driven by positivist and naturalist ontologies.

It is through this framework that I engaged with my PhD research topic. In particular, being a woman, and having an interdisciplinary background and previous fieldwork experience in Africa may explain my interest in gender-related topics and critical perspectives on climate knowledge. Besides study delimitation, my positionality influenced how I addressed my research questions. I suggest that my feminist views and interest in the social dimensions of climate adaptation – rather than technological ones – may have oriented my analysis and interpretations to a certain extent. Similarly, the fact that I do not belong to a faith community may represent a bias in the way I framed climate change response in Muslim SSF communities.

Another area of my work shaped by my positionality relates to data collection. Owing to my plural and intersecting identities, local people perceived me in certain ways, which may have affected their engagement in my study. One dimension to consider is my "whiteness", which made local people see me as a foreigner. They used to call me "*mzungu*", which means "white person" in Swahili. This position gave me particular care and attention from the people I interacted with, which did not apply to my Kenyan collaborators. I do not remember having faced any resentment from local people because of my whiteness. However, this position may have increased people's shyness, or tendency to give biased responses to satisfy my perceived expectations.

These perceived expectations were strengthened by the fact that I am a young single woman. I felt that some men intended to seduce me, hoping to get a white wife. Despite the challenge of managing these marital expectations, being a woman helped me build stronger relationships with other women. As a PhD student working on gender issues, this was a clear advantage for collecting information from

women. Interestingly, I did not experience common challenges faced by other women in the patriarchal society which they navigated. Indeed, although I was a woman, I was first a "*mzungu*" and for this reason I had a very particular status. Unlike other women, I could chat and debate with men without any trouble. Likewise, each time I was eating with my host family, I was served at the same time as the patriarch, whereas the wife – who cooked the meal – used to eat the left overs after us with the children. It was very challenging for me to deal with this privileged position since it strongly conflicted with my personal beliefs and values as discussed above.

Finally, my Arab heritage strongly influenced my fieldwork experience. Although I was not speaking Arabic and did not go for prayers, people were always curious about my name and related it to a Muslim origin. When I confirmed this, they often changed their behavior. They became more friendly and behaved as if I was part of their community. Despite being a "*mzungu*", my Arab roots and Muslim background granted me a sort of special pass to integrate into local communities. This position clearly challenged the fine border between the insider/outsider position divide in my fieldwork experience.

Beyond my own positionality, I must also disclose that of Joey Ngunu Wandiga since, as my interpreter and work partner, he mediated the interactions I had with local people and the way I conducted my research and interpreted my data. An important aspect is his gender. Indeed, his position as a man balanced our duo. Working together, we were able to interact with both women and men and collect gender-disaggregated data. Thanks to his presence, I was accepted in male places such as fishing boats. Reciprocally, women shared stories with me, without feeling embarrassed about having him around. The fact that he was married with a child made it clear to local villagers that our relationship was purely professional.

Further, I wish to locate the broader LICCI project in which my PhD study is embedded, which influenced my research experience. This project is based on the recognition of diverse forms of knowledge related to climate change. I acknowledge, however, that none of the project 's core team members are Indigenous scholars. All of them were trained – at least partly – in Western scientific institutions, which represents a privileged positionality. This limitation shaped the design of the protocol and its implementation (Reyes-García et al., 2023). Despite these ontological and epistemological caveats, the extent of the current climate crisis requires further inclusive climate research building on knowledge pluralism, even if such attempts translate into pragmatic research strategies as for the LICCI project (Orlove et al., 2023).

To address biases linked to my composite positionality, I consciously adopted three main strategies. First, I systematically clarified the purpose of my research before starting to work in any village, and at the beginning of all interviews and surveys. This clarification helped reduce misleading expectations from local communities. Second, I learned the Swahili language to better communicate with local people. The simple effort of learning completely changed my relationship with local people. When realizing that I could understand Swahili a little, they became more friendly and more open to answering my questions. Finally, the duration of my fieldwork was a key factor in better understanding emic perspectives from the studied communities.

While it would be naive to imagine completely bridging the gap between my own positionality and those of the local communities I work with, I believe that my reflexivity throughout my PhD program and the mitigation steps I have taken may have limited some of the bias linked to my inherent subjectivity. In this PhD thesis, I provide accountability for my ontological and epistemic standpoints, and offer a rigorous, emotionally sensitive, action-oriented, and ethical piece of work.

4.6. Limitations and caveats

"*We do not know: we can only guess*" (Popper, 2002, p. 278).

Karl Popper's words, extracted from his influential book about the philosophy of science "*Logic of Scientific Discovery*", rightly remind us that no research work can pretend to provide the truth. Indeed, any study carries explicit or implicit methodological bias. These shortfalls pose a challenge to a study robustness and may impact its outcomes and reproducibility (Ross & Zaidi, 2019). This is why any research must clearly state its limitations in a spirit of scientific rigor and integrity (Resnik & Shamoo, 2017). Acknowledging methodological shortfalls is necessary to advance academic work by suggesting further research improvements, and for ethical aspects (Bunniss & Kelly, 2010; Eva & Lingard, 2008; Greener, 2018). According to Price & Murnan (2004), there are two main limitation categories affecting either the internal or external validity of a study.

I acknowledge that I intentionally narrowed my research scope to people involved in SSF activities and to a specific geographical site, the South Coast of Kenya. Therefore, the insights derived from my work can only apply to this well-defined research context. Further, in this section, I provide an overview of the most saliant limitations of my PhD study, which may not have been consciously chosen. Following the approach recommended by Ross & Zaidi (2019), I describe the sources of my limitations and potential implications for the study validity. This transparent assessment is supported by practical mitigation steps I took to reduce these limitations (Table 1.2). A more detailed presentation of these limitations is discussed in each of the core chapter of this PhD dissertation.

Major limitations in my study stem from the ethnographic approach I applied in the field, which posed challenges in terms of timeframe, positionality, and language. First, owing to the limited amount of time I spent in my study area, I may not have fully captured the complexities of my research topic and local livelihoods. For instance, climatic patterns in my study area experience a high natural decadal and intra-annual variability, which makes it challenging for an outsider to identify anthropogenic climate signals over a short time. Besides time limitations, my positionality mediated my relationships with local people and the data I gathered as discussed above. Lastly, the use of Swahili as the main research language represented an obstacle since most respondents were more comfortable in their local languages which were related to Swahili but distinct. This language barrier may have led to some nuances being missed in our interactions with local people.

Another important limitation of my work revolves around gender conceptualization in my study design. There is an emerging literature that critically examines persisting major gender bias in research methodology, such as the lack of gender-disaggregated variables or unintended gender bias in survey design and implementation (House et al., 2023; Vercillo et al., 2022; Weber et al., 2021). While I made efforts to avoid most of these gender pitfalls, I acknowledge that I based my work on a binary view of gender, limiting my analysis to two gender identities: women and men. I am aware that this limited gender conceptualization may lead to overlooking gender minorities or misclassifying other gender identities. I take accountability for this decision, which was mostly driven by practical considerations. In my study site, dominated by strong religious norms, non-binary views of gender were not culturally appropriate. Such alternative views would have led to some challenges and potentially compromised my trusting relationship with local people. Recognizing that gender categorizations are dynamic and meant to be improved (Puckett et al., 2020), my practical approach appeared the most adequate at the time of my fieldwork and given my specific research context. Furthermore, despite strongly supporting the relevance of intersectionality as a powerful analytical lens to study SSF, I mostly focused on gender in this PhD work. Except for chapter 6, I did not include other social identity markers such as ethnicity or marital situation in my study design. This shortfall can be explained by the lack of resources and time in the field to include a systematized intersectional framework. These two limitations may have affected the internal validity of my study. They may have reduced the granularity of the data collected and

resulted in limited understandings of the multifaceted and complex nature of power relationships in SSF. In addition, since gender dynamics are context-dependent, my results may not be generalized to other SSF communities, thus potentially undermining the external validity of the study.

Lastly, the lack of secondary data on gender and SSF management, and environmental parameters constitutes an important limitation of my study. This is notably illustrated in the results of my systematic review on women's participation in SSF management (Chapter 3), where I found that 40% of the examined peer-reviewed publications did not provide gender-disaggregated information on the subject, echoing other assessments in SSF (FAO et al., 2023) and in different sectors such as climate mitigation (Vercillo et al., 2022) or global health (Weber et al., 2021). This evidence highlights the extent to which gender-related topics represent the forgotten dimension of SSF research, which already face specific data collection challenges in comparison with industrial fisheries (FAO et al., 2023). Besides limited access to gender literature on SSF management, my work was also challenged by the lack of long-term and integrated *in situ* data on climatic variables and coastal and marine ecosystems for my study area. In particular, data on local SSF production were not usable. I could access catch data for certain time periods but there were many gaps in time and data coding was not uniform. These limitations affected my data collection and analysis since they limited the scope of the data I gathered and the range of possible analysis, thus potentially affecting the external validity of my study.

Table 1.2: Summary of the main limitations of the doctoral study.

Limitation		Source type	Implication	Reasons for limitations	Mitigation step
Ethnographic experience	Time limitation	Data collection	Internal and external validity	Personal constraints linked to my social positions and PhD timeframe	Conducting a second fieldwork trip during another period of the year to capture seasonal variability in gendered fishing activities
	Student's positionality		Internal and external validity		- Conducting a second fieldwork trip to increase trust with local communities - Clarifying the research purpose before starting any interview/survey to reduce unfounded expectations - Rephrasing questions in interviews/survey to cross-check information
	Language barrier		Internal validity		- Learning Swahili basics - Relying on the same main research collaborator who became familiar with the local languages throughout the whole fieldwork period
Gender conceptualization		Study design	Internal and external validity	Non-binary views of gender were not culturally appropriate; Limited capacity and time constraints in the field	- Conducting semi-structured interviews on gender identities to gain a more nuanced understanding of emic views on gender roles and norms - Using relief maps methods to analyze gender power dynamics in CBFM
Lack of secondary data		Data collection and analysis	External validity	Beyond the capacity of a single PhD student	- Collecting gender-disaggregated data at my study-site level - Training three Kenyan students in qualitative and quantitative research methods

5. Specific objectives and structure of the thesis

The main goal of this thesis is to advance the understanding of the adaptation of SSF communities to climate change impacts through CBFM approaches using a gendered perspective. This main research aim unfolds into four specific objectives developed in four core chapters:

1. To assess women's participation in SSF management and related socio-cultural, environmental, and economic impacts globally (Chapter 3);
2. To investigate the contributions of fisherwomen and fishermen to the SSF sector in co-managed SSF communities with consideration for local food security (Chapter 4);
3. To explore LEK on climate change impacts and its relation to scientific knowledge in co-managed SSF communities through a gendered approach (Chapter 5);
4. To examine gender-inclusiveness in CBFM with intersectional considerations (Chapter 6).

This work is presented in seven chapters and divided into four main parts. The first part consists of an overall introduction of the study subject (Chapter 1) and a presentation of the general characteristics of the Kenyan coast selected as the study area for this research (Chapter 2). The second part of the dissertation provides a comprehensive state-of-the-art of women's participation in SSF management in the format of a systematic literature review (Chapter 3). The third part includes three empirical chapters grounded in coastal Kenya and addressing CBFM through a gendered perspective (Chapter 4, 5 and 6). The final part corresponds to a concluding chapter providing the main conclusions of the doctoral research, key recommendations for future research work, and policy recommendations (Chapter 7). Chapters in the second and third part of this work have been published or submitted to peer-reviewed journals.

While the methodological sections of the three empirical chapters of this thesis may present some overlap with the general introduction, I decided to retain their initial format of submission for the purpose of internal consistency. Throughout the manuscript, I included the local language terminologies for relevant parts describing local livelihoods and fishing activities by indicating the Swahili translation in italic and in bracket. As of May 2024, the systematic review (Chapter 3) has been published in *Reviews in Fish Biology and Fisheries*. In addition, the three empirical chapters have been accepted pending major and minor revisions in peer-reviewed journals (Chapter 4, *Ocean & Coastal Management*; Chapter 5, *Environmental Science & Policy*; Chapter 6, *Maritime Studies*). Each of these articles has been written with co-authors but I assumed the lead author role.

Chapter 1 outlines the main overall topic and the selection of the WIO region, within which I focus on the Kenyan coast as a study area. Specifically, it gives an overview of the research topic, presenting the motivation and primary aim of the research, synthesizing the state of knowledge on climate change impacts on coastal and marine SES, stemming from both scientific and local knowledge and identifying regional research gaps. Further, this chapter describes the three main analytical lenses at the crossroads of SES resilience thinking, adaptive fisheries co-management, and FPE scholarship, as well as the methodology used to achieve the objectives of this study.

Chapter 2 introduces the study area by summarizing the main biocultural characteristics of the Kenyan coast and describing the SSF sector as well as gender dynamics in the area to contextualize the empirical chapters in the third part of the dissertation. In addition, this chapter presents the location of the study site at the county-level and situates the studied fishing villages in their specific social-environmental context.

Chapter 3 synthesizes the state of knowledge on women's participation in SSF management and related impacts at the global level. To do so, I performed a systematic review of peer-reviewed literature to examine women's participation in SSF management and associated socio-cultural, environmental, and economic impacts. I discuss the need to tackle the paucity of gender-disaggregated data in fisheries

research, especially in Asia and Africa, and argue that women's meaningful participation in SSF management is necessary for improving management strategies while achieving socio-economic outcomes. This chapter corresponds to the article "A synthesis of women's participation in small-scale fisheries management: Why women's voices matter", published in *Reviews in Fish Biology and Fisheries* in October 2023.

Chapter 4 documents and quantifies women's and men's participation in small-scale fishing with consideration for fisheries management and food security through a case study in coastal Kenya. Specifically, I used a mixed and interdisciplinary methodology combining qualitative and quantitative approaches to explore the influence of gender on fishing practices, catch, effort and income, and the specific contribution of fisherwomen to local diets in co-managed small-scale fishing communities in the South Coast of Kenya. The chapter opens the discussion to the importance of women's contribution to subsistence fishing in the context of climate change, especially in nearshore fisheries that are often female-dominated. Further, I highlight the necessity of fostering research on gleaning activities to improve baseline data on coastal ecosystems and improve fisheries management strategies. This chapter corresponds to the article "The gendered dimensions of small-scale fishing activities: A case study from coastal Kenya", accepted pending minor revisions in *Ocean & Coastal Management* in March 2024.

Chapter 5 examines LEK on climate change impacts on coastal SES and its relation to scientific knowledge through a gender lens in co-managed SSF communities in coastal Kenya. I used a mixed and transdisciplinary methodology combining qualitative and quantitative approaches to bring together scientific evidence and local gendered knowledge on climate change impacts in the WIO and assess potential overlaps and complementarities. In this chapter, I discuss the need for adopting a gender lens in research on climate change to thoroughly capture the social-ecological scope of climate change impacts and to drive effective gender-inclusive climate policies. This chapter corresponds to the article "Weaving scientific and local knowledge on climate change impacts in coastal Kenya, Western Indian Ocean", accepted pending major revisions in *Environmental Science & Policy* in March 2024.

Chapter 6 assesses gender-inclusiveness in CBFM through intersectional perspectives and focusing on SSF communities in coastal Kenya. I applied qualitative methods to examine women's and men's participation levels in CBFM, identify the main barriers to women's participation in such management approaches, and explore other power structures interacting with gender in shaping CBFM power dynamics. Based on the findings, I reflect on the need to adopt holistic gender-transformative management strategies and develop intersectional research on SSF. This chapter corresponds to the article ""Men don't feel comfortable with successful female leaders": Exploring participatory exclusion in community-based fisheries management, South Coast of Kenya", accepted pending major revisions in *Maritime Studies* in May 2024.

Chapter 7 consists of a synthesis of the research results exposed in the preceding chapters of the dissertation. Specifically, this chapter situates the doctoral research in the academic landscape by presenting its theoretical, methodological, and empirical contributions to the existing literature. This chapter ends by suggesting key avenues for future research work and recommendations for gender-transformative fisheries management and policies based on this study.

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Chapter 2
Study area

Small-scale fishers along the Kenyan coast use a wide range of fishing techniques. Basket traps are one of the most common and emblematic gears used in artisanal fisheries to catch reef species.

Study area

This PhD delves into climate change adaptation of co-managed SSF communities through a gendered perspective with a focus on the Kenyan coast. This geographic area is also known as the northern Swahili coast owing to socio-cultural factors that shaped centuries of human development (Wynne-Jones & LaViolette, 2017). Acknowledging the heavy legacy of colonialism and slave trade in the East African region (Cooper, 1981), I provide a critical stance that embraces an interdisciplinary lens by bridging natural sciences with anthropology, archaeology, and history thus providing an overview of the biocultural dimensions of the study area. This contextualization aims to situate this research on gender, knowledge pluralism, and climate adaptation, conducted in the Shimoni-Vanga seascape on the South Coast of Kenya, with respect to broader historical, political, and socio-economic drivers that influence regional dynamics. Recognizing that I base this work on the available literature, including many publications by Western authors, and acknowledging my privilege positionality, this outline may be incomplete and partial, yet necessary to contextualize my research project and give ground for more decolonial studies in the region.

1. The Kenyan coast: a distinct biocultural region connected to the WIO

1.1. Geographical and cultural delimitation

What is known as the Swahili coast within the WIO region corresponds to a coastal belt and several islands spread along the East African coast that share a history marked by the strong influence of the Swahili culture (Fleisher et al., 2015; Kusimba & Walz, 2021). This coastal belt stretches about 16 000 km from Cabo Delgado in Mozambique in the south to Juba River in Somalia in the north. In addition, the Swahili coast includes islands such as Zanzibar and Mafia archipelagos in Tanzania or Lamu archipelago in Kenya (Prins, 1967). This area of Swahili influence is interspersed with important ancient Swahili towns such as Mogadishu (Somalia), Mombasa (Kenya), or Stone town (Tanzania, Zanzibar). My work focuses on the northern section of the Swahili coast, corresponding to the present-day Kenyan coast (*"pwani"*). While I recognize that people living on this coastal strip have had different identities than the Kenyan identity, sometimes overlapping with it, hereafter I will use the term "Kenyan coast" for practical purpose. Alternatively, I will refer to the "Kenyan coastal region" to describe not only this 16 km-wide coastal belt, but the broader coastal society that includes the six coastal counties of Kenya. As detailed in the following sections, the Kenyan coast stands out from the rest of Kenya from a climatic, geological, ecological, historical, cultural, and socio- economic viewpoints (Hoorweg et al., 2000; Salim, 1973). These specificities emphasize its socio-environmental embedding within the Swahili coastal area.

1.2. Biogeographical characteristics

1.2.1. Geographical settings

The Kenyan coastline spreads over 640 km, from the border with the United Republic of Tanzania in the south to the Federal Republic of Somalia in the north (Kimani et al., 2018). National waters include a relatively narrow continental shelf, extending towards the north of the country. A key feature of the region is its extensive fringing reef that runs parallel to the coast. This reef is relatively continuous until Kilifi County and gets patchier in the northern part of Kenya (Obura et al., 2017a). The

Kenyan coastal region comprises six administrative counties: Kilifi, Kwale, Lamu, Mombasa, Taita–Taveta and Tana River (Figure 2.1). Two main river systems end up in the WIO: the Tana and Sabaki rivers (Kimani et al., 2018). The former represents the longest river in the country, stretching across nearly 1000 km. It originates from the Aberdare ranges and Mt Kenya in the Central highlands region of Kenya and reaches the ocean through the Tana Delta, along the Malindi-Ungwana Bay. The Tana Delta itself supports a rich and endemic biodiversity and represents a major source of water for local communities (Hamerlynck et al., 2010). However, this delta is increasingly subject to land and water grabbing by large-scale development projects (Duvail et al., 2012). Sabaki River is the second longest Kenyan river and originates in the outskirts of Nairobi. It enters the Indian ocean in Malindi bay, forming a productive riverine ecosystem. In addition, some streams also occur in the region but are mostly seasonal.

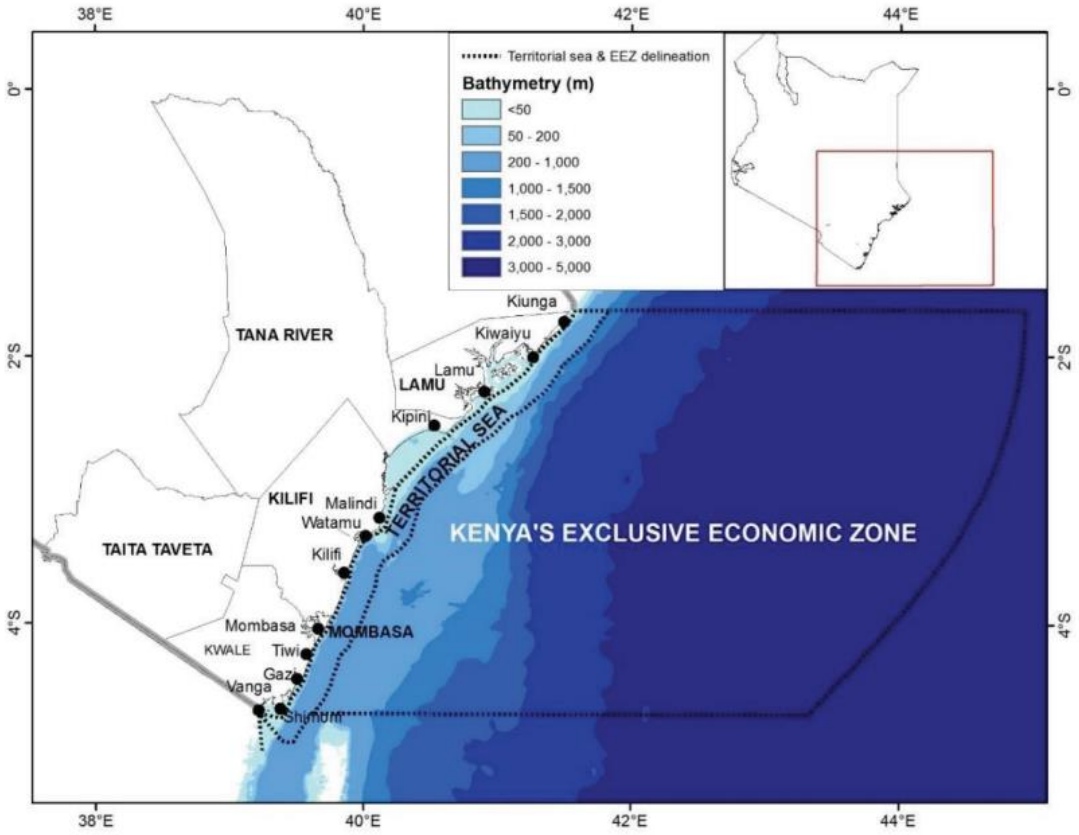

Figure 2.1: Location map of the Kenyan coastal region. This map shows the six administrative counties, the main coastal towns and cities, and Kenya's territorial waters and exclusive economic zone (EEZ) boundaries (from Kimani et al., 2018, Figure 1.1.1, p.1).

1.2.2. Climate

The Kenyan coastal climate is modulated by the dynamics of the Inter-Tropical Convergence Zone, known for its strong seasonal and inter-annual variability (Gebrechorkos et al., 2019). It is characterized by two reversed monsoon seasons – the Northeast (November-March – NEM) and the Southeast monsoons (April-October – SEM), respectively called "*Kaskazi*" and "*Kusi*". The NEM is defined by relatively drier conditions and weaker winds (3 ms^{-1}) compared to the SEM (5 ms^{-1}) (Envasses Environmental Consultants Limited [EECL], 2020; McClanahan, 1988). In addition, the NEM season experiences lower marine primary productivity and higher seawater salinity than the SEM. The transition between the two seasons lasts up to two months and is characterized by reduced winds (Obura, 2001). The alternance between the two seasons shapes oceanographic conditions (McClanahan, 1988) and fishing activities in the Kenyan coast (Alati et al., 2023; Jury et al., 2010). According to the Köppen-Geiger classification, the Kenyan coast falls within a tropical dry savanna

climate (Aw) (Beck et al., 2018). Air temperatures vary only slightly over the year, from 23 to 28 °C in average (EECL, 2020) (Figure 2.2). The warmest season corresponds to the NEM (27°C in average), whereas the coldest temperatures are experienced during the SEM (24.5°C in average). The average annual rainfall for the site is estimated at 940 mm/year but it greatly varies across the year. There are two main rainy seasons: one period of heavy rains between April and May – brought by winds from the open Indian ocean – and one brief rainy episode between October and November. The rest of the year experiences lower rainfalls. This regional climate variability is attributed to natural climate forces such as the El Niño Southern Oscillation, the Indian Ocean Dipole and movement of the inter-tropical convergence zone (Endris et al., 2015; Mpelasoka et al., 2018) which modify winds patterns and moisture fluxes, thus influencing the amount of rainfall (Endris et al., 2018).

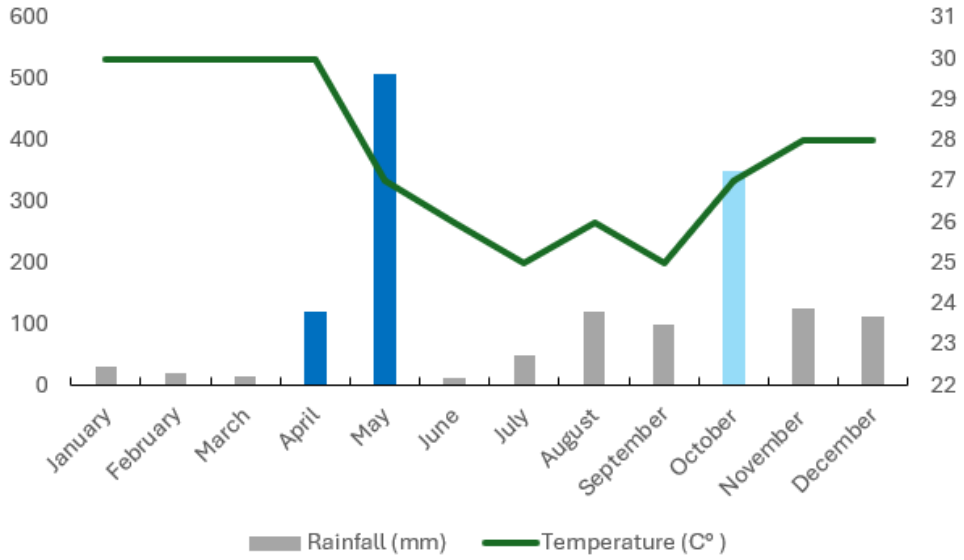

Figure 2.2: Monthly average rainfall (mm) and temperature (C°) in Shimoni area, Kwale county, for the year 2019 (data from EECL, 2020). The short and long rainy seasons are indicated in light and dark blue color respectively.

1.2.3. Ocean dynamics

The major monsoon-driven offshore currents in the study area comprise the East African Coastal Current (EACC), the Somali Current (SC), the Equatorial Counter Current (ECC) and the Southern Equatorial Current (SEC) (Jacobs et al., 2021; Kimani et al., 2018). The EACC is oriented northwards, flowing from the Equator into the Arabian Sea during the SEM, and diverting eastwards during the NEM. The SC follows the alternating cycle of the monsoon seasons flowing northwards during the SEM (about 2 ms^{-1}) and southwards during the NEM (about 1.5 ms^{-1}) (EECL, 2020). Near the equator, the SC and EACC merge into the ECC of a maximal depth of 400 m. Finally, the SEC flows from northern Madagascar to the Tanzanian coastline, bringing cool and low productive waters (Jury et al., 2010; Schott, 1983). These seasonal currents have a considerable effect on the ocean physio-chemical and biological processes (Brakel, 1982).

In coastal systems, Kenyan waters are characterized by semi-diurnal tides, with a reported maximum tidal range of 4 m (Brakel, 1982; McClanahan & Kosgei, 2023). Wave variations are directly affected by monsoon seasons. During the NEM, waves come from the Northeast, whereas during the SEM the waves originate from the opposite direction and the sea gets rougher. Besides tidal action, coastal dynamics are also shaped by local rivers, which bring nutrients and turbidity to marine waters.

1.2.4. Geology, topography and water resources

The Kenyan coastal region includes mixed sediments dating from the Tertiary to the Precambrian age (UNEP, 2001). Sediments are particularly diverse owing to past geological processes linked to the formation of the African Rift system. The area constitutes a passive continental margin,

characterized by a low-lying relief and a large fossil reef. Four main topographic zones occur in the region, gradually rising from the shoreline to the hinterland: the Coastal Plain, the Foot Plateau, the Coastal Uplands, and the Nyika Plateau (Jaetzold & Schmidt, 1983; Toya et al., 1973). The Coastal Plain consists of a narrow coastal belt extending 10 km inland and quite low in altitude (0-60 m). Extending to the west, the Foot Plateau reaches up to 135 m and is characterized by a flat topography. The following Coastal Uplands correspond to the continuation inland of the Foot Plateau, ranging between 150 and 460 m. They are characterized by fertile soils and include the Shimba hills. Finally, the Nyika Plateau lies further inland at lower elevations (about 300 m) and is made of clay soils, less fertile than those of the Coastal Uplands. Over time, this regional topography has been shaped by tidal action which led to coral breaking through watering and sedimentation. As a result, the region is now famous for its white sandy beaches that support a flourishing tourism sector (UNEP-Nairobi Convention & WIOMSA, 2015).

Access to drinking freshwater in the coastal region relies on rivers, including Tana, Sabaki, Ramisi and Umba rivers (Government of Kenya [GoK], 2017a). There are also seasonal streams supplying water mostly during the longer rainy season. Other water sources for coastal communities include natural springs and boreholes such as Tiwi boreholes, Mzima or Marere spring (Ochiewo, 2001). Overall, water supply in the region is not reliable owing to the high inter-annual rainfall variability, the lack of permanent streams and common salt intrusion in boreholes located close to shorelines (GoK, 2017a; Ochiewo, 2001). The risk of freshwater shortages is exacerbated by increased demand and land use changes.

1.2.5. Coastal and marine ecosystems

The Kenyan coastal region is known for its rich and productive ecosystems that support the livelihoods of local communities. Main coastal and marine ecosystems include coastal wetlands, coral reefs, mangrove forests, sandy dunes and beaches, and seagrass beds (GoK, 2017a; Tuda & Thoya, 2021).

Coastal wetlands

Coastal wetlands in Kenya represent up to 6% of the land surface (GoK, 2013a). Wetlands include diverse formations such as deltas or estuaries. The Tana delta consists of the largest delta in Kenya with a surface area of about 130 000 ha, and the second most important delta in East Africa owing to the ecological significance of its floodplains and mangrove forests (Hamerlynck et al., 2010). Estuaries correspond to river mouths where a river joins the sea. They are characterized by brackish environments of various salinity levels that support a productive biodiversity. Along the coast, estuaries are particularly vulnerable to climate-induced change in rainfall patterns since river dynamics are dependent on rainfall (Kitheka & Mavuti, 2016). They are also experiencing increasing stress owing to change in land cover, damning and water extraction (Duvail et al., 2012).

Coral reefs

Coral reefs are among the most biodiverse and socio-culturally important ecosystems in the world (Miththapala, 2008). Although they cover less than 0.1% of the ocean surface, coral reefs are known for their high species richness and sustain the functioning of contiguous ecosystems like mangrove forests and seagrass beds (Fisher et al., 2015). According to a recent study by Obura et al. (2022), coral reefs along the Kenyan coast are vulnerable to collapse under continuous climate stress. The most harmful bleaching event on record occurred in 1998 and severely impacted between 50 and 90% of Kenyan reefs (Obura et al., 2017b; UNEP-Nairobi Convention & WIOMSA, 2015). Since then, other climate-induced bleaching events happened in 2005, 2010 and 2016 (Gudka et al., 2024; Obura et al., 2022).

Mangrove forests

Connecting land and sea, mangrove forests are a very productive – yet fragile – ecosystem on which millions of people's livelihoods depend on globally (International Union for Conservation of Nature [IUCN], 2008a). Mangrove forests are known for their role as nursery ground for juvenile fishes and invertebrates, thus playing a critical role in supporting fishing activities. Recent studies have also emphasized their importance as a major blue carbon ecosystem that favours carbon sequestration globally (Jiang et al., 2022). However, in Kenya, as in many other coastal countries, mangrove forests are experiencing a severe decline owing to a combination of anthropogenic stressors such as overexploitation, land conversion, infrastructure development and pollution (Bosire et al., 2015; Kirui et al., 2013). Out of the nine mangrove species censed in Kenya, *Rhizophora mucronata*, *Avicennia marina* and *Ceriops tagal* are the most common ones.

Sandy dunes and beaches

Sandy dunes and beaches are formed by sedimentation processes over time. They represent important habitats for the life cycles of coastal animal species such as sea turtles or crabs (GoK, 2017a). They also support coastal livelihoods by providing water from the underground aquifers, and protection from extreme events. This ecosystem is particularly dynamic owing to the effect of ocean currents, tides, winds and sedimentation on the dunes and beaches. Current drivers of change include plastic pollution, coastal development, and sand harvesting.

Seagrass beds

Seagrass beds provide multiple nature's contributions to people in coastal communities worldwide, ranging from fish nursery to carbon storage and nutrient cycling (Unsworth et al., 2015). Emblematic species such as the dugong (*Dugong dugon)* are known for finding refugee in those productive ecosystems (Nakaoka, 2005). Seagrasses also play a key role for climate adaptation by representing a natural buffer against coastal erosion (IUCN, 2008b). In coastal Kenya, seagrass beds are mostly found on tidal flats, lagoons, and creeks (UNEP-Nairobi Convention & WIOMSA, 2015). The main threats to seagrass ecosystems include destructive fishing practices such as beach seining, land-based pollution, and climate change (Gullström et al., 2002).

The government of Kenya has established since the late 1960s a marine protected areas (MPA) network meant to protect biodiversity while supporting local livelihoods (Tuda & Thoya, 2021). This network includes four marine national parks and six marine national reserves along the coast, covering about 941 km² (Nairobi Convention, 2024). Marine national parks serve the only purpose of preserving biodiversity (i.e., no take zones), whereas marine national reserves adopt a more flexible regulation by authorizing artisanal fishing and tourism activities. This network is managed by a governmental body, the Kenya Wildlife Service, under the Wildlife Conservation and Management Act (GoK, 2013b). In addition to these state managed MPA, coastal communities have also developed their own customary conservation rules through a network of Locally Managed Marine Areas (LMMA) (Kawaka et al., 2017). It is estimated that about 20 LMMA are spread along the coast.

1.3. From glowing to marginality? A brief history of the Kenyan coast

While it is beyond the scope of this thesis to provide a comprehensive analysis of the Kenyan coastal history, this section gives an overview of the main historical drivers influencing contemporary coastal societies. I acknowledge that I am writing this story from a privileged viewpoint that is shaped by the colonial history of my country and its cultural, economic, and political domination over African cultures and lives. This European domination on the African continent – and East Africa in particular – is problematic for all the injustices and structural socio-inequalities it caused. But it is also problematic from an historical standpoint since the colonial legacy silenced and marginalized Indigenous voices about their own history (Ogott, 2001), thus highlighting the need for more in-depth research on the topic from a coastal emic perspective.

Archaeological research on early coastal societies, especially the Swahili, has grown over the past three decades (Fleisher et al., 2015). This recent work contributes to challenging the common narrative attributing historical coastal development to the external influence of the Arabs and recognizes instead the Indigenous character of early coastal settlements and their social organization (Kusimba, 1999). Combining archaeological, historical, and linguistic evidence, scientists estimate that people from inland territories started to settle along the coast from the late first millennium B.C.E (Fleisher et al., 2015). Over the first millennium C.E., life in coastal societies was cadenced by small-scale farming and trade activities with Arab merchants (Cooper, 2000). These activities lasted for centuries and relied on seasonal monsoon-driven migrations without durable Arab incursions (Freeman-Grenville, 1962). There is no clear dating of the beginning of the Muslim period in the East African coast (Wynne-Jones & LaViolette, 2017). Historians estimate that Arabs started to settle on the Kenyan coast during the first century C.E as documented in "*The Periplus of the Erythraean Sea"* by an unknown author of the same period, which is considered a key historical source about maritime trade during this time period (Casson, 1989). Some of these Arab settlements initially may have been temporary before becoming permanent over time (Geus, 2013). Archaeological remnants suggest that early towns were inhabited by non-Muslims and Muslims (Horton & Middleton, 2000; Kusimba & Walz, 2021). From the second millennium C.E., the Kenyan coast was characterized by the development of coastal towns which included from south to north: Vanga, Mombasa, Kilifi, Gedi, Malindi, and Lamu (Chittick, 1965). Each of these urban centres were governed by a Sultan, probably of a Shirazi Arab descent (Casson, 1989; Wynne-Jones & LaViolette, 2017). According to Fleisher et al. (2015), from the 12th century C.E. and onward, Swahili communities along the coast became increasingly oriented towards the ocean (*"bahari*"), developing a maritime identity. This "sea change" is reflected by reported discontinuities in town development, fishing and sailing activities, and architecture, which suggest a greater engagement towards the maritime world (Fleisher et al., 2015, p.102). By the 15th century, Islam and the Swahili language were spread all over most of the Kenyan coast (Horton, 1991; Insoll, 2003; Sinclair & Richmond, 2011).

Between the 15th and 17th century, the Kenyan coast experienced a period of European colonization under the Portuguese rule. The Portuguese settled in the region in 1498 with the goal to take advantage of local wealth, control the Indian Ocean trade and spread Christianity (Cooper, 2000). However, they faced a strong opposition both from local coastal populations and the Omani Arabs who defeated them by 1700. Despite their singular contribution to Mombasa town through the impressive Fort Jesus on the island, the Portuguese invasion on the Kenyan coast was short lived. The Portuguese withdrawal from the region was not immediately followed by the Omani domination. Coastal towns remained independent for about a century until the Omani Arabs took over the Kenyan coast in 1837. Their establishment coincided with the institutionalization of slavery through the caravan trade (Abir, 1968). As a result of European interests in African trade resources and a high demand for slave labor in tropical plantations, the exchange of goods and slaves between the Kenyan coast and the African hinterland grew exponentially during this period (Berg, 1968). Over the 19th century, the Omani Arabs increased their power establishing the State of Zanzibar that exerted their authority over the East African coast (Glassman, 2003). This Omani legacy can nowadays be found in old Swahili buildings, doors, and historical monuments (Wynne-Jones & LaViolette, 2017).

The Omani hegemony in the region was challenged by the growing influence of Britain from the end of the 19th century (Cooper, 2000). This rivalry culminated in the signing of a treaty between the British East Africa Company and the Sultan of Zanzibar in 1888, which gave official power to the British over the coast. In 1895, the present-day Kenyan coast was included in the East Africa Protectorate controlled by Britain. While the rest of the territory became a British colony in 1920, this 16 km-wide coastal strip kept its status of protectorate. Despite this special status, in practice the Kenyan coast was increasingly governed by British authorities. During this colonial era (1895-1962), the newly created Nairobi city gained importance and became the capital of the East Africa Protectorate (Salim, 1973). Colonial authorities created a whole segregated system based on racial power hierarchies in which Europeans

held full power, Asians were considered as middlemen and Africans were socio-culturally, economically, and politically marginalized. In the Kenyan coast, colonization brought two major breaks in local socio-economic dynamics. First, the colonial power led to the abolishment of slavery and slave plantations (1907), thus reshaping local identities, economies, and power relationships. Second, the focus of development policies on Nairobi and the central regions resulted in a gradual disengagement of the Kenyan State from the coast. Once central to the Indian Ocean trade economy, the Kenyan coast became marginalized from central politics originating from Nairobi (Lonsdale, 2001; Salim, 1973). Against this backdrop, and shortly before Kenyan independence, Arab groups called for a greater autonomy of the coast, resulting in the *mwambao* movement (1956-1963) (Brennan, 2008). This emancipatory initiative drew upon the special status of the coast and similar movements in Zanzibar and Egypt. However, this movement failed in achieving its autonomous aspirations because of internal conflicts between Muslims (e.g., Arabs and Swahili) and non-Muslims (Salim, 1973). The 1961 elections highlighted a striking divide between these two groups. Muslims largely supported the Kenya African National Union (KANU) party in favor of a centralized post-independence government, whereas non-Muslim groups mostly voted for the Kenya African Democratic Union (KADU) party that promoted a decentralized system. These cultural divisions have become structural to coastal political dynamics, explaining to some extent the lack of coastal leaders within the national political landscape.

After the independence of Kenya in 1963, the KADU party soon dissolved, thus creating room for the newly elected government to fully embrace the centralized system promoted by KANU, further limiting the autonomy of the coast (Willis & Gona, 2013). Political clientelism became a dominant feature of post-independence political mobilization (Otenyo, 2023). Owing to its cultural diversity, the Kenyan coast has often been instrumentalized by successive Kenyan governments in their economic and political agenda (Meilink, 2000). Despite its marginality to Kenyan central politics, the coast increasingly attracts up-country Kenyans and foreigners for its rich biocultural diversity and living conditions (GoK, 2017a).

1.4. Peoples from the coast

1.4.1. A strong cultural diversity

More than four million people live in the Kenyan coastal region, about 9% of the national population (GoK, 2019a). About 45% of this coastal population lives in urban centers, of which Mombasa is the most populated. Coastal people include Swahili and non-Swahili groups, forming a broad coastal "oikumene" characterized by the long-standing influence of Swahili trade middlemen and strong socio-cultural ties with Arab and western Indian regions (Hoorweg et al., 2000). This very mixed population comprises Indigenous and recent immigrant inhabitants (GoK, 2017a).

Indigenous coastal people include Cushitic and Bantu-speaking groups. Cushitic people form the oldest but least represented group in the Kenyan coastal region (Middleton, 2000). They originate from the north, or what corresponds to present-day Somalia. Early allusions to Cushitic settlements along the Kenyan coast date to the first century C.E. (Casson, 1989). They are mainly considered pastoralists, although they also engage in some form of trade with other coastal groups (Amutabi, 2023). Over the first millennium C.E., Cushitic people were gradually displaced by Bantu groups originating from the south (Fleisher et al., 2015). Nowadays, modern Cushitic subgroups include the Boni, Orma, Sanye and Somali. Some of them have kept a semi-nomadic lifestyle. By contrast, the Bantu-speaking people represent a large ethnic majority along the coastal region (Middleton, 2000). They inhabit the coastal strip as well as the immediate hinterland and hills. Coastal Bantu populations are made up of four main groups: the Mijikenda, Pokomo, Taita-Taveta and Swahili.

The Mijikenda ethnic group is a modern construction in the context of anticolonial struggles in Kenya (Hornsby, 2013; Willis, 1993). In the first half of the 19th century, nine distinct – yet culturally related– coastal Bantu groups agreed on merging together under a broader ethnic designation for political

motivations, hence the name of "Mijikenda" meaning "*the nine tribes*" in the languages of their ethnic subgroups (Spear, 1990). The Mijikenda group comprises the Chonyi, Digo, Duruma, Giriama, Jibana, Kambe, Kauma, Rabai and Ribe. Among these nine subgroups, the Digo and Duruma are dominant along the South Coast, whereas the Giriama is the largest group in the north. These different ethnic groups, commonly called "tribes" in Kenya, have in common a patrilineal system, except for the Digo (matrilineal) and Duruma (double descent) (Orchardson, 1986). Most of these tribes combine their own religions with Christianity except the Digo, who adopted Islam. The Mijikenda used to rely primarily on small-scale farming and coconut growing but are now engaged in more diverse livelihoods including trade and tourism (Middleton, 2000). The Mijikenda's culture and governance system is deeply linked to sacred forests ruled by customary laws, known as "*kaya*" (Orchardson, 1986).

The Pokomo is another Bantu group represented in the Tana valley and divided into various subgroups (Werner, 1913). Pokomo people primarily engage in fishing and rice growing. Around the Taita hills are found the Taita and Taveta groups. Taita people predominantly farm maize, rice and legumes using dry and irrigation farming (Merritt, 1975) and rely on livestock breeding. Some of their production is exported to Mombasa markets. Taveta people represent a smaller group inhabiting a small patch surrounded by forests in the south of the Taita hills (Momanyi, 2002).

Finally, the Swahili represent the most culturally dominant group within the coastal region (Fleisher et al., 2015; Wynne-Jones & LaViolette, 2017). While they share linguistic and ethnical traits with the other Bantu groups, they differ from them in many aspects (Kusimba & Walz, 2021). Their name "Swahili" comes from "Sahil" (ساحل in Arabic, meaning "the coast"). Unlike other Bantu groups, the Swahili have largely adopted the culture and language of Omani Arabs by developing their own language, converting to Islam, living in coastal towns, and specializing in long-distance maritime trade (Glassman, 2003). Depending on their location, Swahili people are divided in different subgroups including Amu, Bajun, Mvita, Shela, Shirazi, Siyu, Ozi, Pate and Vumba (Khalid, 1977).

In addition to these Indigenous groups, recent immigrations have added to the cultural diversity of the coastal region (GoK, 2017a). Muslim communities from Arab and Persian regions have settled in Swahili towns from the 15th century, followed by people from India, Comoros, and Europe during the colonial period (19th -20th century) (Middleton, 2000). More recently, since the independence of Kenya, mixed Kenyan groups coming from the hinterland and the capital Nairobi have moved to the coast for economic opportunities. The coastal region, and the cosmopolite urban area of Mombasa in particular, have thus built on diverse cultural, linguistic, and religious influences.

However, analyzing these tribal systems requires some caution since these categories are dynamic and have fluctuated throughout the history of the Kenyan coast (Wynne-Jones & LaViolette, 2017). In other words, belonging to the Swahili or Mijikenda group does not imply a definite and bounded ethnical identity. Instead, coastal people have often changed language, religion or kin relations and take over new identities from one generation to another, which highlight the complexity of studying Indigenous cultures in coastal Kenya (Giles, 2014). Another challenge is linked to the importance of oral traditions in the region that limits the availability of written sources on the cultural life of these different tribes (Amutabi, 2023). A few groups such as the Swahili and Giriama have been relatively well studied but mostly through the lens of colonial explorers, missionaries, or researchers, which provides biased information (Middleton, 2000).

1.4.2. Coastal religions and spiritualities

Like for ethnicity, religious affiliations are not rigid or exclusive among coastal populations but show a great flexibility (Wangila, 2023). Coastal people have adopted a diversity of religions, often blending Indigenous traditions with Islam and Christianity (Sperling, 2000). Owing to Indian migrations

from the 19th century, a small fraction of the population follows Hinduism. Overall, these different religious beliefs and practices influence each other (Wangila, 2023).

Islam was introduced in the region from about 650 C.E. when Arab people settled along the East African coast (Fleisher et al., 2015; Mbiti, 1989). By contrast with its rapid diffusion in northern Africa, conversion to Islam in coastal Kenya occurred over centuries, gradually blending with Indigenous beliefs (Wynne-Jones & LaViolette, 2017). Christianity was introduced much later, first by the Portuguese in the 15th century, and then the British over the 19th century. Yet, it did not spread among local populations as much as Islam. This situation contributes to accentuate the divide between the coast and Christian-dominated inland regions in Kenya. However, migrations from up-country people to the coast over the past decade resulted in an increase in Christian communities along the coast (Sperling, 2000).

Indigenous religions remain prevalent in many coastal societies, despite a greater exposure to Islam and Christianity (Wangila, 2023). While the lack of written documentation challenges the study of these Indigenous spiritualities, they appear to share common specificities. Many coastal societies believe in a supreme being and spirits and adopt a holistic religious worldview without separating the sacred from the profane realms (Mbiti, 1989). Indigenous religions permeate all components of individuals' lived experiences and draw moral and social rules. The influence of these different religious identities varies across localities and ethnic groups. For example, populations of the South Coast are predominantly Muslim, whereas Mombasa is more mixed (Sperling, 2000).

1.4.3. Livelihood and subsistence activities

Coastal people have combined diverse livelihood activities for centuries (Hoorweg et al., 2000). These activities often vary from one ethnic group to another. For instance, Swahili people are based in coastal towns and have specialized in distanced maritime trade with other regions of the WIO (Fleisher et al., 2015), whereas Mijikenda people mostly rely on small-scale farming (Middleton, 2000). The main contemporary economic activities in the coast comprise agriculture, tourism, port development and shipping, industries, support services and marine fisheries (GoK, 2017a). While land in the coastal region is often considered less agriculturally productive than in the central and western regions of Kenya, it does support local farming production. Common cultivated crops include maize, cassava, coconut, cashew, and banana. The tourism sector has grown exponentially along the coast since Kenyan independence and is now a major driver of the national economy. Regarding port operations, and the industrial and service sectors, they are mostly concentrated in the main urban centers, in particular Mombasa. Financial services in coastal rural areas are mostly informal involving systems of rotating, savings, and credit associations (e.g., women's saving groups called "*chamas*"), familial support and community-based organizations such as BMU (GoK, 2017a).

2. Marine small-scale fisheries in Kenya

Marine fisheries in Kenya cover both the territorial waters and the Kenyan exclusive economic zone (EEZ). This sector is dominated by SSF, which account for about 80% of the total production (Kimani et al., 2018). This section details the historical, socio-cultural, and economic importance of SSF, the different fishery types, their temporal and social patterns, and management and governance issues. In this section, I use data from the national marine artisanal fisheries frame survey (GoK, 2016a). This

biennial catch assessment survey represents the most updated and comprehensive source of information about SSF production and fishing efforts along the Kenyan coast, the continuation of which has been impacted by the Covid-19 pandemic.

2.1. Early small-scale fishing activities

Archaeological and historical evidence indicate that people along the East African coast have long relied on SSF for their subsistence (Badenhorst et al., 2011; Fleisher, 2003; Quintana Morales, 2013; Van Neer, 2001). To reconstruct past coastal livelihoods, ichthyo-archaeological analyses are particularly useful since fish remains represent the main source of archaeological evidence in the region (Quintana Morales & Horton, 2014). Researchers use these remains to link fish species with past fishing strategies and habitats. While the earliest fish remains discovered in the East African coast are dated from the early Iron age (Chami, 2004; Crowther et al., 2012), most of the archaeological faunal evidence is dated between the 7th and 15th centuries C.E. (Quintana Morales & Horton, 2014). In addition to fish remains, historical sources also support the importance of SSF in earlier coastal societies (Casson, 1989; Freeman-Grenville, 1962). Altogether, archaeological and historical evidence suggest that small-scale fishing was one of the main livelihoods of early societies along the East African coast, mostly operating across inshore habitats such as mangrove forests and coral reefs and using a wide range of fishing gears (e.g., hand lines, cast nets, traps) (Horton, 1996; Prins, 1965). The period between the 11th and 12th century C.E. is considered a major historical break owing to a greater engagement of early coastal societies in offshore fishing, as supported by archaeological records indicating the use of specific boats and gillnets to fish in the open sea (Quintana Morales & Horton, 2014). For instance, in contrast to previous time periods, archaeological samples found in Shanga (North Coast of Kenya) in the late first millennium C.E. include remains of sharks (Selachii), bonito (Scombridae) and tuna (Scombridae) species, which mostly occur offshore (Fleisher et al., 2015). Despite these regional trends, scientists recognize that fishing practices and fish consumption greatly varied along the East African coast according to local social-environmental contexts of past coastal societies (Quintana Morales & Horton, 2014).

2.2. Socio-economic importance of marine SSF

Small-scale fisheries are essential for the coastal economy in Kenya, generating an average annual catch of 24 000 tons (Kimani et al., 2018). A recent study by Fondo et al. (2024) suggests that Kenyan SSF provide a medium to high contribution towards SDG n°8 “Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all”, which aims at sustainable growth and employment. Beyond fisherfolk, fish processors, traders, fishmongers, fish dealers, and cooks also rely on fish production to sustain their livelihoods (Kimani et al., 2018). In addition, SSF are critical for meeting local nutritional needs. According to Taylor et al. (2019), about 77 % of marine fisheries in Kenya provide food security to coastal communities in the country. In some parts of the coast, such as in the Shimoni-Vanga seascape, this contribution may be even higher (GoK, 2017a; McClanahan et al., 2024). Moreover, SSF form a key component of local cultural identities, which are tightly connected with the ocean. Shaped by centuries of trade across the Indian ocean, Swahili people and other coastal groups have developed strong cultural ties with their marine environment (UNEP-Nairobi Convention & WIOMSA, 2015). As an illustration, cowrie shells were long used as a domestic currency during the East African caravan trade because of their high aesthetic value (Chaudhuri, 1985). Coastal biodiversity is also appreciated by local communities for spiritual, ornamentals, and medicinal reasons. For instance, seagrass species such as *Enhalus accoroides* and *Halophila* species are of particular importance in traditional medicines to treat diseases such as malaria or stomach problems (UNEP-Nairobi Convention & WIOMSA, 2015).

2.3. Description of marine SSF: biological and social factors

2.3.1. Fishery types

Small-scale fisheries in coastal Kenya have been classified into six main categories according to their target functional group (Kimani et al., 2018) (Appendix 2 - Table S2.1). **Pelagic fisheries** refer to fishing activities targeting both large and small pelagics. The former category includes high valued species that are highly mobile and migrate seasonally in offshore waters such as tuna (Scombridae), barracuda (Sphyraenidae), sailfish (Istiophoridae), or sharks (Selachii). The most common tuna species found in Kenya EEZ comprise Yellowfin tuna *(Thunnus albacares),* Skipjack tuna *(Katsuwonus pelamis),* and Bigeye tuna *(Thunnus obesus).* By contrast, small pelagics occur in nearshore and shallow waters and include taxa like sardines (Clupeidae) and anchovies (Engraulidae). In between, Kenyan waters also host medium pelagics such as Spanish mackerels (Scombridae) or little tuna (*Euthynnus alletteratus*). A large part of SSF catch is also made of **demersal species** which are finfish reef species found in the inner reef waters and that directly contribute to local subsistence. This fishery targets *inter alia* rabbitfish (Siganidae), wrasse *(*Labridae), or parrotfish (Scaridae). Then, **crustacean fisheries** specialized in shrimp, lobsters, and crabs. These species often require specific skills and know-how to be caught and are highly valued on the market. Another important fishery targets **cephalopods**, including octopus, squids, and cuttlefishes, that are sold both to domestic and external markets. Likewise, **holothurians** (i.e., sea cucumbers) represent a niche market, almost exclusively sold to Asian countries. Finally, despite their lesser contribution to the marine SSF production, **marine shells and aquarium fisheries** are important for meeting the demand of international ornament-driven markets.

2.3.2. Landing sites and fishers' population

The marine SSF sector in Kenya comprises 197 landing sites, distributed throughout the Kenyan coast (GoK, 2016a). Access to basic facilities on landing sites such as electricity supply, cold rooms or toilets has improved over time but remains quite inequal across counties. It is estimated that more than 13 000 fishers ("*wavuvi*") engage in marine SSF in Kenya (GoK, 2016a). However, this estimate calls for caution, given that a significant part of the Kenyan fishers' population does not have a fishing license and is thus not recorded. Fishers' distribution varies along the coast, with most fishers registered in Kilifi (35%) and Kwale counties (26%) (Appendix 2 - Figure S2.1).

2.3.3. Fishing vessels

The total number of registered SSF vessels along the Kenyan coast is estimated at 3 000 (GoK, 2016a). Dugout canoes are the dominant fishing craft (48%), followed by *Mashua* (21%), *hori* and *dau* (10% each), and small outriggers called *ngalawa* (7%) (Table 2.1). Overall, most of the SSF vessels in Kenya are non-motorized using paddles or sails. Only 20% of the fishing crafts are provided with an engine. In addition, about 18% of the fishers access their fishing grounds by foot, hence their classification as foot fishers. This specificity challenges an effective monitoring of fishing activities since foot fishers do not rely on a specific landing site.

Table 2.1: Main vessels used by fishers on the Kenyan coast, their characteristics and frequency.

Vessel type	Characteristics	Frequency *(% of total registered vessels)*
Dugout canoe	Canoe with curved bottom	48
Mashua	Large plank wood-made vessel mostly used for long line and net fishing beyond the reef	21
Hori	Small plank wood-made canoe	10
Dau (or dhow)	Plank wood-made vessel with a flat bottom and small sails	10
Ngalawa	Canoe with outriggers and small sails	7
Other less common vessels (i.e., mtori, surf and rafts)	Small plank wood-made crafts	4

Source: GoK, 2016a.

2.3.4. Fishing gear

Small-scale fishers employ a large diversity of fishing gears, of which the most common in the South Coast are detailed in the Appendix 2 (Table S2.2) (Samoilys et al., 2011). Three of them – beach (or reef) seines, spearguns, and monofilament nets – are considered illegal since 2001 owing to their negative impact on the environment (Gok, 2016a). Hand gathering, hook sticks and scoop nets represent the most selective gears, whereas beach seines, gillnet, handlines, longlines and monofilaments usually attract a greater number of species, with potential negative consequences for coastal and marine ecosystems.

2.3.5. Fishing seasonality

Small-scale fishing activities are strongly shaped by the alternating monsoon seasons. During the SEM season (April-October), there is a lot of wind and rain, and the sea is particularly rough (Kimani et al., 2018). These cool conditions favor foot fishing but discourage fishers using vessels from going out at sea for safety reasons. During the NEM season (November- March), sea conditions are reversed which makes it a high season for fishing onboard vessel. Throughout the year, fishing activities are also combined with small-scale farming and other livelihoods activities. This flexibility ensures a regular source of income and food for coastal households.

2.3.6. Recent changes

Over the last four decades, major changes have been reported in Kenyan marine SSF (GoK, 2016a). A striking point is the constant increase in the number of people involved in fishing over time, by about 10% each year (Kimani et al., 2018). Scientists consider that fishers' concentration along the coast – estimated at 15-20 fishers/km² – exceeds the theorical limit required to meet maximum sustainable yield in marine fisheries (Obura et al., 2017b). The increase in fishing effort over time may have contributed to the observed decline in fishery production since the 1980s. A meta-analysis conducted by Samoilys et al. (2017) on Kenyan SSF fisheries over a 20-year period, between 1984 and 2007, reveals a declining trend by a factor of 4 in catch per unit of effort and a drop in species richness of catch for the whole coast.

2.4. Gendered dimensions of SSF

Fisheries-related activities on the Kenyan coast are highly gendered. Women and men engage in different parts of the SSF value chain, which may sometimes overlap (Figure 2.3). Women are mostly involved in the post-production sector, either as fish processors, or vendor/traders. Women fish processors include women who buy fish to fry it ("*mama karanga*") and those who specialize in the boiling of small sardines, locally called *dagaa* ("*mama chemsha*"). Women also engage in the sale of fish in local shops ("*biashara*" or "*duka la Samaki*") or restaurants, and more rarely in trade as fish dealers. In the production sector, women take part in fishing capture although they are less numerous than men. Beyond the value chain itself, women are largely in charge of family support and caring duties at home, which are necessary for sustaining the whole SSF sector. For instance, by cooking food for their husbands, women provide a hidden – yet critical – service to the fishing workforce. Given their gender role as family provider, men have more flexibility in the use of their time and mobility. As such, they engage in most stages of the SSF value chain. They take part in pre-production tasks such as the preparation of boats and net repair. They also engage in direct fishing and post-production as fish dealers, vendors, or traders. These diverse roles held by men and women are fundamental drivers of their respective identities and epitomize their gender-specific connection to the ocean.

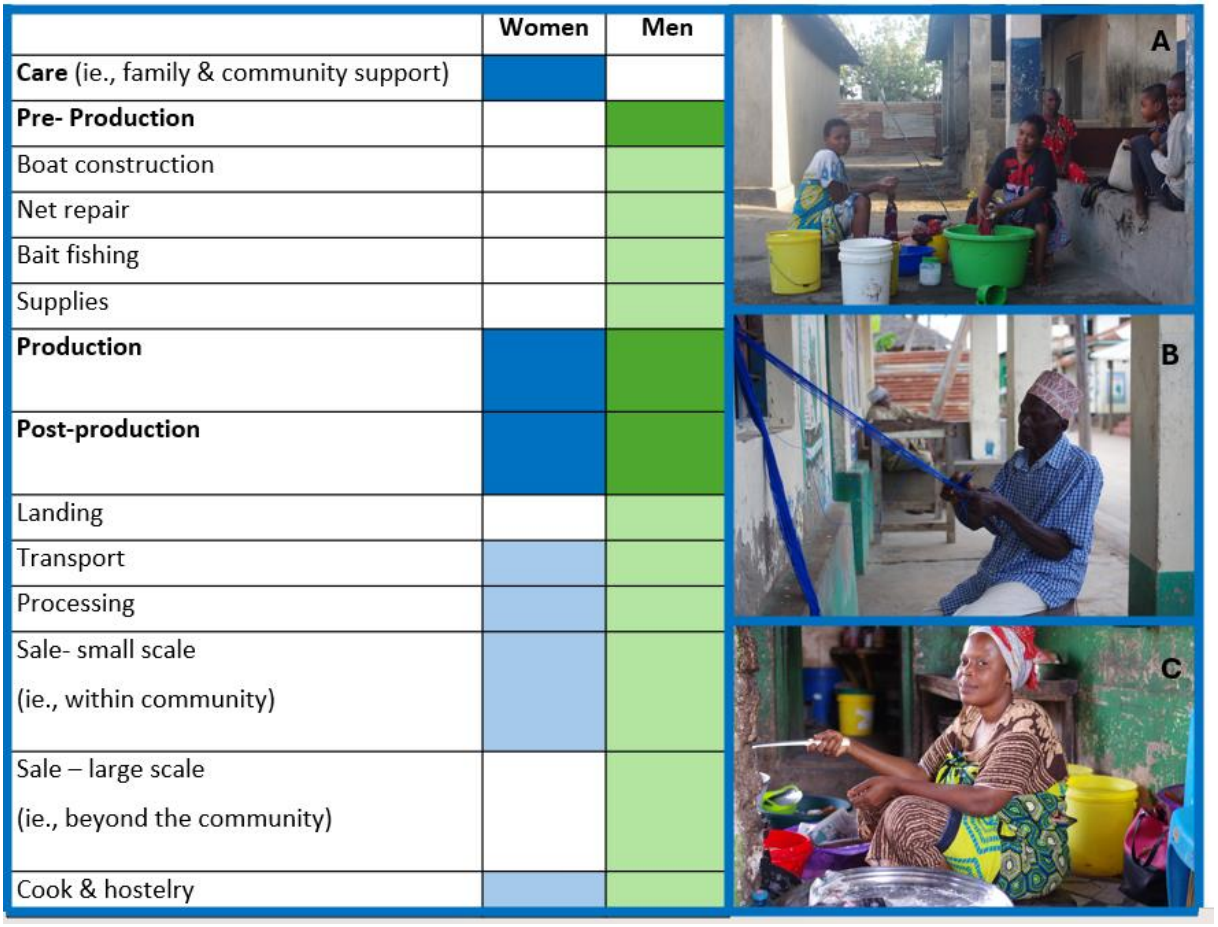

Figure 2.3: Main roles of women and men in the small-scale fisheries (SSF) value chain. **A) Care activities** are mostly done by women. **B) Pre-production** tasks such as net repair are male-dominated. **C)** Both women and men engage in **post-production** but through different activities. For instance, local restaurants in coastal villages are often held by female cooks and entrepreneurs. Pictures: © M. Chambon 2021-22.

2.5. Fishers' migrations within the WIO

Fishers' migrations represent a key element of the SSF sector both at the Kenyan and WIO scales. A study by Wanyonyi et al. (2016) highlights that the East African coast is a hotspot for fishers' migrations, especially in Kenya, Tanzania, and Mozambique. In this region, fishers' migrations are called "*kwenda-ago*" or "*dago*", which literally expresses a change in fishing grounds for variable time periods, from a couple of weeks to several months (Fulanda et al., 2009; Jiddawi & Ohman, 2002). Usually, fishers' movements follow the biological cycles of their catch (Nunan, 2010; Randall, 2005) but the type of fishing vessel and gear also influence the trip duration. Most Kenyan migrant fishers move within the national waters, crossing administrative boundaries. In addition, the country hosts an increasing influx of migrants originating from Tanzania. In Vanga for instance, the migrant fishers' population is almost equal to that of local fishers (48.4%), whereas it represents about a third of the total fishers' population in Shimoni (Wanyonyi et al., 2016). Fishers from Pemba Island, located offshore of mainland Tanzania, represent a special case. They form one of the oldest migrant fishers' groups in coastal Kenya, with records dating back to the 1940s (Wanyonyi et al., 2016). They are known for their fishing skills and their long-distance migration, from Pemba to the Kenyan coastline (Fulanda et al., 2009; Jiddawi & Ohman, 2002).

2.6. SSF management and governance

Fisheries management and governance in Kenya are embedded in multiple frameworks, at the international, regional, and national levels. Achieving sustainable SSF in Kenya requires thus an efficient coordination of these overlapping governance layers (Kimani et al., 2018). Kenya is part of several

Multilateral Environmental Agreement and regional frameworks holding a mandate on fisheries governance (Appendix 2 - Table S2.3). These instruments include notably the Nairobi Convention, the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (1973) or the UN Food and Agriculture Organization (FAO)'s SSF Guideline (2015).

At the national level, the importance of the fisheries sector is reflected both in the national Constitution and specific dispositions. At the top of the hierarchy of laws, Article n°69 of the Constitution of Kenya (2010) affirms that the Kenyan State is responsible to "*ensure sustainable exploitation, utilization, management and conservation of the environment and natural resources, and ensure the equitable sharing of the accruing benefits*". This ambition is reflected in national fisheries regulations such as the Fisheries Act (Cap 378) (GoK, 2012) and the Fisheries Management and Development Act (GoK, 2016b), which defines the main management approaches applied in the country. Several governmental bodies are involved in SSF management including the Ministry of Mining, Blue Economy and Maritime affairs (central decisions), Kenya Fisheries Service (decentralized operations) and KMFRI (research and capacity building).

Over the last 30 years, the government of Kenya has embraced SSF co-management by bringing governmental representatives and local communities together in SSF decision-making processes (Kawaka et al., 2017). In some areas of the Kenyan coast, co-management development built on local customary management rules. For instance, local rules in Wasini Island (South Coast), prevent people from reaching certain islets surrounding the island. Rules transmitted through local stories contribute to regulate the use of coastal resources, thus echoing similar taboos in the WIO region (Cinner, 2007; Masalu et al., 2010). In other areas, co-management approaches provided an institutional ground for social learning and enhancing the capacities of coastal communities in the management of their fisheries. Beach Management Units form the core institution of SSF co-management in Kenya. Established in 2007 through the 2007 BMU regulation (GoK, 2007), BMU promote the participation of local users in the management of their marine area of jurisdiction in cooperation with governmental bodies and other stakeholders. Local users are both granted rights and responsibilities regarding their environment, including the designation of LMMA which corresponds to community driven MPA (Kawaka et al., 2017). Current challenges faced by BMU in the management of their fisheries include i) issues related to data collection and monitoring, ii) the lack of licenses of some fishers and vessels iii) fish handling and post-harvest losses, iv) lack of capacity of BMU leaders and v) conflicts about shared fishing grounds (Kimani et al., 2018). In addition, environmental changes linked to invasive species, pollution, overfishing, and climate change exacerbate exiting tensions within SSF communities.

3. Gender dynamics

3.1. Gender considerations in the national context

Since Kenyan independence and the advent of multiparty politics, women's political movements have expended in Kenya and pushed for a feminist political agenda (Kimani & Kabira, 2012; Parsitau & Nyakwaka, 2023). These movements laid the foundations for gender mainstreaming in Kenyan politics. In 1985, Kenya took an international leadership on gender-related issues by hosting the UN Third World Conference on Women which assessed the outcomes of the UN Decade for Women (1975–85) and defined new priorities for international cooperation supporting gender equality and women's empowerment. Kenya's gender equality commitments are reflected in its endorsement of several international and regional instruments such as the Convention on the Elimination of All Forms of Discrimination against Women (UN General Assembly [UNGA], 1979), the UN Global Agenda 2030 (SDG n°5) (UN Department of Economic and Social Affairs [UN DESA], 2016) and the African Union

Development Agenda 2063 (Goal n°17) (UNEP, 2013). Key achievements at the national level include the adoption of the new Constitution of Kenya (2010) which sets a robust framework for promoting inclusive policies and introduces a gender representation quota, known as the two-thirds gender principle. In practice, this constitutional rule implies that women should represent *a minima* one third of any elective or appointive body (Bouka et al., 2019). Another major advancement is the creation of the State Department for Gender in the Ministry of Public Service, Youth and Gender which oversees mainstreaming gender in all sectors and developing gender-responsive instruments such as the National Gender and Development Policy (GoK, 2019b).

Despite that progress, gender inequalities remain a critical issue within the Kenyan society (Parsitau & Nyakwaka, 2023). According to UN Women (2024), there is room for improving currents efforts toward gender equity in Kenya. This UN organization estimates that 23% of women between 15 and 49 years old have experienced physical or sexual abuse by their current or former partner. In the political sphere, the two-thirds gender principle is not yet fully applied with only 22% of female representatives in parliament as of 2021 (UN Women, 2024). Parsitau & Nyakwaka (2023) suggest that dominant patriarchal views and gender stereotypes represent major obstacles to gender equity in Kenyan politics. However, a serious lack of gender-disaggregated data hampers a comprehensive assessment of the gender gap in Kenya, especially in certain sectors such as informal care activities or communication technology skills (UN Women, 2024).

3.2. Gender relations in coastal Kenya

Social life and economic activities in the Kenyan coast are strongly influenced by gender norms and values (Askew, 1999; Mitullah, 2000). Gender roles ascribed to men as family providers imply that they are expected to sustain their wife and female relatives both economically and materially, whereas women as nurturers are expected to support their family and obey their husband, father, or brothers (Chandler, 1979). These distinct gender roles generate a clear gendered division of labor. Men tend to engage in trade, commercial fishing, and cash crop farming while women take predominant responsibility for house chores and subsistence activities close to their home (Champion, 1967; Gilette, 1980). However, gender relations are highly dynamic, so that this labor division is becoming more and more porous owing to an increase in women's access to higher education and economic development. Especially in coastal cities, women are increasingly engaging in wage labor, creating businesses, and taking over responsibilities traditionally restricted to men (Three Swahili women, 1989).

Despite evolving gender norms, gender inequalities in coastal Kenya remain high. While patriarchy – or male dominance in socio-economic and political systems – forms a structural element of Kenyan society (GoK, 2019b; Parsitau & Nyakwaka, 2023), what is specific to the coast is the strong influence of Islamic-Arab traditions and customs shaped by its unique history (Mitullah, 2000). The dominance of Islamic-Arab norms tends to reinforce the distinctions between men and women and relegate women to lower socio-economic and political positions (Strobel, 1979). Marital laws provide a good illustration of how Islamic norms contribute to normalize inequal gender rights. For instance, polygyny is a practice that is commonly valued and encouraged for men – as long as they can sustain all their wives – whereas polyandry is not culturally accepted (Kameri-Mbote, 1995). Inheritance laws are also very speaking when it comes to gender inequalities given that women can only inherit one-third of their familial heritage (Kameri-Mbote, 1995). Overall, this legislative arsenal supports the domination of men over women in coastal Muslim communities as reflected in the public sphere (Mitullah, 2000). Coastal men have free access to public streets, shops, coffee places whereas women's presence is restricted to the private domain and only tolerated in public spaces if they cover themselves adequately.

Another sector strongly influenced by Islam is education (Mitullah, 2000). Most of Muslim people in the Kenyan coast support the Islamic school called "*madrasa"* that teaches educational programs focused on the understanding and respect of the Quran. Attendance to this school is often coupled with the national educative system as prescribed by Kenyan laws but Muslim families tend to prioritize children's engagement in the *madrasa* (Ndzovu, 2023). This cultural preference towards Islamic

teaching may partly explain why literacy rates in the Kenyan coast are lower than in central regions (GoK, 2017a). Given that school completion rates for girls are globally lower than for boys (Tao, 2018), this situation may exacerbate exiting gender biases in education access. In the political arena, women have been historically sidelined from coastal politics (Mitullah, 2000). They were not allowed to attend public meetings or run for political elections. These gender restrictions are gradually shifting, partly because of new socio-economic realities and the exposure to other social norms through an increased influx of tourists.

4. Study site location: social-environmental context

In this section, I combine secondary data with primary research based on participant observation and SSI conducted through my ethnographic study. Within the Kenyan coast, my fieldwork was carried out in the Shimoni-Vanga seascape (4.45-4.35°S, 39.10-39.30°E), Kwale county, South Coast of Kenya bordered by Tanzania (Figure 2.4). This study site was selected for three main reasons: i) fisheries management within the site is characterized by a dynamic BMU network that manages several operational LMMA, ii) BMU chair positions in the area are held by women and men which provides an avenue for a gender analysis on BMU governance, iii) the site falls within the nearshore waters along the Kenya-Tanzania border, which are identified as a climate refugia (McClanahan & Kosgei, 2023). Owing to local currents linked to the Pemba channel that maintain cooler conditions than in other parts of the Kenyan coast, this nearshore area is considered a buffer from climate change impacts (Beyer et al., 2018; McClanahan & Azali, 2021). Altogether, these characteristics of the Shimoni-Vanga seascape make it a relevant study site to explore the role of gender in CBFM as an adaptive response to climate change impacts.

The Shimoni-Vanga seascape is endowed with productive ecosystems that support the livelihoods of coastal communities. As the rest of the coastal region, the main ecosystems include coral reefs, mangrove forests, and seagrass beds, along with the Umba and Ramisi river estuaries (GoK, 2017b). Local mangrove forests cover about 6 624 ha across the site and are dominated by *Avicennia*, *Ceriops*, and *Rhizophora* species (GoK, 2017b). During low -tides, reef flats get exposed and are commonly strode by foot fishers to catch invertebrates in intertidal areas (Alati et al., 2023). Emblematic marine animals found across the site comprise dolphins, humpback whales, rays, sharks, and sea turtles (EECL, 2020).

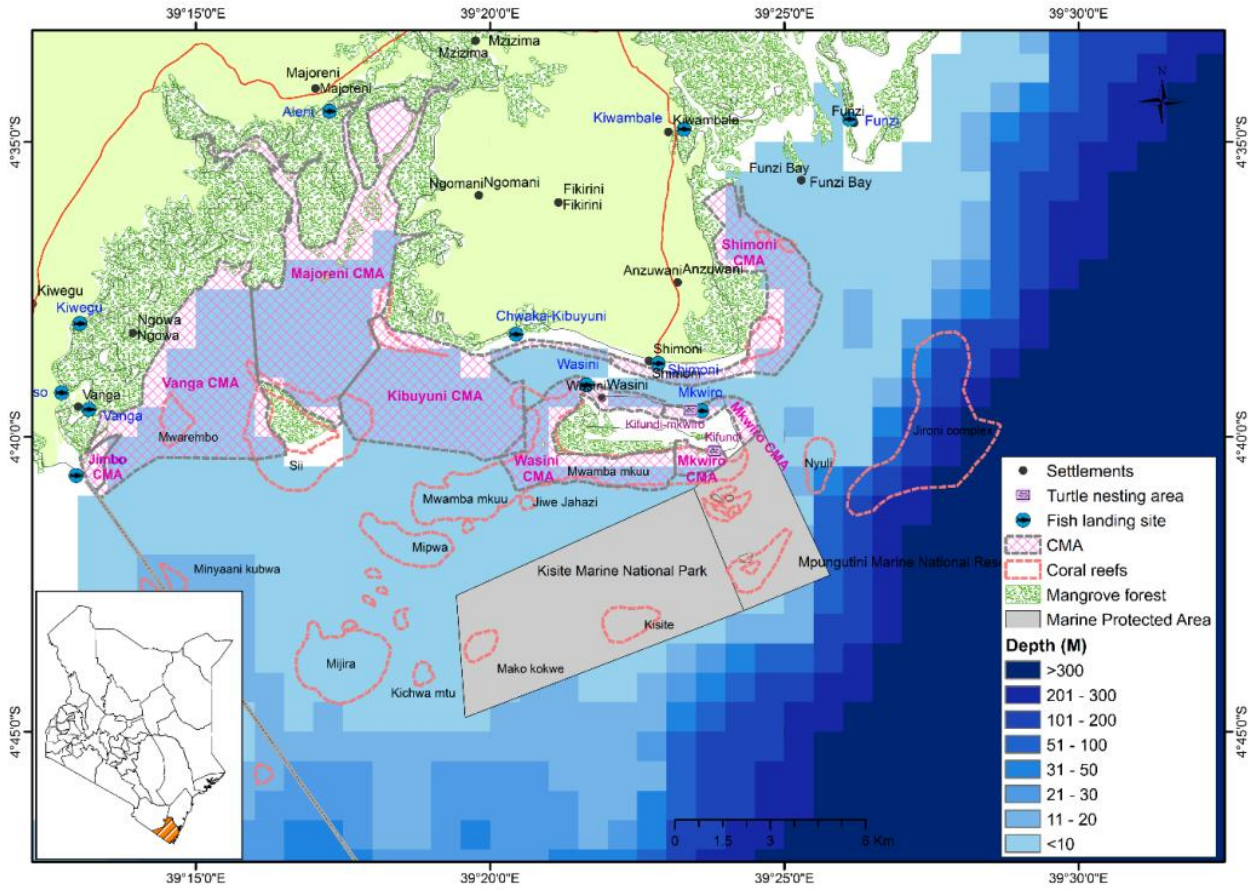

Figure 2.4: Location map of the Shimoni-Vanga seascape on the South Coast of Kenya. The map shows the main coastal ecosystems within the study site, turtle nesting areas, landing sites, Beach Management Units' co-management areas (CMA) and the Kisite-Mpunguti Marine National Park and Reserve (marine protected area) (from GoK, 2017b, Figure 1, p.11).

About 18 000 people of mixed ethnic groups live within the Shimoni-Vanga seascape (GoK, 2017b). Swahili people are divided into two subgroups: the Fundi (or Shirazi) and the Vumba. Local legends by Swahili people recount that long time ago, Maasai people arrived in a place called "*Vumba Kuu*" inhabited by the Swahili's ancestors. Famous for their warriorship, the Maasai wanted to fight with the Swahili and steal their cattle. To avoid the massacre, some of the Swahili escaped by the sea, knowing that the Massai were unable to swim. They reached the island of Wasini and the semi-island of Vanga and settled down in those areas. Over the years, they intermarried with other Bantu-speaking groups, mostly the Digo. The local history of the Shimoni-Vanga seascape is maintained over time through oral stories. Some of the most recent events are well vivid in the community memory as informed by SSI with local elders during my fieldwork experience (Appendix 2 - Table S2.4).

Within the study site, my ethnographic work indicates that SSF represent the main livelihood activity, followed by small-scale farming, tourism, and seaweed farming (Appendix 2 - Table S2.5). The SSF sector is essential to the local economy, especially during the NEM season. For instance, it is estimated that fishing activities in Shimoni produced on average 281 and 118 mt over the 2010-2019 period during NEM and SEM respectively (EECL, 2020). About 70% of the landing is sold to markets in other coastal towns, mostly Mombasa (EECL, 2020). Main fishing grounds comprise Mijira, Mpunguti, Mwamba mkuu and Nyuli among others (Figure 2.4). A recent study by McClanahan & Kosgei (2023) shows that SSF in the study site are characterized by a low maximum sustainable yield, which suggests the need for carefully monitoring fishing effort. In conjunction with fishing activities, local people practice subsistence and cash crop farming as a complementary source of livelihood. Common subsistence

crops comprise maize ("*mahindi*"), beans ("*maharagwe*"), okra ("*mabenda*"), mangoes ("*maembe*"), bananas ("*ndizi*") or diverse green vegetables ("*mboga*"). Some farmers also breed livestock such as cattle ("*ng'ombe"*), chicken ("*kuku*"), or goats ("*mbuz*i"). Owing to the rich local marine biodiversity, the tourism industry has significantly grown over the past decade. There are about 200 tourists' operators working in the area using 50 vessels (EECL, 2020). Tourists often come to visit the Shimoni Slave Caves and the Shimoni Slave Museum, coral garden, mangrove boardwalks, or to snorkel and spot dolphins. Tourist influx depends on seasons, with a reported peak in December-January, but has declined considerably since the Covid-19 pandemic. Finally, seaweed farming is an important source of income in some villages, especially Kibuyuni and Mkwiro. It has been developed as an alternative livelihood for women's groups and focuses on two main species: *Eucheuma denticulatum* (spinosum) and *Kappaphycus alvarezii* (cottonii).

Infrastructures and amenities in the Shimoni-Vanga seascape are less developed than in other parts of the coast but fast-growing. Two tarmac roads connect the local villages and towns. The main road links Mombasa to Shimoni and Vanga. More recently, works started in 2017 to build a new road between Lunga-Lunga and Vanga. At the time of my fieldwork, there was only one small port in Shimoni, and a jetty used for commercial and transport purposes. However, recent economic development resulted in the jetty extension and a project of a commercial fishing port, which may have severe impacts on coastal SES in the future. The liaison between the mainland and Wasini island is nowadays operated by motorboats which has substantially improved passengers' safety. Main medical services are found in Shimoni and Vanga. A dispensary operates on Wasini island but only during weekdays. Regarding schooling, there are *madrasa* and primary schools in most villages, but secondary schools are restricted to a few locations (e.g., Shimoni). There is no higher education institution within the study site, thus after high school some students move to Mombasa or other parts of the country. Most villages use wood fuel as a main source of energy and have access to electricity, except on Wasini island. As of December 2023, most of the households on Wasini island did not have access to electricity and relied on small solar sources, which limited fishing storage facilities. Electrification work started at the end of 2023 only. Likewise, water access greatly varies from one village to another. On the mainland, people mostly depend on wells and pipes for water usage. On Wasini island, water access is challenged by recurrent droughts given that the population exclusively relies on rainwater stored in household and community tanks. In case of extended droughts, villagers commonly leave the island early morning and cross the Wasini channel by boat to buy water bottles from shops on the mainland. This situation is costly both timewise and financially and generates anxiety for local people in the absence of governmental support.

This study site comprises the Kisite-Mpunguti Marine National Park and Reserve, managed by the Kenya Wildlife Service (2015). Kisite Marine National Park was created in 1973 and covers 28 km² where no fishing activity is allowed. Following conflicts between the government and local fishers, Mpunguti Marine National Reserve was established in 1978, covering 11 km² and authorizing regulated human activities such as traditional fishing (e.g., basket trap or handline fishing). Outside of the Park and Reserve, marine resources are managed by seven adjacent BMU, namely Jimbo, Kibuyuni, Majoreni, Mkwiro, Shimoni, Vanga, and Wasini. Each of these BMU is responsible for managing its marine area of jurisdiction, called co-management areas. These areas may include no-take zones, referred as community conservation area, LMMA or "*tengefu* ". Within the study site, three *tengefu* have been established in Kibuyuni (16 ha), Mkwiro (14 ha) and Wasini (30 ha) (EECL, 2020). Other community-led conservation initiatives under the BMU umbrella include mangrove (Kibuyuni, Vanga) and coral (Wasini, Mkwiro) restoration programs (e.g., Knoester et al., 2023). Since 2017, these seven BMU have joined their effort, in collaboration with governmental bodies and non-governmental organizations, to form the Shimoni-Vanga Joint Fishery Co-Management Area to improve the management of their common marine resources (GoK, 2017b). This joint area extends to the boundaries of the territorial waters and covers 860 km² across the Wasini channel, excluding the marine Park and Reserve. Through this joint

area, local BMU collaborate in addressing management issues such as fishing temporal and spatial restrictions, protection of vulnerable species, data monitoring or control and surveillance.

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Chapter 3

A synthesis of women's participation in small-scale fisheries management: Why women's voices matter

Women contribute significantly to the small-scale fisheries sector globally, especially in post-production. This photo was taken in the Shimoni-Vanga seascape where fish processing is a female-dominated activity. Women called "*mama chemsha*" have specialized in the boiling of sardines ("*dagaa*"). Before selling it to customers, they need to dry the fish from a few hours to several days depending on sun intensity.

Abstract

While women globally make up nearly half of the fisheries workforce, their contribution to the sector has long been overlooked with implications for fisheries management. To assess women's participation in SSF management and related socio-cultural, environmental, and economic impacts, we conducted a systematic review of peer-reviewed literature (n= 124 case studies). Women had no or limited participation in more than 80% of the examined case studies reporting their participation level in SSF management. Women's exclusion from SSF management resulted in negative outcomes, whereas their active participation was associated with various positive impacts at multiple scales. Most of the documented impacts were socio-cultural, suggesting a gap in documenting environmental impacts stemmed from women's participation in SSF management. Importantly, most impacts reported affected the social-ecological system scale, suggesting that gender inclusion may contribute to improving the management of SSF social-ecological systems. We conclude by highlighting the need to foster gendered perspectives in data collection methods used in fisheries research, in SSF management, and in ecological research on SSF social-ecological systems.

Key words: Artisanal fisheries; Fisheries management; Gender; Inland fisheries; Ocean sustainability; Women

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1. Introduction

Despite the entrenched view that fishing is a male domain (Lentisco & Lee, 2015), women actually make up 47% of the fisheries workforce worldwide (FAO, 2016). Women's contribution to small-scale fisheries (SSF), also called subsistence or artisanal fisheries, is particularly important given that this sector represents a key source of protein for millions of people globally, especially in coastal communities (Österblom et al., 2020). Although women engage in different parts of the SSF value chain, their participation in the sector has long been invisible, ignored, and unrecognized (Harper et al., 2013; Women in the Seafood Industry organisation [WSI], 2020), partly due to narrow definitions of fishers, which exclude women's fishing activities, and partly due to gender biased sampling methods (Kleiber et al., 2015). In El Salvador, for instance, fishers are defined as people capturing fish in the open sea using boats and nets. Since Salvadorian fisherwomen seldomly use a boat to fish, their contribution to the SSF economy remains unreported in national fishery statistics (Gammage, 2004). This definition focusing on the capture node of the SSF value chain also makes invisible Salvadorian women's work in pre- and post- production activities. Data collection methods in fisheries research may also lead to the under-representation of the number of women engaging in fisheries activities. This is the case for example of survey methods targeting household heads, which may favour male over female respondents (Kleiber et al., 2015).

Against this background, over the last 30 years, some scholars have strived to give visibility to women's involvement in SSF. This trend started with the "women in fisheries" (WIF) approach, which focused on women's multiple contributions to the SSF sector (Williams et al., 2002). This research field shed light on the various roles played by women all along the SSF value chain, from pre- to post-production. WIF studies highlighted how women take part in time-consuming pre-production tasks such as repairing nets (Browne, 2002; Sotto et al., 2001) as well as in direct fish capture activities, including the case of fisherwomen using scoop nets and traps in Malaysia (Yahaya, 2001), or boats to harvest small sardines ("*dagaa*") in the Tanzanian side of Lake Victoria (Tungaraza, 1986). Several scholars also documented women's involvement in post-production activities (Ahmed et al., 2001; Siason et al., 2001). Finally, some other studies with the same approach have looked at women's caring activities for communities and households, which are also essential for the maintenance of fishing activities (dela Pena & Marte, 2001; Sotto et al., 2001). More than other activities, women's care-work, although critical for sustaining SSF activities, is often informal, unpaid, and overlooked (Williams, 2019).

More recently, the "gender and fisheries" (GAF) perspective has emerged as a new approach to document the importance of gender – defined as the socially constructed attributes associated with what is to be a female or male in various socio-cultural contexts – in SSF value chains (Bennett, 2005; Williams et al., 2002). In that sense, GAF research has explored topics ranging from intersectionality in SSF to feminist fisheries political economy (Williams, 2019). As it has become increasingly recognized that women engage in every step of the SSF value chain, GAF research has stressed the need for gendered perspectives in SSF management processes (Williams, 2010).

Fisheries management refers to the complex and continuous process aiming at using fisheries resources sustainably through different stages, from setting management plans and objectives to the implementation of required actions (Berkes et al., 2001; FAO, 1997). Scholars distinguish three main approaches to SSF management depending on the participation level of resource users: top-down processes, defined by a distant central government with no or little participation of local communities; community-led management, or approaches in which all resource users are directly and fully participating in natural resource management; and co-management, characterized by a shared authority between the community and the central government for managing fishery resources (Twyman, 2017). While there are various definitions of participation, in this study we adopt the one

proposed by Agarwal (2001) who broadly defines participation as "a dynamic interactive process in which the disadvantaged have voice and influence in decision-making" (p. 1624). Some scholars have criticized such concept suggesting that participatory approaches are more likely to reinforce existing social inequalities instead of shifting power relationships (Cooke & Kothari, 2001; Stone & Nyaupane, 2014). Conversely, a wide range of empirical studies have documented the benefits of participation for conservation outcomes and equity (Gilmour, 2016; Khan et al., 2023). In the SSF sector, local communities' participation in fisheries management has increasingly been promoted by institutions (FAO, 2015) and researchers (Cohen & Steenbergen, 2015; Jentoft, 2005; Jupiter et al., 2014), gradually shifting the debate from a focus on the participatory approach itself to its implementation on the ground (Berkes & Nayak, 2018).

In this context, a growing body of literature has emphasized the need to increase women's participation in fisheries management both for intrinsic (i.e., for its own sake) and instrumental motivations (i.e., as a mean of achieving specific outcomes) which, in turns, influences the ways that gender equity is assessed in practice (Lawless et al., 2021). On the one hand, achieving gender equity in SSF management is seen as desirable for fairness and justice principles, to guarantee that both women and men have the same rights and opportunities (FAO, 2016). On the other hand, women's participation in SSF management has also been promoted as a mean of preventing socio-environmental pitfalls (Kleiber et al., 2013; Rohe et al., 2018). In particular, previous studies have documented how failing to incorporate gender considerations in SSF management may lead to an overall under-evaluation of the actual fishing effort and catches (Mills et al., 2011), biased understandings of coastal social-ecological systems (de la Torre-Castro, 2019; Kleiber et al., 2015) or negative social impacts (Weeratunge et al., 2010; Williams, 2010).

Facing these concerns, international agencies (e.g., FAO, 2017) and researchers (e.g., de la Torre-Castro, 2019; Koralagama et al., 2017) have called for the adoption of inclusive management processes, including all resource-users, regardless of their gender, and recognizing their knowledge, perspectives, and needs in fisheries management (de la Torre-Castro, 2019; Nessa et al., 2020; Resurreccion, 2006). On the institutional front, the FAO created in 2017 a dedicated handbook on gender equity in SSF as an extension of the SSF Guidelines (FAO, 2015) to specifically address SSF challenges while improving gender equity in SSF management. In academia, research on the topic has significantly grown over the past decade (Galappaththi et al., 2022) particularly focusing on women's tasks in SSF governance (Galappaththi et al., 2022) and barriers and enablers for women's participation in SSF management and governance (Galappaththi et al., 2022; Lentisco & Lee, 2015). Some scholars have also explored the impacts related to the participation of women in such arenas. Yet, the few studies on the topic have used a limited sample size for the SSF sector (Galappaththi et al., 2022; Lentisco & Lee, 2015) or did not find sufficient evidence to be extrapolated at the global level (Leisher et al., 2016, 2017). To the best of our knowledge, no studies systematically assessed the extent of women's participation in SSF management and related impacts at a global scale and using a large sample size. This gap is surprising, as researchers have documented impacts associated to the engagement of women in other sectors including ecological restoration (Broeckhoven & Cliquet, 2015), forestry conservation (Agarwal, 2009), and environmental management (de la Torre-Castro, 2019). Addressing this research gap is not only necessary for intrinsic reasons, from a human rights perspective, but also to favor effectiveness in the sustainable use of fisheries resources in line with the FAO's SSF guidelines (2015), the Convention on Biological Diversity's Global Biodiversity Framework (target n°23) and the Sustainable Development Goals Indicators framework (SDG n° 5 and 14 in particular).

To address this knowledge gap, our work reviews documented impacts associated to strengthening women's participation in SSF management and decision-making. The originality of our review is to provide the first global quantitative assessment of women's participation level in SSF management and related socio-cultural, environmental, and economic impacts. We acknowledge the heterogeneity and diversity that exists amongst women and, more broadly, people of diverse gender identities in consideration with intersectional aspects (Kenny & Tapu-Qiliho, 2022). However, for the purpose of our

review, we chose to focus on women as a group of study since much of the literature on gender and fisheries applies a binary view and tends to emphasize women's roles within the sector as different from men's roles (House et al., 2023). Specifically, we ask the four following questions to the existing peer-reviewed literature:

(RQ1) What is the extent of women's participation in SSF management?

(RQ2) What are the socio-cultural, environmental, and economic impacts associated to women's participation -or lack thereof- in SSF management?

(RQ3) How does the direction of these impacts (i.e., positive, negative) vary depending on women's participation level in SSF management?

(RQ4) At what scale are these impacts unfolding (i.e., individual, community, SES)?

2. Materials and methods

2.1. Publication selection

We built on the methodological principles of the systematic literature review (Haddaway et al., 2015) to synthesize the existing evidence on women's participation in SSF management and related impacts in peer-reviewed journal articles, book chapters, and conference papers. To assess the literature, we performed a topical search (in title, abstract, and keywords) in two databases: Web of Science (WoS) Core Collection and Scopus. We conducted an initial search in June 2021 and updated it in June 2022. To select our search terms, we drew on Smith and Basurto's (2019) review which defines specific keywords for SSF that cover both current (e.g., artisanal fisher, Aburto et al., 2021) and historical terms (e.g., small-scale fisher, Thomson, 1980) referring to SSF. We adjusted these search terms to include gleaning activities which are often female-dominated (de la Torre-Castro, 2019) and added key words related to gender and management. The search string used was TOPIC: "small-scale fish*" OR "local fish*" OR "traditional fish*" OR "artisanal fish*" OR "subsistence fish*" OR "glean* "AND TOPIC: "gender*" OR "women* "AND TOPIC: "Management" WITHOUT TOPIC: "sex ratio". We used asterisks to broaden the scope of the search outputs. Our search did not include any geographical restriction and included both inland and marine fisheries. The search resulted in a total of 444 entries (WoS=241; Scopus=203), from which we removed 141 duplicates to screen a total of 303 publications (Figure 3.1).

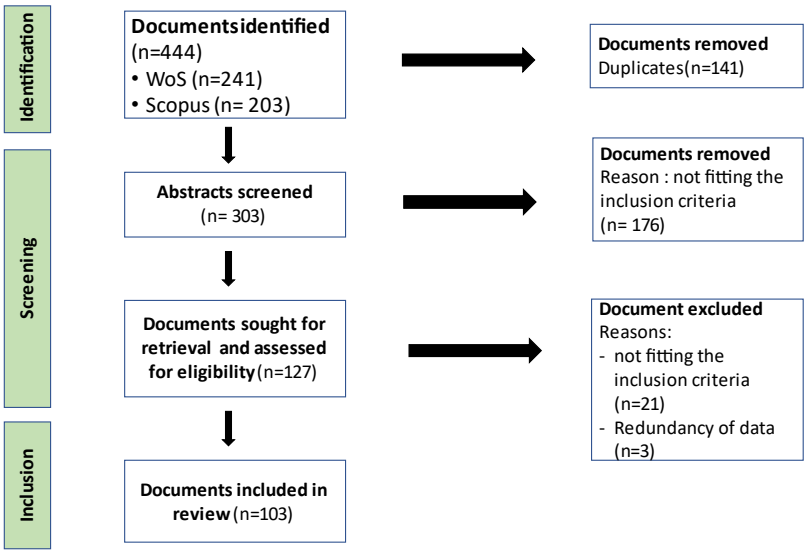

Figure 3.1: Flow chart presenting the selection of documents.

For a publication to be reviewed, it had to meet four inclusion criteria: i) use primary data, ii) have an explicit SSF context, iii) explicitly mention the term fisheries management in the body of the article (either to describe management processes and activities in the local SSF context, or to provide further recommendations) and *iv*) include information on women's participation in at least one stage of the SSF value chain (i.e., pre-production, production, post-production, care-work) and/or management tasks and activities (e.g., monitoring, administration). We chose these inclusion criteria to capture women's participation in SSF management in its broadest sense, recognizing the complexity, diversity and tangled nature of the SSF sector (Smith & Basurto, 2019). Decisions on inclusion were taken during the screening process which followed two stages. First, two coders simultaneously screened the titles and abstracts considering the inclusion criteria. Second, the lead author performed the full-text screening for all publications that passed the first selection stage. In total, we identified 103 peer-reviewed publications detailing women's participation in SSF management and related impacts. The list of publications included and the justification for document's exclusion is presented in Appendix 3 (Table S3.1; S3.2).

2.2. Data collection and coding

We collected data from the selected publications and coded information regarding women's participation in SSF management and related impacts, defined here as outcomes affecting the socio-cultural, environmental, or economic dimension of individuals, communities, or SES (Appendix 3 - Table S3.3). Two coders read the publications and coded the information following a two-step process. First, each coder was allocated half of the publications to read and code. In a second stage, the lead author checked the quality of data entry and verified the uniqueness of each publication to avoid double counting those based on the same case study. Some publications reported information from more than one case study. In these cases, we collected information separately for each case study, resulting in a total sample size of 124 case studies (Figure 3.2).

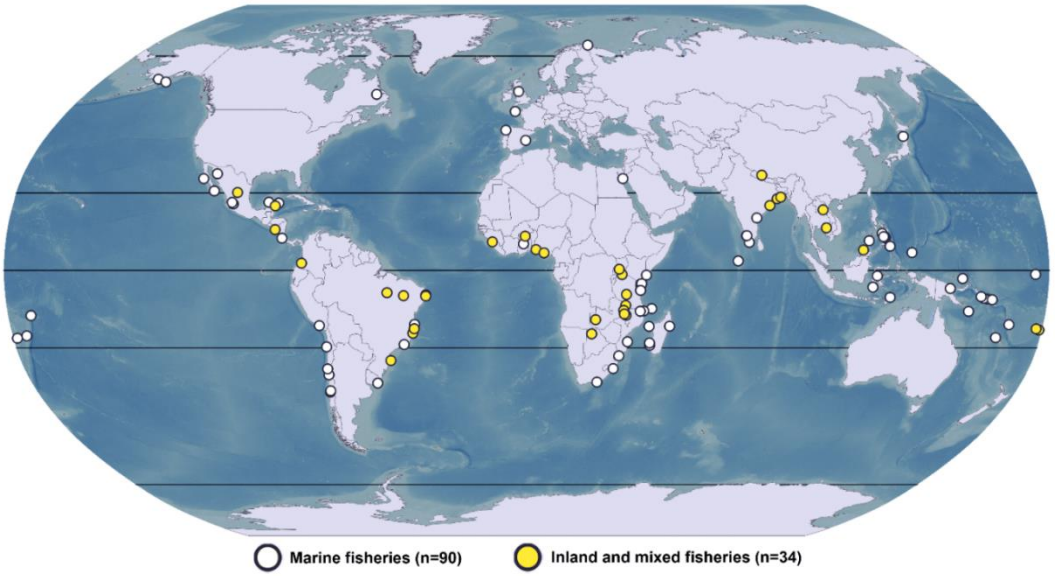

Figure 3.2: Geographical location of the 124 case studies, per fisheries type. The map was built under QGIS 3.22.7, using bathymetric data from General Bathymetric Chart of the Oceans (gebco.net).

For each publication, we recorded *verbatim* statements from selected publications referring to women's participation in SSF management. We then classified women's participation levels in SSF management. To do so, we simplified Agarwal's typology (2001) of women's participation in natural resource management by using three main level categories: excluded, limited participation, and active (Appendix 3 - Table S3.4). Then, we examined the reported impacts of women's participation in SSF management by categorizing the reported impacts as socio-cultural, environmental, or economic. Within this broad division, we created 18 subcategories of impacts using an inductive qualitative content analysis. To design these subcategories, we read through the *verbatim* statement of impacts extracted from the publications and applied in vivo coding to identify emerging types. This qualitative method is useful for coding data with a strong emphasis on *literatim* statements (Manning, 2017). In addition, we reported the direction of each impact using the same extracted *verbatim* statements and based on how the impact was framed by the author, either as a positive or negative impact. Finally, we differentiated between three scales for each impact: the entire SES, the community – including households –, and the individual scales.

2.3. Data analysis

To assess the extent of women's participation in SSF management (RQ1) and explore related impacts (RQ2), we used descriptive statistics. Specifically, we counted the frequency of each reported women's participation level in SSF management as excluded, limited participation, and active. Likewise, we ordered the different categories of impacts (i.e., socio-cultural, environmental, and economic) by frequency count. Where relevant, we illustrated quantitative results with quotes from the documents examined. To examine the relation between women's participation level in SSF management and impact direction (RQ3), we first distinguished between impacts related to either the exclusion or participation (i.e., limited; active) of women in SSF management, as well as their direction (i.e., positive or negative). Then, taking the case study as unit of analysis, we used the Pearson's Chi-squared test (Pearson, 1900) with Yates' continuity correction to statistically assess the relationship between women's participation level and impact direction. To provide a visual representation of this relationship, we used a non−metric multidimensional scaling (NMDS) as a rank-based approach that spatially displays the distance between objects in a low-dimensional space. This method can be used both with qualitative and quantitative variables (Kruskal 1964). All statistical analyses were performed with R Statistical Software (v4.2.1; R Core Team, 2021) using the *vegan* package (Oksanen et al., 2022). We considered that a difference was statistically significant when p-values were below 0.05. Finally, to assess the scale of the reported impacts (RQ4), we used descriptive statistics to count the frequency

distribution of each reported impact unfolding either at the SES, community or individual scales and combined this analysis with quotations.

3. Results

3.1. Women's participation in SSF management

Among the 124 case studies documented, 75 (60%) provided information on women's participation in SSF management. The other case studies did not give details specific enough to categorize women's participation. In these cases, the authors often provided insufficient information on gendered differences in relation to SSF management or did not mention women's role in these processes. Furthermore, we found geographical variations in gender-data provided in the reviewed literature. While most case studies were in Africa (n= 36), Oceania (n=23) and Asia (n=22), we found that only about 50% of the cases in Africa and Asia reported on women's participation level in SSF management. Conversely, although we recorded fewer studies in Europe (n=6), all of them provided this information.

Within the subsample of studies detailing women's participation level in SSF management, more than 80% of the case studies reported either women's limited participation or exclusion from SSF management. In most cases, women had limited participation in SSF management (n=39), with the documents typically signaling that women attended management meetings but did not have full opportunities to speak up and influence the outcome. This situation is illustrated by Singleton's et al. (2019) study on SSF communities in Southwest Madagascar: "Whilst women may attend meetings, few voice opinions at them, and few are confident that they have influence (…)" (p.8). Common barriers that hampered women to actively participate in SSF management processes included cultural norms and gender stereotypes that contribute to undervalue women's opinions in meetings and alter their confidence. For instance, women's limited participation, as reported by Singleton et al. (2019), was directly associated to their sense of inferiority regarding old Malagasy men who also attended SSF management meetings in their communities: "In follow-up focus groups, women stated (…) their opinion is not respected in the presence of '*nahodas*' (older men)" (p.8).

Nearly a third of the examined cases with information on women's participation in SSF management (n=22) reported the exclusion of women from management processes. In those cases, women were not joining SSF management meetings, nor other related tasks or events, either owing to formal exclusion – such as not being a member of the local SSF management body – or to informal social barriers. For example, Cele (2020) describes how female mussel collectors in poor black communities in coastal South Africa face formal gender barriers to access to SSF management activities: "(…) even when State departments such as DAFF [Department of Agriculture, Forestry and Fisheries], and Ezemvelo KZN Wildlife engage with community-based fishing organizations, they do not invite women mussel harvesters to these meetings. Such tendencies deprive women of access to pertinent harvesting information, and training, and further perpetuate gender divisions in the industry" (p.145). Entrenched gender inequalities can also prevent women to join these activities, even if their formal access is guaranteed. In particular, domestic duties and childcare were reported as a major constraint for women as SSF management meetings often happen in the evening, thus overlapping with women's house chores and excluding them *de facto* from these events (Gustavsson et al., 2021; Santos, 2015; Torell et al., 2021).

By contrast, only 14 case studies documented women's active participation in SSF management. This is, for example, the story of the CoopeTarcoles R.L SSF cooperative in Costa Rica: "Slowly, CoopeTárcoles

R.L has been expanding beliefs on the role of women, promoting the fact women can and do play an active role and contribute on a daily basis to the community's economic, social, and cultural life. Women have been accepted in the cooperative and have taken active roles in the Administrative Council" (Rivera et al., 2017, p.13).

3.2. Typology of impacts related to women's participation in SSF management

Among the 124 selected case studies, 98 (about 80%) reported impacts related to women's participation in SSF management. We recorded a total of 190 socio-cultural, environmental, and economic impacts derived from either women's participation (n= 121) or exclusion (n= 69) in SSF management. We documented impacts considering 18 different categories as presented in Table 3.1.

Table 3.1: Reported socio-cultural, environmental, and economic impacts related to women's participation- or lack of – in SSF management processes.

Scale	Category	Subcategory	Example	Corresponding quote & reference
Social-ecological system	Socio-cultural	Change in the understanding of the gender dynamics within the SSF[b] SES[c] (Comprehensiveness)	Gendered perspectives in SSF management in Brazilian Amazonia highlight differences between fishermen and fisherwomen's practices, hence providing a comprehensive view for fish stock assessments	"*The study results also confirmed our hypothesis that differences between fishermen and fisherwomen in species composition of catches were influenced by the types of gear used and fishing sites explored"* (Zacarkim et al., 2015, p. 415)
		Change in the impact of management decisions on women (Gendered management impact)	Women's exclusion from the designation process of a marine closure in the Solomon Islands has negative social consequences on their daily lives	*"Women were more constrained in their fishing activities because a marine closure was located where mainly women used to fish. Our study highlights the importance of paying attention to women's needs and actions in the governance of the fishery"* (Rohe et al., 2018, p.155)
		Change in the recognition of gendered ecological knowledge (Gendered ecological knowledge)	The deep-rooted knowledge of fisherwomen on salmon distribution and abundance can guide the management of salmon fisheries in Alaska	*"The experience and knowledge of these women can inform fishery managers of various aspects of environmental change. For example, their knowledge of change in salmon distribution and abundance over the years, can be used to triangulate data used by managers for decision making regarding the resource" (*Lavoie et al., 2019, p.336)
		Change in the compliance to management measures (Compliance)	The engagement of women's and men's groups contribute to fostering local support and acceptance to a fishery management plan in Samoa	*"Regardless of legislation or enforcement, the responsible management of marine resources will only be achieved when fishing communities themselves see it as their responsibility. Accordingly, the strategy focused on mobilizing each community through direct contact with key village groups. These included women's groups and untitled men's groups to ensure the widest community participation and eventual ownership of the village fisheries*" (King & Faasili, 1999, p.2)
		Change in the diversity of perspectives for SSF management (Diverse perspectives)	Women's participation in SSF management leadership positions brings new views and skills that favor the development of co-management in the Chile's Biobio region	"*Some of them* [fishermen] *mentioned that women's management skills when assuming a leadership position was favored: "In a short time, she has gotten two projects that never happened before. . . women have another way of thinking (fisherman member #9)"* (Franco-Melendez et al., 2021, p.14)
	Environmental	Change in the long-term use of fisheries resources (Sustainable management)	The participation of Galician women in the management of shellfish in Spain allows to sustain shellfish resources over the long term	*"Some interviewees highlighted the particular management logic of the shell fisherwomen, in which they take a systemic view of resource Management"* (Fadigas, 2017, p.565)
		Change in human pressure on local ecosystems (Ecological pressure)	The exclusion of Fijian fisherwomen from fisheries management decisions raises concerns about the risk of increasing ecological pressure on coastal resources	*"As many more women enter commercial markets, there is a growing concern that women may be harvesting and selling undersized juvenile fish from these habitats, affecting the sustainability of some of the common fisheries."* (Thomas et al. 2021, p.7)

[b] Small-scale fisheries (SSF)
[c] Social-ecological system (SES)

Community	**Socio-cultural**	Change in food security (Food security)	The important role of fisherwomen for providing fresh fish to their households has implications for fishery management in the Maldives	*"This suggests that women's involvement in small-scale reef fisheries, while not necessarily direct, might still be important to consider especially from the point of view of island food systems and the processes that contribute to the nutritional health of communities"* (Yadav et al., 2021, p.3)
		Change in adaptive capacity (Adaptive capacity)	Women's roles in small-scale fishing communities in Peru and Japan contribute to improve the capacity of their community to adapt to external chocks	"*In the two cases reported here, women are taking responsibilities and applying innovative activities to adapt to disturbances in the fishery system*" (Delaney et al., 2019, p.292)
		Change in the social attributes of the community (Community social attributes)	Women's action through self-help groups favors solidarity within small-scale fishing communities in Kerala, India	"*The empowerment of women through SHGs leads to benefit not only the individual women and women groups, but also the family and community as a whole through collective action and solidarity*" (Jeeva & Gopal, 2021, p.175)
		Change in the transmission of traditional knowledge (Cultural heritage)	The participation of native women in a Marine Extractive Reserve in Brazil has the potential for preserving the traditional knowledge of their community	"*Their participation [of women] in the management is expected to contribute rules for political strengthening and income production, thus keeping the traditional knowledge and maintaining the native population in the area* " (Di Ciommo, 2007, p.65-66)
	Economic	Change in community income (Community income)	Women's participation in SSF management through fishing permits in Isla Arena, Mexico, brings more revenue for their households	"(…)*an aspect that is cross-sectional in these arrangements is financial motivation, since having the permits is something that strengthens the reception of economic resources by the families*" (Uc-Espadas et al., 2017, p.392)
Individual	**Socio-cultural**	Change in well-being (Well-being)	Women's engagement in the management of their local fisheries resources in Chile's Biobio region enhances their feelings of tranquility and security	"*Several fisherwomen emphasised the feelings of tranquillity and the security of having something of "their own" that they could nurture*" (Gallardo-Fernandez & Saunders, 2018, p.184)
		Change in capacity building (Capacity building)	Fisherwomen who are part of a union in Chile's Biobio region learn new skills in the process of managing their local fisheries resources	*"We learned to work together… in group; because this work was always done individually; we learned to manage; we learned to find nexus networks, in which to support us to continue the struggle"* (Gallardo-Fernandez & Saunders, 2018, p.184)
		Change in women's empowerment (Empowerment)	Women's participation in a Costa Rican SSF cooperative gives them personal confidence	*" (…) opportunities have opened up for some of the women fishing leaders to participate in activities, conferences and seminars that broaden their horizons and build their self-esteem*"(Rivera et al., 2017, p.13)
		Change in gender roles (Gender roles)	Women's participation in the co-management of arapaima fisheries in Brazilian Amazonia contributes to change gender dynamics and alter traditional gender roles	*"They* [Women] *also pointed out the opportunity of having both genders working together, and of women being able to take part in an activity that used to be male-dominated" (*Freitas et al., 2020, p.6)
		Change in women's leisure time (Women's leisure time)	The transference of fishing permits from men to women in Isla Arena, Mexico, is associated with an additional workload that reduces women's free time	"*We found testimonies such as the following where the woman permit holder expressed that this condition represents a load of tasks for women, particularly because of the paperwork and trips they have to make" (*Uc-Espadas et al., 2017, p.394)
	Economic	Change in women's income (Women's income)	Women's participation in the co-management of arapaima fisheries in Brazilian Amazonia leads to an increase in their fishing revenue	" (…) *woman living in a community with arapaima co-management would have a mean probability of 77% of earning money from fisheries, compared to only 8% for a woman living in a community without arapaima co-management* " (Freitas et al., 2020, p.5)

Most reported impacts of women's participation in SSF management were socio-cultural (n= 153). The most frequently reported impact was change in the impact of management decisions on women (n=28), referring to cases where the management measures taken had unintended social consequences on women's lives. In most reviewed cases (93%), this impact was associated to women's exclusion from SSF management processes rather than their participation (Figure 3.3). For instance, women in the Solomon Island were excluded from a discussion on the designation of a marine closure, which had a negative social impact on their daily life: "Women were more constrained in their fishing activities because a marine closure was located where mainly women used to fish" (Rohe et al., 2018, p.155). Another very common socio-cultural impact was change in the recognition of gendered ecological knowledge (n=20). This impact was predominantly associated to cases where women participated in SSF management (limited or active participation). In those cases, women's participation in management processes allowed to express specific gendered local knowledge that helped management operations such as determining salmon stocks (Lavoie et al., 2019), generating a map on fisheries resources (Paul et al., 2016), or assessing SES vulnerability in coastal communities (Tilley et al., 2021). The third most cited impact was change in the diversity of perspectives for SSF management (n=17). Women's participation in SSF management was associated to new viewpoints and skills that broadened the scope of reflection for management processes. As an illustration, women's participation in leadership positions in the Chile's Biobio region led to the development of a co-management program owing to their organizational and managerial skills (Franco-Melendez et al., 2021).

Women's level of participation in SSF management had a much lower number of reported environmental (n= 21) and economic impacts (n= 16). The most common environmental impact associated to women's participation in SSF management was change in human pressure on local ecosystems (n= 13), whereas the predominant economic impact was change in community income (n= 9).

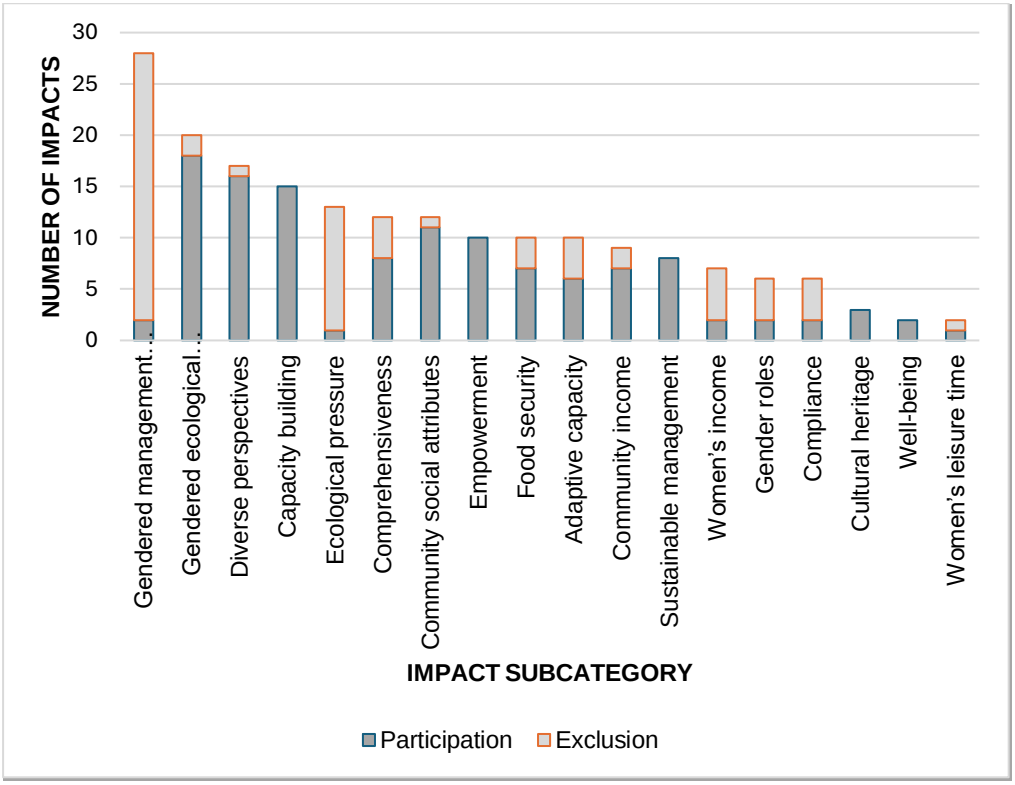

Figure 3.3: Number of impacts per subcategory (n=190). The impacts displayed in dark grey are associated to cases where women participate in SSF management (i.e., limited or active participation) whereas impacts in light grey are those associated to women's exclusion cases.

In this sample, 120 impacts were considered positive and 70 as negative. As an example, change in women's leisure time was both associated to positive impacts when leisure time increased (Paul et al. 2016) and negative impacts when it decreased (Uc-Espadas et al., 2017). The NMDS analysis suggests that there is an association between women's level of participation in SSF management and the direction of impact (Figure 3.4). While women's exclusion from SSF management was often associated to negative impacts, their active participation was mostly related to positive impacts. This is the case, for example, of Chilean women who participated in the management of a surf clam fishery in Coquimbo Bay, resulting in benefits for the whole community: "The presence of women in the present organization has helped to reduce conflicts and provide better organization" (Aburto et al., 2021, p.5). Limited participation was associated both to negative and positive impacts. For example, Gustavsson et al. (2021) who analyzed cases in Chile, France, the United Kingdom, and Tanzania, highlight how women's marginalization in SSF management and governance resulted in reinforcing distributive injustice. In contrast, in another study by Franco-Melendez et al. (2021) on Chilean coastal communities, women's participation in SSF management – though limited – led to their personal empowerment. Results of a Pearson's Chi-squared test confirmed a statistically significant relation between women's participation level in SSF management and the report of positive impacts (p-value =0.001).

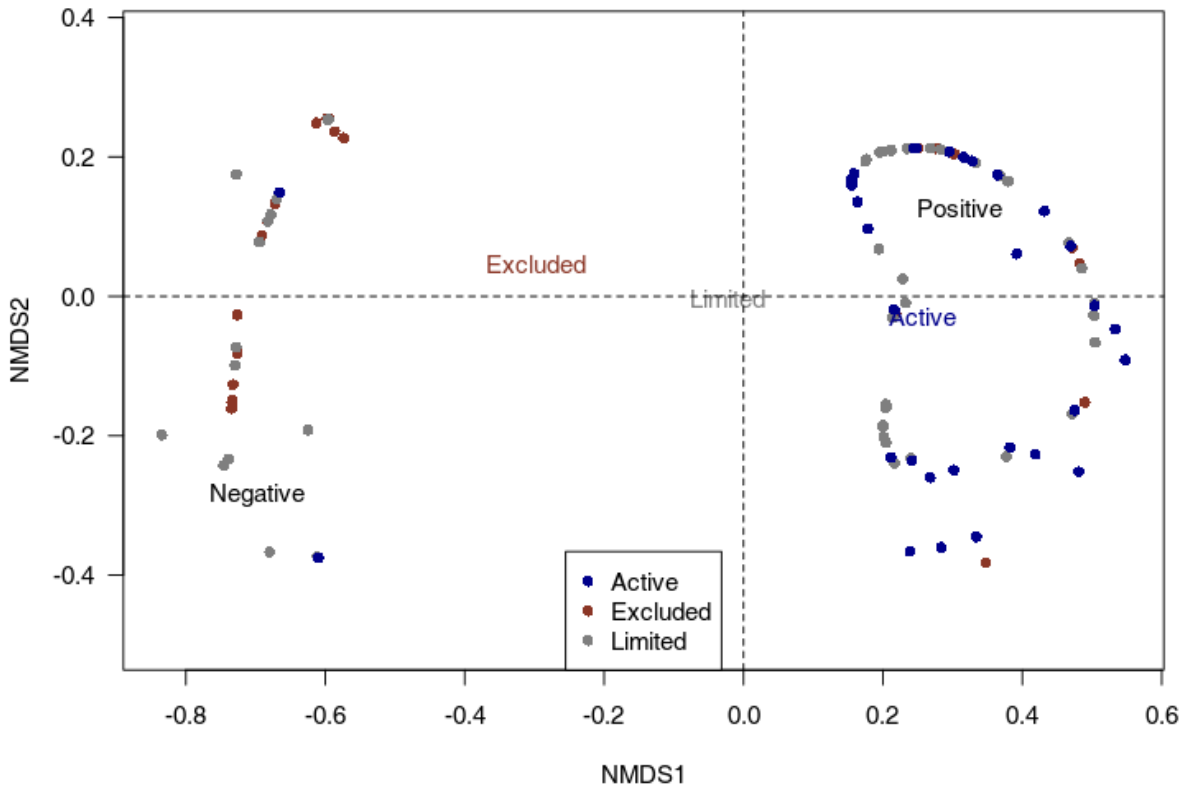

Figure 3.4: Non-metric multidimensional scaling (NMDS) ordination plot illustrating differences in impact direction among women's level of participation in SSF management processes (i.e., excluded, limited, active). The points to the left are impacts perceived as negative, the ones to the right are positive; colors indicate women's participation level in SSF management, and the colored words indicate the estimated center of each management category in this space.

3.3. Scale of the impacts of women's participation in SSF management

We found that impacts of women's participation in SSF management affected SES, local communities, and women's life (Figure 3.5).

Most reported impacts primarily affected the whole SES (n= 104). As aforementioned, the most common one was change in the impact of management decisions on women (n=28), followed by change in the recognition of gendered ecological knowledge (n=20), change in the diversity of perspectives for SSF management (n=17), change in human pressure on local ecosystems (n=13), and change in the understanding of the gender dynamics within the SSF SES (n=12). Because these impacts shape SSF management outcomes, they influence the dynamics of the SSF SES system. For instance, the inclusion of gendered perspectives in SSF management in Brazilian Amazonia contributed to the improved understanding of gender differences in fishing practices, thus improving SSF management outcome (Zacarkim et al., 2015).

Women's participation in SSF management also affected local communities (n = 44), particularly through change in the social attributes of the community (n=12), change in adaptive capacity (n=10), and change in food security (n=10). As an illustration, Delaney et al. (2019) show that women's participation in a local fishery cooperative association in Japan contributed to the adaptation of their households and community to socio-economic uncertainty. Similarly, studies also documented how impacts affected women's personal life (n= 42) through capacity building (n=15) or women's empowerment (n=10), to cite the most common ones. In the latter case, we used Kabeer 's (1999) definition of empowerment as "a process by which those who have been denied the ability to make strategic life choices acquire such an ability" (p.1), interlacing the concepts of resources (both material and immaterial), agency and achievements.

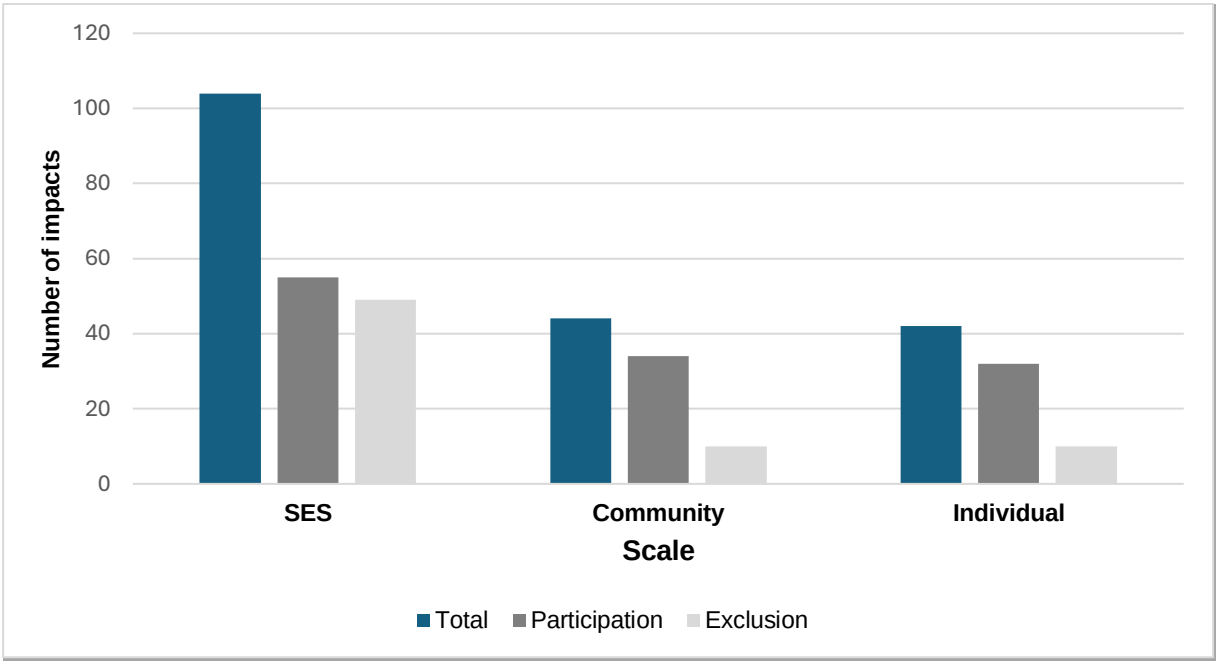

Figure 3.5: Bar chart displaying the number of reported impacts at the social-ecological system (SES), community, and individual scales (n=190 impacts). The impacts displayed in dark grey are associated to cases where women participate in SSF management (i.e., limited or active participation) whereas impacts in light grey are those associated to women's exclusion cases.

4. Discussion

Our work analyses the state of academic knowledge on women's participation in SSF management and related socio-cultural, environmental, and economic impacts. Unfortunately, 40% of the studies do not report on women's participation in SSF management. Results from the studies reporting on women's participation in SSF management suggest that their participation is low, as most case studies report the exclusion or limited participation of women in SSF management. Our results also suggest that women's exclusion from SSF management was associated to negative outcomes whereas women's active participation in those processes was associated to positive outcomes. Most of the identified outputs of women's participation were socio-cultural, bringing to light a gap on assessing the potential environmental and economic impact of women's participation in SSF management. A final finding of this work is that most of the reported impacts unfolded at the SES scale, suggesting a win-win situation between gender-inclusive SSF management and outcomes at the SES scale.

Before commenting these results, we highlight some caveats of our work. We are aware that our review has several limitations streaming both from data availability and from the data collection methods. First, results from our work are limited by the overall lack of data on women's contribution to the SSF sector, as also underscored in the literature (Alonso-Población & Siar, 2018; Kleiber et al., 2015; Williams, 2010). We believe that the scarcity of gender information is not neutral but value-laden, since our dataset reflects authors' interests and priorities who may chose or not to report on women's participation in SSF management. This unavoidable authors' subjectivity might also shape the type of reported impacts. Therefore, our results shall be interpretated with caution as they likely underestimate the total number of existing impacts associated with women's participation in SSF management. Such data gaps represent a severe obstacle to the development of a thorough gender analysis in the fisheries sector, and we hope that our study may encourage researchers to pay more attention to gender issues and related impacts in the future. Besides, the lack of data on women's participation in SSF management was not homogeneous across regions, but larger in Africa and in Asia, which suggests the need to strengthen research in these two regions. This is especially critical given that most of the reviewed cases were precisely located in Africa and Asia, regions where SSF is very important. Second, our results are also limited by our data collection methods, as we restricted our search to two search engines which mostly feature publications in English and exclude the wealth of studies and reports produced by non-governmental and other organizations (Kleiber et al., 2015). Such drawbacks underline the difficulty of developing comprehensive gender assessments in fisheries and reinforce the need for improving the collection of gender-disaggregated data.

4.1. Women's participation in SSF management

According to the reviewed literature, women's participation in SSF management is low, with women having no or limited participation in more than 80% of cases reporting women's participation. The finding is consistent with the work of Rabbitt et al. (2022) that also builds on Agarwal's (2001) participation typology in the context of CBFM in Melanesia. Their results suggest that the equal number of women and men in fisheries committees, although necessary, is not sufficient to ensure the meaningful participation of women in CBFM. In the same vein, Lawless et al. (2022) found that most local organizations in the Pacific Islands region aimed to increase the number of women in traditionally male-dominated arenas without addressing structural gender inequalities. Because this approach does not displace existing gender barriers, it limits the active participation of women in SSF management

and policy. Other authors have also criticized this quantitative view of women's participation in natural resource management as a form of box-ticking approach with no transformative value (Cornwall, 2003). Our results point to the fact that fisheries management is very androcentric, as also documented by other studies in SSF (Kleiber et al., 2015; Williams, 2010), and echoing studies in other activity sectors such as forestry (Mwangi et al., 2011), agriculture (Buchy & Basaznew, 2005; Huyer, 2016), wildlife conservation (Massey et al., 2022), and more generally in environmental governance systems (Alonso-Población & Siar, 2018; Organization for Economic Co-operation and Development [OECD], 2021). Literature on the topic identifies common barriers to women's participation in SSF management processes such as gender norms and stereotypes and domestic responsibilities (Bradford & Katiro, 2019; Galappaththi et al., 2022; Murunga, 2021; Secretariat of the Pacific Community [SPC], 2018). Our findings on women's restricted access to SSF management and decision-making processes also echo Agarwal's work (2001) on forestry showing that even when women can formally access community forestry groups, social norms and perceptions hinder their actual participation in meetings. In the case of patriarchal societies, women's ability to fully participate in fisheries management is constrained owing to social norms that contribute to maintain their marginalized status and perpetrate gender inequality (Bennett, 2005; Murunga, 2021). To that extent, our study adds to existing evidence suggesting that many SSF communities in the world are characterized by patriarchal social structures (Bradford & Katiro, 2019; Lentisco & Lee, 2015). These findings imply that moving towards gender equity in SSF management will require to address structural social constructions (McDougall et al., 2021).

4.2. Typology of impacts related to women's participation in SSF management

One key finding of our work is the great diversity of reported socio-cultural, environmental, and economic impacts associated to women's participation-or lack of- in SSF management. These results reinforce the need to integrate a gendered perspective into SSF management and governance by looking at women's specific engagement in those processes, as stressed by previous studies (de la Torre-Castro, 2019; Galappaththi et al., 2022; Lentisco & Lee, 2015).

Interestingly, we found that the most frequently reported impact – namely change in the impact of management decisions on women – was associated to the exclusion of women from SSF management and not to their participation. This finding concurs with the overall low level of women's participation in SSF management assessed on the reviewed literature. Moreover, this result highlights how women's exclusion from SSF management may lead to negative social consequences derived from exclusionary management, further reinforcing gender inequalities. In this sense, our findings dovetail with those from an emerging literature documenting the diverse negative impacts of gender blind SSF management policies in relation to the establishment of MPA (Walker & Robinson, 2009), fisheries commercialization (Hapke, 2004), or access to fisheries resources (Harper et al., 2013; Siar, 2003).

Another important reported impact was change in the recognition of gendered ecological knowledge through a utilitarian perspective, suggesting that researchers are more inclined to report this impact for instrumental purpose. This result is in line with Harper et al.'s (2013) review of women's roles in SSF. Examining various cases in different world regions, the authors highlight the untapped value of women's marine ecological knowledge as a source of information for fisheries management in data poor countries. Likewise, House et al.'s (2023) review of gender and participatory monitoring in CBFM also highlights the value of women's knowledge for fisheries management by showing that it represents one of the main instrumental motivations for researchers on CBFM to study gender in relation to participatory monitoring. The instrumental importance of women's ecological knowledge is not unique to SSF, but rather resonates with other research fields. In the forestry sector for instance, Agarwal (2009) shows how women's specific knowledge on forest plant species and their harvesting methods were useful for conservation outcomes in Indian and Nepalese local forests.

Contrasting with the variety of socio-economic impacts of including women in SSF management, we recorded fewer environmental impacts. While one explanation for this finding could be that women's participation in SSF management does not have noticeable environmental impacts, we suggest instead that women's participation in SSF management is mostly studied through a social lens, thus challenging a thorough gender analysis of the whole SES. Such findings align with Kleiber et al. (2015), who showed that gender and fisheries research is mostly characterized by social and qualitative approaches and identified a data gap with regards to the environmental dimension of women's fisheries-related activities. Such a gap might also reflect the common idea that women's practices represent a low pressure on coastal ecosystems. Yet, existing evidence is too scarce to assess the actual impact of women's fishing activities on coastal species and habitats. Indeed, the scanned existing evidence goes in both directions: in some cases, women's extractive activities in coastal areas may be deleterious for local ecosystems (Gammage, 2004), while evidence from the past suggest that in other cases certain fishing practices used by women such as clam gardens can enhance ecological outcomes in SES (Deur et al., 2015; Thrush, 2006). Overall, this ecological understanding appears necessary for comprehensively assessing the health status and dynamics of marine and coastal ecosystems (Kleiber et al. 2015). Further research is thus needed for analyzing women's participation in management in relation to the sustainable use of fisheries resources.

Overall, our results suggest that women's lack of participation in SSF management was associated to negative outcomes. These findings echo the literature in other fields, such as the work of Buchy & Basaznew (2005), showing that the absence of gender considerations in agricultural policy in Ethiopia resulted in reinforcing women's economic marginalization. On the contrary, women's active participation in SSF management activities led to positive outcomes. As highlighted by some scholars, women often have recourse to informal social networks to counterbalance their restricted access to formal institutions (Agrawal, 2000; Molyneux, 2002; More, 1990). This level of interdependency has been suggested by Westermann et al. (2005) as a driver for fostering collaboration, solidarity, and conflict resolution among women's groups, thus bringing positive outcomes in natural resource management. Other studies have also documented positive outcomes in the SSF sector when gender norms and stereotypes are overcome and the enabling conditions are met for women to effectively participate in resource management and decision-making (de la Torre-Castro, 2019; Galappaththi et al., 2022; Lentisco & Lee, 2015). This suggests that encouraging women's meaningful participation in SSF management is needed for driving positive social outcomes.

4.3. Scale of the impacts of women's participation in SSF management

A striking result of our study is the multiscale nature of the reported impacts, ranging from the whole SES to the individual level. Importantly, we found that a great proportion of the reported impacts unfolded at the SES scale with potential for win-win situations in SSF management. This finding aligns with previous reviews in the SSF literature suggesting that women's participation in SSF management has knock on effects in the governance system of the SES (Galappaththi et al., 2022; Lentisco & Lee, 2015). This is also consistent with studies from other resource management systems supporting that women's participation in resource management leads to better outcomes for the whole SES and for local communities (Agarwal, 2009; Westermann et al., 2005). In particular, a body of studies (Boserup, 1970; Duflo, 2012; Verschuur et al., 2021) and institutional reports (UN Women, 2019) have documented a ripple effect from improved women's income and economic development at the local level. Finally, our results also suggest that women's participation in SSF management might also lead to positive change in women's own lives. Such findings fall into the existing body of work on environmental governance and development showing how women's participation in decision-making processes can foster their personal empowerment (de la Torre-Castro, 2019) or networking capacities (Arora-Jonsson, 2014). Overall, the literature identifies major enablers for women's participation in SSF management such as state institutions (Alonso-Población & Siar, 2018) and initiatives favoring women's capacity building and self-organisation (Lentisco & Lee, 2015; Murunga, 2021).

Altogether, our results suggest that women's participation in SSF management is not only necessary from an intrinsic viewpoint, but also in instrumental terms since it has the potential to contribute to improving SSF management strategies at the SES scale, while providing benefits to local communities. These results imply the need to overcome gender barriers "to ensure that women are given both a clear voice and decision-making power" (Westerman et al., 2005, p 13). In this sense, our findings support the recent call made by scholars for a blue justice that integrates gender in SSF governance (Engen et al., 2021; Too Big To Ignore [TBTI], 2018). The concept of blue justice proposes a shift from an economic-oriented perspective in ocean governance, the blue economy, to the recognition of social justice within those debates (Bennett et al., 2021). Our article builds on this work and highlights the need for a new coastal management and ocean governance model that fully includes women in decision-making processes.

4.4. The way forward

Given the highly gendered nature of SSF (Gallois & Duda, 2016; Koralagama et al., 2017), there is a need to consider gendered dimensions in its management (Harper et al., 2013; Kleiber et al., 2015). In this article, we assessed women's participation in SSF management and related socio-cultural, environmental, and economic impacts based on existing peer-reviewed academic literature. Taken together, our findings support a better integration of gendered perspectives into (1) data collection methods in fisheries research (2) SSF management and decision-making, and (3) ecological research on SSF social-ecological systems.

First, we need to address the paucity of gender data in fisheries research to improve our understanding of SSF and design thorough management. One major limitation we faced in this review was the lack of gender-disaggregated data which constrained our assessment of women's participation in SSF management, especially in regions where SSF plays a significant role for food security such as Africa and Asia (FAO, 2020; Mills et al., 2011). Broadly speaking, gender myopia in SSF might result in a general underestimation of the number of fishers, fishing effort, fishing management activities, and therefore in a biased understanding of ecosystem health (Kleiber et al., 2013; Williams, 2010). Second, we found that women's participation in SSF management was low, yet their active engagement produced multiple positive outcomes. We argue that women's active participation in SSF management and decision-making processes appears desirable for achieving gender equity in SSF and improving SSF management. Our findings align with the recent call for inclusive management in SSF, which encourages the participation of actors with diverse identities in management processes (de la Torre-Castro, 2019; Nessa et al., 2020; Resurreccion, 2006). For instance, women's participation in monitoring has been recommended as a way to improve data collection, while facilitating women's access to decision-making processes (House et al., 2023). Finally, our results identified a knowledge gap on the environmental aspects related to women's participation in SSF management. This reflects that gendered perspectives in fisheries research remain concerned by social issues and are poorly mainstreamed into environmental studies on fisheries (Kleiber et al., 2015). It is essential to foster gender knowledge in environmental research on SSF to provide a comprehensive and meaningful analysis of the role of women in SSF management.

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Chapter 4
The gendered dimensions of small-scale fishing activities: A case study from coastal Kenya

In the Shimoni-Vanga seascape, small-scale fishing activities are highly gendered with both men and women engaging in fishery production but in different ways.

Abstract

Although women contribute substantially to the small-scale fisheries sector globally, in many countries there is a severe lack of gender-disaggregated data on fishing activities. This gender data gap hampers a comprehensive understanding of small-scale fisheries dynamics with implications for fisheries management and food security. In this study, we investigate women's and men's engagement in small-scale fishing through a case study in coastal Kenya, a region characterized by a high dependence on fisheries for local livelihoods and nutritional needs. We applied a mixed method approach, combining participant observation, photography, semi-structured interviews on gender identities (n=11) and gendered fishing practices (n=28), an individual survey (n=141), and pebble games (n=35). Our results reveal a marked gendered division of labor across the seascape, with women mostly fishing in intertidal areas and men beyond the reef. Further, we find that women's fishing practices are characterized by less fishing gear, less catch, a lower functional diversity of catches, less fishing effort, and less income than those of men. However, women's catches contribute significantly to local diets, accounting for up to 50% of the fish and seafood consumed in fisherwomen-headed households. Despite women's fishing activities appearing less productive and profitable that those of men, they are important for achieving food security in Kenyan coastal communities. Results from this study contribute to broadening our understanding of the gendered dimensions of small-scale fishing and highlight relevant information for developing gender-inclusive management strategies. We conclude by providing key recommendations for fisheries research, management, and governance.

Key words: Artisanal fishing; Fisheries management; Food security; Gleaning; Western Indian Ocean; Women

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1. Introduction

Globally, small-scale fisheries are pivotal for local livelihoods, economy, and food security (FAO et al., 2023). Small-scale fisheries, also called artisanal fisheries, stand out for their lack of consensual definition within the scientific community (Smith & Basurto, 2019). They are broadly understood as multi-gear and multispecies fisheries with common technical and socio-cultural characteristics such as low-capital fishing methods, which differentiate them from industrial fisheries (FAO, 2022). Small-scale fisheries are the largest employer in the marine sector, representing 90% of the world's fishers and providing a key source of income for local communities (FAO et al., 2023). Further, SSF account for 40% of the global catch in capture fisheries and provide proteins and micronutrients for millions of people globally (Österblom et al., 2020). However, SSF often escape fisheries statistics owing to their diverse and informal nature, a certain disregard from governmental administrations, and methodological biases (Basurto et al., 2017). The lack of systematic and accessible data on SSF poses a challenge for the accurate quantification of their contribution to the sector to guide fisheries management (Smith & Basurto, 2019). This data gap is further exacerbated when it comes to considering the gendered nature of SSF.

Although women make up 40% of the SSF workforce (FAO et al., 2023), their engagement in fisheries has long been invisible, ignored, and unrecognized (Chambon et al., 2023; WSI, 2020). The commonly held image of SSF continues to be one of a male-dominated activity as epitomized by the term "fisherman" (Branch & Kleiber, 2015), thus overlooking women's participation in the production node and beyond (Smith & Basurto, 2019). Against this background, there has been a recent interest in fisheries policy development and research in adopting a gender lens to grasp a more complete picture of fisheries (FAO, 2016; Williams, 2008). At the institutional level, the FAO's Gender Handbook (2017), which completes the FAO's SSF Guidelines (2015), reiterates the importance of gender equality and equity in SSF. In academia, the growing study field of gender and fisheries aims to understand how gender – alongside other social categories such as age or ethnicity – influences the engagement of individuals of diverse gender identities in the SSF sector (Williams et al., 2002, 2008).

In this regard, researchers have striven to highlight the important contribution of women in fishing households from caring tasks such as cooking to raising children or managing finances (Raduan et al., 2010; Szymkowiak, 2020). While these support activities are not directly part of SSF, they are necessary for sustaining the whole SSF productive economy (Williams, 2019). Within the SSF value chain, women's participation has been primarily reported in the post-production stage, through fish processing and sales (Chavance & Morand, 2020; Lentisco & Lee, 2015). At the production level, studies have documented how fisherwomen also account for an important part of the fisher population, although their contribution to SSF landings varies regionally (Fache & Breckwoldt, 2023; FAO, 2022; Weeratunge et al., 2010). Research shows that women's fishing practices often differ from those of men, as they mostly consist of gleaning invertebrates in nearshore waters, while men usually fish offshore using boats (Grantham et al., 2020; Kleiber et al., 2015). It has been globally described in the literature how these differences in access and uses of fisheries resources maintain a gendered division of the seascape (Koralagama et al., 2017) – defined here as a spatially heterogeneous marine area, scientifically and strategically defined, and perceived as a mosaic of patches (Boström et al., 2011; Pittman, 2018). Despite these recent efforts to document the gendered nature of fishing activities, gender-disaggregated data on fishing, especially quantitative information, remains particularly scarce, which challenges the development of effective management strategies (Chambon et al., 2023; Kleiber et al., 2015).

In Kenya, SSF dominate the marine fisheries sector, accounting for 80% of the marine catch in volume (Kimani et al., 2018). Like in other tropical coastal countries, Kenyan SSF contribute substantially to

local socio-economic and nutritional needs. While Kenyan SSF have been extensively studied from a social-ecological point of view (Cinner et al., 2012; Evans et al., 2011; Lau et al., 2021), little research has adopted a gendered approach and examined women's roles in the fisheries sector (Matsue et al., 2014). The limited number of studies on the topic have mostly focused on women's participation in pre- and post-production. For instance, previous research has highlighted the importance of female small-scale fishmongers for SSF management and governance in Kenya (Matsue et al., 2014). Overall, there is a major data gap regarding women's participation in small-scale fishing. Although the Kenyan authorities estimate that fisherwomen represent less than 2% of the total fisher's population (GoK, 2016), current gender biases in fisheries research methods (Kleiber et al., 2015) are reason to consider this number with caution. A handful of studies have started describing women's fishing practices in Kenya by examining their ecological knowledge (Alati et al., 2020), their engagement in specific fisheries such as the shelled mollusc fishery (Alati et al., 2023), and their vulnerability to external shocks such as Covid-19 (Lau et al., 2021), calling for further research on fisherwomen's activities and contributions to local livelihoods.

The data gap on fisherwomen in Kenya is problematic from an ecological, socio-economic, and governance standpoint. First, the lack of information about women's fishing practices may lead to underestimating their fishing efforts as well as the range of species and ecosystems they target, with direct implications for fisheries management (Kleiber et al., 2015). For instance, Kleiber et al. (2013) show how the limited definition of what a "fisher" is in SSF communities of the Central Philippines obscured the gleaning activities of women, leading to an underestimation of the total fishing effort and catch. This gender data gap also poses a challenge for a thorough understanding of Kenyan coastal social-ecological systems (SES) and the interconnections between fisherfolk and fisheries resources. Second, overlooking fisherwomen's activities may lead to an under-valuation of their socio-economic contribution to their communities and households, particularly in terms of food security. For example, the importance of women's contributions to subsistence fishing has been widely documented in other regions of the world (Harper et al., 2013; Hauzer et al., 2013; Thomas et al., 2021), but evidence in Kenya is scarce. This lack of information may mask the importance of fisherwomen's catches for local food security and household income. Finally, the lack of gender-disaggregated data in fishing has implications for fisheries governance since it may generate a gender-blind feedback loop which, in turn, excludes women from management and governance positions (FAO et al., 2023). As long as fisherwomen's practices remain undocumented, their needs and views may fail to be included in management and decision-making (Chambon et al., 2023; Mangubhai & Lawless, 2021).

To address the gender gap in SSF in Kenya, in this paper we document and quantify the respective contributions of fisherwomen and fishermen to the SSF sector with regard to local food security. More specifically, our research aims at:

(O1) Understanding how gender identities shape the access and uses of the seascape;

(O2) Documenting gendered fishing practices and their spatiotemporal fluctuations;

(O3) Comparing daily fishing catch, effort, and income of fisherwomen and fishermen;

(O4) Analyzing the composition of local meals and fisherwomen's contribution to diets.

While we acknowledge the diversity of gender identities within fisherfolk (Kenny & Tapu-Qiliho, 2022), we apply here a binary view of gender (i.e., women and men) since this approach was culturally appropriate. Although this study did not address all aspects of gender that influence local power dynamics, we expect it to make a significant contribution to emerging research on gender and fisheries in Kenya.

2. Materials and methods

2.1. Study site

Our study site is located in coastal Kenya, which stretches along 640 km of coastline. More specifically, we conducted research in the Shimoni-Vanga seascape area, Kwale County, South Coast of Kenya. The study site is characterized by the Inter-Tropical Convergence Zone, which experiences two reversal monsoon seasons – the Northeast monsoon (NEM) and Southeast monsoon (SEM), from November to March and from April to October respectively. Three main ecosystems occur in the coastal region, namely mangrove forests, seagrass beds, and coral reefs (World Wide Fund for Nature [WWF], 2001) (Figure 4.1). These ecosystems fall into different protection regimes, including one governmental MPA, the Kisite-Mpunguti Marine Park and Reserve (04°42' S, 39°21' E), and an array of LMMA (GoK, 2017). These LMMA are run by local communities with the support of the Kenyan government (Kawaka et al., 2017). The area, however, is expected to experience large disturbances with the ongoing construction of an industrial fishing port in the study area, which began in 2022. This project is anticipated to negatively impact local coastal ecosystems and SSF livelihoods (EECL, 2020).

As does the rest of the Kenyan coast, the Shimoni-Vanga area features great cultural diversity. While Swahili people are the dominant group, Mijikenda people are also common in the area. The total site population is estimated at 18 000 people (GoK, 2017). The main local livelihood activity is small-scale fishing, with people of different genders engaging in the SSF value chain (Gok, 2017). We conducted research on five villages which were selected for both their diversity and representativeness of the social-ecological characteristics of the site. All selected villages are constitutive of the Shimoni-Vanga Joint Fishery Co-Management Area which is locally managed by BMU.

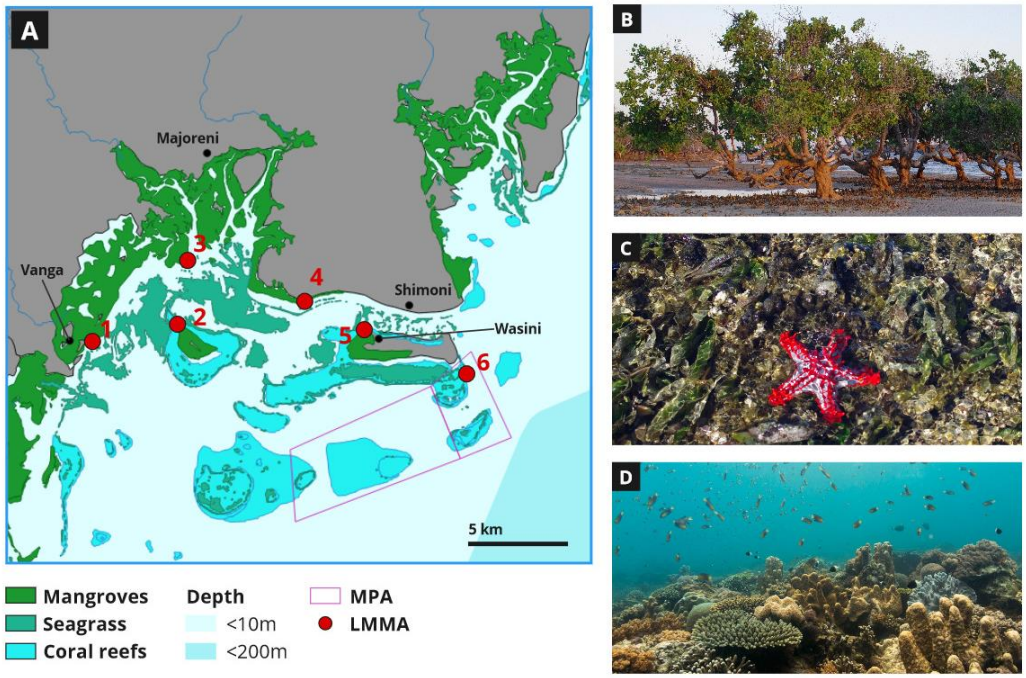

Figure 4.1: Location map of the study site. (**A)** Ecological features of the Shimoni-Vanga seascape (QGIS 3.28.0) – including mangrove forests, seagrass beds, and coral reefs – and marine protected areas (MPA) such as the Kisite-Mpunguti Marine Park and Reserve and six Locally Managed Marine Areas (LMMA): 1-Vanga, 2-Jimbo,3-Majoreni, 4-Kibuyuni, 5-Wasini and 6-Mkwiro. Major marine ecosystems in the Shimoni-Vanga seascape comprise**: (B)** mangrove forests **(C)** seagrass beds, and **(D)** coral reefs. Pictures: © M. Chambon 2021 (B-C) and D. Knoester 2021 (D), from Reefolution Foundation Shimoni.

2.2. Data collection

Before starting fieldwork, we received the ethics approval of the Ethics Committee of the Universitat Autònoma de Barcelona (CEEAH CA01) (Figure 4.2). We gathered Free Prior and Informed Consent from each village and individual who engaged in the study. We also obtained the consent of local authorities over the site. In the field, we worked with Kenyan collaborators who helped to conduct the study and translate the interviews and surveys from English to Swahili. To acknowledge the knowledge of our key informants we used the citation template by MacLeod (2021), adopting pseudonyms in order to respect their anonymity. Respondents' gender identities were derived from their self-identification, and we systematically ensured a gender-balance in our sampling. We combined both qualitative (i.e., participant observation, photography, SSI) and quantitative methods (i.e., survey and pebble games) for data collection, as detailed below.

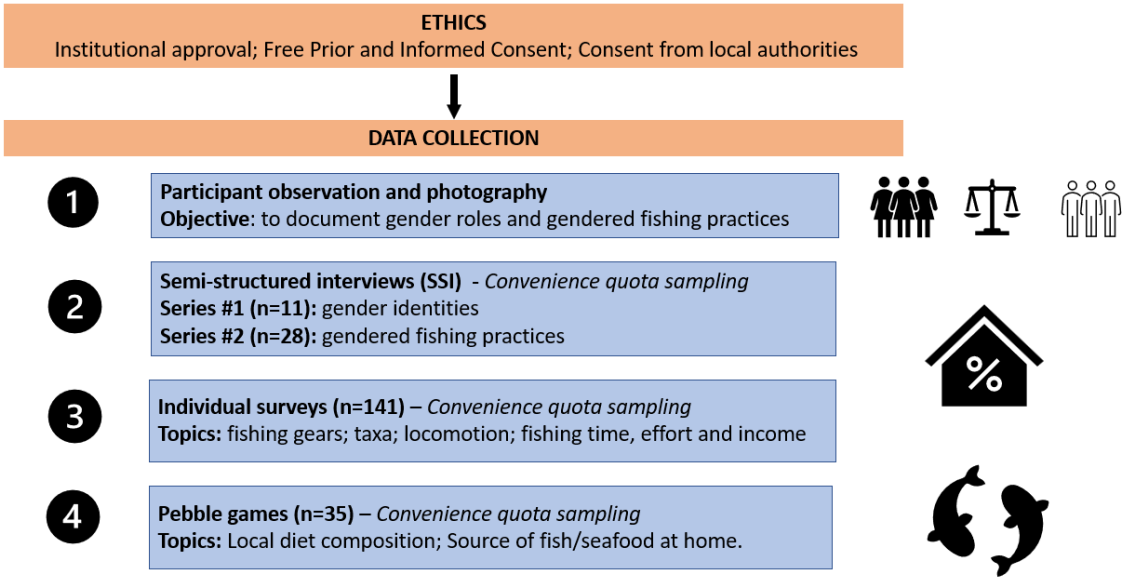

Figure 4.2: Flow chart picturing the methodological approach used in this study from ethical procedures to data collection. Main methods for data collection comprised: **1)** participant observation and photography; **2)** semi-structured interviews (SSI); **3)** individual survey; and **4)** pebble games.

2.2.1. Qualitative methods

We conducted participant observation in the studied villages as a relevant research tool to collect qualitative information on gender roles and norms in SSF communities, women's and men's fishing practices, and their respective economic situations (Kawulich, 2005). We considered as fisher any person who harvested fisheries resources on an occasional, periodic, or daily basis. To complement participant observation, we also used photography. As a well-established method in anthropology, photography provides a powerful medium to bring complementary information to verbal expressions (Soukup, 2014). Here, we used photography to document people's relationships with fisheries and highlight gendered specificities and power asymmetries that may not be described by words. Specifically, the research team took pictures of fishing techniques used by fisherfolk, fishing gears, vessels and catches, coastal ecosystems, and scenes of interaction between women and men at home or in public spaces.

Further, we performed two series of SSI on i) gender identities and ii) gendered fishing practices. We provide the list of questions for the two SSI series in Appendix 4 (List S4.1.). To select participants for SSI, we used convenience quota sampling to reflect fishers' diversity in terms of gender and fishing technique (Rukmana, 2014). First, we selected 11 key informants to explore the emic approach of the

understanding and identification of gender identities within the study site. During the interviews, we addressed questions related to gender identification, differences, and gaps, as expressed in the studied communities. Next, we ran another SSI series on gender-differentiated fishing practices and uses related to fisheries, partly based on the Protocol for the collection of cross-cultural comparative data on local indicators of climate change impacts on fisheries (hereafter: "LICCI Fisheries Protocol") by Miñarro et al. (2021). More specifically, we interviewed 28 respondents (14 women and 14 men) and discussed their daily fishing routine, including their fishing schedule, fishing grounds, technique(s) used, and target taxa.

2.2.2. Quantitative methods

We ran an individual face-to-face survey to gather gender-disaggregated information related to fishing temporalities, locomotion, gears and techniques, target taxa and fishing catch, effort, and income. We used convenience quota sampling to capture gender diversity among respondents at the site level. In total, we interviewed 141 fishers (62 women and 79 men). To build the survey, we used a list of fishing gears and target taxa derived from the SSI on gendered fishing practices. To determine the scientific names of the reported taxa, which were initially expressed in their local names, we used the marine fisheries identification guide developed for Kenya by the FAO (Anam & Mostarda, 2012). However, as this guide does not provide detailed information on invertebrate species, we used instead a booklet with pictures of invertebrate taxa and their scientific names to identify women's target taxa. We tested the survey with 10 respondents during a pilot stage. The final survey comprised three sections related to the interviewee's i) fishing gear(s), ii) target taxa, and iii) fishing locomotion, time, effort, and income. We provide the final version of the survey in Appendix 4 (List S4.2).

Finally, we ran two pebble games using the "pebble distribution method" (Colfer et al., 1999; Lynam et al., 2007). We selected 35 households across the study site using convenience quota sampling and interviewed any available household member who was a fisher to allocate a given number of "pebbles" (i.e., marine shells) across different items. The first game involved items related to weekly fish and seafood portions in diets, while the second focused on the source of fish and seafood in local households. During the first game, we specifically asked participants to indicate the respective portions of fish, vegetables and staple foods based on carbohydrates (i.e., maize dish, chapatis or rice) which they eat weekly at home during both NEM and SEM seasons. Then, moving on to the second game, we asked the same participants to specify the eaten portions of fish and seafood at home that originate from men's catches, women's catches, purchased products or gifts from relatives and friends during both seasons. We used this method to document i) the average weekly fish and seafood composition in diets during NEM and SEM seasons and ii) fisherwomen's contribution to local subsistence (i.e., providing fish or seafood).

2.3. Data analysis

To understand how gender identities shape the access and uses of the seascape (O1), we used data from the SSI on gender identities, photos, and participant observation. We identified common themes from the SSI using content analysis and articulated them with a visual analysis of the coastal environment. We distinguished four main coastal habitats: seagrass beds and reef flats, fore-reef areas, rocky and sandy bottoms, and deeper waters. More specifically, based on participant observation, we drew a schematic representation of the gendered uses of the seascape across these four coastal habitats using a watercolor painting, which we linked to a narrative of the local gender identities (Figure 4.3). Then, to investigate the influence of gender on fishing practices (O2), catch, effort and income (O3), we used survey data. Specifically, to calculate a fisher's catch per unit of time (CPUT) – as a quantitative metric widely used to describe fisheries globally (Appelman, 2015) – we used data on fishing time and catch. We divided the average daily catch (kg) by the daily fishing time (hour). Overall, we combined descriptive and statistical methods to analyze the influence of gender on a set of fishing variables related to fishing temporalities, gears and techniques, target taxa and fishing catch, effort,

and income. First, we determined the average, minimum and maximum values of the numeric variables and counted frequencies of qualitative variables. Next, we applied the Welch Two Sample t-test (Kalpić et al., 2011) and the Chi-square test (Agresti, 2007) to explore statistical differences between fisherwomen and fishermen in numeric and categorical variables of interest. Further, to visually represent the gendered distribution of target taxa by coastal habitat, we generated a color-coded heatmap with R version 4.2.1 (2021) portraying the frequency of catch by gender and coastal habitat. To analyze the composition of local meals and fisherwomen's contribution to diets (O4), we used data from the pebble games and applied descriptive statistics. We used the household as a unit of analysis. Specifically, we compared mixed households where both men and women fished with fisherwomen-headed households where only women provided catch.

2.4. Research positionality statement

As researchers from a distinct socio-cultural, economic, and ontological background other than Kenyan coastal communities, we acknowledge that our methods might have only captured a partial and situated understanding of the relationships between these communities and their coastal environment. Especially, the gendered dimension of such local interactions has been grasped through the prism of our own gender identities and cultural context. Thus, our results should be considered with caution, while encouraging the development of East African gender studies on the topic to foster gender analyses in SSF contexts.

3. Results

3.1. Gendered division of the seascape

Within the SSF communities from the Shimoni-Vanga seascape [hereafter "Shimoni-Vanga SSF communities"], gender norms play a key role in driving individuals' behaviors and aspirations, which in turn leads to a strong gender division of the seascape. Individuals growing up as men are socially expected to take on certain responsibilities such as providing resources to fulfil their family's needs (role of provider). To do so, men are usually encouraged to spend most of their time outside their home and engage in productive sectors to sustain their family. Individuals growing up as women are ascribed reproductive roles, such as taking care of their family and house chores (role of caregiver). As such, women are not expected to work in formal activities and spend most of their time at home to complete their domestic duties. While these norms are constantly shifting, notably towards a higher engagement of women in paid work, dominant views expressed within the studied communities contribute to maintaining a clear distinction between women's and men's realms.

This gendered division of labor influences the ways in which both genders interact with the coastal environment, and with fisheries particularly. It is socially accepted for fishermen to go out to sea and access areas beyond the reef. Conversely, fisherwomen are expected to fish in areas that are compatible with their domestic tasks. This implies fishing in direct vicinity of their house and with a flexible time schedule, sometimes accompanied by children. As a result, while men use the whole seascape to fish – from the coastline to areas beyond the reef –, women's fishing activities are usually restricted to the shoreline, which includes seagrass beds and reef flats. Coral reefs act as a clear barrier between fisherwomen's and fishermen's uses of the seascape (Figure 4.3).

Gender differences in the access to the seascape are further reflected in the type of locomotion used by fishers to reach their fishing grounds. Results from the survey show that fishermen use predominantly traditional boats and motorboats (51% and 42% of surveyed fishermen, respectively),

followed by foot fishing (1%). A few of them use a combination of both (6%). By contrast, all surveyed women are foot fishers.

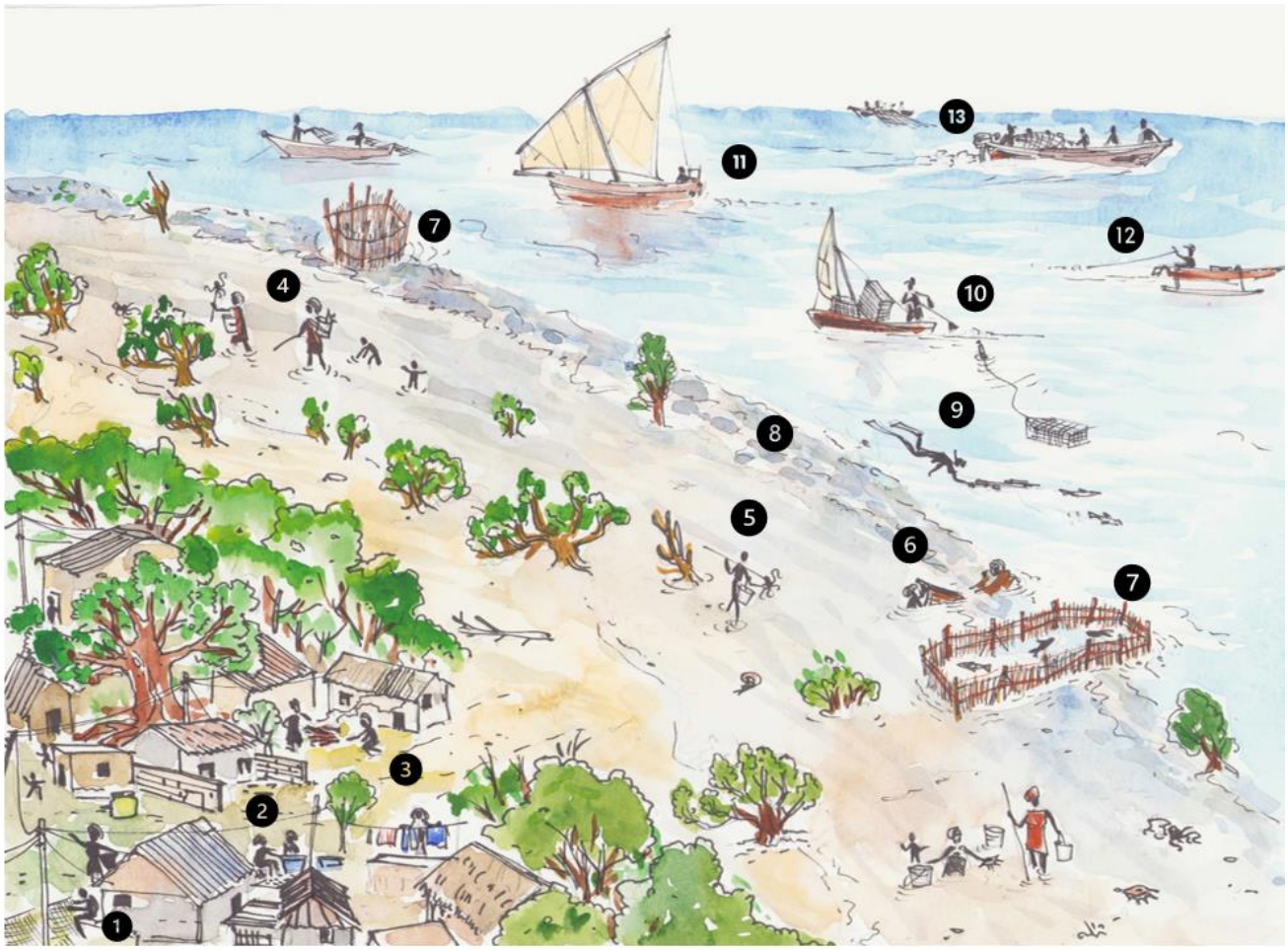

Figure 4.3: Gendered division of labor across the Shimoni-Vanga seascape**.** Daily fisheries and related activities are strongly gendered in the village and in the different coastal habitats: **Village - 1-** Man repairing his nets. **2-** Female fish processors boiling sardines ("*mama chemsha*"). **3-** Woman doing house chores: making fire for cooking, drying clothes. **Seagrass beds and reef flats** - **4-** Group of women with children gleaning shells and fishing octopus along the shoreline. **5-** Man fishing octopus with a pointed stick. **6-** Young girls using a traditional cloth to catch small fish in the reef ("*kuranda*" technique). **7-** Fence trap. **8- Reef crest** marking the boundary between the reef flats and the fore-reef areas. **Fore-reef areas and rocky and sandy bottoms**: **9-** Man catching fish in the reef with a speargun. **10-** Basket trap fisherman. **11-** Swahili traditional dhow used for fishing and trading ("*Jahazi*"). **12-** Handline fisherman. **Deeper waters - 13-** Ringnet fishermen on their motorboat fishing in offshore waters. Drawing: © J. Dupont 2023.

3.2. Fishing practices

3.2.1. Fishing temporalities

Fishing activities are determined by the alternance of the two monsoon seasons, NEM and SEM. This alternance of seasons has strong implications for the gendered division of labor since it modulates fishers' access to certain target species and gendered fishing preferences. The NEM season corresponds to a period of high catch for most fishermen since the sea is quite calm, which allows them to navigate at sea and access various catches. Conversely, during the SEM season most fishermen are reluctant to go out to sea owing to unfavorable weather and sea conditions (e.g., strong wind). Women's fishing activities follow the opposite trend. Women prefer the SEM season for fishing since cooler temperatures and lower sunlight favor the catch of invertebrates in intertidal areas. Besides the

importance of seasonality, women's fishing activities also follow a semimonthly pattern. In particular, octopus or "*pweza*" (*Octopus cyanea* or *Octopus vulgaris)* is only fished during periods of spring tides, locally called "*bamvua",* which happen twice a month. For this reason, most of the women focus their fishing effort on the *bamvua* and fish more opportunistically during the rest of the month. Results from the survey confirm field observations by indicating that women fish closer to their homes and for significantly less time and less often than men (Table 4.1). On average, fisherwomen go to sea for 3h30, nine days a month, whereas fishermen go to sea for 5h and fish 21 days a month.

Table 4.1: Comparison between fisherwomen and fishermen regarding fishing temporalities, gears and techniques, target taxa, fishing catch, effort, and income. Stars (*) indicate fishing variables for which we found statistically significant differences comparing fisherwomen's (n=62) and fishermen's (n=79) samples using a Welch Two Sample t-test (n=141 fishers in total) on R software (2021).

Variable	***Definition***	***Average value for fisherwomen***	***Average value for fishermen***	***P-value***
Fishing temporalities				
Daily commuting time (hour)	Number of hours spent to access to fishing grounds	0.5	1.2	< 0.001*
Daily fishing time (hour)	Number of fishing hours per day	3.5	5	< 0.001*
Monthly fishing days (day)	Number of fishing days per month	9	21	< 0.001*
Fishing gears and techniques				
Number of fishing gears (gear)	Number of fishing gears used by the respondent	2	4	< 0.001*
Target taxa				
Number of commonly target taxa (taxa)	Number of taxa commonly targeted by the respondent	5	14	< 0.001*
Fishing catch, effort, and income				
Average daily catch weight (kg)	Average daily amount of catch	3	46	0.021*
Catch per unit of time (CPUT) (kg/hour)	Amount of catch obtained by the respondent per hour	1	7	0.005*
Daily fishing income during the NEM season (Kenyan Shillings with equivalent in United States Dollar - USD)[4]	Respondent's fishing income per day during the NEM season	584 (5.3 USD)	3 627 (33 USD)	< 0.001*
Daily fishing income during the SEM season (Kenyan Shillings with equivalent in United States Dollar - USD)[4]	Respondent's fishing income per day during the SEM season	749 (6.8 USD)	2 068 (18.8 USD)	< 0.001*

3.2.2. Fishing gears and techniques

Results from the survey indicate that fisherwomen use a significantly lower number of fishing gears than fishermen: 2 and 4 fishing gears, respectively, on average (Table 4.1). We also found gender

[4] We converted the daily fishing income values expressed in the local currency (i.e., Kenyan Shillings) to United States Dollar using the exchange rate of 2021, which corresponds to our data collection period (https://www.exchangerates.org.uk/KES-USD-spot-exchange-rates-history-2021.html)

differences in the distribution of fishing gear types (Figure 4.4). We provide the total list of reported fishing gears used in our survey in Appendix 2 (Table S2.2).

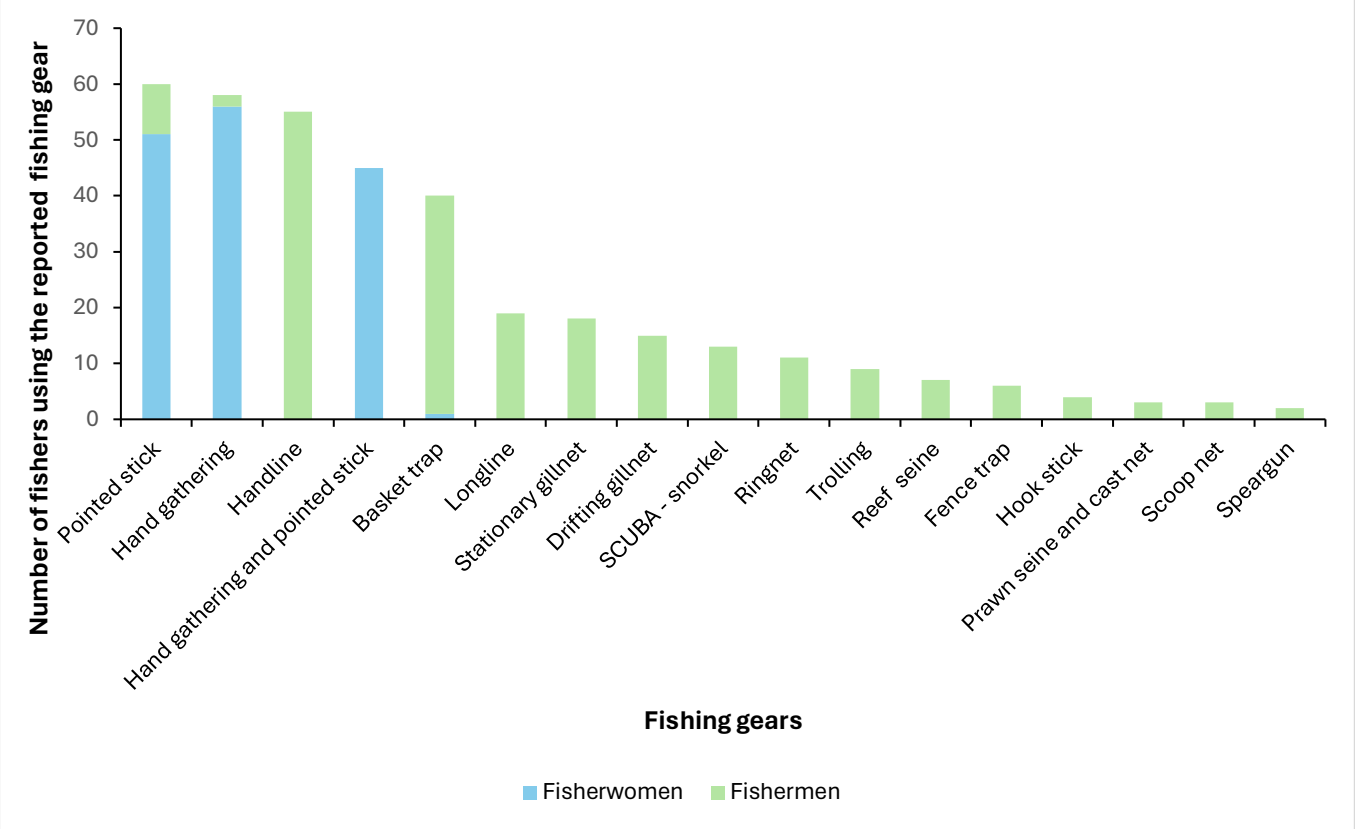

Figure 4.4: Gendered distribution of fishing gears in the Shimoni-Vanga seascape. Number of reported fishing gears by fisherwomen (n= 62 fisherwomen) and fishermen (n =79 fishermen).

The most common fishing gears used by fishermen include handline (70% of fishermen), basket trap (49%), and longline (24%) (Figure 4.5A; Appendix 4-Table S4.1). While handline and basket traps are used to catch reef species such as emperor fish (Lethrinidae family) or snappers (Lutjanidae), longline is used farther at sea to catch pelagic species (e.g., Scombridae such as tuna or king fish). Hand gathering and speargun are the least reported fishing gears by fishermen (3% respectively). Fisherwomen, on the other hand, predominantly use hand gathering (90%), pointed stick (82%), or a combination of both (73%) (Figure 4.5B). We found one case of a fisherwoman using basket traps (2%). In this specific case, the respondent combined basket trap fishing with seaweed farming activities. Women use hand gathering to collect various species of shells and sea cucumbers along the shore, a technique called gleaning ("*kuchukua*"). As they are walking, women store the shells in a bucket on their backs and look for octopus at the same time. When they spot an octopus' den, they use a pointed stick to poke inside the den to check whether it is inhabited or not. If applicable, women stab the octopus, hang it on the stick and proceed to another location. In addition to the survey, field observations and interviews revealed another fishing technique used mostly by young girls and teenagers. This fishing technique, locally called "*kuranda*", consists of using traditional clothes to catch small fish in the intertidal parts of the reefs.

Figure 4.5: Gendered fishing techniques across the Shimoni-Vanga seascape**. A. Men's fishing techniques: A1**- Basket trap fisherman. Basket traps ("*malema"*) are one of the most common and iconic traditional fishing gears used in nearshore shallow waters. Usually, fishers leave at dawn to access their fishing grounds in paddle canoes or outrigger sailboats. Once they reach the site, they identify where their basket traps are located by looking for plastic bottles or buoys. They take each of the traps, collect the catch, if any, refill the traps with bait like brittle stars or green algae and lower them down back into the water. The making of basket traps is a male-dominated artisanal know-how of weaving bamboo fibers and is passed on from one generation to the next. **A2-** Fence trap fisherman heading out at sea. This fisherman navigates by paddle canoe ("*mtumbwi*") through mangrove channels to reach his fence trap. This kind of traditional trap, made of mangrove stakes or palm leaves, is usually set perpendicularly to nearshore waters to catch fish during spring tides. Once the tide goes out, fish get stuck inside the trap. After one or two days, fishers come to collect the catch. **B. Women's fishing techniques: B1-** Female gleaners using hand gathering. Fisherwomen usually leave early in the morning to walk along the shore in small group of friends or relatives. They use their fishing time to share stories and news from the village and to learn from each other. Sometimes children come with them. After fishing, most the fisherwomen return home to prepare lunch and complete house chores. **B2-** Female octopus fisher using pointed stick. Women's fishing activities are heavily influenced by the lunar calendar. For instance, octopus is only fished during the spring tide period, locally called "*bamvua*", which lasts eight days and occurs twice a month, before and after the new and full moon. During these periods, foot fishers can access the reef flats during low tides and look for octopus or shells. They usually poke octopus' dens with a pointed stick and stab any octopus found inside. This fishing technique requires fine skills to identify octopus in their natural habitats. Pictures: © S. Wachia 2021, 2023 (A1, A2) & M. Chambon 2021 (B1, B2).

3.2.3. Target taxa

Results from the Welch Two-Sample t-test show that fisherwomen target a lower number of taxa than men: 5 and 14 taxa, respectively, on average (Table 4.1). We provide the complete list of reported target taxa used in our survey in Appendix 4 (Table S4.2). In addition, we found that fishermen fish a wider diversity of taxa than fisherwomen (Appendix 4 – Table S4.3; S4.4). Fishermen predominantly target reef fish (95% of fishermen), followed by invertebrates (76%), pelagic fish (72%), elasmobranchs (65%) and crustaceans (27%). The four families the most targeted by fishermen are all reef fish families and include Lethrinidae (targeted by 86% of fishermen), Mullidae (84%), Siganidae (79%) and Scaridae (79%). By contrast, all fisherwomen fish invertebrates (100% of fisherwomen) and a few of them also target reef fish (10%), reflecting a lower functional diversity than men's catches. Fisherwomen's catches are mostly composed of octopus (*Octopus cyanea* and *Octopus vulgaris)* (targeted by 82% of fisherwomen), gold ring cowrie (*Monetaria annulus*) (79%), common spider conch (*Lambis lambis*) (71%), and lynx cowrie (*Lyncina lynx*) (57%). Furthermore, findings from the survey indicate that taxon distribution varies by the fisher's gender and coastal habitat (Figure 4.6). Fisherwomen concentrate their efforts on seagrass beds and reef flats, while fishermen fish mostly in fore-reef area, rocky and sandy bottoms, and deeper waters.

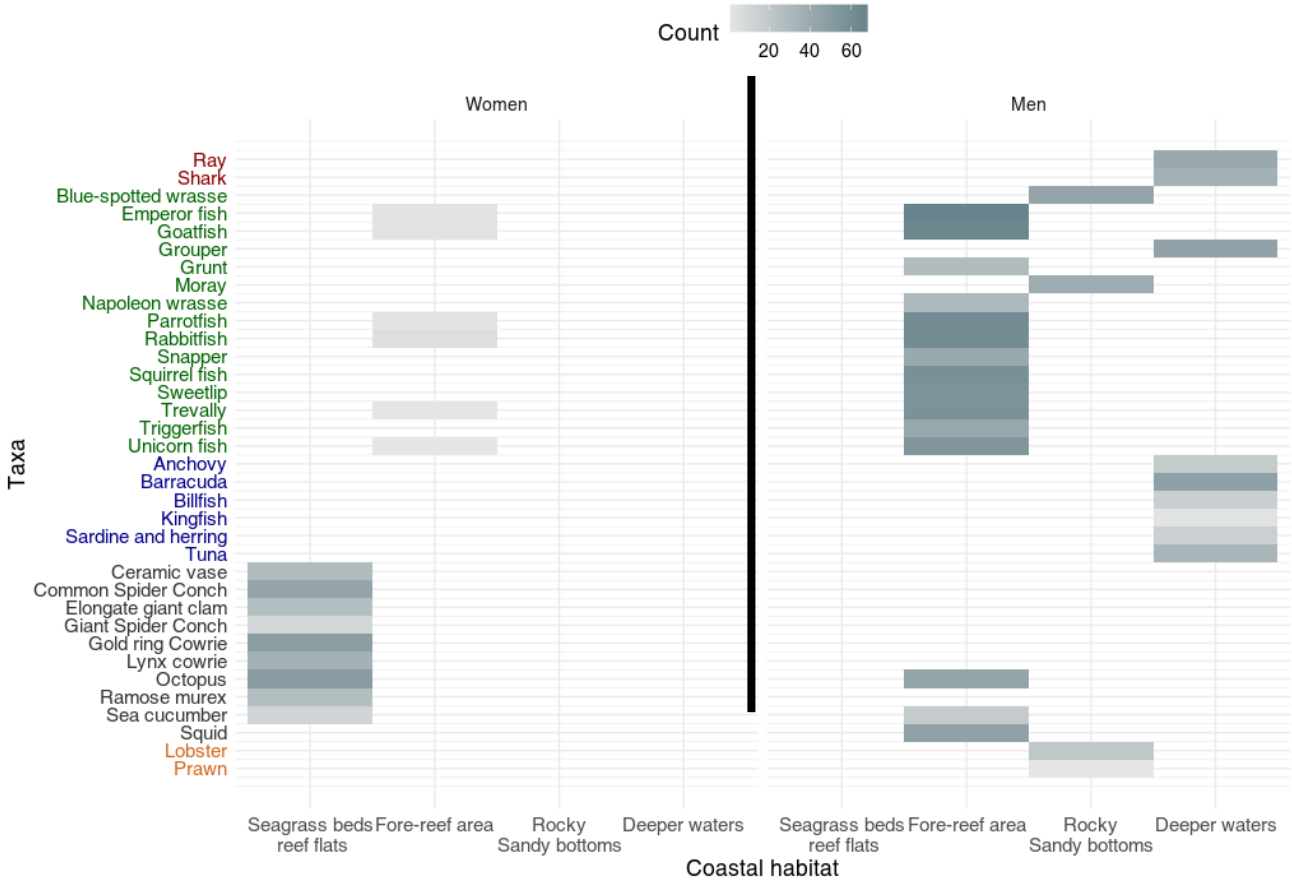

Figure 4.6: Gendered distribution of target taxa by coastal habitat. Heatmaps showing the number of fisherwomen (n=62) and fishermen (n=79) targeting the main taxa included in the survey by coastal habitat (i.e., seagrass beds and reef flats; fore-reef areas; rocky and sandy bottoms; deeper waters). Functional groups of the target taxa are indicated by different colors: red for elasmobranchs, green for reef fish, blue for pelagic fish, grey for invertebrates and orange for crustaceans.

3.2.4. Fishing catch, effort and income

We found that on average, women make significantly lower daily catches and CPUT than men (Table 4.1). Similarly, fisherwomen's average daily income derived from their fishing activities is significantly lower than that of fishermen, although we notice a seasonal variation. While fisherwomen earn more during the SEM season, fishermen get higher benefits during the NEM season. Consequently, during the NEM season, women's average daily fishing income is 6 times lower than that of fishermen, but 2.8 times lower during the SEM season.

3.3. Fisherwomen's contribution to diets

Results from the pebble games indicate that respondents eat significantly more fish and seafood during the NEM than during the SEM season (p-value: 0.043), representing about a third (29,4%) and a fourth (23,7%) of diets for the two seasons respectively. Respondents supplement fish with vegetables (19,2% and 26,8% during NEM and SEM) and staple foods (51,4 % and 49,5% respectively). In addition, we found that about two-third of the catch eaten at home is provided by the man and the rest by the woman in mixed households (respectively 67% and 33% during the NEM season; 68% and 32 % during the SEM season) (Appendix 4- Table S4.5). However, in fisherwomen-headed households, women's catches contribute about half of the total amount of fish and seafood consumed at home (50% and 51% during the NEM and SEM seasons respectively) (Appendix 4- Table S4.6). The other half corresponds to purchased and given fisheries products.

4. Discussion

This paper investigates women's and men's participation in small-scale fishing and the resulting nutritional implications through a case study in coastal Kenya. Our results reveal a pronounced gendered spatial and ecological division across the seascape. While women contribute to fishing, their practices are characterized by fewer fishing gears, less catch, a lower functional diversity of catches, less fishing effort, and less income than men. However, we find that women's contribution to diets is significant, representing one third of the catch eaten at home in mixed households, and up to 50% of the fisheries products consumed in fisherwomen-headed households. These findings suggest that, while fisherwomen's direct contribution to the SSF formal economy may be counted as lower than that of fishermen, their fishing activities provide key nutritional benefits for their households.

We are aware of two main limitations of our study. First, the use of Swahili as the main research language in this study may have erased certain nuances about the respondents' fishing experiences, since most of them were more comfortable expressing themselves in their local languages, which are different from Swahili. This difficulty raises the need to reflect on language pluralism in research and foster academic collaboration with local communities. Second, despite recognizing the value of applying an intersectional framework in fisheries research, we only focused on gender and did not include other related social variables such as age or ethnicity owing to time constraints in the field. We acknowledge that this limitation may restrict the scope of our analysis of local power dynamics and reinforces the need to consider intersectionality in gender and fisheries research (House et al., 2023).

4.1. The gendered division of labor in small-scale fishing activities

Although fishing is commonly considered a male domain (Lentisco & Lee, 2015), our findings in the Shimoni-Vanga seascape indicate that women also engage in fishing, in line with literature challenging the predominance of men in other sectors such as hunting (Reyes-García et al., 2020) or agriculture (FAO, 2021). In that sense, our findings contribute to the growing "women also fish" discourse that builds on case studies reporting the cultural diversity of women's fishing practices

throughout the world (Harper et al., 2013; Williams, 2010). Furthermore, our study highlights major differences between fisherwomen's and fishermen's practices, thus adding to the existing literature that illuminates gender variations in the use of fisheries (FAO et al., 2023; Kleiber et al., 2015). In terms of effort and volume, fisherwomen appear to fish less than fishermen, in agreement with previous studies (Bradford & Katikiro, 2019). Moreover, fisherwomen are more spatially constrained in their fishing activities than fishermen. While women mostly concentrate their fishing effort on intertidal areas, men use the whole seascape for fishing. This contrasting pattern was first reported by Chapman (1987) in Oceania and has been documented globally since then (Alati et al., 2023; Koralogama et al., 2017; Siar, 2003). Our findings also show that women and men tend to use distinct techniques and target different species. Our results align with previous studies showing that fisherwomen are primarily involved in gleaning (Alati et al., 2020). In addition, we found that, while women employ other fishing techniques to harvest fish, most of their catches consist of invertebrates. By contrast, men use more diverse fishing gears to catch essentially reef fish, which confirms the general statement that "*shells are for women, fish are for men*" (Siar, 2003, p.578) although some exceptions have been reported in the literature (Lentisco & Lee, 2015).

Overall, our findings suggest that the gendered division of labor in our study site stems directly from local gender norms and values, confirming evidence from the global gender and fisheries literature (De la Torre Castro, 2019). In many societies, women are primarily ascribed reproductive roles, which implies that they must take care of their house and family (Lawless et al., 2019). This caring work is often perceived as not valuable in economic terms, and thus escapes assessment of the formal SSF sector (Williams, 2019). In turn, these gender norms and expectations limit women's time and mobility to engage in economic activities, for example restricting them to fish near their home. In addition, research in other fisheries settings also suggests that socio-economic barriers such as limited access to capital or cultural taboos challenge women's access to fishing vessels, thus preventing them from fishing in deeper waters (Thomas et al., 2021). These complex and interlaced factors contribute to sustaining this gendered demarcation of fishing activities globally.

4.2. Small-scale fishing activities as a matrix of gender constructs

Beyond revealing local gender asymmetries, the observed gendered division of labor in SSF also contributes directly to the construction of gender roles. In other words, because of their gender-specific characteristics, women's and men's respective fishing practices become, in turn, constitutive elements of their gender identities. SSF thus plays a key role in setting gender boundaries by defining who is a woman and who is a man. This phenomenon has been discussed in the literature through the notion of occupational sex segregation (West & Zimmerman, 1987), which refers to the spatially differentiated occupations performed by women and men. Although gender construction processes encompass a wide range of social spheres, this notion is useful for understanding how fishing – as an occupation – may be pivotal in building and reinforcing gender identities in SSF communities. For instance, Yodanis (2000) applied this concept to understand why women from certain SSF communities in the United States did not perceive themselves as fishers, in contrast to men, even though some of them engaged in fish capture. The author argues that one of the main reasons was gender construction processes resulting from SSF activities. Since fishing was perceived as a male attribute, women tended to distance themselves from this activity: "*I found that gender in fishing villages is defined in relation to fishing. "Man" is defined as one who fishes and "woman" is defined in opposition to that which is a fisherman*." Similarly, Santos (2015) describes how fisherwomen's and fishermen's roles in Brazilian SSF, which are perceived as synergetic, do contribute to shape local gender identities, defining what a woman is in relation to men and vice versa.

Further, our results indicate that the construction of gender identities through SSF contributes to reinforcing gender inequalities. We found that fisherwomen had significantly less catch and earned less

fishing income than fishermen. We suggest that this outcome is directly linked to fisherwomen's spatiotemporal and technical restrictions. Since women only fish along the coast, for a limited amount of time, and with a reduced number of fishing gears, it seems likely that their productivity will be lesser than that of fishermen. Our findings align with those of previous studies in SSF documenting how women's constraints in the SSF value chain result in a lower income than those of men (Bradford & Katiro, 2019; Siar, 2003). For instance, investigating shelled mollusk fisheries in coastal Kenya, Alati et al. (2023) reported that a larger number of fisherwomen than fishermen earned a daily fishing income below the poverty line. The precarious situation of fisherwomen may be worsened in case of shocks such as climate-related disasters, which may increase gender gaps in local incomes (Brody et al., 2008). Taken together, our findings illustrate how a gender lens applied to SSF allows for a better understanding of the complex gender dynamics around the access to fisheries and shed light on gender economic disparities. In line with other feminist scholars (Davis & Nadel-Klein, 1992; De la Torre Castro et al., 2017), we support the need to bring a political dimension to the analysis of gender power relationships in fisheries settings (Alati et al., 2023; Mangubhai & Lawless, 2021).

4.3. The importance of fisherwomen's contribution to local subsistence

Despite their economic marginalization within the SSF sector, our results suggest that fisherwomen provide a substantial part of the fisheries products eaten at home, accounting for one third of the catch consumed in mixed households and 50% of fish and seafood eaten in fisherwomen-headed households. Fisheries resources are essential for coastal diets in many regions of the world, providing proteins and micronutrients that are critical for household food security and child growth (Hicks et al., 2019; Kawarazuka & Béné, 2011). Our findings suggest that fisherwomen's catches represent a critical complement to diets that are locally dominated by carbohydrates. Thus, our study adds to previous evidence shedding light on the significance of women's fishing activities for food security in SSF communities (Rabbitt et al., 2019; Thomas et al., 2021).

We also found that gleaning represents the women's main fishing technique, as reported elsewhere (Alati et al., 2020; Stiepani et al., 2023). Gleaning activities are recognized as being more predictable – and thus reliable – than other fishing techniques in providing food since they target invertebrates. These species are mostly sessile, thus easier to catch than mobile species like pelagics, whose distribution is highly variable in time and space (Chapman, 1987). Further, our results show that Shimoni-Vanga SSF communities consume more fish during the NEM than the SEM seasons. This may imply that, during the SEM period when men's catches are scarce, the contribution of fisherwomen to household diets through their gleaning activities is particularly important. While a general trend described in the literature and confirmed by our study is that women's fishing productivity tends to be lower than men's, fisherwomen's catches appear to be critical for SSF households since they provide their families with a stable amount of fish products (Rabbitt et al., 2019).

This essential role played by fisherwomen in providing fish and seafood to SSF households may become even more important in the future, especially considering climate change. Studies have highlighted the importance of women's fishing activities as a safety net during periods of instability and socio-environmental shocks (Agarwal, 2018). Given that SSF are identified as one of the food production systems most vulnerable to climate change impacts (FAO et al., 2023), SSF households may increasingly depend on women's contribution for their protein intake over the coming years. However, as warned by several feminist researchers, a greater involvement of women in fishing activities and economic development may also represent an additional burden on them, superimposing upon their traditional reproductive responsibilities (Williams et al., 2019).

5. Conclusions

Addressing the persisting gender data gap in fisheries, especially on fishing activities, will require deep transformations in fisheries research, management, and governance. Our findings support three main recommendations to achieve gender inclusivity in the SSF sector. First, our study highlights the importance of integrating gender-disaggregated data in fisheries assessments to capture a comprehensive picture of coastal SES, thus providing a robust basis for developing appropriate and inclusive SSF management decisions. Specifically, we concur with other scholars to support the need to collect data on women's gleaning activities to improve baseline data on invertebrate stocks and mitigate potential negative environmental impacts (Alati et al., 2023; Stiepani et al., 2023). Second, our findings call for a better recognition of women's contribution to subsistence and artisanal fishing to optimize the nutritional outcome of certain fisheries, especially nearshore fisheries where fisherwomen predominate (Thomas et al., 2021). The potential of women's subsistence fishing for achieving food security is particularly important in East Africa where severe drought events have been increasingly reported over the past decades, posing severe threats on food security (Kimutai et al., 2023). Finally, insights from our work highlight the strong female presence in the fisher population in coastal Kenya, supporting the need to include women in SSF management and decision-making positions. A better participation of women in fisheries management has been documented for providing multiple benefits to SSF social-ecological systems (Chambon et al., 2023). Gender-inclusive management strategies are thus critical for ensuring that both men and women have equal access to SSF, and for building synergies between socio-economic, nutritional, and environmental considerations. We believe that driving change in the SSF sector in these recommended directions would directly contribute to achieving gender equitable and sustainable SSF, in line with the FAO's Gender Handbook of the SSF Guidelines (2017) and the Sustainable Development Goals n°5 and 14.

6. References

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Chapter 5

Weaving scientific and local knowledge on climate change impacts in coastal Kenya, Western Indian Ocean

Climate change impacts on the Shimoni-Vanga seascape, combined with overfishing, threaten the livelihoods of octopus fishers like Amina. She struggles to find shells and octopuses because of changes in the timing of the spring tide period ("*bamvua*"): "*Bamvua are less predictable than before. Tides might come earlier or later than expected.*" She ends up spending less time fishing and more time looking for alternative sources of income, such as selling firewood.

Abstract

Climate change is posing severe threats to tropical coastal social-ecological systems (SES) worldwide. Recent calls in climate research and policy support stronger collaboration between scientific and local ecological knowledge (LEK) systems, aiming to address the long-standing marginalization of local communities in climate discussions. Yet studies that have attempted to explore knowledge pluralism have seldom considered the gendered nature of climate change impacts. Here, we contribute to this growing literature by exploring LEK on climate change impacts and its relation to scientific knowledge through a gendered approach and focusing on the Western Indian Ocean (WIO) region, and more specifically on Kenya. We adopted a mixed methodology combining qualitative and quantitative approaches. We found evidence of pronounced climate change impacts on coastal SES both in the scientific literature and in reports by local small-scale fisheries (SSF) communities. Our findings highlight that there is an extensive overlap between information derived from scientific and LEK systems. Importantly, our study revealed reports of change that were only provided by SSF communities, namely changes in coastal dynamics, a decrease in rainfall, and a decrease in the abundance of green algae. Although we found gendered variations in changes reported by SSF communities, gendered differences of climate change impacts on SSF were not detected in the reviewed literature. Overall, our results suggest that knowledge cross-fertilization generate a holistic, relational, and place-based view of climate change impacts, which may support sound and gender-inclusive adaptive policies. We conclude by indicating areas for future work in climate research ethics, methodology, and policy.

Key words: Climate change; East Africa; Gender; Local ecological knowledge; Scientific knowledge; Small-scale fisheries

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1. Introduction

As climate change escalates, its effects amplify worldwide (IPCC, 2021). In the ocean, climate change is substantially affecting coastal and marine ecosystems in complex and connected ways (Scheffers et al., 2016). Further, coastal and marine ecosystems are closely interwoven with human societies in dynamic social-ecological systems (SES), with climate change considerably altering coastal communities worldwide (Eddy et al., 2021). Given their high reliance on fish for their daily protein needs and a weak adaptive capacity to a changing climate, tropical regions in particular are severely affected by climate change impacts on marine fisheries (UNEP-Nairobi Convention & WIOMSA, 2015). In turn, climate risks in tropical regions are exacerbated by other anthropogenic stressors such as overfishing or pollution, which accentuate the overall vulnerability of local communities (IPCC, 2021; UNEP-Nairobi Convention & WIOMSA, 2015).

Against this background, there has been a growing interest in studying responses of tropical coastal SES to climate change impacts (Cinner et al., 2012). The existing scientific literature on the topic predominantly originates from the natural sciences (Doblas-Reyes et al., 2021). However, recent studies have noted limitations on these approaches in terms of accuracy, positionality, and comprehensiveness (Reyes-García et al., 2024). First, scientific knowledge based on large-scale climate datasets often lacks robustness at fine-scale resolutions, which may undermine the definition of climate impacts at the local level (Fernández-Llamazares et al., 2017). Second, current climate research is largely driven by Western researchers and institutions which may not always reflect the views and needs from other societies (Reyes-García et al., 2024). Finally, the natural sciences tend to focus on biophysical systems, thus overlooking the importance of interconnections between people and the rest of the natural world (McNeeley & Lazrus, 2014). For these reasons, climate modelling and instrumental-based observations may provide only a situated and partial view of the variability of climate change impacts (Klenk et al., 2017). This patchy picture may challenge the development of adaptation policies that are suitable for local communities and address the full complexity of climate change (Orlove et al., 2023).

Alongside climate sciences, some scientists as well as the IPCC strongly support the recognition of other ways of knowing, especially knowledge held by Indigenous Peoples and local communities (IP & LC), in the assessment of climate change impacts (IPCC, 2022; Reyes-García et al., 2024). In particular, there is a growing recognition of the importance of LEK systems, understood as holistic and complex systems developed by diverse local communities across the world and encompassing their ways of life, practices, knowledge and beliefs in relation to nature (Orlove et al., 2023). Recent research efforts actively value LEK as knowledge systems as legitimate as scientific knowledge derived from the climate field (Reyes-García et al., 2016). In the same vein, global climate policies, through Article 7.5 of the Paris Agreement (UNFCCC, 2015), recognize the need to include IP & LC and their specific knowledge in climate discussions for matter of respect and equity. However, LEK is characterized by great variability within and across social groups (Howard, 2003). For example, gender might influence the views and world realities perceived by individuals of diverse gender identities, which vary considerably across world regions (Nyangweso Ochieng et al., 2023; Wall et al., 2018). In many societies, women are usually assigned reproductive roles, while men engage more considerably in formal productive sectors. Studies have documented how this division of labor induces gendered climate perceptions (e.g., Bee, 2014; Dankelman, 2010) and vulnerabilities (e.g., Djoudi & Brockhaus, 2011). Adopting a gender lens thus appears necessary to thoroughly capture the social-ecological scope of climate change impacts and to drive effective gender-inclusive climate policies.

Scholars have identified three main logics when working across various knowledge systems – also called knowledge pluralism – in environmental science-policy arenas: integrationism, parallelism, and pragmatism (White & Lidskog, 2023). Most of the recent attempts to bring together LEK and climate

sciences have used an integrationist logic that aims to integrate elements from plural knowledge systems into a single system. Yet some researchers have rejected this approach by denouncing the risk of exclusion and disempowerment of local knowledge holders since it often results in the evaluation of LEK through scientific validation (Roue & Nakashima, 2018; Torrents-Ticó et al., 2021). Conversely, the parallelist logic strives to achieve collaboration between knowledge systems by considering each given system as a distinct and autonomous entity (Snively & Williams, 2016). In this line, Tengö et al. (2014) have proposed the MEB approach as an approach "whereby indigenous, local and scientific knowledge systems are viewed to generate different manifestations of knowledge, which can generate new insights and innovations through complementarities" (p. 579). In this approach, the validation process operates within each knowledge system rather than across them or through the lens of a particular one. A third path is the pragmatic logic that is context-dependent and addresses knowledge pluralism by seeking to favor positive impacts and maximize outcome efficiency.

In this study, we contribute to the flourishing discussion on knowledge pluralism in climate research and policy by drawing upon the MEB approach to support pragmatic ends. Given that LEK has long been excluded from climate discussions (Orlove et al., 2023), with potential omissions and underestimates of local climate change impacts, this study aims to tackle the historical power imbalance in climate knowledge production by exploring LEK on climate change impacts. Specifically, we investigate how LEK relates with scientific knowledge on climate change impacts in the WIO through a gender lens. It is estimated that more than 30% of the population in the WIO lives near the coast and strongly depends on fisheries resources for food and income (Obura et al., 2017). Individuals of diverse gender identities are substantially engaging in the fisheries value chain. In this context, there is a critical need to better understand the gender-differentiated impacts of climate change on the fisheries sector and on local livelihoods (Bell et al., 2016; Taylor et al., 2019). However, to date, only a couple of studies have explored such impacts through a local perspective from small-scale fishing communities in the WIO region. Those that have been undertaken have aimed to link scientific evidence and local reports of environmental changes without applying a gender-inclusive analysis (e.g., Lemahieu et al., 2018; Makame & Shackleton, 2020). Therefore, attempts to cross-fertilize scientific knowledge and LEK that consider the gendered nature of climate change impacts in the region are still in their infancy. This research gap undermines our ability to build comprehensive assessments of climate change impacts on coastal SES and may challenge the formulation of culturally acceptable and equitable adaptation policies (Guodaar et al., 2021). We address this gap by focusing on a case study in coastal Kenya, in the WIO region, where populations largely rely on fish for their protein intake (Taylor et al., 2019) in a context in which the marine fisheries sector is highly vulnerable to climate change (Cinner et al., 2012). The specific objectives of our study are:

(O1) To assess the state of scientific knowledge on climate change impacts on coastal SES in the WIO.

(O2) To examine whether local meteorological measurements for the period 1991-2018 align with regional climate trends reported in the literature.

(O3) To analyze perspectives on climate change impacts by local small-scale fishing communities using a gendered approach.

(O4) To explore LEK on climate change impacts on coastal SES in the WIO and its relation to scientific knowledge.

This research was carried out within the framework of the LICCI project (https://www.licci.eu/), a research project aiming to bring Indigenous and local knowledge systems into climate research and policy (Reyes-García et al., 2023).

2. Materials and methods

2.1. Study site

This study was conducted in the Kenyan coast within the WIO region. Specifically, we worked within the Shimoni-Vanga seascape, Kwale county, South Coast of Kenya. The study site lies within the Inter-Tropical Convergence Zone, which is a key element of the Earth's climate system. The study site is characterized by two opposite monsoon seasons – the Northeast (November-March– NEM) and the Southeast monsoons (April-October – SEM). This unique wind reversal pattern influences the physical, biological, and chemical processes in the ocean (McClanahan, 1988). The main marine ecosystems in the study area include vast mangrove forests, coral reefs, and seagrass beds (WWF, 2001). The current population of the Shimoni-Vanga seascape is estimated at 18 000 people (GoK, 2017). While this region is culturally diverse, the Swahili culture predominates in the organization of local social systems. Small-scale fishing is the main livelihood activity in the area, with up to 100% of the population relying, at least partially, on fish for a living (Gok, 2017). People of different gender identities engage in every stage of the SSF value chain, including direct capture (Lau et al., 2021). Fishing activities in the area follow gender-differentiated seasonal patterns. The NEM season, characterized by calm conditions at sea, corresponds to the high fishing season for fishermen. Conversely, women who go fishing by foot are less dependent on wind intensity or currents strength and favor fishing during the SEM season, when the conditions are cooler.

Within our study site, we selected five villages that were representative of the site variability in terms of ecological and socio-cultural diversity, while sharing certain characteristics (Figure 5.1). The five selected villages are all part of the Shimoni-Vanga Joint Fishery Co-Management Area under which the coastal environment and fisheries resources are jointly managed by local BMU. A commercial fishing port is currently under construction in the study area. The port is expected to have major adverse effects on local marine biodiversity and SSF livelihoods and to reshape the local economic landscape (EECL, 2020).

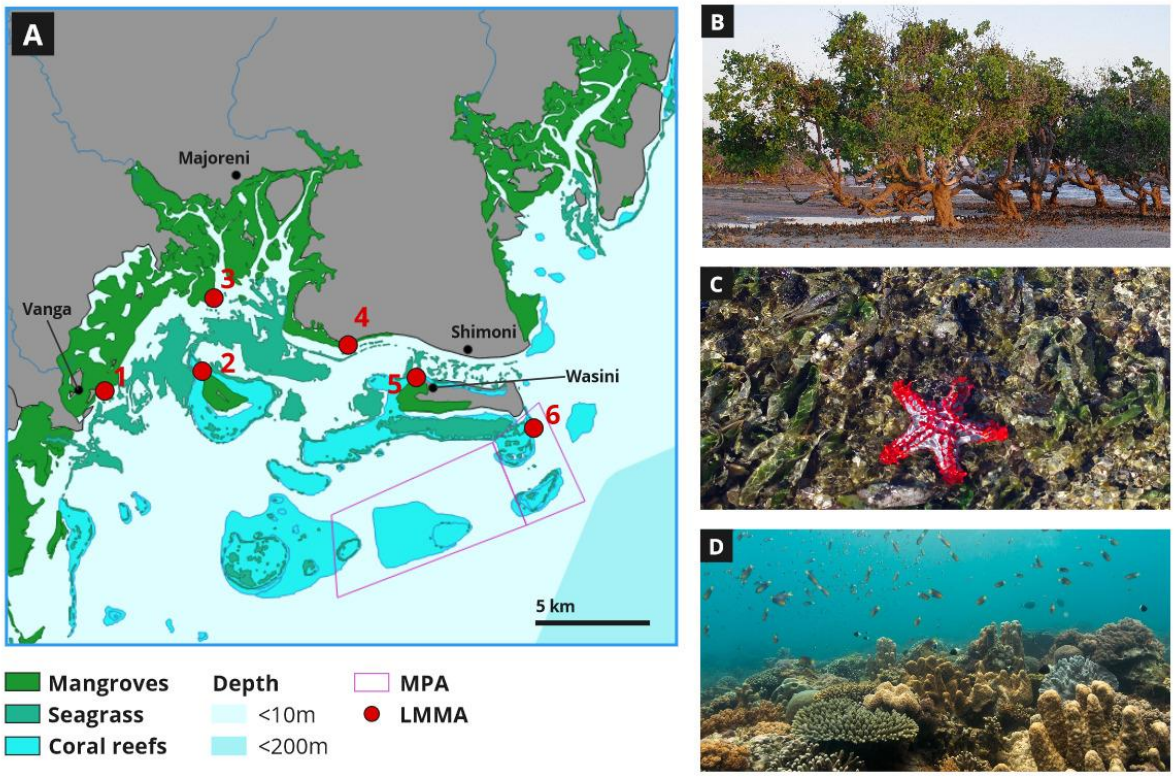

Figure 5.1: Location map of the study site. **A)** Main ecosystems present in the Shimoni-Vanga seascape, including mangrove forests, seagrass beds, coral reef cover and marine protection tools such as the Kisite-Mpunguti Marine Park and Reserve (MPA) and six Locally Managed Marine Areas (LMMA): 1-Vanga, 2-Jimbo, 3-Majoreni, 4-Kibuyuni, 5-Wasini and 6-Mkwiro. The three main marine ecosystems in the Shimoni-Vanga seascape: **B)** mangrove forests, **C)** seagrass beds, and **D)** coral reef ecosystems. The map was built under QGIS 3.28.0. Pictures: M. Chambon (B&C) and D. Knoester of Reefolution Foundation Shimoni (D).

2.2. Data Collection

We used a mixed-method approach for data collection and analysis, combining qualitative and quantitative research methods. We collected i) secondary data from the scientific literature, ii) meteorological and ocean surface temperature data, and iii) primary data on reports of local indicators of climate change impacts. To ensure comparability between instrumental data and local information, we asked for individual reports of change over the last 30 years.

2.2.1. Scientific literature

We performed a narrative review of the scientific literature on climate change impacts on coastal SES in the WIO. This type of literature review was chosen because of its relevance for examining the state of the art of a particular research topic and identifying potential research gaps (Snyder, 2019). We applied a topical search (in title, abstract, and keywords) in Web of Science® Core Collection, which is characterized by a multidisciplinary scope that suits our research topic (Birkle et al., 2020). The search string used was TOPIC: “climate chang*” AND TOPIC: “Western Indian Ocean”. Our search did not include any temporal restriction and returned 298 publications. We used two inclusion criteria to select the publications to be reviewed: i) providing an analysis at the WIO level by considering at least two WIO countries; and ii) examining climate change impacts on coastal SES. We screened these publications and made a decision about their inclusion through a two-step process. First, we read all titles and abstracts and selected 63 publications that were relevant to our research topic based on our inclusion criteria. Second, from the pre-selected publications, we performed a full-text screening using the same criteria. In total, we selected 54 peer-reviewed publications providing information on climate

change impacts on coastal SES in the WIO region. We have provided the final list of publications in Appendix 5 (Table S5.1).

2.2.2. Meteorological data

We obtained meteorological data for the Kwale county from the Kenya Meteorological Department. We focused on three main measurements that were openly accessible: i) daily minimum temperature; ii) daily maximum temperature; and iii) daily mean rainfall. We obtained those data for the period 1991-2018. This meteorological data at the county level is obtained from the Enhancing National Climate Services ENACTS approach (Dinku et al., 2018), which aims to provide African countries with quality datasets for meteorological and climate studies. This method optimally merges the discontinuous data (in space and time) from eleven meteorological stations across the Kenyan coast with continuous data from satellite datasets and meteorological re-analyses. Meteorological measurements obtained for the Kwale county are thus continuous in time, but not directly based on local meteorological data, since there is no meteorological station at this specific location. However, estimates can be considered representative of the temperature and precipitation regions over the entire county. We also used the National Oceanic and Atmospheric Administration Daily Optimum Interpolation Sea Surface Temperature (NOAA OI SST V2 High Resolution) dataset to describe the observed warming trends in the WIO for the period 1982-2021. We obtained this data set from the NOAA PSL website (https://psl.noaa.gov/).

2.2.3. Local indicators of climate change impacts

We collected primary data on local reports of climate change impacts using the Local Indicators of Climate Change Impacts data collection protocol (hereafter "LICCI Protocol") (Reyes-García et al., 2023). To collect field data, we were supported by Kenyan collaborators who ensured the translation from English to Swahili and *vice versa*. According to the guidelines suggested by MacLeod (2021), we cite informants in references, as knowledge holders, although we used pseudonyms to protect their anonymity. From all existing gender identities, we focus on two that were culturally understood and appropriate: women and men. However, we acknowledge gender diversity beyond this binary view and encourage the development of gender-inclusive methodologies in social sciences (Cameron & Stinson, 2019). We collected information on the respondents' gender identities based on their self-identification and we respected a balance sample between men and women respondents.

We conducted SSI with 28 key informants to explore the gendered dimensions of local marine knowledge and observed changes in the coastal SES (Figure 5.2). We specifically asked the respondents what changes they had noticed in their coastal environment since they were young. For each report of change, we recorded the direction (e.g., stop; start) and the driver of the change (e.g., climate conditions; illegal fishing). In a second step, we conducted a series of FGD (N=8), with 4 to 9 people in each group, to examine the level of agreement for all reported changes using convenience quota sampling. We organized two FGD per village, except in one village where we did not secure enough participants. We combined reports of local indicators of climate change impacts, hereafter "indicators", following a two-step process. First, we selected reports of changes for which the driver was directly or indirectly related to changes in elements in the atmospheric system. Then we categorized the reports of change according to the classification by Reyes-García et al. (2023) (for more details, see: https://www.licci.eu/licci-tree/licci-tree.svg). Finally, we conducted a face-to-face survey to assess variation in individual observations of a subset of indicators. We used convenience quota sampling (Rukmana, 2014) to capture gender diversity among respondents at the site level. We randomly selected households in each of the five surveyed villages. In each household visited, we interviewed one or two adult(s). In total, we surveyed 203 individuals, of which 51% were women. To build the survey, we used the list of indicators compiled from the SSIs and validated through FGD (Appendix 5-Table S5.2). Out of the initial list of 60 indicators agreed, we randomly selected 30 (50%). We tested them with ten individuals to ensure variation in individual observations. For the final version of the survey, we selected a total of 19 indicators, which corresponded to the ones showing the most variation

among respondents during the pilot-testing phase. The final version of the survey is available in Appendix 5 (List S5.1).

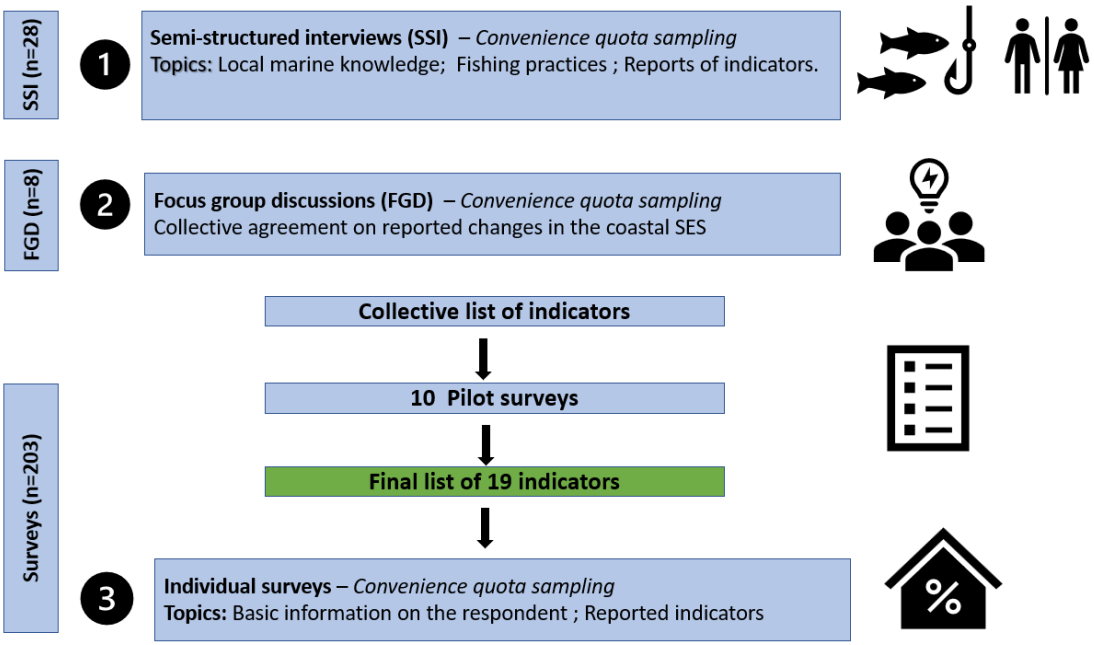

Figure 5.2: Summary of the LICCI protocol applied at the study site. Main steps include **1)** semi-structured interviews (SSI); **2)** focus group discussions (FGD); and **3)** individual surveys based on the final list of indicators.

2.3. Data analysis

To assess the state of scientific knowledge on climate change impacts on coastal SES in the WIO (O1), we applied a content analysis to identify and describe key thematic patterns derived from the literature (Braun & Clarke, 2006). We also used the NOAA OI SST V2 High Resolution dataset to compute the anomaly of the sea surface warming trend between 1982 and 2021 using a linear regression of the annual average anomaly relative to the mean warming over the Indian Ocean to time (the anthropogenic signal can be considered quite linear over the 1982-2021 period).

To examine whether local meteorological data for the 1991-2018 period align with regional climate trends reported in the literature (O2), we used available meteorological data for Kwale county from the Kenya Meteorological Department. We first calculated the monthly mean of daily minimum and maximum atmospheric temperatures at 2m height to reduce the aliasing from high-frequency variations. This gave us a time series of 336 observations of monthly atmospheric temperatures over 28 years. Then we performed a time series analysis on R version 4.2.1 (2022) to estimate linear trends in atmospheric temperature and assess their statistical significance using the Seasonal Decomposition of Time Series by Loess function. We applied the same method to assess trends in rainfall by considering both monthly mean rainfall and the number of consecutive dry days per month calculated from daily rainfall data.

To analyze perspectives on climate change impacts by local SSF communities using a gendered approach (O3), we first used descriptive statistics to identify the indicators most often reported by respondents. In a second step, we compared the reports of indicators between men and women using data from individual surveys. We analyzed whether there was a difference in the number of indicators reported by women and men using a Welch two-sample t-test (Rasch et al., 2011). We also used a Chi-square test (Agresti, 2007) to assess whether there was a significant relationship between gender and the type of indicators reported.

Lastly, to explore LEK on climate change impacts on coastal SES in the WIO and its relation to scientific knowledge (O4), we applied the MEB approach (Tengö et al., 2014) as an integrated and qualitative approach to bring together the main findings from the scientific literature and local meteorological measurements with the indicators reported by SSF communities. We examined indicators in the light of the trends reported for the corresponding regional scientific variables as detailed in Appendix 5 (Table S5.3). More specifically, we identified cases where indicators were also reported in scientific data sources and coded their alignment (i.e., overlap; divergence), as well as cases of change reported by Shimoni-Vanga SSF communities but not associated with scientific evidence, either because the lack of scientific documentation or lack of scientific consensus. We coded this latter category as "local insight".

2.4. Research positionality statement

We are aware that we only provide a partial and situated understanding of local perspectives of climate change impacts on coastal SES in the WIO, mostly shaped by our own epistemic background as researchers who do not originate from the Kenyan coast. Hence, some dimensions of the local knowledge system, especially those related to cultural values, ethics, and spiritual practices, may not be well reflected in our research work developed from a positivist standpoint despite our effort to adopt an inclusive approach. This limitation should invite caution in the interpretation of our results, while encouraging further studies on the topic to improve the understanding of knowledge held by Kenyan coastal societies and its connection to scientific epistemology.

3. Results

3.1. Scientific knowledge

3.1.1. Review of scientific literature: climate trends in the WIO

Examining the selected literature, we found a strong climate signal in the WIO, with researchers reporting a significant increase in mean atmospheric temperatures (Vincent et al., 2011). This trend is expected to be amplified in future decades in a "business as usual" scenario (Maina et al., 2021). The long-term change in regional rainfall patterns is more difficult to detect, although current trends suggest a decrease in mean and daily extreme rainfalls (Vincent et al., 2011). Models predict hotter and drier future conditions in the WIO, with more extreme seasons (Maina et al., 2021). Climate change could also amplify the magnitude of a natural mode of climate variability that strongly impacts rains over East Africa and may cause more frequent extreme events (Cai et al., 2013). Climate change may further modify the dynamics of the Inter-Tropical Convergence Zone.

Mean SST in the WIO have increased by up to 1.28 °C at a rate of 0.1 °C/decade since 1900 (Roxy et al., 2014; Vincent et al., 2011). In that sense, the WIO represents a "special case" as it has been warming faster than any other tropical region (Roxy et al., 2014), including the other parts of the tropical Indian Ocean (Figure 5.3). In addition to continuous warming, the WIO has also experienced the highest frequency of marine heatwaves recorded for the whole Indian Ocean basin (Saranya et al., 2022). Models predict that this warming trend will continue in the next decades (Jacobs et al., 2021). As in most other basins, the WIO will experience an increased oceanic acidification with a drop of surface pH, and a seasonal reduction of near-surface nutrients available for ocean marine productivity (Jacobs et al., 2021). The WIO region should also experience major changes in ocean circulation and winds (Painter et al., 2021), which in turn are expected to affect ocean currents and coastal upwelling systems (Praveen et al., 2016). A regional sea level rise is more complicated to detect owing to relatively short tide-gauge records and the high natural variability in the WIO region (Church et al., 2006).

In addition, other studies have examined how these anthropogenic climate change effects affect coastal biodiversity. Most publications have focused on the adverse impacts of climate change on coral reef ecosystems (Gudka et al., 2020; McClanahan et al., 2020). Projections suggest an increase in the frequency and severity of bleaching events over the next decades (Couce et al., 2023), representing a major risk of collapse for coral reef ecosystems in the WIO (Obura et al., 2022). While past trends indicate a substantial reduction in net primary production (Roxy et al., 2016), future trajectories are likely to be heterogeneous within the region (Wilson et al., 2021). Combined with increased ocean warming, changes in marine productivity will affect the rest of the food web with an amplified effect at higher trophic levels (Wilson et al., 2021) and lead to potential shifts in species distribution towards cooler regions (Painter et al., 2021) and eventually species extinction (Feare et al., 2007). This situation has severe socio-economic implications for fisheries-reliant coastal communities in the WIO. Several studies anticipate a sharp decline in fish catch in the region by the end of the century (Anildo et al., 2011; Jacobs et al., 2021). Especially, Wilson et al. (2021) project a significant decline in fish species biomass in the Kenyan and Tanzanian EEZs (median reduction of 63-76% and 56-69% respectively), as well as in species richness, over the 21st century under the RCP8.5 scenario. This alarming trend is projected to increase regional food insecurity (Painter et al., 2021).

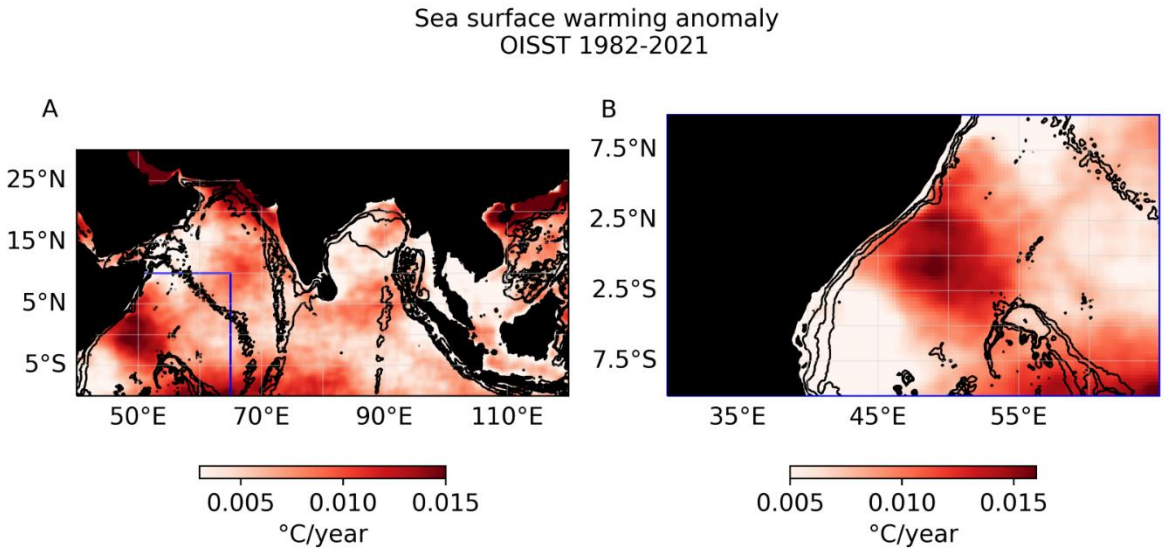

Figure 5.3: The Western Indian Ocean (WIO) is a global warming hotspot within the Indian Ocean basin. The maps represent the anomaly of sea surface warming (relative to the annual mean trend over the Indian Ocean) at **A)** the WIO basin level and **B)** along the East African coast using linear regression on the National Oceanic and Atmospheric Administration ¼° Daily Optimum Interpolation Sea Surface Temperature between 1982 and 2021.

3.1.2. Local meteorological measurements in coastal Kenya

Using available meteorological data from the Kenya Meteorological Department, our statistical analysis indicates an increasing trend in mean atmospheric temperatures of + 0.47°C/decade in Kwale county between 1991 and 2018 (F-statistic=683.8; p- value < 2.2e-16) (Figure 5.4). This general trend is in line with the observed increasing mean seasonal temperatures during both the Northeast and Southeast monsoon seasons (F-statistic=244.4; p-value < 2.2e-16; F-statistic=330.8; p-value < 2.2e-16 respectively). However, we did not find any statistically significant trend in rainfall, neither in terms of monthly mean rainfall nor in terms of consecutive dry days per month.

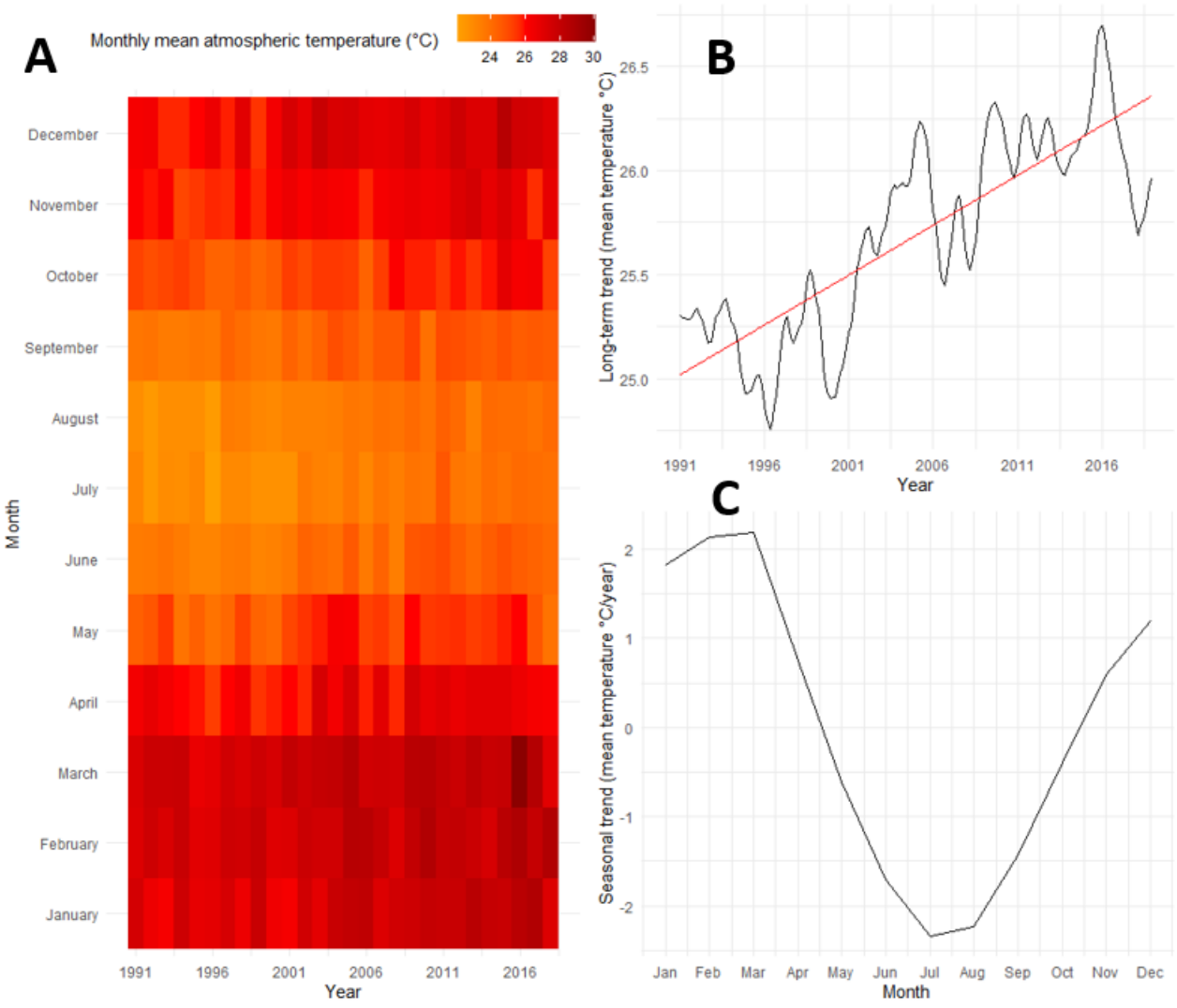

Figure 5.4: Significant increasing trend in mean annual atmospheric temperatures for Kwale county. **A)** Heatmap and linear regression showing **B)** long-term and **C)** seasonal trends in monthly mean atmospheric temperatures in Kwale county between 1991 and 2018.

Overall, we found an agreement between regional trends in climate change impacts reported in the reviewed literature and trends found in local meteorological data. These two data sources are consistent in indicating a marked increase of atmospheric temperatures – correlated with rising SST– and an absence of significant signals for long-term change in regional rainfall patterns. The reviewed literature further emphasized how changes in the climate system are increasingly affecting marine biodiversity and, subsequently, coastal livelihoods in the WIO region.

3.2. Local ecological knowledge

3.2.1. The ocean as a way of life

SSF communities from the Shimoni-Vanga seascape [hereafter "Shimoni-Vanga SSF communities"] have a strong connection to the sea. People's lifestyle is fully shaped by their daily interactions with the sea, especially through small-scale fishing activities which play a key role in food security. Across generations, local people have accumulated and maintained in-depth knowledge on the species they fish, sell, or eat, their behavior or marine habitats, as explained by Juma (2021), a local fisherman: "*Here, everyone is doing fishing,* [this knowledge] *is passed on by our parents. It is how I have learned how to fish*."

Local ecological knowledge on the marine environment is gendered. Fishermen use the whole seascape, from the beach to the open ocean, to harvest fisheries resources, while fisherwomen are restricted to the intertidal areas. This can be summarized in the words of Mariam (2021), a renowned female octopus fisher: "*Men go out in the deep ocean to fish octopus. They use boats to reach their fishing grounds and then diving instruments. But women are restricted to the shoreline since they do not know how to dive and can only get around on foot.*" Consequently, women and men usually target distinct species and hold gender-specific knowledge of marine resources. For example, fisherwomen possess very particular knowledge about the tides, the lunar cycle, and the ecology of their targeted species, which mostly consists of octopus and shell species. Conversely, fishermen's knowledge is more centered on currents, winds, and pelagic and demersal fish species since they commonly fish beyond the reef and can access the open ocean by boat. The gendered nature of LEK held by women and men in Shimoni-Vanga SSF communities, combined with long-term interactions with their coastal environment, allow them to detect fine changes in the seascape.

3.2.2 Local indicators of climate change impacts

Shimoni-Vanga SSF communities have observed numerous climate-driven changes in their coastal environment over the last 30 years. The five indicators most frequently reported by Shimoni-Vanga SSF communities from the survey data are 1) a decrease in the amount of catch of marine animal and plant species (reported by 98% of survey respondents), 2) an increase in the average atmospheric temperatures (97%), 3) a decrease in average rainfall (97%), 4) an increase in temperatures during the NEM season (locally called *"Kaskazi"*) (94%), and 5) an increase in the frequency of extreme droughts (92%). Shimoni-Vanga SSF communities attributed catch reduction to a combination of both climatic – i.e., rising SST – and non-climatic drivers – i.e., the degradation of fish habitats and overfishing. Further, they witnessed an increase in atmospheric temperatures, especially during the NEM season – which corresponds to the high fishing season. Changes in rainfall patterns were also commonly reported and perceived as an additional source of uncertainty for local livelihoods. Overall, Shimoni-Vanga SSF communities perceived that these complex cascading changes resulted in reduced incomes, with implications for the whole local economy.

3.2.3. Gender variation in the report of indicators

The total number of indicators reported by men and women in survey responses was not significantly different (t = -0.32381, df = 198.9, p-value = 0.7464). We found that both women and men reported an average of 14 (74%) indicators out of the proposed 19 (min = 6 (32%); max = 19 (100%)). We also found a similar distribution of reports for each indicator across men and women respondents (Figure 5.5). For two indicators, we found a statistically significant difference in the frequency of women's and men's reports. Women had a higher probability of reporting changes in mean rainfall (X^2=7.7909; p-value: 0.02033) and in atmospheric temperatures during the SEM season (X^2=7.5831; p-value: 0.02256) than men.

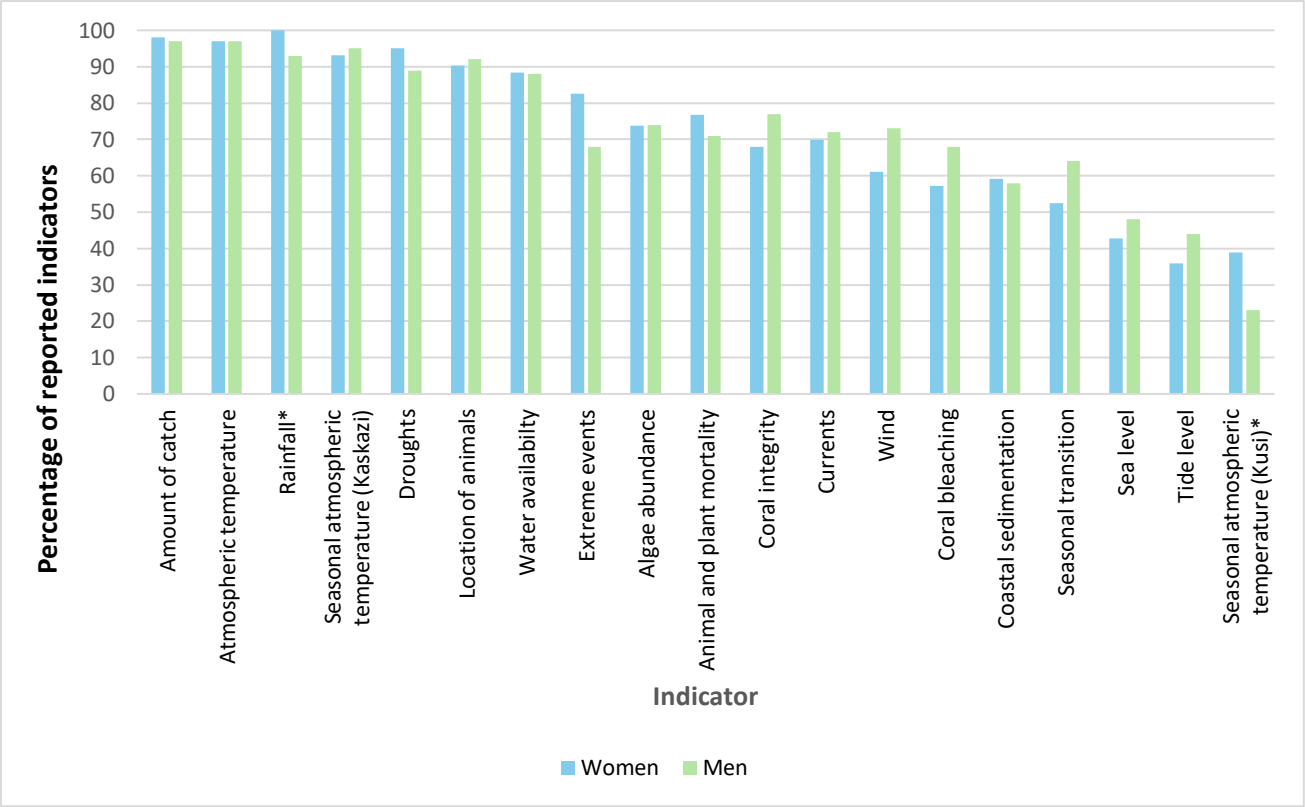

Figure 5.5: Gendered distribution of reported indicators. Percentage of indicators of climate change impacts reported by women (n = 103) and men (n = 100). Stars (*) denote indicators for which we found statistically significant differences in reports comparing women and men's samples using a Chi-square test.

3.3. Insights from scientific and local ecological knowledge

We found an important overlap level between scientific knowledge and LEK regarding climate change impacts, with 74% of the indicators reported by Shimoni-Vanga SSF communities found in the scientific literature (Figure 5.6). Especially, four of the five indicators most frequently reported (i.e., decrease in the amount of catch, increase in mean and seasonal atmospheric temperatures, and increase in extreme drought events) are also documented in peer-reviewed scientific publications at the WIO scale. We also identified five indicators of change (26% of the total) reported by Shimoni-Vanga SSF communities that were not documented in the literature. Specifically, Shimoni-Vanga SSF communities reported changes in local coastal dynamics – sea level rise, increase in coastal currents and shifts in temporal tidal patterns – and a decrease in the abundance of marine algae (*Ulva* genus) used as bait ("*chambo*") by fishermen. As explained by Said (2021), a basket trap fisherman: "*We noticed a lack of green algae because of reduced rains. Then we get less tafi* [i.e., rabbitfish] *because we need this alga to attract these fish*." We did not find evidence of such changes in the reviewed literature. Further, Shimoni-Vanga SSF communities reported a decrease in mean rainfall, a trend still debated in the literature for the study area. We did not find cases of divergence between local indicators and scientific evidence from the reviewed literature.

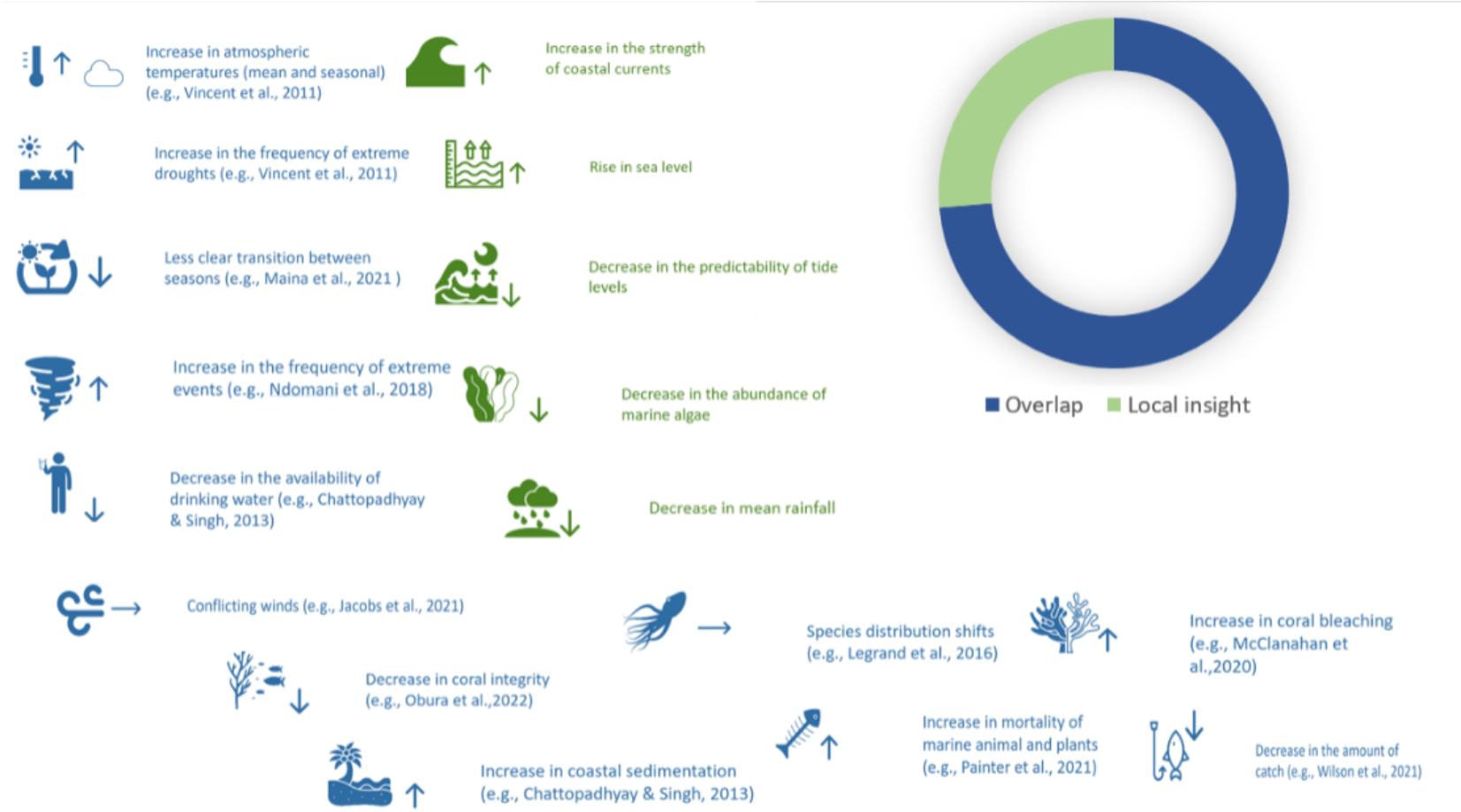

Figure 5.6: Overall picture of climate change impacts on coastal social-ecological systems (SES) in the Western Indian Ocean (WIO) derived from both scientific and local ecological knowledge (LEK). Overview of the main climate change impacts on coastal SES in the WIO as reported both in the scientific literature and by local small-scale fishing (SSF) communities from the Shimoni-Vanga seascape. Impacts overlapping between scientific and LEK systems are indicated in blue and those only mentioned by SSF local communities in green.

4. Discussion

This study explores LEK on climate change impacts and its relation to scientific knowledge through a gender lens. Scientific literature on the topic documents pronounced climate change impacts in the WIO region with negative implications for the SSF sector, but there is no consideration of impacts differentiated by gender. Indicators of change reported by Shimoni-Vanga SSF communities indicate substantial changes in the coastal SES, with few but noticeable gendered differences. When bridging scientific and local ecological knowledge, we found a great degree of overlap between the two, but also unique insights provided by Shimoni-Vanga SSF communities on fine changes in coastal dynamics, algae abundance, and rainfall. Our results suggest that LEK is very insightful on the social and gendered contexts in which climate change impacts are felt and understood.

Before discussing our results, we acknowledge two main limitations in our research methodology. First, owing to the absence of local meteorological stations at our study site, we relied on a hybrid data collection source, combining both *in situ* data and extrapolations. This limitation reveals the difficulty of producing long-term and thorough meteorological datasets in some parts of the African continent (Dinku et al., 2017). Second, owing to limited capacities in the field, we mostly focused on gender and did not include other social categories that might shape how people experience climate change. This might restrict a thorough assessment of the complex power dynamics of climate change impacts, thus calling for further intersectional approaches in climate research (Djoudi et al., 2016).

4.1. Scientific knowledge

The literature review indicates that the WIO is experiencing a stronger warming than the remainder of the Indian Ocean and other tropical ocean basins. This warming trend is expected to intensify in the future with negative knock-on effects on coastal and ocean processes. These findings emphasize the need to improve the accuracy of projections at fine spatial and temporal scales to refine climate change impact projections in the region (Kwiatkowski et al., 2020). Further, the literature documents the detrimental impacts that climate change is having on WIO marine fisheries. This situation is particularly worrying given the considerable importance of SSF for local communities from social, economic, and nutritional standpoints (Savo et al., 2017). Our findings support the call made by scientists (D'agata et al., 2020; Mcleod et al., 2019) and the FAO (Barange et al., 2018) to urgently develop adaptive strategies in the region that are brought forward at the level of local communities, such as developing adaptive fishery management plans, strengthening MPA networks, and reinforcing local capacity building.

However, one major blind spot highlighted in our study is the absence of gender considerations in the examined climate change impacts on SSF in the reviewed literature. Yet researchers and the IPCC have documented the gender-differentiated impacts of climate change and related vulnerabilities globally (IPCC, 2021; Pearse, 2017). Without developing a "sociology of climate change" that sheds light on the social and gendered nature of climate change (MacGregor, 2010, p. 137), some climate change impacts on WIO local livelihoods may be overlooked (Djoudi et al., 2016; Pearse, 2017). There is thus a critical need to foster gendered perspectives in regional climate and ocean research to soundly address gender along other social inequalities in climate policies.

4.2. Local ecological knowledge

Our study provides a general overview of the large bodies of knowledge held by Shimoni-Vanga SSF communities, which were acquired over time through an intimate and deep-rooted connection to the coastal environment. In that regard, our findings corroborate previous ethnoecological work documenting the diversity and richness of knowledge held by various small-scale fishing communities worldwide (Cordell, 1978; Johannes, 1981). We also found that LEK held by Shimoni-Vanga SSF communities is gendered as reported in many other parts of the world (Ferguson, 2021; Rohe et al., 2018). Since women and men tend to fish in different parts of the seascape with gender-differentiated techniques, they catch different species and may possess gender-distinct knowledge of marine resources. Gender and fisheries research scholars have notably shed light on gender-distinct knowledge on marine habitats and fishing grounds (Thomas et al., 2021), animal behavior (Andrade et al., 2016), or fishing techniques (Tilley et al., 2021).

Shimoni-Vanga SSF communities do report a wide array of indicators of climate change impacts. These results confirm previous research showing that coastal communities worldwide are at the frontline of climate change, which makes them able to detect its direct and indirect impacts on coastal SES (Makame & Shackleton, 2020). As documented in many coastal communities, a decrease in catch is strongly noticeable by fisherfolk. Catch decreases represent a major source of concern for coastal communities as it has direct implications for their daily protein supply (Kawarazuka & Béné, 2010). These findings have strong implications for future adaptation decisions and policies and current discussions about loss and damage from climate change. Our findings suggest that Shimoni-Vanga SSF communities are particularly affected by climate change impacts and should thus be included on discussions regarding the design of suitable place-based adaptation strategies (Savo et al., 2017).

Further, our results indicate a high degree of similarity between indicators reported by women and men, suggesting that both genders are aware and observe a broad range of climate change impacts in their surrounding environment. However, we found significant gender differences in the report of two particular indicators. Notably, we found that women report more changes in mean rainfall than men. We argue that this difference can be explained by the fact that women are the primary caregivers and responsible for fetching water for domestic uses. As such, they may be more sensitive to a decrease in rainfall, as it may have direct implications for their capacity to cook and fulfil household needs. Similarly, we found that women also report significantly more changes in atmospheric temperatures during the SEM season than men. We suggest that because this period corresponds to the high catch season for women (but not for men), they may be more exposed to an increase in atmospheric temperature and the related consequences on their catches during this time. Taken together, our findings highlight the importance of the gendered division of labor in WIO coastal communities in relation to people's reports of climate change impacts. These findings illustrate how gender considerations may contribute to drawing a comprehensive picture of the diversity of related impacts and social consequences derived from climate change, improving climate information obtained from instrumental data collection, and guiding adaptation policies.

4.3. Weaving scientific and local ecological knowledge

Importantly, we found a considerable level of overlap between indicators of climate change impacts derived from scientific and local ecological knowledge. This finding is consistent with earlier work documenting consistency between scientific and local ecological knowledge related to climate change (Laidler, 2006; Reyes-Garcia et al., 2024). The overlap suggests that bringing both knowledge systems together might improve the explanatory power of climate dynamics and help broadening the understanding of climate change impacts and their implications for local SSF livelihoods (Reyes-García et al., 2016; Savo et al., 2017).

Further, we found that five changes reported by Shimoni-Vanga SSF communities were not documented in the literature. That is the case for information regarding coastal dynamics linked to an

increase in local currents and shifts in sea and tide levels, a decrease in rainfall, and a decrease in the abundance of green algae used for attracting fish by basket trap fishermen. All these changes directly relate to local fisheries activities. We also found gender differences in the reporting of two indicators, whereas gender differences in the reporting of climate change impacts on SSF had not been identified in the scientific literature. These findings suggest that LEK held by SSF communities reflects a holistic perspective on climate change impacts and situate them in a particular socio-cultural context. Weaving the two knowledge systems together would thus highlights the relational and place-based nature of climate change impacts and their gendered dimension. This complementarity is much needed to identify adaptation strategies that align with local priorities and needs. To that extent, our study falls within the growing literature documenting the value of knowledge pluralism in climate research and policy (Orlove et al., 2023).

5. Conclusions

Improving our understanding of climate change impacts on coastal SES and designing future gender-inclusive adaptation policies will require us to rethink conventional knowledge production and embrace collaborative knowledge approaches (Bai et al., 2015; Fazey et al., 2020). While acknowledging the challenges related to such an endeavor, we highlight three avenues for future work. First, scientists need to transform research ethics towards an increased recognition of other knowledge holders, especially IP & LC. According to Berkes (2008), making room for IP & LC and their specific knowledge in academia may reflect “the need to develop a new ecological ethic in part by learning from the wisdom of traditional knowledge holders” (p. 19). Second, in line with other scholars, we encourage the development of collaborative research methods for braiding diverse knowledge systems (Coombes et al., 2014; Jonhson et al., 2016). Gender-inclusive methodologies and intersectional approaches are also much needed to capture more acutely the complexities of climate vulnerabilities and adaptive responses (Djoudi et al., 2016). Finally, transforming research paradigms could not occur without a radical political reframing of knowledge production, access, and governance. In particular, the science-policy interface on environmental governance, through assessment processes like the IPCC, would gain effectiveness in adopting clear and fair procedures for connecting knowledge systems and ensuring the actual and legitimate participation of local knowledge holders in a gender-equitable way (Tengö et al., 2014). Only under those conditions can one envision a future where equity across diverse knowledge systems and gender identities is truly achieved, further contributing to the co-production of new positive ways of knowing, valuing, and caring for human-nature relationships.

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Chapter 6

"Men don't feel comfortable with successful female leaders": Exploring participatory exclusion in community-based fisheries management, South Coast of Kenya

Community-based fishery management through local Beach Management Units (BMU) in the Shimoni-Vanga seascape contribute to protect the environment and restore degraded areas as illustrated in this BMU member's t-shirt: "I plant mangroves, I protect the environment" (translated from Swahili).

Abstract

While community-based fisheries management (CBFM) is promoted as a promising approach to achieving sustainable fisheries management, its inclusiveness is increasingly questioned in the literature. Studies that explore the inclusion of gender along other intersectional social identities in CBFM are scarce. This research gap may limit a comprehensive understanding of power dynamics in fisheries settings, while reinforcing exclusionary approaches in fisheries governance. In this study, we use an intersectional approach to examine gender-inclusiveness in CBFM through a case study on the South Coast of Kenya. We applied qualitative data collection methods, combining participant observation, semi-structured interviews (n=18), focus group discussions (n=6) and relief maps (n= 32). Our findings indicate that women's participation in CBFM is limited and systematically lower than men's participation. Barriers to women's participation in CBFM are complex and interlaced, including socio-cultural, economic, and institutional barriers, and specific restrictions to women's access to leadership. In addition, our findings highlight the intersecting nature of lived experiences related to CBFM places and suggest that CBFM may sustain and reinforce social inequalities in fishing communities. Overall, our results tend to confirm the relevance of the participatory exclusion concept to CBFM in coastal Kenya. Our study demonstrates the importance of applying an intersectional framework to study the complexity of power relationships in CBFM contexts, as well as fisheries management and governance. We conclude by providing key recommendations towards transformative management approaches in fisheries settings.

Key words: Community-based fisheries management; Gender; Inclusiveness; Intersectionality; Ocean sustainability; Western Indian Ocean

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1. Introduction

> "*Women's presence in decision-making may not guarantee outcomes in their favor but it could guarantee them representative voice, and this has both intrinsic worth and instrumental value*." (Agarwal, 2010, p. 13)

Human activities are driving major adverse impacts on biodiversity globally, requiring transformative governance (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES], 2019). Community-based natural resource management (CBNRM) has been proposed as a transformative entry point to mitigate biodiversity erosion and facilitate climate adaptation (Twyman, 2017). However, mainstream approaches in CBNRM have often neglected gender along other intersecting markers of social identities, with implications for social justice and equity (Agarwal, 2001; Rabbitt et al., 2022).

Shifting from top-down governance approaches, CBNRM has been promoted by development actors and scholars since the 1980s for its potential to achieve both environmental and socio-economic outcomes (Jentoft et al., 2014; Roka, 2019; Twyman, 2017). At the core of the approach is the participation of local users in the decision-making process related to the use and management of their environment. While the definition of participation is debated in the literature (Agarwal, 2001; Arnstein, 1969), it broadly relates to the engagement of people in governance, implying a certain degree of power devolution (Graham et al., 2006; Jentoft et al., 1989). Scholars argue that, after several decades of practice, CBNRM is facing a "crisis of identity and purpose" that contradicts its original ethos (Dressler et al., 2010, p.5; Robinson et al., 2021). An important line of critique revolves around its inclusiveness, or its capacity to engage a diversity of local users throughout all management and decision-making processes (Johnson et al., 2021; Quick & Feldman, 2011). Instead of supporting equitable participation in decision-making, CBNRM has been decried for exacerbating power imbalances (Johnsson et al., 2021). In particular, women – among other marginalized groups – have long been excluded from participation in CBNRM, as extensively documented in the literature (Leisher et al., 2017; Rohe et al., 2018). This observation gave grounds to the notion of "participatory exclusion", developed by Agarwal (2001) to designate the formal exclusion of women in CBNRM settings that are supposedly based on participatory and inclusive principles.

Two decades after it was first proposed, the concept of "participatory exclusion" continues to be relevant in the SSF sector, commonly perceived as a male-dominated sphere (Chambon et al., 2023; Frangoudes et al., 2019; Lentisco & Lee, 2015). While women account for 40% of the labor force in SSF, the informal and unpaid nature of their activities, along with other factors, mean that women's actual contribution to the sector is downplayed (Harper et al., 2017; Kleiber et al., 2015). In turn, the undervaluation of women's roles in the SSF economy increases their marginalization in SSF management and governance (FAO et al., 2023). Research on CBNRM in the fisheries sector – or community-based fisheries management (hereafter CBFM) – shows that participatory projects tend to favor men's over women's participation in decision-making, suggesting that gender-inclusiveness in CBFM is lacking (Cinner et al., 2012; Evans et al., 2011; Rabbitt et al., 2022). As reported in the literature, barriers that hinder women's participation in SSF management encompass social, cultural, economic, and institutional dimensions (Bradford & Katiro, 2019; FAO et al., 2023; Galappaththi et al., 2022). Nonetheless, the few case studies that document the active participation of women in SSF management highlight the multiple positive outcomes of such inclusion at multiple levels (Chambon et al., 2023; Leisher et al., 2017), which supports the need to integrate gendered perspectives in CBFM processes both for intrinsic (i.e., for its absolute value) and for instrumental motivations (i.e., as a mean of pursuing certain objectives) (Lawless et al., 2021).

Feminist scholars have increasingly examined inclusiveness in SSF by investigating how power structures beyond gender, such as ethnicity, religion, or class, interact to generate specific social

positions within society that shape the access and control over fisheries (Colwell et al., 2017; Lau & Scales, 2016). Central to this concept, known as intersectionality (Crenshaw, 1989), is the importance of lived experiences of inequalities (Rodó-Zárate, 2022). Early intersectional researchers explored the oppressed experiences of black women in the United States to theorize about the intersection between gender, race, and class (Collins, 1990; Crenshaw, 1989, 1991). In this regard, emotions have been used as a useful vector to capture the intimate and political dimensions of lived experiences related to inequalities. In particular, the notion of (dis)comfort, which relates to a wide range of emotions, has been theorized by Ahmed (2007) regarding the notion of whiteness to characterize the emotional fit of individuals in a given environment. In the author's own words, "*[t]o be comfortable is to be so at ease with one's environment that it is hard to distinguish where one's body ends and the world begins*" (p.158). Some scholars working on intersectionality have notably attempted to bridge the gap between intersectional and feminist geography theories by relating the notion of comfort to places (Rodó-Zárate, 2023; Valentine, 2007). This research area points out the relevance of using a geographical approach in intersectional studies, recognizing that emotions associated with certain social identities are contingent on places that engender and may reinforce social inequalities.

Studies that have applied an intersectional framework to assess gender-inclusiveness in CBFM processes are scarce (House et al., 2023). This blind spot in the literature causes three main concerns regarding fisheries research, governance, and ethics. First, the lack of consideration for gender in relation to other power structures in CBFM research may lead to potential bias in the understanding of participatory approaches in SSF management, ultimately resulting in partial and incomplete views of social-ecological systems. Acknowledging other views provides a more nuanced understanding of CBFM, which contrasts with narratives assuming homogeneity among fisherfolk. Second, the paucity of gender and intersectional analysis in CBFM contexts has direct implications for management and governance as it may entrench gender blindness in SSF policies and reinforce social inequalities in SSF communities (FAO et al., 2023). As an example, the lack of data on female gleaners in Indonesian SSF communities of South Sulawesi Province contributed to women's under-representation in SSF management processes (Nessa et al., 2020). Third, embracing inclusive approaches in CBFM development is a matter of social justice that is necessary to achieve the objectives of gender equity and equality in SSF and marine conservation in lines with the FAO's Gender Handbook of the SSF Guidelines (2017), the Kunming-Montréal Global Biodiversity Framework (CBD, 2022), and the UN 2030 Agenda for Sustainable Development. In this paper, we contribute to enlarging the literature exploring gender inclusiveness and applying an intersectional framework to CBFM processes through a case study. More specifically, our study seeks:

(O1) To assess women's and men's participation levels in CBFM;

(O2) To identify the main barriers to women's participation in CBFM; and

(O3) To examine to what extent other power structures interact with gender in shaping lived experiences related to CBFM places.

The Beach Management Units (BMU) network on the South Coast of Kenya is an ideal case for exploring gender and intersectional dynamics related to CBFM. Community-based fisheries management initiatives through the BMU framework have mushroomed along the coast of Kenya over the two past decades to respond to local social, economic, and environmental imperatives, while incorporating gender considerations in their institutional development (Kawaka et al., 2017). As a result, this case study offers a relevant ground to assess the extent of inclusiveness of such processes based on empirical evidence. We acknowledge that our findings may not apply to other fisheries settings since gender relationships and their interactions with other social identities vary in space and time and are highly context-specific (Cornwall & IAI, 2005).

2. The rise of CBFM in Kenya through Beach Management Units

"*Our Beach Management Unit is like a tree, if you cut it down, it will take away the benefits of the shade and you remain burning in the sun*." (Mariam, fisherwoman, Shimoni-Vanga seascape, 2021).

As in many other tropical countries, SSF management in Kenya has long been centralized by the state, which alienated local communities from their coastal and marine resources (Kiaka, 2012; Maina et al., 2012). Since the 1960s, five national MPA were established in the coastal region under state management, within which subsistence fishing was limited or forbidden (Samoilys & Obura, 2011). This top-down approach failed in providing tangible benefits to local communities, thus generating a lot of resentment and lowering compliance from local users to the management regime (Munga et al., 2010; Wanyonyi et al., 2008). Against this background and pressed by local communities supported by non-governmental organizations and international donors, from the 1990s, Kenyan fisheries management has shifted towards the recognition of the need for a greater participation of local users in SSF management processes (Kawaka et al., 2017).

The shift in the Kenyan fisheries management approach has been reflected in the promotion of CBFM, an approach in which the responsibility for managing fisheries is driven by local users with the support of the government and other stakeholders (Cinner & McClanahan, 2006; GoK, 2016; Leeney et al., 2019). CBFM was first introduced by the Department of Fisheries in Western Kenya around Lake Victoria through the BMU framework, which built on grassroots organizations and collectives who used to manage their fisheries at the community level (Nunan et al., 2012). The framework provided a formal recognition to local fisheries organizations by gazetting them as BMU. These formal community-based institutions are responsible for implementing SSF management on the ground, in collaboration with the state, non-governmental organizations, international agencies or research institutes. Since 2007, this model has been extended from Lake Victoria to the rest of the country to enhance and formally support the participation of local communities in the management of fisheries as specified by the BMU regulation of 2007 legal notice no. 402 (GoK, 2007).

Officially, BMU comprise three main governance bodies: the general assembly, the executive committee (EC), and the board. The general assembly is made up of all registered BMU members and convenes every three months to approve and discuss the decisions taken by the EC. Membership to BMU is conditioned to certain administrative criteria, such as being an adult Kenyan citizen, but it is largely open to all individuals who depend on fisheries for their livelihoods (GoK, 2017). The EC corresponds to the decision-making body of the BMU and is elected by the general assembly every four years. It is made up of nine to 15 members, of which five are nominated to constitute the BMU board, which has a final say on decisions.

The rise of CBFM in Kenya has been concomitant with the growing recognition of the need to support women's representation in SSF management and decision-making. The Kenyan State has expressed its commitment to support gender equality in fisheries governance in line with Sustainable Development Goal N°5 (target 5.5) by ratifying several Multilateral Environmental Agreements that guarantee an equitable access to natural resources. At the national level, the Constitution of Kenya (GoK, 2010) posits equity and inclusiveness as core national values and principles of governance (article 10). More specifically, the Constitution of Kenya introduced a key governance rule – known as the two-thirds gender principle – which requires that "*not more than two thirds of the members of elective or appointive bodies shall be of the same gender*" (article 27 (8)). These constitutional dispositions are completed in national legislation through Sessional Paper No. 02 of 2019 on National Policy on Gender and Development (GoK, 2019) which notably aims to "*enhance women's participation in fisheries sector and the blue economy*" (p.34). This gendered dimension in the fisheries sector is also integrated in sectoral policies and laws such as the Kenya National Fishery Policy (GoK, 2020), the Fisheries

Management and Development Act (GoK, 2016), and the Fisheries BMU Regulations (GoK, 2007). In practice, this legislative arsenal, and especially the two-thirds gender principle, implies respecting a minimum quota of 33% women representatives in BMU executive committees.

3. Materials and methods

3.1. Study site

We carried out research within the Shimoni-Vanga seascape, South Coast of Kenya. The study site experiences two main monsoon seasons – the Northeast (November-March) and the Southeast monsoons (April-October). Marine ecosystems found across the study site include seagrass beds, mangrove forests, and coral reefs (WWF, 2001) (Figure 6.1). The study site encompasses the Shimoni-Vanga Joint Fishery Co-Management Area, a coastal area jointly managed by seven BMU (GoK, 2017). In addition to this common area of jurisdiction, some of these BMU have designated their own LMMA which they manage with the support of county fisheries authorities. It is estimated that about 18 000 people of diverse ethnic groups live in the Shimoni-Vanga seascape (GoK, 2017), of which the Swahili people are the largest cultural group. Local people primarily rely on SSF for their livelihoods (Lau et al., 2021).

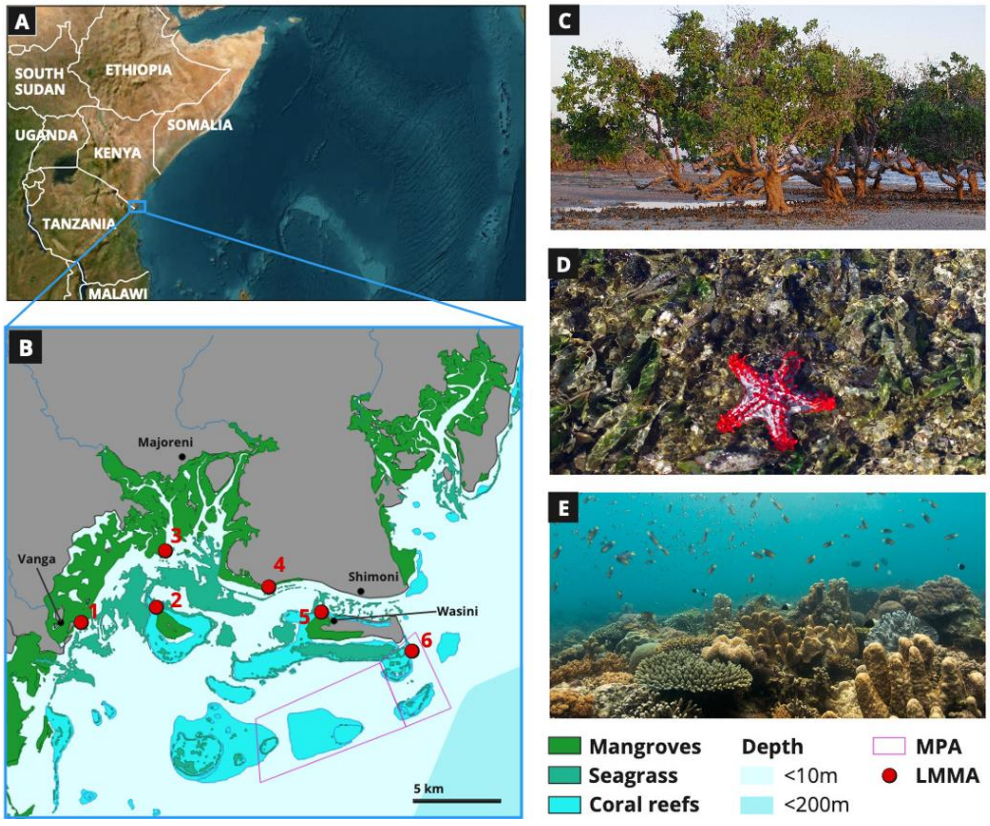

Figure 6.1: Location map of the study site. **(A)** Situating the study site along the East African coast (based on OpenStreetMap, 2024). **(B)** Ecological characteristics of the Shimoni-Vanga seascape (QGIS 3.28.0) and conservation tools such as the Kisite-Mpunguti Marine Park and Reserve (MPA) and six locally managed marine areas (LMMA): 1-Vanga, 2-Jimbo, 3-Majoreni, 4-Kibuyuni, 5-Wasini and 6-Mkwiro. Main ecosystems in the Shimoni-Vanga seascape include: **(C)** mangrove forests (**D)** seagrass beds, and **(E)** coral reefs. © M. Chambon 2021 (C-D) and D. Knoester 2021 (E), from Reefolution Foundation Shimoni.

Within our study site, we selected three communities that share socio-environmental features, while representing the socio-cultural diversity of the site (Table 6.1). Although Community 2 (C2) comprised two villages, we consider that they form one single community since they share strong historical and family ties. In each community, CBFM is operated by BMU structures. Both women and men engage in SSF but in different segments of the value-chain. The access to intertidal areas is a determining factor of women's participation in the production sector. Owing to the proximity of C2 to reef flats, women in this community collect shells and fish octopus along the shore. By contrast, Communities 1 and 3 (C1 and C3) do not have direct access to intertidal areas. As a result, women in these communities are mostly involved in the post-production segment of the SSF value chain. In the three communities, men engage throughout the whole SSF value chain.

Table 6.1: Background information on the three studied communities. Summary of the geographical settings, Beach Management Unit (BMU) places, BMU's history and conservation tools (LMMA), and gendered roles in the small-scale fisheries (SSF) value chain in each community.

	Community 1	**Community 2**	**Community 3**
Geographical setting	Mainland community located on the coastline, with no direct access to intertidal areas	Located on a coral-made island, separated from C1 by a maritime channel	Surrounded by mangrove forests with no direct access to intertidal areas
Number of villages	1	2	1
Number of BMU	1	2	1
BMU places	**BMU office:** EC meetings, administration and accounting, storage of resources and facilities	**BMU office:** EC meetings, administration and accounting, storage of resources and facilities **Eco-friendly building:** large meetings with partners and the general assembly; conservation activity planning	**Social hall:** large meetings with partners and the general assembly **Landing site *(Bandarini):*** data collection and monitoring
BMU foundation year	2008	2008 (BMU-1), 2009 (BMU-2)	2007
LMMA	No	Yes, operational	Yes, non-operational
Women's roles in the SSF value chain	Post-production	Production; post-production	Post-production
Men's roles in the SSF value chain	Pre-production; production; post-production	Pre-production; production; post-production	Pre-production; production; post-production

3.2. Data collection

Prior to collecting data, we obtained the approval of the Ethics Committee of the Universitat Autònoma de Barcelona (CEEAH CA01). We compiled Free Prior and Informed Consent from each community and individual who participated in the research as well as consent from local authorities. We cited our key informants as knowledge holders following the citation template by MacLeod (2021)

and used pseudonyms to anonymize their identities. We primarily identified respondents' genders according to their self-identification. We respected a gender-balance in all our sampling methods. We applied qualitative data collection methods, using both primary and secondary data as detailed below (Figure 6.2).

3.2.1. Primary data

In the three studied communities, the lead author used participant observation to explore intersectional power dynamics related to participation in CBFM (Kawulich, 2005). More specifically, the lead author attended meetings of the BMU general assembly and the EC whenever possible, joined community fisheries-related activities, visited conservation initiatives, and assisted local users in their daily activities.

We also conducted SSI on gender equity in BMU across the study site. For SSI, we selected 18 key informants (nine women and nine men) using purposive sampling. Specifically, we selected people who were strongly involved in the BMU in each community. We ran SSI to collect qualitative information on women's and men's participation in the BMU through questions related to the history of local BMU, women's and men's representation in the BMU, and their respective management activities. The lead author conducted all SSI.

Further, we conducted six FGD, two in each community, to collectively discuss women's and men's participation in management and decision-making processes. We selected FGD participants using convenience quota sampling and gathered between four and nine people in each FGD. Given the context in our study site, which implied a spatial separation of women and men and power asymmetries, FGD were done separately by gender to ensure that everyone felt comfortable discussing in public.

Finally, we used relief maps to capture intersectional dynamics through a geographical, psychological, and social lens (Rodó-de-Zárate, 2014). More specifically, we used this method in C2 and C3 to investigate the intersectional dimensions of CBFM through the analysis of lived experiences in BMU places. We adapted the digital relief map method to our research context by i) using a manual approach based on hand drawings, ii) adjusting it to rural and fisheries settings, and iii) making it accessible to illiterate people. In a first step, we asked BMU members during meetings to identify places frequented on a weekly basis, and especially places related to BMU activities. For this study, we focused on BMU places as defined in Table 6.1. We then selected 32 participants using convenience quota sampling and respecting a gender balance and asked them to define their comfort level in each place and through their multiple identities. Identities were defined according to six power structures relevant to the socio-cultural context of our study site and research topic: administrative status; age; education level; ethnicity; gender and marital situation. We considered that the way respondents relate to each power structure was constitutive of their plural and fluid identities, which then affected their lived experience and participation in BMU places. From discussions with participants, we derived narratives related to their personal experiences in BMU places. Lastly, participants used papers and colored pencils to draw lines of their relief maps with three dimensions. BMU places were indicated on the abscissa axis (geographical dimension) and respondent's lived experiences expressed by their comfort levels on the ordinate axis (psychological dimension). Different colors were associated with each power structure of interest (social dimension). Since some participants were illiterate, we used symbols for "happy" and "unhappy" faces to represent the gradation from comfort to discomfort.

All interviews, meetings, and group discussions were first translated from Swahili to English, and then transcribed. Owing to time constraints and to ensure the fluidity of the discussion, only the main points raised by participants during FGD and BMU meetings were summarized and translated. By contrast, the interviews were fully translated and transcribed *verbatim.*

3.2.2. Secondary data

We obtained gender-disaggregated data on BMU governance from the BMU boards in each studied community. Specifically, we compiled data on the number of women and men in the three main BMU governance bodies: the general assembly, the EC, and the board.

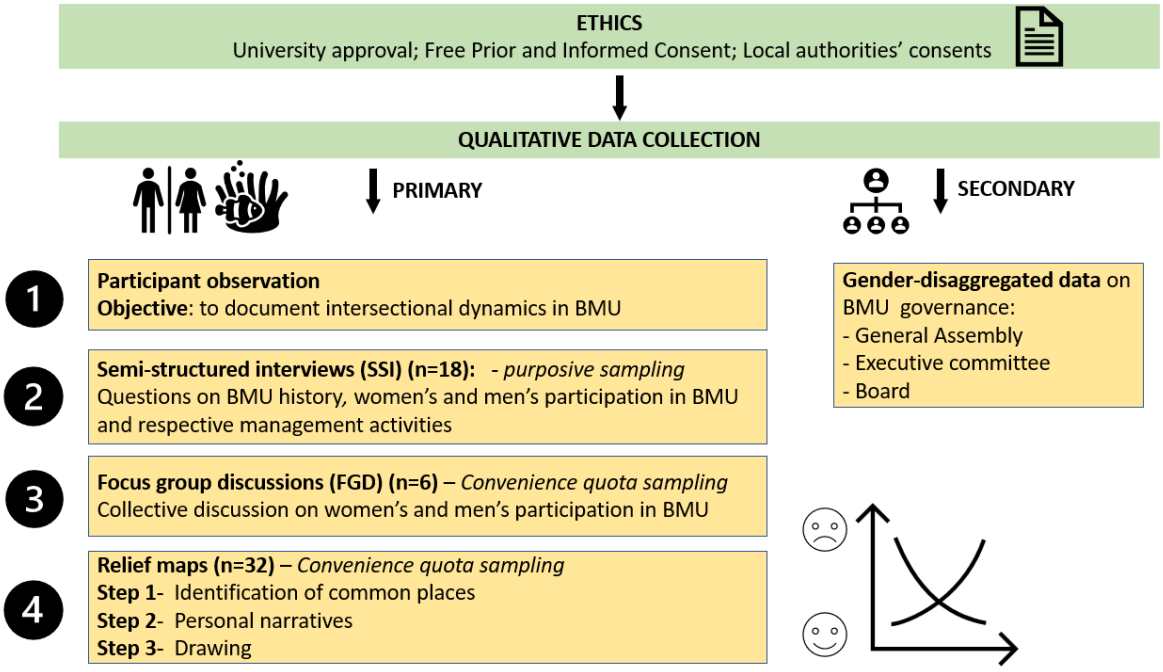

Figure 6.2: Summary of the methodological approach applied in this study from ethical considerations to data collection. Main tools for primary data collection include **1)** participant observation, **2)** semi-structured interviews (SSI); **3)** focus group discussions (FGD) and **4)** relief maps. Primary data were completed by gender-disaggregated data on BMU governance.

3.3. Data analysis

To assess women's and men's participation levels in CBFM (O1), we used gender-disaggregated data on BMU governance and information from participant observation, SSI, and FGD. We built on Rabbitt et al. (2022)'s women's participation model which comprises six participation levels (i.e., no participation, nominal, passive, consultative, active, and interactive (empowering) participation) and that adapted Agarwal's typology (2001) of women's participation in forestry management to SSF settings. To capture the gendered dimensions of CBFM, we broadened Rabbitt et al. (2022)'s model by applying it to both female and male BMU members. Specifically, we applied the model drawing on both quantitative and qualitative information. First, we used descriptive statistics based on BMU gender-disaggregated data to calculate gender ratios of the BMU general assembly, EC, and board. Then, we gathered qualitative information and examined a certain number of criteria described in Table 6.2 to distinguish between different participation levels.

Table 6.2: Criteria used to assess women's and men's participation levels in community-based fisheries management (CBFM) based on Rabbitt et al. (2022)'s six-stage participation model (adapted from Agarwal, 2001). Criteria in bold correspond to limiting factors that restrict the access to higher participation levels in this model.

Participation level in CBFM	Characteristics	Related assessment criteria
None	Women or men are excluded from participating in CBFM committees, and from attending meetings.	- **No access to BMU membership** - **No regular attendance to BMU meetings**
Nominal	Women or men are members of the CBFM committee but do not necessarily attend meetings.	- Access to BMU membership - **No regular attendance to BMU meetings**
Passive	Women or men are members of the CBFM committee, regularly attend meetings, but do not contribute to meeting discussions.	- Access to BMU membership - Regular attendance to BMU meetings - **Passive attitude during BMU meetings reflected in verbal or non-verbal expressions/postures**
Consultative	Women or men are members of the CBFM committee, regularly attend meetings and contribute to meetings discussions, but are largely ignored.	- Access to BMU membership - Regular attendance to BMU meetings - Active attitude during BMU meetings reflected in verbal or non-verbal expressions/postures - Engagement in various management tasks - **General feeling of exclusion from BMU decision-making** - **Restricted access to BMU leadership positions that would empower people of the same gender identity**
Active	Women or men are members of the CBFM committee, and regularly attend meetings where their ideas are valued and discussed. They are actively involved in all stages of resource management, from initial consultations and decision-making, through to ongoing monitoring and evaluation.	- Access to BMU membership - Regular attendance to BMU meetings - Active attitude during BMU meetings reflected in verbal or non-verbal expressions/postures - Engagement in various management tasks - General feeling of inclusion in BMU decision-making - **Restricted access to BMU leadership positions that would empower people of the same gender identity**
Interactive (empowering)	Women or men are members of the CBFM committee, attend and contribute to meetings where their ideas are valued and discussed, and they are involved in all stages of management. Women or men hold specific roles within the committee that empower other members of the same gender identity.	- Access to BMU membership - Regular attendance to BMU meetings - Active attitude during BMU meetings reflected in verbal or non-verbal expressions/postures - Engagement in various management tasks - General feeling of inclusion in BMU decision-making - Access to BMU leadership positions resulting in the empowerment of people of the same gender identity

To identify the main barriers to women's participation in CBFM (O2), we used the transcriptions from SSI and FGD. We applied an inductive qualitative content analysis to identify four main categories of barriers: socio-cultural, economic, institutional, and leadership. Within these broad barriers categories, we further identified subtopics. To do so, we read through our transcription texts and used in vivo coding to capture emerging common themes (Manning, 2017).

To examine to what extent other power structures interact with gender in shaping lived experiences related to CBFM places (O3), we analyzed relief maps and their narratives using narrative inductive analysis (Josselson & Hammack, 2021). We examined and compared relief maps between men and women to identify specific patterns in the context of their gendered narratives. We analyzed how the power structures examined interacted with gender in influencing respondents' experiences in BMU

places and characterized their intersectional relations. We completed this qualitative approach by using descriptive statistics to compare the number of relief maps displaying flat or discontinuous lines between male and female respondents. The flat lines pattern corresponds to relief maps expressing the respondent's high comfort feelings in each of his or her identities and regarding all BMU places, whereas discontinuous lines reveal places that are not frequented by the respondent. We calculated the respective frequencies of relief maps with flat or discontinuous lines among female and male respondents.

3.4. Research positionality statement

We acknowledge that our research team's attributes contrast culturally, socially, economically, and ontologically with those of the studied SSF communities. As a result, our study may have not fully grasped the complexities of intersectional power dynamics related to participation in CBFM in coastal Kenya. For this reason, our findings should be cautiously examined, while we recommend developing gender and intersectional studies on CBFM in the WIO region to improve understandings of these critical issues.

4. Results

4.1. Gendered participation levels in CBFM

4.1.1. Community 1

In C1, the two-thirds gender principle is not respected in any of the three BMU bodies, with male members largely outnumbering female members (Table 6.3). Only a small percentage of women attend BMU meetings. For instance, during the 2022 BMU annual general assembly, only 21% of the attendants were women. Women who join BMU meetings usually adopt a passive posture, listening to men without intervening. Further, female FGD members feel that their opinions do not count as much as male members' opinions. Even though there are three female representatives within the EC, these women feel oppressed by the other male members and forced to keep quiet. This feeling limits their engagement in decision-making within the EC. In addition, female members feel that they do not benefit from the same economic opportunities and access to information about fisheries management than men. Female FGD participants believe that this situation would not happen with a BMU chairlady, who would likely better represent their interests. Given minimal women's interventions in BMU meetings and their limited role in the EC, we consider women's participation level in CBFM in C1 as passive.

Men regularly attend BMU meetings and meaningfully contribute to management-related discussions. They are involved in a wide diversity of management tasks, including data collection, patrol, finance, the coordination of two sub-committees, and the organization and chairing of meetings. Since men actively participate in management tasks and meetings, and feel fully included in decision-making processes, we consider that they have an interactive (empowering) participation in CBFM.

Table 6.3: Gender ratios of the main Beach Management Unit (BMU) governance bodies (i.e., general assembly, executive committee, and board) by community. Cases where the two-thirds gender principle is not respected (i.e., less than 33% of women represented in a given elective body) are indicated in red color.

Community	Village	Gender	General assembly		Executive committee		Board	
			Headcount	Percentage	Headcount	Percentage	Headcount	Percentage
C1	/	Men	570	73	12	80	5	100
		Women	210	27	3	20	0	0
C2	V1	Men	185	60	9	60	4	80
		Women	124	40	6	40	1	20
	V2	Men	117	45	5	38	3	60
		Women	143	55	8	62	2	40
C3	/	Men	551	77	9	69	4	80
		Women	167	23	4	31	1	20

4.1.2. Community 2

In the two villages of C2, the two-thirds gender principle is respected both in the general assembly and EC (Table 6.3). Women are part of the board as vice-secretary (V1,2) or treasurer (V2), although in the two villages, the chairperson is a man.

Most women in C2 attend BMU meetings and some of them are very vocal in expressing their opinion. Women in C2 oversee fisheries data collection, lead entrepreneurship and conservation groups, and coordinate BMU sub-committees. Female FGD participants are enthusiastic about their roles within the BMU and feel that their opinion is as valued and listened to as that of men. However, in both villages, they nuance their feelings by indicating that they feel excluded from specific management activities that challenge traditional gender roles. In V1, women cannot take part in the patrol sub-committee because their male counterparts, especially within the board, consider that this activity is not suitable for women arguing it is too unsafe and physically demanding for them : "*It is only men who are part of the patrol sub-committee because there are some works ladies cannot do: going out at night… also going out in the waters… It is physically difficult. You see*?" (V1 BMU Chairman, 2021). Yet female FGD participants in V1 express their willingness to contribute to patrolling activities. Similarly, women in S2 are denied tour guiding activities since these activities require them to go on a vessel and interact with men. For these reasons, female FGD participants do not feel well represented within the BMU. Since women in C2 participate and express their opinions during BMU meetings and actively engage in various management tasks, we classify their participation level in CBFM as active. However, the fact that they feel excluded from specific management activities and are not well represented in leadership positions constitute limiting factors to their interactive participation.

In C2, men usually attend BMU meetings and participate in management tasks such as data collection, patrol, finance, and BMU sub-committees' coordination. Male FGD participants do not feel excluded from decision-making processes. They rather consider that their opinions are appreciated and considered by the board. Since men are involved in a great diversity of management activities and feel well represented and included in decision-making processes, we consider that they have an interactive participation in CBFM.

4.1.3. Community 3

Community 3 is characterized by a weaker BMU governance than the other studied communities owing to a long history of BMU corruption. The two-thirds gender principle is neither respected in the general assembly, the EC, nor the board (Table 6.3). While the BMU is led by a chairlady, all other board members are men.

Women are invited to attend BMU meetings but barely do so because of their lack of trust in the BMU. When women attend meetings, they usually keep quiet. Female FGD participants are not enthusiastic about their roles in the BMU and do not feel included in the decisions related to the LMMA or the organization of seminars and trainings. Women complain that power is concentrated in a few hands and regret not having a say in the BMU decisions. Female FGD participants are not satisfied with the current chairlady because they do not feel empowered through her leadership. This is exacerbated by the fact that the chairlady is not representative of the other women. She graduated university, has a high financial capital and does not depend on fisheries for her living. These specificities limit the other women's identification and support to the chairlady. Since women are under-represented in BMU bodies, seldomly attend meetings, do not express their opinions, and feel excluded from decision-making processes, we consider that they have a passive participation in CBFM.

Like women, men in C3 are invited to BMU meetings but usually do not attend them since they do not support the board. Some men engage in BMU sub-committees, but most of them disapprove of BMU's actions and deliberately boycott some initiatives. Male FGD participants feel that both men and women who are BMU members are alienated from BMU decision-making processes. They agree with having women in the board to make sure that women's voices are heard and included in management decisions, but they consider that the current chairlady fails in providing collective benefits to BMU members. Although men and women face similar challenges in accessing BMU opportunities, men outnumber women in all BMU governance bodies. For this reason, we assess men's participation level as consultative.

4.1.4. Gender gap assessment

Overall, in the three studied communities, women's participation levels in CBFM are lower than those of men (Table 6.4). Men mostly participate interactively in CBFM, whereas women's participation levels vary from passive to active. Women's participation level is highest in C2.

Table 6.4: Women's and men's participation levels in CBFM by community.

Participation level in CBFM	Community 1	Community 2	Community 3
Women	Passive	Active	Passive
Men	Interactive (empowering)	Interactive (empowering)	Consultative

4.2. Barriers to women's participation in CBFM

4.2.1. Socio-cultural barriers

Gender roles socialization plays an important part in preventing women from participating interactively in CBFM. In the three studied communities, women are primarily ascribed reproductive roles and are socially valued as mothers and wives, whereas men are considered family providers, responsible for bringing income to their households. As a result, women are expected to take care of children and ensure family cooking tasks throughout the day. These caring tasks often add to other women's daily activities such as fishing or farming, whereas men mostly dedicate their working time to productive activities only. Women's time budgets, and the weight of reproductive tasks, have implications for their participation in CBFM. Often, women are reluctant to go to BMU meetings because they expect delays that will interfere with their house duties.

In addition, the internalization of local gender norms leads to a general depreciation of women's opinion within BMU settings, both from women themselves and from their community. For instance, assertiveness and eloquence are more valued as male than as female qualities. The FGD revealed that women perceive men as more voiceful and more knowledgeable than women. This lack of self-confidence impedes them to speak up during meetings. Likewise, social expectations about women's behavior result in women keeping quiet in front of men.

4.2.2. Economic barriers

Women's lack of financial and material capital often limits their capacity to meaningfully engage in the BMU. For instance, women's lack of financial capital hinders them from owning a boat, and consequently, to be recognized as proper fishers in their communities. Although women formally have the right to become a BMU member, female FGD participants believe that their participation in direct fishing activities may increase their bargaining power within BMU arenas. Furthermore, many women are economically dependent on their male relatives, a situation that influences their behavior in the BMU. Female FGD participants admit their reluctance to express their opinions during BMU meetings because they are afraid of losing the support of their husbands or other male family members, with direct implications on their daily lives.

4.2.3. Institutional barriers

BMU membership represents one barrier to women's participation in CBFM. To become a BMU member, women and men need to make a request to the BMU board. Yet some of the women we interviewed were not even aware about the existence of the BMU and its activities. While BMU awareness appears to be the first condition for taking an active role in CBFM, our interviews and observations suggest that women are less exposed than men to information about the BMU. Women's low level of BMU awareness may reduce their engagement in management processes. In addition, the influence of BMU's institutional partners has been reported to exacerbate existing gender bias at the BMU level. The EC represents the main interface between local users and external stakeholders such as non-governmental organizations, international organizations, or research institutes. Most of these external actors communicate with the EC to provide resources or plan activities. This situation may lead to gender inequalities in the access to resources, information, and capacity building, given that most of the EC examined in our study are male-dominated.

4.2.4. Leadership barriers

Access to the board leadership positions is subject to specific barriers to women in terms of human and social capital and gender discrimination. First, eligibility to board positions requires to have completed education until high school level. Female FGD participants believe that this regulation favors men since male members have a higher education level than female members. Beyond formal requirements, FGD participants consider that the election campaign itself also contributes to sustaining gender inequalities since male members are usually more vocal and have more social connections within the community than female members. This represents two main disadvantages for women getting support from the other members: "*In the end, the BMU election has become political (…) It favors men because they can go to other members and tell them: "vote for me, vote for me". But women are less outspoken*" (Mwanajuma, 2021). Finally, interviews and group discussions reveal a general resentment and discriminatory attitude from male members towards women running for positions within the board. The few women who are part of the EC in C1 confided that they were denied higher leadership positions by male members because of their gender.

4.3. Intersectional experiences of CBFM places

In this section, we present the intersection between gender and other power structures in shaping lived experiences related to BMU places with specific examples of relief maps. One key finding is that 25 % of the male respondents feel comfortable in BMU places *vis-à-vis* all their examined identities, as reflected in their flat relief maps. These respondents do not raise any negative feelings

associated with a specific identity in BMU settings. The profile of male respondents who feel most comfortable corresponds to Kenyan senior men, over 50 years old, and married. The only exception is the case of Ali, a 22-year-old man living in C2, who also feels comfortable in each of his identities in relation to BMU places. Despite his young age, he engages actively in BMU meetings since he is more educated than most of the other members: "*I am fine everywhere because I have a good level of education, which makes me more knowledgeable than others in the village. I can then speak more during meetings*" (Ali, 2023). Ali's story reveals a tension between age and education, with his high education level mitigating the disadvantage of his young age within BMU places. Ali's relief map consists of six flat lines of different colors located at the bottom of the graph – corresponding to the highest comfort level – with no graphic relief (Figure 6.3). By contrast, we did not report these flat lines patterns in women's relief maps, which systematically show a certain level of discomfort in BMU places associated with specific positions.

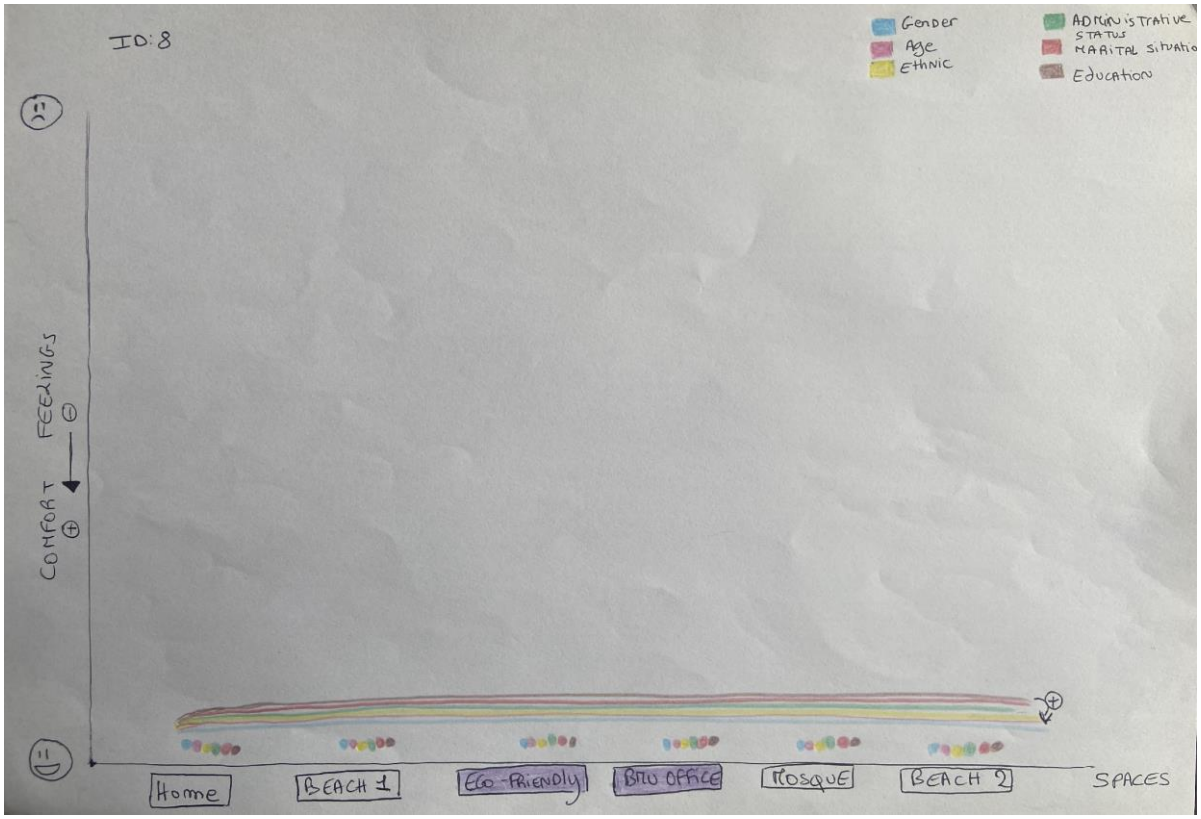

Figure 6.3: Relief map drawn by Ali showing a "flat lines" pattern. Power structures are represented by lines and dots, differentiated by colors (Gender: blue; Age: pink; Ethnicity: yellow; Administrative status: green; Marital situation: red; Education level: brown). Arrows describe intersectional relations between power structures that contribute to increasing ("+") or decreasing ("-") comfort levels of the respondent in Beach Management Unit (BMU) places. This level of comfort is represented on the ordinate axis from a happy (highest comfort level, at the bottom) to an unhappy (lowest comfort level, at the top) face. BMU places – among other places – are indicated on the abscissa axis.

We compared the number of relief maps that displayed discontinuous patterns drawn by men and women. We find that more women (n=4) than men (n=1) drew discontinuous lines, indicating that they are not accessing BMU places because of some of their identities. In the next example, we show the relief map of Aisha (Figure 6.4), a 32-year-old woman who works as a cook in a local restaurant. Every day, she fries and seasons fish and prepares Swahili dishes for local customers. She is Tanzanian and recently moved to C3 to find a job. She has three children who stayed with her mother in Tanzania, and no husband. To make a living and sustain her family, she must work hard at the restaurant. Since

she does not have Kenyan citizenship, she is not able to register with the BMU to become a member and take part in meetings or management activities. In addition, because she does not have much free time and did not go to high school, she is not very much aware of the BMU and how participation may benefit her. Her story illustrates how her administrative status, combined with her gender, her family situation, and her education level prevents her from accessing BMU places. The conjunction of these multiple identities exacerbates her marginalization from CBFM as expressed in her own words: "*I don't know much about the BMU; might be because I just moved to C3 this year (…) Here, I am seen as an outsider to the community. I am not from C3, so I do not go to certain community places like the social hall or bandarini because I would feel out of place. I prefer dealing with my own business*" (Aisha, 2023). This marginalized status regarding the BMU is reflected in the disruptive spatiality of her relief map. Places where she goes (i.e., home, mosque, public road) are displayed with continuous lines whereas BMU places are represented with dashes to show that she does not go there.

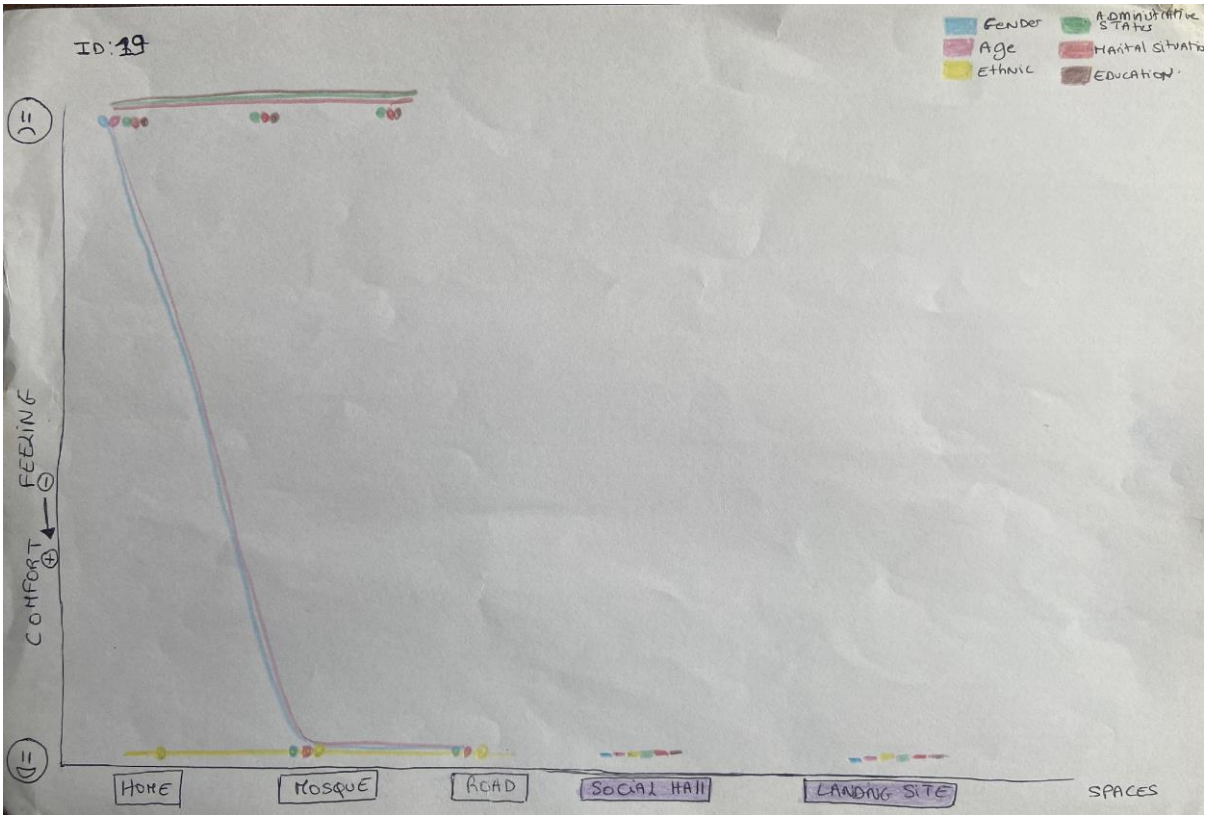

Figure 6.4: Relief map drawn by Aisha. See notes in Figure 3. Dashes indicate places that are not accessed by the respondent.

Finally, we find a strong intersectional dimension in the relations between the examined power structures as illustrated by the case of Mwanahawa's relief map (Figure 6.5). Mwanahawa is a 30-year-old Kenyan female fish processor and BMU member. She lives in C3, has completed primary school, and is married. She spends her day collecting small sardines from fishermen, then boiling and drying them before selling the fish to her community. She is locally called a "*mama chemsha*" (literally: "a woman who boils"). Although she goes to BMU places and attends the meetings, she feels quite uneasy in these settings because of being a woman with a low education level. She only started school when she was 13 years old, when primary education became free in Kenya. However, she could not enroll in high school, and she now feels this lack of education during BMU meetings at the social hall: *"I think that with a higher education level, I would be more respected in meetings. This is even worse because I am a woman. If I were a man, my voice would be more listened to*" (Mwanahawa, 2023). Mwanahawa's experience of BMU places reflects the intersectional dynamics between her gender and education level, two identities that reinforce each other in limiting her meaningful participation in BMU

settings. These intersectional power dynamics are displayed in her relief map where we can notice a marked relief on the blue line that represents her gender associated with the social hall place. Further, the lines associated with her education level and age (in brown and pink respectively) are situated on the top of the map, indicating a high level of discomfort in all places. The arrow between the blue and brown lines materializes her experienced oppression in BMU spaces intensified by the combination of her gender and education level.

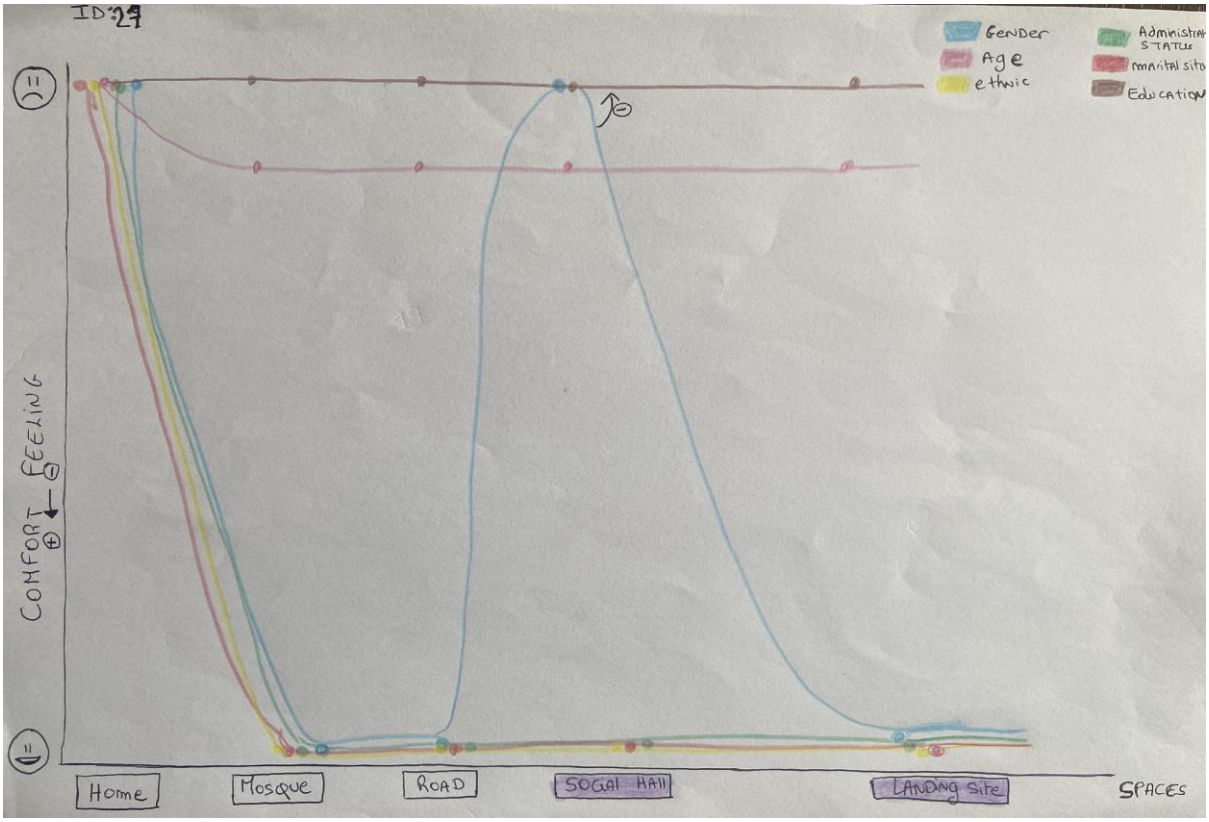

Figure 6.5: Relief map drawn by Mwanahawa**.** See notes in Figure 3.

5. Discussion

This study assesses gender-inclusiveness in CBFM using an intersectional angle and focusing on coastal Kenya. Our results reveal that women's participation in BMU is limited, ranging from passive to active. By contrast, men's participation level is systematically higher than that of women, providing evidence for important gender inequalities in BMU. Barriers to women's participation in BMU are multifold and intertwined, combining socio-cultural, economic, and institutional factors, and barriers specific to female leadership. Moreover, we found that all BMU members do not experience BMU places in the same way, owing to their intersecting identities, suggesting that BMU places may ultimately reproduce social inequalities. These findings tend to indicate that participatory CBFM approaches have the potential to be exclusionary and highlight the relevance of intersectionality as an analytical framework to capture the complexities of power hierarchies in SSF management and governance.

We recognize two main limitations in our research methodology. To begin with, we primarily used Swahili to collect data although some communities appeared more comfortable expressing themselves

in their own language. This may have limited our understanding of the nuances related to intersecting power hierarchies in BMU, thus highlighting the need for a better appreciation of language diversity in academia. Another limitation stems from the selection of the power structures used for the intersectional analysis in this study. While, owing to time constraints, we restricted our analysis to six power structures, we acknowledge that additional social variables may also influence lived experiences related to BMU places. Thus, we encourage the development of relief map methods (Rodó-de-Zárate, 2014) in gender and fisheries research which allow the comparison of relevant variables on the same topic or region.

5.1. Gendered participation levels in CBFM

Our findings reveal that women's participation in BMU is limited and that men dominate leadership positions in BMU. These findings align with evidence from global analyses (Chambon et al., 2023; FAO et al., 2023) and from other case studies on SSF management (Baker-Médard, 2016; Rohe et al., 2018). For instance, Matsue et al. (2014) analyzed the participation of female fish processors – locally called "*mama karanga"*– in SSF management in Mombasa County, Kenya. In line with our findings, they show that, although *mama karanga* are directly affected by management decisions, they are not fully included in SSF decision-making.

While there is room for improving women's quantitative representation in BMU, we found that even when women are represented (as in the case of C2), they do not participate interactively in management processes. This observation suggests that management measures focusing on increasing women's membership or attendance of meetings – though necessary – are not sufficient to achieve their interactive participation in CBFM. Instead, our study highlights the need to go beyond gender quotas and displace structural gender inequalities, a recommendation also supported by other scholars (Lau et al., 2021; Mangubhai & Lawless, 2021; Verge & de la Fuente, 2014).

Furthermore, we found that women's participation level in BMU varies across communities. The highest participation level reported for women is in C2. Given that C2 is the only community included in our study where women engage in the production sector, we suggest that women's roles in the SSF value chain influence their bargaining power and opportunities to access management. In particular, being a fisher seems to be a determinant factor in legitimating women's participation in CBFM processes as suggested in the SSF literature (Kleiber et al., 2015). Our findings also suggest that the election of a female BMU leader does not necessarily reverberate in a greater participation of women in CBFM, as illustrated by the passive participation of women in C3, where the chairperson of the CBFM is a woman. This paradox may be explained by the privileged position of the BMU chairlady, as women of high social status who are elected in positions of power may fail to represent the views of other women (Rabbitt et al., 2019).

Most importantly, our results indicate that, in all studied communities, women's participation level in BMU is lower than that of men. These findings demonstrate the value of applying a gender analysis to the study of SSF management and governance as it provides an enriched picture of power relationships. By using gender-disaggregated data, our study allows a sound comparison of both genders' engagement in BMU and highlights that CBFM approaches in coastal Kenya are male-dominated, thus supporting evidence from literature on SSF management (Baker-Médard, 2016; Hauzer et al., 2013; Kleiber et al., 2015), and environmental governance in general (Organisation for Economic Co-operation and Development [OECD], 2021). Altogether, our findings tend to confirm the relevance of the "participatory exclusion" notion (Agarwal, 2001) in the Kenyan context and adds to the scholarship pointing out the limitations of CBFM in terms of gender-inclusiveness (Johnson et al., 2021; Twyman, 2017).

5.2. Barriers to women's participation in CBFM

Our results illuminate the diversity of barriers that women face to participate in BMU, thus revealing the complexity of gender power relationships in CBFM. These findings are largely consistent with the literature on SSF management globally, suggesting that reported barriers are not specific to CBFM approaches but find ground in a broader SSF governance context (FAO et al., 2023; Galappaththi et al., 2022). The multifaceted nature of these barriers suggests that fostering women's meaningful participation in SSF management requires holistic and multidimensional approaches.

Our findings reveal the significance of socio-cultural, economic, and institutional barriers. In particular, and in line with previous studies on SSF management (Bradford & Katiro, 2019; Fröcklin et al., 2013; Singleton et al., 2019), we found that gender norms play an important role in hampering women's participation in BMU. For example, Vunisea (2008) highlights the predominance of a "culture of silence" in SSF communities of the Pacific, whereby certain groups such as women do not raise their voices in community meetings because of strong cultural norms. As a result, women are disadvantaged in management decisions since their views are not considered.

An additional insight that emerges from our results is the specificity of barriers related to female leadership. Women are largely excluded from leadership positions in the BMU board because of a lack of human and social capital and gender discrimination. This may explain why only women with a high social status may access these positions, thus limiting women's representativity as observed in C3. These findings are consistent with recent studies on women's restricted access to leadership positions in ocean governance, both in Kenya (Ojwala, 2023) and elsewhere (IOC-UNESCO, 2020). Without addressing these barriers to female leadership, achieving women's interactive participation in CBFM, and more broadly in SSF management and governance, will remain deeply compromised (Rabbitt et al., 2022).

5.3. Intersectional experiences of CBFM places

We found that 25% of male respondents to relief maps feel comfortable in all BMU places regarding each of their identities, while the rest of the respondents experienced some extent of discomfort. This finding echoes the notion of systemic comfort (Ahmed, 2007; Rodo-Zarate, 2023), which corresponds to a feeling of general and unquestioned comfort associated with all frequented places and power structures. Our results suggest that men are more likely than women to experience systemic comfort in BMU places. Furthermore, the relief maps reveal that these respondents are mostly senior and married men who are BMU members. According to Rodó-de-Zárate (2023), flat lines lay the outlines for "emotional maps of silence" (p.2) that shed light on their privileged social positions. They show that besides benefitting from their social positions, these senior male respondents have also normalized their personal privilege, to the extent that they do not even notice it. Our findings suggest that this privilege stems from intersecting identities linked to their gender, age, and marital status positions within the BMU. Such situation may have major implications for CBFM and inclusiveness given that board positions in all studied communities are dominated by senior married men in number. Their privileged position may occult the recognition of oppressed identities within the BMU, particularly among women groups but also experienced by men of other identities, thus limiting the development of inclusive management strategies.

More women (25%) than men (6%) drew relief maps showing discontinuous lines. This observation reveals that more female than male respondents experience marginalization in CBFM since they cannot access BMU places owing to specific social positions. This suggests that the experience of discomfort in BMU places both results from existing gender inequalities and reproduces such inequalities by restricting women's access to BMU places and, beyond that, to management opportunities. As such, discomfort feelings must not be seen as static emotions but rather as a dynamic process of production of spatial inequalities. This finding aligns with previous studies documenting women's restricted access to CBFM places (Chitará-Nhandimo et al., 2022).

Our results indicate that gender intersects with other power structures in shaping lived experiences related to BMU places. This suggests that gender is embedded in broader power social dynamics that shape the participation of individuals in CBFM, thus reinforcing the relevance of intersectionality as an analytical lens for capturing power hierarchies (Crenshaw, 1989, 1991). More specifically, our findings support the call made by several scholars to foster intersectional approaches in research on SSF management and governance (Ferguson et al., 2021; Rice et al., 2024). Adopting an intersectional perspective has the potential to improve our understanding of SSF communities by illuminating the social differences produced by intersecting identities among fisherfolk, as opposed to mainstream views that emphasize the homogeneous character of local communities (Ferguson et al., 2021; Ojwala, 2023). While most of the SSF literature using an intersectional framework has focused on social variables such as class (Colwell et al., 2017), ethnicity (Lokuge & Hilhorst, 2017), or place of residence (Rohe et al., 2018), our findings reveal the determining role of education, age, administrative status, and marital situation on an individual's agency in CBFM places, alongside gender. These insights, however, are specific to our study area, and we stress the importance of the local context in situating intersectional dynamics related to CBFM, which supports recent critics against the "one-size-fits-all solution" narrative in SSF communities (Rabbitt et al., 2022; Rohe et al., 2018).

6. Conclusions

Our study on gender inclusiveness in CBFM through the case of BMU on the South Coast of Kenya provides a critical contribution to the academic field of gender and fisheries, and more specifically to intersectional research on CBFM. From a methodological standpoint, the adaptation of the relief maps method to SSF communities demonstrates the relevance of this analytical tool for SSF contexts. This method is powerful in highlighting both privileged and marginalized positions within BMU places, thus contributing to shedding light on the intersecting nature of social inequalities produced by CBFM processes. Moreover, our adaptation of the relief maps revamps this methodological intersectional tool by highlighting the connections between emotions (discomforts) and access and participation to CBFM places through the examination of spatial discontinuities. We encourage the application of this method in gender and fisheries research to improve our understanding of intersectional and geographical dynamics related to participation in SSF management and governance. At the empirical level, our study reveals that CBFM processes in coastal Kenya tend to limit women's participation in SSF management and decision-making, adding evidence to the growing body of literature denouncing the lack of inclusiveness in CBFM approaches (Johnson et al., 2021; Rabbitt et al., 2022).

Altogether, our findings support three main recommendations to foster inclusive management approaches in SSF. First, our study shows the importance of collecting gender-disaggregated data to provide a thorough analysis of gender dynamics related to CBFM. Such a baseline is necessary for tracking changes towards gender-related targets and supporting the development of inclusive SSF management strategies. Second, our study reveals that women's participation in CBFM in coastal Kenya is limited owing to multiple and overlapping barriers. These findings highlight the need for supporting the meaningful participation of women in CBFM. Moving towards this objective requires going beyond gender quotas and embracing holistic gender-transformative management strategies aiming at addressing structural gender barriers, especially those affecting women's access to leadership positions. Finally, our study highlights the heuristic power of intersectional analysis applied to CBFM processes, thus calling for further intersectional research in SSF contexts. Since this area of study is in its infancy, theoretical and methodological development is much needed.

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Chapter 7
Conclusions

Fisher contemplating the ocean, Shimoni-Vanga seascape.

Conclusions

Through an in-depth study of small-scale fisheries (SSF) communities on the South Coast of Kenya, this PhD thesis reveals gender power relationships affecting community-based fisheries management (CBFM) processes in a climate change context. This work demonstrates that gender is a key variable shaping SSF dynamics. Furthermore, while women contribute significantly to SSF social-ecological systems (SES), their participation in CBFM is limited and systematically lower than that of men. Beyond gender, other intersecting power structures play an important role in mediating participation in SSF decision-making. Overall, this work suggests that CBFM may not systematically translate into gender-inclusive management approaches, raising concerns regarding the integration of gendered perspectives into SSF adaptive strategies.

This concluding section highlights the theoretical, methodological, and empirical contributions of this work. The section ends with suggestions for future research and key policy recommendations. While the focus of this study is placed on climate change impacts on Kenyan SSF communities and their adaptation through CBFM, it may be relevant for a broader audience interested in topics related to climate adaptation, marine conservation, gender equity and local ecological knowledge (LEK), or more broadly, to human-ocean interactions.

1. Theoretical contributions

This doctoral work contributes to theoretical advances regarding the three main analytical lenses used in this study. Specifically, it broadens SES resilience thinking by highlighting the importance of knowledge pluralism, adds complexity to the adaptive fisheries co-management literature, and expands feminist political ecology (FPE) analysis to SSF settings.

1.1. Refining SES resilience thinking in light of knowledge pluralism

My findings contribute to reinvigorating current reflections on how to include plural knowledge forms in the study of SES resilience. There is a growing recognition that SES complexity requires various and contextualized knowledge systems to better understand the capacity of SES to respond to unexpected change (Pearce et al., 2015; Rathwell et al., 2015; Tengö et al., 2014). Yet, some scholars have stressed the many difficulties linked to knowledge pluralism in SES research (Stepanova et al., 2020; Varghese & Crawford, 2020).

My work provides one grounded illustration of an attempt to bridge scientific and local knowledge to conceptualize and understand climate change impacts on SSF social-ecological systems in the Western Indian Ocean (WIO) region, where fishers' LEK on climate change is understudied (Chapter 5). This PhD work recognizes diverse and complementary views of drivers and expressions of change in SSF social-ecological systems. Climate change is understood by local SSF communities as one of many drivers shaping change in coastal and marine ecosystems, along with overfishing or habitat degradation, thus revealing the multifactorial and synergistic nature of environmental changes. Moreover, my findings add to previous work highlighting the gendered dimension of LEK (e.g., Porcher et al., 2022; Silva et al., 2019). This perspective supports the recognition of the intracultural variability of LEK in the study of SES adaptation to change. Altogether, these findings support the inclusion of a greater diversity of

epistemologies and worldviews in the conceptualization of human-nature interactions in the face of change. Especially, to design equitable adaptive strategies in SSF social-ecological systems, it is important to consider the worldviews of local SSF communities that may be more place-based, holistic, and spiritual than Western positivist stances.

1.2. A complex, dynamic, and heterogeneous understanding of fisheries co-management

This study addresses a major gap in research on adaptive fisheries co-management by investigating the gendered dimension of CBFM. In this aspect, it contributes to feminist scholarship that aims to deconstruct the mainstream conceptualization of local communities as homogeneous and static entities (Elmhirst, 2011; Rochelau, 2008). My findings add to previous studies challenging this simplified view of communities by making social inequalities more visible. They reveal that CBFM on the South Coast of Kenya is shaped by tensions within local SSF communities regarding access to and control over fisheries resources, fishery economic returns, and access to management decision-making (Chapter 4 and 5). In line with other gender and fisheries scholars (Ferguson, 2021; Rabbitt et al., 2022), I show that these tensions arise from gender power asymmetries, amplified by other forms of social differentiation, ultimately adding complexity to the way people may – or may not – collaborate to sustain their fisheries over the long term. This perspective suggests caution is needed when analyzing success factors in fisheries co-management: questioning the notion of "success": For whom? By what means? Based on what legitimacy? Overall, these findings call for politicizing CBFM and fisheries management and governance more broadly, recognizing the inherent negotiated dimensions of processes aiming to govern fisheries resources.

1.3. Towards an intersectional FPE analysis of small-scale fisheries

This study adds to the growing FPE literature in SSF settings addressing fisheries issues such as catch decline (Bavington et al., 2004), participatory monitoring (House et al., 2023), or women's displacement from certain fisheries (Medard et al., 2019) through a gender lens. More specifically, my findings bring to light the gender power relationships at play in the governance of SSF through CBFM in the context of climate change. Anchoring Rocheleau's (1996) gender analysis in an SSF context, this work highlights the importance of gender in processes related to the access to fisheries resources (Chapter 4), local reports of climate change (Chapter 5), and participation to SSF decision-making on the South Coast of Kenya (Chapter 6). This FPE analysis of SSF contributes to enriching political ecology scholarship by providing nuanced and granular views of the political dimension of human-ocean interactions.

Moreover, my findings contribute to revamp mainstream FPE studies by exploring an intersectional perspective. While a few researchers have applied an intersectional framework to fisheries, this field is still in its infancy and is particularly scarce in the African context (Rice, 2024). This PhD work contributes to filling this conceptual and regional gap by showing how multiple power structures such as administrative status, age, education level, ethnicity, gender, and marital situation can compound together to shape access and participation in coastal Kenyan SSF. Further, I connect this intersectional lens to the analyses of lived experiences in CBFM, thus expanding existing research that demonstrates how the study of subjective emotions may enrich the understanding of complex power dynamics linked to access, use and management of SSF.

2. Methodological contributions

This doctoral dissertation brings forward two substantial methodological contributions to research at the interface of gender, SSF, and climate change.

2.1. Shifting from interdisciplinary to inter-epistemic research on coastal and marine SES

There is an increasing recognition of the need to diversify knowledge systems in ocean research, including scientific, Indigenous, local and citizen knowledge systems (Gerhardinger et al., 2023). Yet, the question of how to operationalize this dialogue between plural knowledge systems is debated in the literature (Johnson et al., 2016; Rice et al., 2024; White & Lidskog, 2023). Specifically, discussions about bridging diverse knowledge systems reveal a tension between knowledge pluralism (i.e., to guarantee that all the dimensions of each knowledge system are equally valued and considered) and knowledge useability (i.e., providing operational knowledge). Such tension may generate a risk of paralysis in certain cases (Pascual et al., 2017).

Besides adopting an interdisciplinary approach by combining theoretical corpuses and methodological approaches from various academic fields (e.g., climate and fisheries sciences, anthropology), this work uses diverse ways of knowing to expand knowledge pluralism in coastal and marine SES. More precisely, this PhD builds on recent studies that value Indigenous and local knowledge in environmental research (e.g., Junqueira et al., 2021; Reyes-García et al., 2024), to understand climate change impacts in the WIO (Chapter 4). Scientific and local conceptualizations of climate change and its impacts are brought together to examine potential synergies and conflicts. While I acknowledge that local knowledge has been captured through my positionality and do not fully reflect the epistemic stance of Kenyan coastal communities, this work contributes hopefully to deepening the understanding of the extent of climate change impacts on SSF societies and their gendered variations.

Furthermore, this PhD work adds to current debates opposing knowledge pluralism to knowledge useability by proposing a pragmatic methodological approach. While I draw on the Multiple Evidence Base (MEB) approach to bridge scientific and local knowledge about climate change impacts in the WIO, I do so by framing the research through pragmatic objectives. By recognizing that Indigenous Peoples and local communities (IP & LC) have long been sidelined from climate discussions, I posit that local and embodied impacts of climate change on SSF communities may have been overlooked. This rationale explains why I take local reports of climate change as an entry point to explore their overlaps and complementarities with scientific evidence. While acknowledging the complexities linked to the application of knowledge pluralism in environmental research, this approach illustrates one way to operationalize it, whereby pragmatic research objectives and positionality guide methodological choices.

Overall, by supporting inter-epistemic research on coastal and marine SES, this doctoral work encourages methodological development aiming to weave knowledge systems to broaden and capture the intricacies of human-ocean relationships.

2.2. Developing intersectional methodologies in SSF research

Despite their potential for unravelling social complexities in various fisheries contexts, intersectional methodologies are insufficiently developed in SSF research (Rice et al., 2024). While some SSF scholars have used intersectional analysis in their work (e.g., Ferguson, 2021; Lokuge & Hilhorst, 2017), most of the gender and fisheries literature applies a binary view of gender as a main analytical frame (House et al., 2023). This PhD work addresses this gap using relief maps to analyze intersectional power dynamics related to CBFM processes (Chapter 6). The relief map methodology arose from feminist geography research as a powerful data collection and analytical tool to study and

visually represent social inequalities through an intersectional lens (Rodó-de-Zárate, 2014). This method aims to illuminate the relationships between the social (i.e., power structures), psychological (i.e., emotions) and geographical dimensions (i.e., places) of social inequalities. In this work, I provide two key contributions – both sectoral and conceptual – to this intersectional methodological tool.

First, I tailored relief maps to SSF settings. While most studies using relief maps have applied it to urban contexts in Western Europe, I used relief maps in East African SSF communities. This contrast required some adaptations including i) the use of hand drawings by participants (instead of an online survey), ii) adjusting question contents and selected places to SSF social-ecological systems, and iii) making the tool understandable by people who do not read by using symbols. This methodological adaptation demonstrates the flexible character of relief maps and their capacity to study intersectional dynamics in a diversity of socio-cultural contexts.

Second, I adapted the original conceptualization of relief maps by exploring issues related to access and participation in SSF decision-making. Through the analysis of spatial discontinuities reflected in discontinuous lines, I show that relief maps may be used to highlight the connections between emotions (i.e., discomfort) and access/marginalization to/from certain places. This innovation may be valuable for scholars working on SSF, but also for those exploring the connections between intersectionality and participatory approaches in other sectors.

In summary, this study contributes to expanding the application of the relief map tool to the SSF sector and to research on participatory processes. Developing this intersectional research tool in various SSF contexts and for other research questions might help to better understand how different social positions may overlap in shaping SSF dynamics.

3. Empirical contributions

This PhD thesis expands the body of research on gender and fisheries by providing original insights stemming from empirical research on the South Coast of Kenya. In this section, I discuss two main empirical contributions to that literature, which may raise interest for further comparative analyses at the regional or global level.

3.1. Detailed gender-disaggregated data on SSF

The lack of gender-disaggregated data in fisheries literature represents a key challenge to improving SSF social-ecological systems baselines and to support gender-inclusive management strategies as discussed in this dissertation (Chapter 3) and elsewhere in the literature (FAO et al., 2023). This study contributes to addressing this gender data gap in fisheries research by providing grounded gender-disaggregated information on i) fishing practices, ii) reports of climate change impacts and iii) participation in SSF management. Women's and men's engagement in small-scale fishing is documented and quantified, showing that fishing techniques, catch, effort and income vary according to fishers' gender (Chapter 4). Specifically, women tend to get significantly lower daily catch than men (1 vs. 7 kg/hour). Moreover, this work suggests that gender partly influences climate-induced changes reported by SSF communities (Chapter 5). For instance, women are more likely than men to report changes in rainfall patterns, which may be linked to their gender roles within society. Another relevant finding relates to gender-differentiated access to SSF decision-making. It has been documented that men's levels of participation in CBFM is systematically higher than that of women (Chapter 6). These empirical findings demonstrate the value of applying a gender analysis to study SSF social-ecological systems and to measure and monitor changes over time.

3.2. Perspectives on gender-inclusiveness in CBFM

This work brings evidence that CBFM on the South Coast of Kenya is male-dominated (Chapter 6), indicating that this management approach may exclude certain social groups in accordance with case studies from other world's regions (Rabbitt et al., 2022; Rohe et al., 2018). This finding suggests that the potential of CBFM for improving participatory and inclusive fisheries governance is not systematic. Yet, this research provides a compelling argument suggesting that women's participation in SSF management in coastal Kenya is desirable both for instrumental (i.e., as a mean of achieving objectives) and intrinsic (i.e., in its own) motivations. On the one hand, women's contributions to SSF social-ecological systems in Kenya's South Coast bring important positive outcomes to local communities. For instance, women's gleaning activities are significant for meeting local nutritional needs (Chapter 4). On the other hand, women's participation in SSF management may be valued *per se* as illustrated by a growing concern among women's groups to have a Beach Management Unit (BMU) Chairlady to represent their specific interests (Chapter 6). Beyond gender dynamics, there is a need to consider other intersecting power structures and address marginalized social positions within CBFM processes, in line with a recent call for inclusive SSF management (de la Torre Castro, 2019).

4. Future research

Based on this PhD work, I state relevant avenues for future research and methodological development that stimulate my intellectual interest and would contribute to filling some of the research gaps identified in the literature on gender and SSF (Rice et al., 2024).

4.1. Promising research lines

4.1.1. Investigating the gendered dimensions of food security

My findings highlight that, despite being *a priori* less productive than men's fishing practices, fisherwomen's activities are important for local nutritional needs on the South Coast of Kenya. My research, however, has only superficially addressed the interplay between gender dynamics and nutritional needs within SSF communities. It could be especially promising to expand this work to quantitatively assess fisherwomen's and fishermen's contributions to diets on a larger scale using statistical analyses. Such work could provide valuable insights into the gendered dynamics shaping catch allocation within households. To that end, it seems necessary to consider heterogeneity among households, ranging from single female or male- headed households to mixed headed-households, since these social configurations may affect trade off logics between uses of catch for commercial or subsistence purposes. In this regard, innovative gender research could investigate the value of women's catches in cases of socio-environmental disturbances, since it has been argued that women's gleaning practices represent a particularly reliable fishing technique (Chapman, 1987).

4.1.2. Developing gender analyses on participatory processes in fisheries management and governance

Since the potential of CBFM to support gender equity appears to be context-dependent (Smallhorn-West et al., 2022), future research on gender and fisheries should rely on in-depth analyses to identify what factors facilitate women's participation in SSF decision-making in specific socio-cultural contexts. Another interesting axis of inquiry would consist of a systematic review of different co-management schemes, varying from state- to community-oriented approaches, in relation to gender equity objectives. This analysis could help determine what type of power-sharing arrangement favors

the most gender-inclusive SSF management approaches. It may require creating bridges with other research fields such as feminist institutionalism (e.g., Verge & de la Fuente, 2014). However, given that gender dynamics are context-specific, this research line calls for fostering long-term empirical research to limit gender bias and risks of over-simplification. For instance, the concept of "participation" as such must be questioned within a given society, since it may have different meanings across and within social groups.

4.1.3. Exploring fishers' gendered ecological knowledge in relation to ocean conservation

Owing to time constraints, I did not explore in -depth the gendered nature of fishers' LEK on the South Coast of Kenya within the framework of my PhD. However, I encourage the development of further research analyzing gender variability in LEK in fisheries species and habitats. This research effort would contribute to improving the understandings of the gendered patterns in fishing knowledge acquisition processes. Beyond fisheries management, another promising research line revolves around understanding how marine LEK may provide insights that would support co-designed marine conservation strategies. Particularly, marine protected areas (MPA) are largely recognized as ocean-based climate solutions (Jacquemont et al., 2022). However, the capacity of MPA to generate positive social outcomes is debated, with some studies highlighting adverse impacts on local communities such as restricted access to coastal and marine resources (Van de Geer et al., 2013). Against this background there is a growing call for involving local communities in MPA management and decision-making (Bennett & Dearden, 2014; Voyer et al., 2015). In this regard, delving into marine LEK and its gender variability offers relevant grounds for reconsidering mainstream approaches in marine conservation towards more collaborative and shared processes. For instance, one concrete application could be using participatory mapping methods (e.g., Duvail et al., 2006) to understand how spatial dimensions of LEK may vary according to certain axes of social differentiation and overlap and/or complement science -based MAP spatial boundaries.

4.1.4. Diversifying knowledge systems in ocean research

This PhD work suggests that knowledge cross-fertilization is necessary to capture a comprehensive view of climate change impacts and its gendered declinations. It could be very promising to expand this research line based on a MEB approach on broader coastal and marine issues since this perspective is important, yet in its infancy (Gerhardinger et al., 2023). Such an approach would contribute to deepening the understanding of the multiple dimensions of the ocean and its plural meanings for different social actors. Future research adopting this approach and making room for local and emic epistemologies should also contribute to decolonize research by making research practices more equitable and transparent to support meaningful dialogue between diverse knowledge holders. It should emphasize participatory approaches throughout the whole research process, from its design, data collection, and interpretation to community feedback. Innovative thinking may also include the development of operational analytical frameworks for bridging plural knowledge systems and transparent research protocols for framing such research.

4.2. Required methodological development

To address these promising research lines, four methodological developments are much needed. First, I encourage the systematization of gender-disaggregated data collection. This PhD highlights the persistent gender data gap in SSF research, which hampers comprehensive assessments of fisheries SES and the development of effective and inclusive management approaches, as supported by evidence from the literature (FAO et al., 2023; Rice et al., 2024; Szymkowiak & Rhodes-Reese, 2020). Gender-disaggregated data should be considered as a prerequisite for conducting quality fisheries research since it helps to rebalance potentially skewed perspectives on fisheries SES that may lead to gender-blind fisheries policies. Designing research projects that include a gendered dimension would help make women's contributions to SSF visible and support more robust research outcomes.

Second, it would be valuable for future research to foster comparative and meta-analysis at the WIO regional level. My findings echo other studies in the WIO that highlight the importance of the two monsoon seasons – the Northeast and Southeast monsoons – in driving fishing activities and document similar women's fishing practices than those reported in the South Coast of Kenya (Barnes & Rawlinson, 2009; Hauzer et al., 2013; Wosu, 2019). These common features observed in gendered fishing practices across the WIO suggest regional biocultural connectivity. Unlike in the Pacific region, where women's fishing practices have been widely documented (Fache & Breckwoldt, 2023; Kleiber et al., 2015; Williams, 2010), as exemplified by the semestrial release of the *Pacific Community's Women in Fisheries Information Bulletin,* efforts to structure and mutualize knowledge about fisherwomen in the WIO are still emerging. Anchoring research on gender and fisheries in a regional perspective would significantly contribute to advancing this academic field and body of knowledge and help craft relevant fisheries management and conservation strategies for regional needs.

Third, there is a growing need to reconceptualize research methods towards supporting a meaningful dialogue between different knowledge holders in ocean and SSF research. I encourage researchers to go beyond an integrationist approach when working with IP & LC and, instead, to embrace methodologies that weave scientific and Indigenous and local knowledge in a respectful way, recognizing that these systems are equally valuable. There are already various methodological approaches that aim to foster equal partnerships between IP & LC, scientists, and other knowledge holders such as participatory action research, or diverse Indigenous methodologies (Coombes et al., 2014; Jonhson et al., 2016; Rice et al., 2024). What lies at the core of these methods is the importance of involving each knowledge holder throughout the whole research process. Given the complex challenges posed by climate change on SSF communities and the regional variability of these impacts, these methodologies need to be expanded and tailored to local contexts and the needs of IP & LC affected by such changes.

Finally, intersectional methodologies should permeate and expand research on gender and SSF. I have argued in this thesis that multiple power structures interact with gender in shaping lived experiences in CBFM. There is a need to engage further in intersectional approaches in SSF to advance understanding of overlapping social dynamics withing SSF communities and their implications for fisheries sustainable management. SSF scholars would benefit from using intersectional analytical tools such as relief maps and/or develop innovative approaches to address this methodological gap.

5. Policy implications

The alarming need to address the adverse impacts of climate change on the ocean and dependent coastal communities is a cross-cutting element of the Paris Agreement (UNFCCC, 2015), the Kunming-Montreal Global Biodiversity Framework (Convention on Biological Diversity [CBD], 2022) and the United Nations (UN) 2030 Agenda for Sustainable Development (UN DESA, 2016). This ambition has been further reaffirmed within the framework of the UN Decade of Ocean Science for Sustainable Development (2021-2030) (Intergovernmental Oceanographic Commission of UNESCO [UNESCO-IOC], 2021). In particular, the interplay between gender equity and sustainable fisheries management is a key focus of the FAO's Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (SSF Guidelines) (2015) and its Gender Handbook (2017). Falling within these overarching frameworks, this PhD work examines the contribution of gender studies to the understanding of SSF management in a climate change context, thus addressing many of the world Sustainable Development Goals (SDG), especially SDG n° 5, 13, 14 and 16. Drawing upon this work, I highlight three main policy implications

that would contribute to support the implementation of these international instruments by policy-makers and move towards sustainable and inclusive SSF social-ecological systems.

While emphasizing gender dynamics in my argument, I acknowledge that SSF are shaped by multiple and overlapping power structures, such as age or ethnicity, thus requiring the expansion of the following recommendations for intersectional perspectives.

5.1. Recognizing women's contribution to subsistence fishing and its implications for food and nutritional security policy

My PhD provides evidence that fisherwomen from the South Coast of Kenya are mostly involved in the gleaning of invertebrates and that these activities contribute significantly to local diets. These findings align with the global literature highlighting fisherwomen's critical contribution to food security at the household and community levels (Rabbitt et al., 2019; Thomas et al., 2021). However, these activities are commonly overlooked in fisheries censuses and analyses, which poses severe risks of undermining food and nutritional security, especially in the Global South (Allegretti & Hicks, 2022). Against this background, there is a need for a better recognition of women's subsistence fishing activities to address nutritional needs within SSF communities. Ambitious and equitable food security policies should include gender analyses and support gender-specific needs and constraints in terms of access to nutrients and proteins in SSF communities. Specific recommendations include:

i) Supporting women's integration in existing fisher groups to provide equal access to fisheries infrastructures, trainings, and opportunities among fishers.
ii) Establishing conservation tools such as MPA that consider women's fishing activities and their nutritional potential in their spatial design to avoid potential conflicts regarding resource access in coastal areas.

5.2. Supporting women's meaningful participation in SSF management and decision-making

By shedding light on gender-differentiated fishing practices and gender inequalities in CBFM approaches on the South Coast of Kenya, this work suggests that fisherfolk may have gender-specific needs that should be considered and integrated in fisheries management and policies. This implies that it is paramount to move towards gender-transformative approaches in SSF management and governance. Gender-transformative approaches are meant to substantially shift systemic gender power imbalances within society. In this way, they contrast with gender-sensitive and gender-responsive approaches, which are limited respectively to the recognition of gender differences or the implementation of stand-alone measures to reduce gender inequalities. Prioritizing gender-transformative approaches in SSF would ensure that women and other marginalized gender identities have a proper say in SSF decision-making. Practical applications of such approaches may be reflected by:

i) Providing the opportunity for women to participate in SSF monitoring to facilitate their access to decision-making.
ii) Supporting women's access to leadership positions in SSF governance.
iii) Shifting from gender quota mechanisms to embrace broader and more holistic indicators of gender equality and equity in SSF governance. This shift may require creating a safe space to reflect on the local meanings and interpretations of gender-related concepts.
iv) Systematically integrating explicit gender equality and equity goals into fisheries policies and strategies, including specific targets to monitor progress over time.

5.3. Including fishers' voices, needs and priorities in the development of SSF adaptive strategies

In this work, I have argued that LEK held by SSF communities contributes to draw a holistic and fine understanding of climate change realities in the WIO context. Specifically, these local insights illuminate the social and gendered dimensions of climate change impacts. This evidence emphasizes the need for fisherfolk's greater involvement in climate discussions and policies, recognizing and valuing their grounded experiences, perspectives, and knowledge on the ocean-climate nexus. Engaging local knowledge holders on ocean and marine issues is first a matter of equity, ethics, and respect. In addition, it may be framed in instrumental terms as a way to increase both the legitimacy and efficiency of climate adaptation policies since they would be more relevant to local SSF contexts. Important dimensions to consider include:

i) ***Tailoring context-specific adaptive strategies.*** Since there is no one-size-fits-all solution for adapting SSF to climate change impacts, there is a need to conduct place-based and detailed analyses of climate change impacts and vulnerabilities through inclusive and participatory processes prior implementing any adaptive strategy in SSF communities.

ii) ***Including gender considerations in the design of adaptive strategies.*** Climate adaptive strategies should integrate analyses of gender differences in climate vulnerabilities and adaptive capacities.

iii) ***Reframing science-policy interfaces on climate change***. Intergovernmental bodies such as the Intergovernmental Panel on Climate Change (IPCC) should establish more inclusive partnerships between knowledge holders of different knowledge systems and go beyond the framing of climate change as a technical problem to recognize its cultural, socio-economic, historical, and political dimensions.

Striving towards these directions would contribute to supporting gender equitable and sustainable SSF, while increasing the resilience of coastal and marine SES in the face of climate change. However, these political and ideological shifts must be coordinated and thought across multiple scales, from the local to the global levels.

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Common Swahili names

Bahari: Ocean.

Bamvua: Spring tides period when foot fishers go at sea to glean invertebrates and catch octopus.

Bandarini: Fish landing site.

Biashara: Small-scale business.

Chama: Women's saving group based on a rotating system.

Dagaa: Small sardines commonly fished in Kenya (and Tanzania).

Duka (la Samaki): Fish shop.

Kaya: Sacred forest by Mijikenda tribes and linked to local knowledge systems and customary laws.

Kaskazi: Northeast monsoon season (November-March).

Kuchukua: Gleaning.

Kusi: Southeast monsoon season (April-October).

Madrasa: Islamic school in coastal Kenya centred around the education of key Islamic principles and beliefs.

Mama chemsha: Female fishmongers who specialize in the boiling of *dagaa*.

Mama karanga: Female fishmongers who specialize in the frying of fish.

Chambo: Bait used by some fishers (e.g., basket trap, handline fishers) to catch fish.

Pwani: Coast.

Pweza: Octopus.

Samaki: Fish.

Tafi: Rabbitfish (*Siganus*). This taxon is commonly caught and eaten on the South Coast of Kenya.

Tengefu: Locally Managed Marine Area (i.e., no take zone).

Wavuvi: Fishers.

Appendices

Appendix 1

Box 1: An historical gaze on African women's representations in the literature

Through history, African women have been the subject of various studies and research work, mostly by non-African scholars (Tamale, 2020). African women's representations in the literature – both scientific and non–academic – alternate between two opposite portrays, either powerless victim of oppressions or active agents of change (Cornwall & IAI, 2005). In addition, historical representations of African women in the literature have tended to overlook the intersecting nature of women's multiple identities.

1900 – 1960: Colonial era

During the colonial period, most of the literature on African women originated from Western white male scientists, missionaries or colonial officers who were influenced by evolutionary theories (Cornwall & IAI, 2005). This work expressed racist and patronizing views on African women, who were portrayed backwards and hypersexualized. This literature contributed to vehiculate stereotypes about African women and biased assessments. For instance, male authors tended to focus on women's roles in the domestic sphere because of their positionality as non-African men, potentially overlooking women's contributions to other sectors of society (Kinyanjui, 2018). Although marginal at this time, Western female-led scholarship contributed to provide a counternarrative to mainstream discourses by highlighting instances of African female leaderships and illuminating the particularities of gender relationships beyond generalizations supported by colonial postures (e.g., Kingsley, 1896; Talbot, 1968).

1960 – 80: Independence movements and second wave of Western feminism

Between the 1960s and 1970s, both male and female Western researchers working in Africa analyzed women's lived experiences in the light of the ideology of the second wave of feminism (Cornwall & IAI, 2005). In this scholarship, an emphasize was placed on women's agency and authority. African women from diverse countries were depicted as heroines capable to emancipate from major sources of oppressions. This period coincided with independence movements throughout the African continent where women played an important role (Hornsby, 2013). For instance, it is recognized that Kikuyu women in Kenya significantly contributed to the Mau Mau uprising for independence by providing food to male fighters and ensuring a continuous link between the war forefront (in the forests) and its backdrop (Gachihi, 1986).

1970 – 90: Women in development global approach

In these decades, the work by Boserup (1970) on women's contribution to economic sectors greatly influenced the literature on women in African societies. While this publication outlined the important role played by women in the economy, it also contributed to spread the view of African women as victims of socio-economic forces. During this period, Western literature on the subject focused on topics related to women's marginalization in different spheres, from households' dynamics to economic activities, education, and public participation. This "women as victim" narrative was supported by global development programs through the Women in development approach that aimed to address perceived women's needs in isolation of other power structures (Williams et al., 2002).

From the 1990s: Gender and intersectional perspectives

Building on gender and intersectionality concepts, recent literature on women in Africa embraces different frameworks and positionalities. While female African and Indigenous scholars do not dominate the bulk of publications on gender in Africa, recent work has contributed to strengthen African women's voices on gender topics in a contextualized fashion, and challenge Western epistemic hegemony (Manyonganise, 2015; Tamale, 2020). Contemporary scholarship on gender in Africa seeks to go beyond essentialization to recognize the diverse and intersecting nature of gender identities. African scholars call for setting their own agenda on gender issues, putting forwards topics such as African sexualities (Tamale, 2011), the gendered dimensions of Ubuntu (Manyonganise, 2015), negotiations of gender roles (Cornwall & IAI, 2005) or relationships between gender and religion (Manyonganise et al., 2023).

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Appendix 2- Chapter 2

Table S2.1: Main fishery types in marine small-scale fisheries in Kenya (adapted from Kimani et al., 2018, Table 1.1.1., p.6).

Fishery type	Indicator species	Status	Characteristics	References
Pelagic- Large	*Katsuwonus pelamis, Thunnus albacares, Euthynnus affinis, Thunnus obesus, Xiphias gladius, Tetrapturus audax*	*Katsuwonus pelamis*: overfished Other species: within maximum sustainable yield	There are large variations in catches across years; stock status unknown for most species	Gopalakrishna & Satheeshkumar, 2012; ISSF, 2018
Pelagic- Small and medium	*Rastrelliger kanagurta, Sphyraena flavicauda, S. jello, S. obtusata, Hemiramphus far*	Overfishing	Large temporal and spatial variations occur	Munga et al., 2016
Demersal	*Siganus sutor, Leptoscarus vaigiensis, Lethrinus lentjan*	Overfishing	Declining yields; Declining sizes; Declining species richness; Changes in species composition	Hicks & McClanahan, 2012; Kaunda-Arara et al., 2004 ; Samoilys et al., 2016 ; Tuda et al., 2016
Crustacean - Shallow water prawn	*Penaeus indicus, P. monodon, P. semisulcatus, Metapenaeus monoceros*	Uncertain	Other environmental factors may impact on the fishery	Munga et al., 2013
Crustacean - Shallow water lobster	*Panulirus ornatus, P. longipes, P. versicolor, P. Homarus, P. penicillatus*	Optimally exploited	Reservoir stocks may exist in deeper reefs	Mueni et al., 2016
Crustacean- Mud crab	*Scylla serrata*	Optimally exploited	/	Fondo et al., 2010
Cephalopods- Octopus	*Octopus cyanea*	Optimally exploited	More active fishing in the South Coast (Vanga and Shimoni)	Fondo, 2008; Kivengea, 2014
Holothurian (i.e., sea cucumbers)	*Holothuria scabra, H. nobilis, H. fuscogilva*	Overfishing	Needs regulation to recover	Muthiga et al., 2010
Marine aquarium	*Amphiprion allardi, A. akallopisos, Pomacanthus imperator, P. chrysurus, P. maculosus*	Overfishing of some species	Evidence of over exploitation of some species; high spatial variations influenced by recruitment patterns	Okemwa et al., 2016

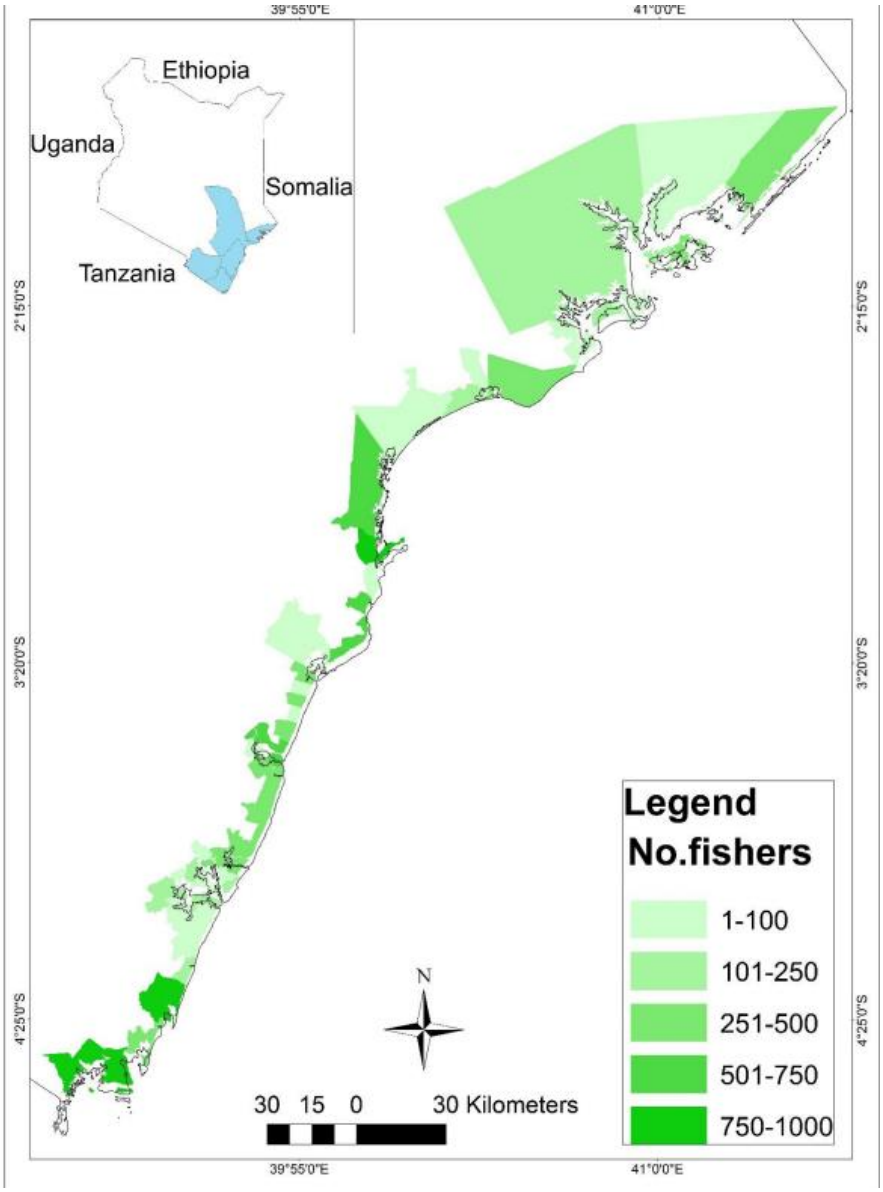


Figure S2.1: Fishers' distribution in the coastal region. Map showing the number of small-scale fishers by locations along the Kenyan coast (from GoK, 2016, Figure 13, p.25).

Table S2.2: Main fishing gears and related techniques used in the Shimoni-Vanga seascape and included in the research survey.

English name of the fishing gear	Local name of the fishing gear (in Swahili)	Related fishing technique	Description of the fishing technique	Photo
Basket trap	Malema/Madema	Basket trap fishing	Basket trap fishers have generally between three to seven traps that they let under water for 24 h. Every day, they leave early morning to reach their fishing grounds in paddle canoes or outrigger sailboat. They usually fish in a crew of two fishers. On their way, they collect baits that consist of green algae (*Ulva* genus), urchins and brittle stars. Once they get to the fishing ground, fishers scout for plastic bottles or small buoys that indicate them the location of their basket traps. They collect their traps attached to an underwater rope, remove the catch inside, refill the trap with fresh baits and lower it down into water. Dead corals or rocks on the side of the trap act as weight to maintain it on the seabed. Once fishers finish to reset their traps, they come back to the shore and rest in the afternoon. Traps have a hexagonal shape and are usually made of interwoven split bamboo, reeds or metal frames. They can last up to six months. Basket trap making is entirely artisanal, which makes it a low-cost gear for fishers.	 © M. Chambon 2021
Drifting gillnet	Nyavu ya kuogelesha	Gillnet fishing	This type of gillnet is used in offshore waters. Fishers usually deploy the net from a canoe or an engine boat at night, set it in the surface waters and let it drift with currents. In the morning, fishers come back fetching the net to haul the catch. However, sometimes the net can get lost and continue drifting for days and months, representing a "ghost fishing" threat on marine life.	 © M. Chambon 2021

Fence trap	Uzio	Fence trap fishing	Fishers set these stationary traps perpendicularly to the shore in the intertidal zone to catch fish. They are particularly used during spring tides. Fish swimming nearshore are trapped by the fence once the tide goes out. After one or two-days, fishers come collecting the trapped fish using their hands, nets or spears. Fences are traditionally made from mangrove stakes and palm leaves which are regularly placed every five meters and tied together.	 © Susana Wachia 2023
Hand gathering	Kuchukua	Gleaning	Gleaners go at sea early morning (the time varies daily depending on the tide level) to collect invertebrates by hand. Their peak of activity occurs during spring tide periods ("*bamvua*"). They walk along the shore with a bucket on their backs and collect by hand, shells and sea cucumbers they spot on their way. They usually go fishing for two to three hours and come back in the late morning or early afternoon depending on the tide. Gleaners can fish alone or in small groups of five to six people, sometimes involving children. This fishing activity is mostly female-dominated and often combined with octopus fishing.	 © M. Chambon 2021
Handline	Mshipi na Ndoana	Handline fishing	Fishers are typically using handlines from a drifted or stationary canoe. They may fish alone or in a small crew of two to three fishers, at night or during the day. The technique consists of throwing a baited hook into the water and waiting until a fish takes it. Then fishers haul the catch to the surface. The line is usually made from a nylon monofilament and the hook in steel. This method is often used in combination with basket trap fishing.	 © M. Samoilys 2011[5]

[5] All photographs taken by M. Samoilys and G. Maina (2011) in this document originate from the following publication: Samoilys, M.A., Maina G.W. & Osuka K. (2011). *Artisanal fishing gears of the Kenyan coast*. Mombasa: CORDIO/USAID

Hook stick	Uvuvi wa kaa	Crab fishing	Crab fishers go to the mangrove early morning or late afternoon (the time varies daily depending on the tide level). They walk along the shore with a long hook stick, identify crab burrows between the roots of mangrove trees, poke it with the stick and pull the crabs out from there.	 © M. Chambon 2023
Longline	Dhulumati/Zulumati	Longline fishing	Longline fishing is an activity done both at night and during the day, which is often combined with other methods like gillnet fishing. As fishers go at sea with their nets, they drag the longline heading to the fishing area offshore. The longline is deployed from an engine boat with buoys at its extremities to maintain it horizontally. Baited snoods are placed all along the main line to attract fish. After three to four hours, fishers pull out the longline and haul the catch from the snoods. Typical catches by longline comprise offshore species such as large pelagic (e.g., kingfish, tuna).	 © M. Samoilys 2011
Pointed stick	Uvuvi wa pweza	Octopus fishing	Foot fishers use pointed sticks to catch octopus in subtidal areas during spring tide periods (locally called "*bamvua*"), about 14 days per month. Octopus fishers walk along the shore with a pointed stick in their hands that they use for poking inside octopus' dens. Once they find an octopus, they stab it with the stick, then tie the dead animal to the stick and proceed to another location. They usually go fishing for two or three hours and come back in the late morning or early afternoon depending on the tide. Octopus fisher can fish alone or in small groups of five to six people. This fishing activity is mostly female-dominated.	 © M. Chambon 2021

Prawn seine and cast net	Kidima na kimia	Prawn seine and cast net fishing	Prawn seine can be used from a small canoe or on foot in shallow waters. In the first case, the monofilament net is drifted from the boat whereas, in the latter, a group of two to three fishers drag it directly in the intertidal areas and haul the catch by pulling two long ropes at its extremity. Fishers often use a stick to beat up the water and scare the prawns to direct them into the net. Cast nets are thrown in the water from shore or from a canoe in shallow waters. The circular-shaped net is maintained in the seabed through weights fixed around its edges. Once the net reaches the bottom, fishers use a foot rope to close it, pull it out of the water and haul the catch.	 © G. Maina 2011
Reef seine	Nyavu ya mwamba/ Nyavu ya kukokota	Reef seine fishing	Fishers use a multifilament net that they deploy in the reef area from a canoe boat. They usually work in a crew of 10 to 20 fishers and leave early morning. At sea, the net is maintained in a vertical position in the water column through float lines and weights at its bottom. The net is usually set during high tide and acts as an underwater scoop to catch the fish. Snorkelers are responsible for scaring the fish and attracting it into the net. The rest of the crew waits for the water to go down to haul the catch. Owing to its notable negative impact on the environment, reef seine is banned in Kenya since 2001.	 © M. Samoilys 2011
Ringnet	Nyavu ya kufunga	Ringnet fishing	Ringnet fishers take part in a large crew, up to 40 people, either in a single vessel or in two vessels (one main boat supported by a small one). First, the school of fish is detected by bird's behavior at the water surface or by snorkelers/ SCUBA divers. In the latter case, the snorkelers/SCUBA divers plunge underwater to scout for fish. Once they spot the group of fish, they indicate its location by pulling their arms or a buoy at the surface. From this moment, the boat starts to go around and encircle the group of fish, while the rest of the crew deploys the net into the water using sand-fill sacks as weights to keep the net vertical in the water column. A foot rope at the net bottom is then pulled to close the net and trap the fish aggregation (like a purse). The net is finally fed out of the water and brought back to the boat. Ringnet fishers are usually fishing in the morning and get back to the landing site around noon where the	 © M. Samoilys 2011

			catch is shared among the crew. The largest catches are typically given to the boat owner, while smaller ones are sold in bunches through auction.	
Scoop net	Kimia/Uvuvi wa Kamba	Scoop net fishing	Foot fishers use this small, handled net to scoop fish along the shore. They pull down the net into water and lift it up to haul the catch. This method can be used in combination to other fishing techniques such as gleaning or spear fishing.	 © M. Samoilys 2011
SCUBA - snorkel	/	Diving	Divers leave early morning, around 6 or 7 am, to join a crew of several divers on an engine boat. The boat brings the divers to different fishing grounds and drop them one by one. There are two types of divers: those who dive in shallow waters, usually using a snorkel, and those who reach deeper waters and seamounts. In the latter case, they use a SCUBA gear or a compressor to keep enough air underwater. They usually do two dives per day of 10 (150 L air capacity) to 35 minutes (200 L air capacity) each. In total, they spend two to three hours in the fishing ground before going back to the landing site with the same boat in the late morning.	 © M. Chambon 2023

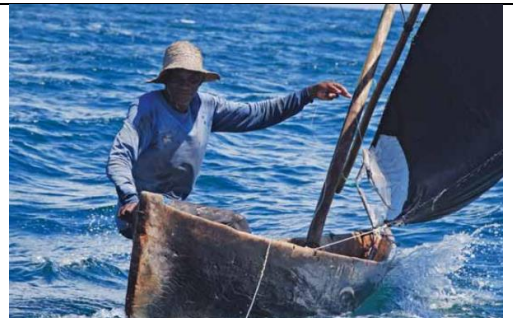
Speargun	Bunduki	Speargun fishing	Fishers go swimming in shallow areas of the reef, often at night, to look for fish and invertebrates with a speargun. The gear is composed of a long gun made with metal or wood attached to a steel harpoon that is flung with rubber strips to shoot the catch in the surface water. Since it requires low-cost investment but provides a high catch yield, this method is favored by some fishers. However, given its significant impact on reef habitats and fish populations, it is banned in Kenya since 2001.	 © M. Samoilys 2011
Stationary gillnet	Jarife/Nyavy ya kutega	Gillnet fishing	Fishers operate gillnets from a canoe or an engine boat. Since this fishing method requires a high physical effort, they are often fishing in a crew of two fishers or more. The net is deployed and set vertically under water using floats. Targeted species determine the type of gillnet: it can be set in surface waters or anchored to the seabed (bottom gillnet). The mesh size depends on the targeted species and the habitat. When the fish tries to pass in the area, it is trapped through the netting. After a few hours, the net is pulled out of water and catches are hauled. A typical gillnet of 16 m long takes about 3 weeks to be made from nylon, which is either obtained from Mombasa or Tanzania.	 © M. Samoilys 2011
Trolling	Mshipi wa kurambaza	Trolling	Fishers leave the beach early morning to reach the fishing grounds with a canoe or an engine boat. One or several trolling lines, of which are attached baited hooks (natural or artificial bait), are dragged from the boat. Fishes swimming in the surface or mid-surface part of the water column take the hooks and are later hauled by the crew.	 © M. Samoilys 2011

Table S2.3: Some of the key fisheries-related instruments enforced by Kenya.

International agreements	Regional fisheries bodies & frameworks
• Convention on the International Trade in Endangered Species of Wild Fauna and Flora • Convention on Migratory Species • FAO Compliance agreement • United Nations (UN) Convention on Biological Diversity • UN Convention Law of the Sea • UN Framework Convention on Climate Change • UN Fish Stocks Agreement • UN 2030 Agenda for Sustainable Development • FAO's Voluntary Guidelines for Securing Sustainable SSF • FAO's Port State Measures Agreement • High-Level Panel for a Sustainable Ocean Economy • 2050 Africa Integrated Maritime Strategy • FAO Code of Conduct for Responsible Fisheries	• Committee for Inland Fisheries and Aquaculture of Africa • Lake Victoria Fisheries Organization • Nairobi Convention • Protocol Concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region • Protocol on Co-operation in Combating Marine Pollution in Cases of Emergency in the Eastern African Region • Indian Ocean Tuna Commission • Protocol on Specially Protected Areas and Wildlife • Southwest Indian Ocean Fisheries Commission • Southern Indian Ocean Fisheries Agreement • East African Community

Table S2.4: Community timeline since the independence of Kenya derived from in-depth interviews with local elders conducted between 2021-22 across the Shimoni-Vanga seascape.

Event name	Description	Time
Independence of Kenya	End of the colonial rule. The coast becomes part of the new independent Republic of Kenya.	**1963**
Visit of the first President of Kenya	Visit of Jomo Kenyatta, first President of Kenya, to Wasini island. A ceremony with traditional drums was held for the occasion.	**1969**
Establishment of Kisite National Marine Park	The establishment of the Kisite National Marine Park by the government of Kenya led to an open conflict with local communities. Local people perceived the park as a restriction tool to their fishing rights. Although a consultation process was engaged with local communities, they felt that their opinion was not considered by the government.	**1973**
Creation of Mpunguti National Marine Reserve	Owing to the resentment of local communities against Kisite National Marine Park, the government decided to create Mpunguti National Marine Reserve in which fishers using traditional fishing gears such as basket traps and handline could continue go fishing.	**1978**
Cholera outbreak # 1	There was an important cholera outbreak on Wasini island where health facilities are particularly limited. Four people died on the island.	**1978**
The dramatic wedding	Important wedding celebration on Wasini island that turned into a sea accident. The day after the wedding, the guests had to cross back the channel between Wasini and the mainland, but the sea was very rough. Only people from Wasini island knew how to swim. Ten people	**1985**

	died in the accident, including people from Kibuyuni and Shimoni.	
Local migration from Goa	After 20 years of continuous beach erosion on Goa Island, the last person inhabiting moved definitely to Vanga. Only a few palm trees are remaining in what used to be a vibrant village in Vanga area.	**2000**
Indonesian Tsunami	A massive tsunami triggered by an earthquake in Indonesia affected the whole Indian ocean, including the Kenyan coast. During this event, people from the coast witnessed extreme changes between high and low tides in only a few minutes. The sea was taking boats away to the open ocean. After this event, no tourists came to visit Wasini island for a whole week. Local people believe that that this tsunami is responsible for large-scale coral destructions in the area, including those of Kisite-Mpunguti Marine Park and Reserve.	**2004**
Heavy rains	There was an episode of intense rains that caused the destruction of the Ramisi bridge, which used to connect Shimoni and Mombasa. Three people died in the accident, and the South Coast got isolated from Mombasa. Local people from the South Coast could only rely on the sea or the air to access to elementary products (food, water) since the road was not useable. They received assistance from boats coming from Tanzania and airborne food delivery from Mombasa.	**2007**
Launch of the seaweed farming project	Official launch of the seaweed farming project in Kibuyuni under the leadership of Mrs. Fatma Mohamed Usi and with the support of KMFRI.	**2009**
Cholera outbreak # 2	Second cholera outbreak on Wasini island	**2016**
Construction of a new seawall in Vanga	Rehabilitation of the previous seawall, which was built in Vanga during colonial times. This new infrastructure prevents the water from the sea to rush into people's houses at high tides.	**2017**
Construction of the road Lunga-Lunga/Vanga	The ongoing building of the road from Lunga- Lunga to Vanga improves the local economy in Vanga since the road eases fish transport and sales to the rest of the South Coast, and Mombasa in particular.	**2017**
Diversion of the Umba river in Vanga	To build a new bridge, a Chinese company diverted the Umba river, which represents the main water source for irrigation in Vanga. Since then, local communities have still not received any compensation neither support from the government to cope with this situation.	**2020**
Establishment of a steel factory in Kibuyuni	A steel company started a new project in Kibuyuni area. Local people are afraid that this project may threaten the integrity of seaweed and coral reef habitats.	**2020**
Impact of the COVID-19 pandemic	Owing to the COVID-19 pandemic and the national lockdown, it became difficult to cross the channel between Shimoni and Wasini island. Tourism activities stopped during the whole period, which led many young men to turn into fishing. No Covid-19 cases were detected on the island, but the management of the pandemic had a high negative impact on the local economy.	**2020-21**

Electrification of Wasini island	Works to electrify households on Wasini island started at the end of 2023 and were marked by a historical presidential visit on the island.	**2023-24**

Source: own data collected through in-depth interviews with local elders across the Shimoni-Vanga seascape (2021-22).

Table S2.5: Livelihood seasonal calendar in the Shimoni-Vanga seascape.

Month		Season	Livelihood activities
November		**NEM (*Kaskazi*)**	**Onboard vessel fishing (nearshore, offshore):** Sea conditions are calm, high fishing season. Fisher(men) go at sea almost every day. **Foot fishing (intertidal areas):** Low season for fishing octopus or collecting shells because of the hot temperatures. Foot fishers go at sea but less assiduously and for lesser time than during SEM. **Seaweed farming:** Low activity because of the hot conditions. **Farming:** Farmers start tilling the land between January and March. **Tourism:** High season of tourism between December and January.
December			
January			
February			
March			
April	***Long rains***	**SEM (*Kusi*)**	**Onboard vessel fishing (nearshore, offshore):** Sea conditions are rough, low fishing season. Fisher(men) go at sea once or twice a week depending on the weather. Fishers with engine boats may go more often. **Foot fishing (intertidal areas):** High season for fishing octopus or collecting shells because of the clouds and frequent rains. Foot fishers go at sea every day during the low-tide seasons (twice a month). **Seaweed farming:** Planting of the seedlings and harvesting in September. **Farming:** Seedlings planting and harvest in August. **Tourism:** Low season for tourism.
May			
June			
July			
August			
Sept			
Oct	***Short rains***		

Source: own data collected through participant observation and semi-structured interviews with key informants across the Shimoni-Vanga seascape (2021-22).

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Appendix 3- Chapter 3

Table S3.1: List of publications included in the systematic review.

ID N°	Reference
1	Short, R.E., Mussa, J., Hill, N.A.O., Rowcliffe, M., & Milner-Gulland, E.J. (2020). Challenging assumptions: the gendered nature of mosquito net fishing and the implications for management. *Gender, Technology and Development,* 24, 66–88. DOI: 10.1080/09718524.2020.1729583
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98	Chitará-Nhandimo, S., Chissico, A., Mubai, M.E., Cabral, A.D.S., Guissamulo, A., & Bandeira, S. (2022). Seagrass Invertebrate Fisheries, Their Value Chains and the Role of LMMAs in Sustainability of the Coastal Communities—Case of Southern Mozambique. *Diversity* 14, 170. DOI :10.3390/d14030170
99	Berenji, S., Nayak, P.K., & Shukla, A. (2021). Exploring Values and Beliefs in a Complex Coastal Social-Ecological System: A Case of Small-Scale Fishery and Dried Fish Production in Sagar Island, Indian Sundarbans. Frontiers in Marine Science, 8, 795973. DOI: 10.3389/fmars.2021.795973
100	Sreya, P.S., Parayil, C., Aswathy, N., Bonny, B.P., Aiswarya, T.P., & Nameer, P.O. (2021). Economic vulnerability of small-scale coastal households to extreme weather events in Southern India. *Marine Policy*, 131, 104608. DOI: 10.1016/j.marpol.2021.104608
101	López-Ercilla, I., Espinosa-Romero, M.J., Rivera-Melo, F.F., Fulton, S., Fernández, R., Torre, J., Acevedo-Rosas, A., Hernández-Velasco, A., & Amador, I. (2021). The voice of Mexican small-scale fishers in times of COVID-19: impacts, responses, and digital divide. *Marine Policy*, 131, 104606. DOI: 10.1016/j.marpol.2021.104606
102	Oloko, A., Fakoya, K., Ferse, S., Breckwoldt, A., & Harper, S. (2022) The Challenges and Prospects of Women Fisherfolk in Makoko, Lagos State, Nigeria. *Coastal Management*, 50, 2, 124-141. DOI: 10.1080/08920753.2022.2022969
103	Casagrande, A., & Rover, O.J. (2021). Institucionalização de pescarias artesanais e diálogo equitativo: o caso do molusco berbigão (Anomalocardia brasiliana) na Reserva Extrativista Marinha do Pirajubaé. *Desenvolvimento e Meio Ambiente,* 58. DOI : 10.5380/dma.v58i0.75245

Table S3.2: Justification for document's exclusion from the second screening process (n=24).

Reference	Reason for exclusion
Kluger, L.C., Alff, H., Alfaro-Córdova, E., & Alfaro-Shigueto, J. (2020). On the move: The role of mobility and migration as a coping strategy for resource users after abrupt environmental disturbance – the empirical example of the Coastal El Niño 2017. *Global Environmental Change,* 63, 102095. DOI : 10.1016/j.gloenvcha.2020.102095	Not meeting criterion *ii*
Paul, T.T., Salim, S.S., S, M., Sarkar, U.K., & Das, B.K. (2020). Understanding variations in socio-economic vulnerabilities and the strategies adopted by small scale fishing communities of tropical reservoirs. *Fisheries Research,* 226, 105523. DOI : 10.1016/j.fishres.2020.105523	Not meeting criterion *iv*
Bradford, K., & Katikiro, R.E. (2019). Fighting the tides: A review of gender and fisheries in Tanzania. *Fisheries Research*, 216, 79–88. DOI: 10.1016/j.fishres.2019.04.003	Not meeting criterion *i*
de la Torre-Castro, M. (2019). Inclusive Management Through Gender Consideration in Small-Scale Fisheries: The Why and the How. Frontiers in Marine Science, 6, 156. DOI: 10.3389/fmars.2019.00156	Not meeting criterion *i*
Fulton S., Hernández, A., Suárez-Castillo, A., Fernández-Rivera Melo, F., Rojo, M., Sáenz-Arrollo, A., Hudson Weaver, A., Cudney-Bueno, R., Micheli, F., & Torre., J. (2019). From fishing fish to fishing data: the role of artisanal fishers in conservation and resource management in Mexico. En: Viability and sustainability of small-scale fisheries in Latin America and The Caribbean. S Salas, M.J. Barragán-Paladines, R. Chuenpagdee(eds.). MARE Publication Series, 19. Springer, Cham. pp. 151-175.	Not meeting criterion *iv*
Lauria, V., Das, I., Hazra, S., Cazcarro, I., Arto, I., Kay, S., Ofori-Danson, P.K., Ahmed, M., Hossain, M.A., Barangé, M., & Fernandes, J.A. (2018). Importance of fisheries for food security across three climate change vulnerable deltas. *The Science of the total environment,* 640-641, 1566-1577. DOI : 10.1016/j.scitotenv.2018.06.011	Not meeting criterion *i*
Hurley, M., & Manel, C. (2015). Coordination, Development and Governance of Senegal Small-Scale Fisheries.	Not meeting criterion *iv*
Sharma, C.M. (2008) Freshwater Fishes, Fisheries and Habitat Prospects of Nepal. *Aquatic Ecosystem, Health and Management,* 11, 75-82. DOI: 10.1080/14634980802317329	Not meeting criterion *iv*
Stacey, N., Gibson, E., Loneragan, N.R., Warren, C., Wiryawan, B., Adhuri, D., & Fitriana, R. (2019). Enhancing coastal livelihoods in Indonesia: an evaluation of recent initiatives on gender, women and sustainable livelihoods in small-scale fisheries. *Maritime Studies,* 18, 359–371. DOI:10.1007/s40152-019-00142-5	Not meeting criterion *i*
Furtado, L.G., Leitão, W.M., & Mello, A.F. (1993). *Povos das águas : realidade e perspectivas na Amazônia.*	Not meeting criterion *i*
Purcell, S.W., Fraser, N.J., Tagica, S., Lalavanua, W., & Ceccarelli, D.M. (2018) Discriminating Catch Composition and Fishing Modes in an Artisanal Multispecies Fishery. Frontiers in Marine Science, 5, 243. DOI : 10.3389/fmars.2018.00243	Redundancy of data: based on the same data than ID 30
Purcell, S.W., Ngaluafe, P., Foale, S.J., Cocks, N., Cullis, B.R., Lalavanua, W. (2016) Multiple Factors Affect Socioeconomics and Wellbeing of Artisanal Sea Cucumber Fishers. *PLoS ONE* 11, 12, e0165633. DOI: 10.1371/journal.pone.0165633	Redundancy of data: based on the same data than ID 42
Amadu, I., Armah, F.A., & Aheto, D.W. (2021). Assessing Livelihood Resilience of Artisanal Fisherfolk to the Decline in Small-Scale Fisheries in Ghana. *Sustainability,* 13, 10404. DOI:10.3390/su131810404	Not meeting criteria *iii* and *iv*

Amadu, I., Armah, F.A., Aheto, D.W., Adongo, A.C. (2021). A study on livelihood resilience in the small-scale fisheries of Ghana using a structural equation modelling approach. *Ocean & Coastal Management*,215, 105952, ISSN 0964-5691. DOI: 10.1016/j.ocecoaman.2021.105952.	Not meeting criterion *iv*
Engen, S., Hausner, V.H., Gurney, G.G., Broderstad, E.G., Keller, R., Lundberg, A.K., Murguzur, F.J.A., Salminen, E., Raymond, C.M., Falk-Andersson, J., & Fauchald, P. (2021). Blue justice: A survey for eliciting perceptions of environmental justice among coastal planners' and small-scale fishers in Northern-Norway. *PLOS ONE,* 16, e0251467. DOI: 10.1371/journal.pone.0251467	Not meeting criterion *iv*
Stacey, N., Gibson, E., Loneragan, N.R., Warren, C., Wiryawan, B., Adhuri, D.S., Steenbergen, D.J., & Fitriana, R. (2021). Developing sustainable small-scale fisheries livelihoods in Indonesia: Trends, enabling and constraining factors, and future opportunities. *Marine Policy*, 132, 104654. DOI: doi.org/10.1016/j.marpol.2021.104654	Not meeting criterion *i*
Lawless, S., Cohen, P. J., McDougall, C., Mangubhai, S., Song, A. M. and Morrison, T. H. (2022). Tinker, tailor or transform: Gender equality amidst social-ecological change. *Global Environmental Change*, 72. 102434, ISSN 0959-3780. DOI: 10.1016/j.gloenvcha.2021.102434.	Redundancy of data: based on the same data than ID 5
Mangubhai, S., Nand, Y., Reddy, C., Jagadish, A. (2021). Politics of vulnerability: Impacts of COVID-19 and Cyclone Harold on Indo-Fijians engaged in small-scale fisheries. Environmental Science and Policy, 120:195-203. DOI: 10.1016/j.envsci.2021.03.003. Epub 2021 Mar 25. PMID: 34867082; PMCID: PMC8629164.	Not meeting criterion *iv*
Kimbu, A.N., Booyens, I., & Winchenbach, A. (2022). Livelihood Diversification Through Tourism: Identity, Well-being, and Potential in Rural Coastal Communities. *Tourism Review International*, 26, 25–40. DOI:10.3727/154427221x16245632411854	Not meeting criterion *iii*
Smallhorn-West, P., Van Der Ploeg, J., Boso, D., Sukulu, M., Leamae, J., Isihanua, M., Jasper, M., Saeni-Oeta, J., Batalofo, M., Orirana, G., Konamalefo, A., Houma, J., & Eriksson, H. (2022). Patterns of catch and trophic signatures illustrate diverse management requirements of coastal fisheries in Solomon Islands. *Ambio,* 51, 1504–1519. DOI:10.1007/s13280-021-01690-z	Not meeting criterion *iv*
Massey, L.M., McCord Camerden, P., Gaos, A.R., Liles, M.J., Seminoff, A.J., & Ahern, A.L.M (2022). Challenging gender inequity in wildlife conservation: a women's group leading sea turtle conservation efforts in El Salvador. *Local Environment*, 27,1, 1-15. DOI: 10.1080/13549839.2021.1997962	Not meeting criterion *iii*
Lee, J., & Kim, D. (2021). Analysis of the Discriminatory Perceptions of Victims on Damage from Environmental Pollution: A Case Study of the Hebei Spirit Oil Spill in South Korea. Land. DOI: Spill 10.3390/land10101089	Not meeting criterion *iii*
Appiah, S., Antwi-Asare, O.T., Agyire-Tettey, F.K, Abbey, E., Kuwornu, J.K.M., Cole, S. &Chimatiro, S.L. (2021). Livelihood Vulnerabilities Among Women in Small-Scale Fisheries in Ghana. The European Journal of Development Research, Palgrave Macmillan;European Association of Development Research and Training Institutes (EADI), 33,6,1596-1624.	Not meeting criterion *iii*
Lawless, S., Cohen, P.J., Mangubhai, S., Kleiber, D., & Morrison, T.H. (2021). Gender equality is diluted in commitments made to small-scale fisheries. *World Development,* 140, 105348. DOI:10.1016/j.worlddev.2020.105348	Not meeting criterion *i*

Table S3.3: Definition of variables used in the systematic literature review.

Variable	***Definition***	***Format***
Women's participation in SSF management		
Women's participation level in SSF management	Women's participation level in SSF management processes	0= Excluded from management processes 1= Participation to some management activities but facing limitations to participate in decision-making processes 2= Active participation in management decision-making processes
Socio-cultural, environmental and economic impacts		
Impact Participation	The reported impact is related to the participation of women in management processes	0= No 1= Yes
Impact direction	The reported impact is presented as positive in the publication	0= No 1= Yes
Impact scale	Scale of the reported impact in the publication (select one only)	1= Social-ecological system (SES) scale 2= Community scale 3= Individual scale
Impact category	Category of the reported impact in the publication (select one only)	1= Socio-cultural impact 2= Environmental impact 3= Economic impact
Impact subcategory	Subcategory of the reported impact in the publication (select one only)	1 = Change in the understanding of the gender dynamics within the SSF SES (Comprehensiveness) 2 = Change in the impact of management decisions on women (Gendered management impact) 3 = Change in the recognition of gendered ecological knowledge (Gendered ecological knowledge) 4 = Change in the compliance to management measures (Compliance) 5 = Change in the diversity of perspectives for SSF management (Diverse perspectives) 6 = Change in the long-term use of fisheries resources (Sustainable management) 7 = Change in human pressure on local ecosystems (Ecological pressure) 8 = Change in food security (Food security) 9 = Change in adaptive capacity (Adaptive capacity) 10 = Change in the social attributes of the community (Community social attributes) 11 = Change in the transmission of traditional knowledge (Cultural heritage) 12 = Change in community income (Community income) 13 = Change in well-being (Well-being) 14 = Change in capacity building (Capacity building) 15= Change in women's empowerment and self-esteem (Empowerment)

		16 = Change in gender roles (Gender roles) 17= Change in women's leisure time (Women's leisure time) 18= Change in women's income (Women's income)

Table S3.4: Adapted classification of the levels of women's participation in small-scale fishery management, after Agarwal's typology[6] of women's participation in nature resource management (2001).

Corresponding level of participation	Agarwal's category	Characteristic features
Excluded	/	/
Limited	Nominal	Membership in the group
	Passive	Being informed of decision ex post facto; or attending meetings and listening in on decision-making, without speaking up
	Consultative	Being asked an opinion in specific matters without decisions
	Activity-specific	Being asked to (or volunteering to) undertake specific tasks
Active	Active	Expressing opinion, whether or not solicited or taking initiatives of other sorts
	Interactive (empowering)	Having voice and influence in the group's decisions

[6] Agarwal, B. (2001). Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework. *World Development, 29* (10), 1623–1648. https://doi.org/10.1016/S0305-750X(01)00066-3

Appendix 4- Chapter 4

List S4.1: Questions of the semi-structured interviews conducted in the Shimoni-Vanga seascape in 2021-2022.

Series 1 – Gender identities *(the questions were adjusted to the gender of the interviewee)*

- In your community, what characteristics are valued for a woman/man?
- Do you agree with this vision?
- When and how did you realize that you are a woman/man?
- How would you explain the differences between a woman and a man to a child?
- Do you think it is necessary for a woman to work? And what is the situation for a man?
- In your community, what are the tasks and responsibilities that women are expected to handle? And what about men, is it similar?
- Are there specific aspects of life that women/men cannot understand? Which ones?
- Have you ever thought that "it would be better if I were a woman/man"? If so, in what circumstances?
- Have you ever sensed any inequality between women and men in your community? If so, could you please describe?
- Have you ever been frustrated as a woman/man? If so, why?
- Have you ever felt harassed? If so, do you feel sharing the story with us?
- Is there anything else that you would like to add about your experience as a woman/man?

Series 2 – Gendered fishing practices

- How often do you fish?
- What time do you go fishing usually?
- How long do you fish for? /What time would you be back home?
- Where are you fishing usually?
- How do you access this area?
- Are you fishing alone or in a group?
- What technique(s) do you use to fish (including the fishing gear(s))?
- What are the most common species that you target?
- Does it vary across seasons?
- Could you tell us more about your daily fishing routine?

List S4.2: Questions of the individual survey conducted in the Shimoni-Vanga seascape in 2021-2022.

Section 1- Fishing gears

Which fishing gear(s) do you use from the following list?

- Basket trap
- Drifting gillnet
- Fence trap
- Hand gathering
- Handline
- Hook stick
- Longline
- Pointed stick
- Prawn seine and cast net
- Reef seine
- Ringnet
- Scoop net
- SCUBA – snorkel
- Speargun
- Stationary gillnet
- Trolling

Section 2- Target taxa

Which taxa do you catch when fishing from the following list?

- Anchovy
- Barracuda
- Billfish
- Blue-spotted wrasse
- Ceramic vase
- Common spider conch
- Elongate giant clam
- Emperor fish
- Giant spider conch
- Goatfish
- Gold ring cowrie
- Grouper
- Grunt
- Kingfish
- Lobster
- Lynx cowrie
- Moray
- Napoleon wrasse
- Octopus
- Parrotfish
- Prawn
- Rabbitfish
- Ramose murex
- Ray
- Sardine and herring
- Sea cucumber
- Shark

- Snapper
- Squid
- Squirrel fish
- Sweetlips fish
- Trevally
- Triggerfish
- Tuna
- Unicorn fish

Section 3- Fishing locomotion, time, effort and income

1. Over the last week (men)/last *bamvua* period (women), how many days did you go fishing?
2. Last week/*bamvua*, on your fishing trips, how many hours were spent to get to and from the fishing sites; i.e. not including the fishing time?
3. What type of locomotion do you use to get to and from the sites?
4. Over the last week (men)/last *bamvua* period (women), how many hours per day did you spend in the water fishing?
5. Yesterday/ during the last *bamvua*, what amount of catch did you get?
6. Yesterday/ during the last *bamvua*, how much did you earn from fishing? And what do you usually get during the other season (i.e., SEM)?

Table S4.1: Fishing gears by gender.

Fishing gear	**Women**		**Men**	
	Headcount	***Percentage of respondents***	***Headcount***	***Percentage of respondents***
Basket trap	1	1,6	39	49,4
Drifting gillnet	0	0	15	19,0
Fence trap	0	0	6	7,6
Hand gathering	56	90,3	2	2,5
Hand gathering and pointed stick	45	72,6	0	0
Handline	0	0	55	69,6
Hook stick	0	0	4	5,1
Longline	0	0	19	24,1
Pointed stick	51	82,3	9	11,4
Prawn seine and cast net	0	0	3	3,8
Reef seine	0	0	7	8,9
Ringnet	0	0	11	13,9
Scoop net	0	0	3	3,8
SCUBA - snorkel	0	0	13	16,5
Speargun	0	0	2	2,5
Stationary gillnet	0	0	18	22,8
Trolling	0	0	9	11,4
Total of respondents	**62**	**100**	**79**	**100**

Table S4.2: Main taxa targeted by fishers in the Shimoni-Vanga seascape and included in the research survey.

Common name in English	**Scientific name of the family *(if applicable)***	**Scientific name of the species *(if applicable)***	**Local name (Swahili)**	**Functional group**	**Associated ecosystem**
Anchovy	Engraulidae	/	Dagaa	Pelagic fish	Pelagic, coastal waters
Barracuda	Sphyraenidae	/	Kisumba	Pelagic fish	Deep waters
Billfish	Istiophoridae	/	Sulisuli	Pelagic fish	Pelagic, deep waters
Blue-spotted wrasse	Labridae	*Anampses caeruleopunctatus*	Mbono	Reef fish	Benthic, coral and rock reef, sandy bottoms
Ceramic vase	Turbinellidae	*Vasum ceramicum*	Changa mawe	Invertebrate	Benthic, rock and reef flat
Common spider conch	Strombidae	*Lambis lambis*	Nyaale	Invertebrate	Reef flats, mangrove areas
Elongate giant clam	Cardiidae	*Tridacna maxima*	Kumbe ta	Invertebrate	Benthic, rock and reef flat
Emperor fish	Lethrinidae	/	Changu	Reef fish	Benthic, coral reef
Giant spider conch	Strombidae	*Lambis truncata*	Nyaale	Invertebrate	Benthic, coral reef
Goatfish	Mullidae	/	Mkundaji	Reef fish	Benthic, coral reef
Gold ring cowrie	Cypraeidae	*Monetaria annulus*	Kunkugu	Invertebrate	Shallow tidal waters, reef flats
Grouper	Serranidae	/	Tewa	Reef fish	Outer reef to deep water
Grunt	Haemulidae	/	Paramamba	Reef fish	Benthic, coral reef
Kingfish	Scombridae	/	Nguru	Pelagic fish	Pelagic, deep waters
Lobster	Homaridae	/	Kambamawe	Crustacean	Benthic, hard and mud substrate
Lynx cowrie	Cypraeidae	*Lyncina lynx*	Pasi	Invertebrate	Benthic, rock and reef flat
Moray	Muraenidae	/	Mkunga	Reef fish	Coral and rock reef

Napoleon wrasse (or humphead wrasse)	Labridae	*Cheilinus undulatus*	Badu	Reef fish	Benthic, lagoon and coral reef
Octopus	Octopodidae	*Octopus cyanea; Octopus vulgaris*	Pweza	Invertebrate	Benthic, coral reefs, reef flat
Parrotfish	Scaridae	/	Pono	Reef fish	Benthic, lagoon and coral reef
Prawn	Crangonidae	/	Kamba	Crustacean	Benthic, shelf area, sandy and mud bottoms
Rabbitfish	Siganidae	/	Tafi	Reef fish	Benthic, coral reef
Ramose murex	Muricidae	*Chicoreus ramosus*	Kombe miba	Invertebrate	Benthic, rock and reef flat
Ray[7]	/	/	Taa	Elasmobranch	Shallow to deep waters
Sardine and herring	Clupeidae	/	Simu/Kerenge/Simsim	Pelagic fish	Pelagic, inshore waters
Sea cucumber	Holothuroidea	/	Jongoo	Invertebrate	Benthic, shallow waters and coral reef
Shark[7]	/	/	Papa	Elasmobranch	Pelagic but also found in coral reef
Snapper	Lutjanidae	/	Tembo	Reef fish	Benthic, lagoon and inshore coral reef
Squid[8]	/	/	Ngisi	Invertebrate	Shallow to deep waters
Squirrel fish	Holocentridae	/	Kifudu	Reef fish	Benthic, lagoon and coral reef
Sweetlips fish	Haemulidae	/	Fute	Reef fish	Benthic, lagoon and coral reef

[7] Not defined at the family level. Class Chondrichthyes
[8] Not defined at the family level. Class Cephalopoda

Trevally	Caranigidae	/	Kolekole	Reef fish	Coastal water and deeper coral reef
Triggerfish	Balistidae	/	Gona	Reef fish	Benthic, lagoon and coral reef
Tuna	Scombridae	/	Jodari/Kiboma	Pelagic fish	Mesopelagic or pelagic, deep water
Unicorn fish	Acanthuridae	/	Puju	Reef fish	Benthic, lagoon and coral reef

Table S4.3: Functional groups of target taxa by gender of the fisher.

Functional group	**Women**		**Men**	
	Headcount	***Percentage of respondents***	***Headcount***	***Percentage of respondents***
Crustacean	0	0	21	26,6
Elasmobranch	0	0	51	64,6
Invertebrate	62	100	60	75,9
Pelagic fish	0	0	57	72,2
Reef fish	6	10	75	94,9
Total of respondents	**62**	**100**	**79**	**100**

Table S4.4: Target taxa by functional group and gender of the fisher.

Functional group	Target taxa	Women		Men	
		Headcount	***Percentage of respondents***	***Headcount***	***Percentage of respondents***
Crustacean	Lobster	0	0	21	26,6
Crustacean	Prawn	0	0	1	1,3
Elasmobranch	Ray	0	0	41	51,9
Elasmobranch	Shark	0	0	36	45,6
Invertebrate	Ceramic vase	29	46,8	0	0
Invertebrate	Common spider conch	44	71,0	0	0
Invertebrate	Elongate giant clam	27	43,5	0	0
Invertebrate	Giant spider conch	11	17,7	0	0
Invertebrate	Gold ring cowrie	49	79,0	0	0
Invertebrate	Lynx cowrie	35	56,5	0	0
Invertebrate	Octopus	51	82,3	44	55,7
Invertebrate	Ramose murex	27	43,5	0	0
Invertebrate	Sea cucumber	12	19,4	18	22,8
Invertebrate	Squid	0	0	46	58,2
Pelagic fish	Anchovy	0	0	18	22,8
Pelagic fish	Barracuda	0	0	47	59,5
Pelagic fish	Billfish	0	0	16	20,3
Pelagic fish	Kingfish	0	0	3	3,8
Pelagic fish	Sardine and herring	0	0	15	19,0
Pelagic fish	Tuna	0	0	33	41,8
Reef fish	Blue-spotted wrasse	0	0	44	55,7
Reef fish	Emperor fish	3	4,8	68	86,1
Reef fish	Goatfish	2	3,2	66	83,5
Reef fish	Grouper	0	0	46	58,2
Reef fish	Grunt	0	0	29	36,7
Reef fish	Moray	0	0	39	49,4

Reef fish	Napoleon wrasse	0	0	31	39,2
Reef fish	Parrotfish	2	3,2	62	78,5
Reef fish	Rabbitfish	5	8,1	62	78,5
Reef fish	Snapper	0	0	41	51,9
Reef fish	Squirrel fish	0	0	59	74,7
Reef fish	Sweetlips fish	0	0	56	70,9
Reef fish	Trevally	1	1,6	57	72,2
Reef fish	Triggerfish	0	0	42	53,2
Reef fish	Unicorn fish	1	1,6	55	69,6
Total of respondents		**62**	**100**	**79**	**100**

Table S4.5: Fisherwomen's and fishermen's contributions to local diets in mixed households across seasons.

Season	Northeast monsoon	Southeast monsoon
Part of the catch eaten at home provided by fishermen (%)	67	68
Part of the catch eaten at home provided by fisherwomen (%)	33	32

Table S4.6: Fisherwomen's contribution to local diets in fisherwomen-headed households across seasons.

Season	Northeast monsoon	Southeast monsoon
Part of fish/seafood consumed at home provided by fisherwomen (%)	50	51

Appendix 5- Chapter 5

Table S5.1: List of publications included in the narrative review.

ID N°	Reference
1	Cinner, J.E., McClanahan, T.R., Graham, N.A., Daw, T.M., Maina, J.M., Stead, S.M., Wamukota, A.W., Brown, K., & Bodin, Ö. (2012). Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. Global Environmental Change-human and Policy Dimensions, 22, 12-20.
2	McClanahan, T.R., Cinner, J.E., Maina, J., Graham, N.A.J., Daw, T.M., Stead, S.M., Wamukota, A., Brown, K., Ateweberhan, M., Venus, V., and Polunin, N.V.C. (2008) Conservation action in a changing climate. Conservation Letters, 1 (2). pp. 53-59
3	McClanahan TR, Cinner JE, Graham NA, Daw TM, Maina J, Stead SM, Wamukota A, Brown K, Venus V, Polunin NV. Identifying reefs of hope and hopeful actions: contextualizing environmental, ecological, and social parameters to respond effectively to climate change. Conserv Biol. 2009 Jun;23(3):662-71. doi: 10.1111/j.1523-1739.2008.01154.x. Epub 2009 Feb 24. PMID: 19245493.
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Table S5.2: Compiled list of local indicators of climate change impacts resulting from semi-structured interviews (n=28) and focus group discussions (n=8). Final indicators included in the survey are indicated in bold.

ID number	Local indicator of climate change impacts	Reported direction of the change
1	**Changes in atmospheric mean temperature**	increase
2	**Changes in atmospheric mean temperature during a given season (i.e., NEM or SEM)**	increase
3	Changes in the frequency of unusual temperatures in a given season	increase
4	Changes in the temperature during the night	increase
5	Changes in the temperature during the day	increase
6	Changes in sunshine intensity	increase
7	**Changes in the mean of rainfall**	decrease
8	Changes in variability of rainfall	increase
9	Changes in the predictability of rainfall	decrease
10	Changes in the predictability of rainfall in a given season	decrease
11	Changes in the amount of rainfall in a given season	decrease
12	Changes in the number of days with rainfall / rainy days	decrease
13	Changes in the intensity / strength of heavy rainfall events	decrease
14	**Changes in frequency of extreme events**	increase
15	**Changes in frequency of extreme droughts**	increase
16	Changes in the intensity of drought	increase
17	Changes in the length / duration of drought	longer
18	Changes in the timing (onset or end) of seasons	sooner
19	Changes in the timing (onset) of winds	later
20	**Changes in wind direction**	conflicting winds
21	Changes in wind strength or speed during a given season	increase
22	Changes in wind stability	decrease
23	Changes in wind strength or speed	increase
24	Changes in the intensity / strength of extreme hot seasons	increase
25	**Changes in the transition between seasons**	Less clear
26	Changes in the length /duration /disappearance of seasons	longer
27	Change in the frequency of storms (not further specified)	less
28	Changes in the sea temperature in a given season	increase
29	**Changes in the strength of coastal currents**	increase
30	Changes in coastal erosion	increase
31	**Changes in coastal sedimentation**	increase
32	**Changes in sea level**	increase
33	**Changes in the predictability of tide levels**	less
34	Changes in the predictability of tide levels during a given season (spring tides)	less
35	Changes in the behaviour of marine animals	Away from shore
36	Changes in the behaviour of marine animals during a given season	Away from shore
37	Displacement of animal marine species	Away from shore
38	**Displacement of animal marine species during a given season (i.e., NEM or SEM)**	Away from shore
39	Changes in the abundance of marine animal and plants species	increase

40	Changes in the abundance of marine fish	decrease
41	Changes in the abundance of marine animals excluding fish (mammals, birds, crustaceans, etc)	decrease
42	Changes in the colour of seaweed	lighter
43	Changes in the frequency of diseases of marine algae-seagrass	increase
44	**Changes in the abundance of marine algae seagrass**	decrease
45	Changes in land cover	disappearance
46	Changes in habitat integrity	decrease
47	**Changes in coral bleaching**	Increase
48	**Changes in coral reef integrity**	decrease
49	Changes in the sea surface temperature	increase
50	**Changes in the mortality of marine animal and plants**	increase
51	**Changes in the availability of drinking water from wells**	decrease
52	Changes in water self-sufficiency	less
53	Changes in the cost of water-related expenses	increase
54	**Changes in the amount of catch of marine animal and plant species**	decrease
55	Changes in the amount of catch of marine species in a given season	decrease
56	Changes in the price of marine species	increase
57	Change in the duration for drying sardines	decrease
58	Changes in seaweed crop productivity	decrease
59	Changes in the frequency of human skin diseases	increase
60	Changes in shade availability in the village	decrease

List S5.1: Questions of the individual survey conducted in the Shimoni-Vanga seascape in 2021-2022.

Section 1- Information on the respondent

1. Do you consider yourself belonging to any ethnic group? If so, which one?

2. Do you have a position of authority or respect in the village?

3. How old are you?

Section 2- Information on local indicators of climate change impacts (LICCI)

- **LICCI n°1: Changes in the mean of rainfalls**
  - Have you noticed a decrease in rainfalls compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?
  -
- **LICCI n°2: Changes in wind direction**
  - Have you noticed conflicting winds compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°3: Changes in the transition between seasons**
  - Have you noticed fewer clear transitions between the NEM and SEM seasons compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°4: Changes in the strength of coastal currents**
  - Have you noticed an increase in the strength of coastal currents compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°5: Changes in sea level**
  - Have you noticed an increase in sea level compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°6: Changes in the predictability of tide levels**
  - Have you noticed that tides became less predictable compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°7: Changes in coastal sedimentation**
  - Have you noticed an increase in coastal sedimentation compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°8: Changes in coral bleaching**
  - Have you noticed an increase in coral bleaching compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°9: Changes in coral reef integrity**
  - Have you noticed a decrease in coral reef integrity compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°10: Changes in the mortality of marine animals and plants**
  - Have you noticed an increase in the mortality of marine animals and plants compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°11: Changes in the location of animal marine species migration areas and route during a given season**
  - Have you noticed that animal marine species are moving farther from shore compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°12: Changes in the abundance of marine algae-seagrass**
  - Have you noticed a decrease in the abundance of marine algae seagrass compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°13: Changes in the amount of catch of marine animal and plant species**
  - Have you noticed a decrease in the amount of catch of marine animal and plant species compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°14: Changes in the availability of drinking water**
  - Have you noticed a decrease in the availability of drinking water from the wells compared to when you were young?
  - Have you noticed a decrease in the amount of catch of marine animal and plant species compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°15: Changes in the frequency of extreme events**
  - Have you noticed an increase in the frequency of extreme events compared to when you were young?
  - Have you noticed a decrease in the amount of catch of marine animal and plant species compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°16: Changes in mean temperature**
  - Have you noticed an increase in air temperatures compared to when you were young?
  - Have you noticed a decrease in the amount of catch of marine animal and plant species compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°17: Changes in the temperatures during the SEM season**
  - Have you noticed an increase in air temperatures during the SEM season compared to when you were young?
  - Have you noticed a decrease in the amount of catch of marine animal and plant species compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°18: Changes in the temperatures during the NEM season**
  - Have you noticed an increase in air temperatures during the NEM season compared to when you were young?
  - Have you noticed a decrease in the amount of catch of marine animal and plant species compared to when you were young?
  - How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
  - Can you explain me how this change affects your life and the one of your household?

- **LICCI n°19: Changes in the frequency of extreme droughts**
  - Have you noticed an increase in the frequency of extreme droughts compared to when you were young?

- Have you noticed a decrease in the amount of catch of marine animal and plant species compared to when you were young?
- How much does this change affect your life and the one of your household (e.g., does not affect me at all, affects me a little, affects me a lot)?
- Can you explain me how this change affects your life and the one of your household?

Table S5.3: Examination of alignment and complementarities between indicators reported by local small-scale fishing communities and scientific evidence.

Local indicator of climate change impact	Direction of the change	Corresponding scientific variable	Scientific evidence	Scientific trend	Relation between local and scientific reports
Changes in atmospheric mean temperature	Increase	Annual mean air temperature	Vincent et al., 2011	Increase – strong signal	**Overlap**
Changes in atmospheric mean temperatures during the SEM season	Increase	Seasonal mean air temperature during SEM	Local meteorological measurement for Kwale County	Increase	**Overlap**
Changes in atmospheric mean temperatures during the NEM season	Increase	Seasonal mean air temperature during NEM	Local meteorological measurement for Kwale County	Increase	**Overlap**
Changes in the mean of rainfall	Decrease	Mean rainfall	Maina et al., 2011 ; Schwarzald et al., 2022 ; Vincent et al., 2011	Scientifically debated	**Additional local insight**
Changes in frequency of extreme droughts	Increase	Consecutive dry days	Vincent et al.,2011	Increase	**Overlap**
Changes in the transition between seasons	Less clear	Timing, duration and intensity of seasons	Maina et al., 2021 ; Schwarzald et al., 2022	Later onsets and ends, more extreme in intensity	**Overlap**
Changes in frequency of extreme events	Increase	Magnitude of natural modes of variability (e.g., Indian Ocean Dipole, El Niño Southern Oscillation)	Cai et al.,2013 ; Ndomani et al., 2018	Increase	**Overlap**
Changes in wind direction	Conflicting	Intensity and direction of wind	Jacobs et al., 2021	Changes in intensity of opposing winds	**Overlap**
Changes in the strength of coastal currents	Increase	Strength of currents	NA	NA	**Additional local insight**
Changes in sea level	Increase	Sea level	Church et al., 2006	Scientifically debated	**Additional local insight**

Changes in the predictability of tide levels	Less	Tide level	NA	NA	**Additional local insight**
Changes in coastal sedimentation	Increase	Coastal sedimentation	Chattopadhyay & Singh, 2013	Increase	**Overlap**
Changes in coral bleaching	Increase	Bleaching intensity and frequency	Atewerbehan et al.,2010 ; Graham et al., 2015; Jouval et al., 2023 ; Maina et al., 2008, 2011 ; McLanahan et al.,2007,2008;2009, 2014, 2016, 2020 ;McNeil et al., 2010; McNeil & Graham,2010 ;Obura et al.,2004	Increase	**Overlap**
Changes in coral reef integrity	Decrease	Coral reef health	Counce et al., 2023; D'agata et al., 2022; Obura et al., 2022; van Hordonk et al., 2013.	Decrease	**Overlap**
Changes in the mortality of marine animal and plants	Increase	Marine biomass	Painter et al., 2021 ;Wilson et al., 2021	Decline	**Overlap**
Displacement of animal marine species during the NEM season	Away from shore	Species distribution	e.g., seabirds : Legrand et al., 2016; e.g., Large pelagics : Anilda et al.,2011; Painter et al., 2021; Sequeira et al., 2013	Shift towards cooler areas	**Overlap**
Changes in the abundance of marine algae seagrass	Decrease	Algae abundance	NA	NA	**Additional local insight**
Changes in the amount of catch of marine animal and plant species	Decrease	Fish biomass	Anildo et al., 2011 ; Wilson et al., 2021	Decrease	**Overlap**
Changes in the availability of drinking water from wells	Decrease	Saltwater intrusion	Chattopadyay & Singh, 2013	Increase	**Overlap**

Appendix 6

List of other scientific publications and communications

Throughout my PhD, in addition to the four articles derived from this thesis that have been published or submitted to peer-reviewed journals, I have contributed to the following research products:

Peer-reviewed publications

- Simmen, B., Harpet, C., Hladik, A., Edmond, R., Pioch, C., Combo, A.S., Andriaholinirina, N., Ranarijaona, H.L.T, Randriamanana, L.M.E., **Chambon, M.,** Li, T., Rasoamanantenaniaina, C., Randriarisoa, A.M., Razanajatovo, H., Manzi, O.J.L., Hladik, C-M. & Riera, B. (2022). Forest Fragments, Lemur Communities and Local Perception of Nature in a Protected Area of Northwestern Madagascar. *Frontiers in Ecology and Evolution*. https://doi.org/10.3389/fevo.2022.772808
- Gerhardinger, C.L., Rudolph, T.B., Gaill, F., Mortyn, G., Littley, E., Vincent, A., Herbst, D.F., Ziveri, P., Jeanneau, L., Laamanen, M., Cavallé, M., Gietzelt, J.M., Glaser, M., **Chambon, M.,** Jacquemont, J., Selim, S.A., Brugere, C., Brito, C., Pereira, L.M., Amezaga, S., Fernández Muñoz, N., Becquet, L., Lalo, A. & Colonese, A.C.(2023). Bridging Shades of Blue: Co-constructing Knowledge with the International Panel for Ocean Sustainability. *Coastal Management*, *51*, 4, 244-264. https://doi.org/10.1080/08920753.2023.2244082
- Reyes-García, V., García-Del-Amo, D., Álvarez-Fernández, S., Benyei, P., Calvet-Mir, L., Junqueira, A. B., Labeyrie, V., Li, X., Miñarro, S., Porcher, V., Porcuna-Ferrer, A., Schlingmann, A., Schunko, C., Soleymani, R., Tofighi-Niaki, A., Abazeri, M., Attoh, E. M. N. A. N., Ayanlade, A., Avila, J. V. C., Babai, D., Bulamah, R. C., Campos-Silva, J., Carmona, R., Caviedes, J., Chakauya, R., **Chambon, M.,** Chen, C., Chengula, F., Conde, E., Cuní-Sanchez, A., Demichelis, C., Dudina, E., Fernández-Llamazares, A., Galappaththi, E. K., Geffner-Fuenmayor, C., Gerkey, D., Glauser, M., Hirsch, E., Huanca, T., Ibarra, J. T, Iquierdo, A., Junsberg, L., Lanker, M., López-Maldonado, Y., Mariel, J., Mattalia, G., Miara, M. D., Torrents-Ticó, M., Salimi, M., Samakov, A., Seidler, R., Sharakhmatova, V., Shrestha, U. B., Sharma, A., Singh, P., Ulambayar, T., Wu, R. & Zakari, I. S. (2024). Indigenous Peoples and local communities report ongoing and widespread climate change impacts on local social-ecological systems. *Communications Earth and Environment, 5*, 29. https://doi.org/10.1038/s43247-023-01164-y
- Reyes-García, V., García-del-Amo, D., Porcuna-Ferrer, A., Schlingmann, A., Abazeri, M., Attoh, E. M. N. A. N., Ávila, J. V. C., Ayanlade, A., Babai, D., Benyei, P., Calvet-Mir, L., Carmona, R., Caviedes, J., Chah, J., Chakauya, R., Cuní-Sanchez, A., Fernández-Llamazares, A., Galappaththi, E. K., Gerkey, D., Graham, S., Guillerminet, T., Huanca, T., Ibarra, J. T., Junquiera, A. B., Li, X., López-Maldonado, Y., Mattalia, J., Samakov, A., Schunko, C., Seidler, R., Sharakhmatova, V., Singh, P., Tofighi-Niaki, A., Torrents-Ticó, M. & **LICCI Consortium.** (2024). Local studies provide a global perspective of the impacts of climate change on Indigenous Peoples and local communities. *Sustainable Earth Reviews*, *7*, 1. https://doi.org/10.1186/s42055-023-00063-6

Oral presentation in scientific conferences and workshops

- **Chambon, M.,** Miñarro, S., Alvarez Fernandez, S., Porcher, V., Reyes-Garcia, V., Tonalli Drouet, H. & Ziveri, P. (2022). Making waves in small-scale fisheries: A systematic review of gender-inclusive management. *8th Global symposium on gender in aquaculture and fisheries*. Kochi, Kerala, India, November 2022.
- **Chambon, M.,** Wambiji, N., Alvarez Fernandez, S., Azarian, C., Ngunu Wandiga, J., Vialard, J., Ziveri, P. & Reyes-Garcia, V**.** (2022). The hidden contribution of fisherwomen to local diets in a changing climate: a case study from coastal Kenya. *7th Humboldt Kolleg in Kenya "Food security and climate change in Africa: Consolidating gains from diverse research disciplines in Africa for the future."* Kisumu, Kenya, October 2023.

- **Chambon, M.,** Ziveri, P., Alvarez Fernandez, S., Chevallier, A., Dupont, J., Ngunu Wandiga, J., Wambiji, N. & Reyes-Garcia, V. (2023). The gendered dimensions of small-scale fishing activities: a case study from coastal Kenya. *Workshop: Exploring the gendered dimensions of East African small-scale fisheries through ethnographic approaches: Insights from fishing communities in Tanzania and Kenya*. Institute for Development Studies (IDS) – University of Dar es Salaam, Tanzania, December 2023. Online.
- **Chambon, M.,** Bach, P., Tudela Casanovas, S. & Okeri, M. (2024). *Policy debate – Sustainable fisheries in a changing climate: What challenges for science, policy, and society?* Growth vs Climate Conference 2024 –ICTA-UAB, Barcelona, Spain. March 2024.

Research dissemination.

- Contribution to the MOOC on Climate Change and Indigenous People and local communities: video "Climate change impacts on the biological system: local perceptions of changes in living organisms": https://www.coursera.org/learn/climate-change-indigenous-communities
- Photo exhibition based on research findings titled: "*Kenyan small-scale fishing communities at the frontline of climate change- Insights from the Shimoni-Vanga seascape, South Coast*". Alliance française, Mombasa, Kenya, September-October 2023.