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Empowering Local Stewardship of Coastal Ecosystems in Zanzibar: Participatory Models for Habitat Rehabilitation and Resilience

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Abstract
Coastal ecosystems in Zanzibar like mangroves, coral reefs, and seagrass beds provide vital ecological and socioeconomic services yet face over degradation from deforestation, destructive fishing, pollution, and climate change. This empirical research seeks to assess the empowerment of local stewardship of coastal ecosystems in Zanzibar through participatory models for habitat rehabilitation and resilience. This necessitates extensive habitat restoration efforts. Community-based approaches that empower local stakeholders through participatory planning, implementation, and monitoring of initiatives like mangrove replanting, coral gardening, and sustainable fisheries management can foster greater buy-in and stewardship responsibility over time. However, securing enduring success requires long-term supporting frameworks from governments and partners, including financing, expertise, infrastructure, and policy assistance to fortify on-the-ground action. Regional coordination of local efforts can also optimise outcomes through information exchange and landscape-scale connectivity. Ultimately, centering restoration initiatives within community structures, traditional governance systems, and indigenous knowledge while ensuring dedicated external backing through integrated frameworks promises impactful and sustained coastal habitat rehabilitation.

Keywords: Coastal Restoration, Community Participation, Mangrove Reforestation, Climate Resilience, Sustainable Fisheries Management

1. Introduction

Ecosystem restoration refers to "the approach of supporting an ecosystem that has undergone damage degradation, or destruction." (SER, 2004) [38]. The Society for Ecological Restoration (SER) further defines ecosystem restoration as "a purposeful action that starts or speeds up ecosystem recovery with respect to its health, integrity, and sustainability...to emulate a specified reference ecosystem". The goal of ecosystem restoration is to return the ecosystem to a close approximation of its condition prior to disturbance. Ecosystem restoration is an increasingly important tool for reversing environmental damage and improving ecological health and functioning.

Zanzibar is situated along the coastline of Tanzania, is an archipelago that is highly dependent on and renowned for its extensive coastal habitats, including mangrove forests, seagrass beds, and coral reef ecosystems. Coastal ecosystems in Zanzibar play a pivotal role in supporting the region's ecological, economic, and social well-being. The intricate network of mangroves, coral reefs, and seagrass beds serves as a crucial habitat for diverse marine life, contributing to the overall biodiversity of the Indian Ocean. These ecosystems serve as breeding grounds for fish species, providing a vital breeding ground that sustains local fisheries. These sensitive ecosystems directly support over 80% of the population in small-scale fisheries, seaweed farming, and tourism (Hamad *et al.*, 2018) [15].

According to the Zanzibar Coastal Zone Environmental Management Project (ZACOMP), mangroves in particular are identified as essential for the reproduction and growth of numerous fish species, including economically significant ones such as snappers and groupers (ZACOMP Report, 2019) [54].

Moreover, the coral reefs of Zanzibar are recognised as biodiversity hotspots, supporting an array pertaining to the science of the sea and acting as natural barriers that protect the coastline from erosion and storm damage. Beyond their ecological significance, coastal ecosystems are integral to the livelihoods of Zanzibar's coastal communities. The United Nations Development Programme (UNDP) highlights the dependence of these communities on fisheries for sustenance and income, with over 70% of the local population relying directly on marine resources for their livelihoods (UNDP, 2020) [43]. Additionally, tourism, an essential component of Zanzibar's economy, heavily relies on the allure of pristine coastal environments.

However, Zanzibar has experienced dramatic degradation of over 50% of its mangroves and 75% of its coral reefs due to deforestation, destructive fishing techniques like dynamite blasting, sedimentation, sewage pollution from rapid coastal development, and the effects of climate crisis (Muhando & Rumisha, 2008) [26]. An approximation indicated that more than 40% of the islands' reef biodiversity and ecosystem functionality have been lost. The degradation of these ecosystems not only threatens the intricate equilibrium of the marine ecosystem life but also jeopardies the socio-economic stability of the coastal villages and livelihoods through increased erosion risks, declining fish catches, and loss of tourist revenue potential. The Zanzibar Environmental Management Authority (ZEMA) stresses that the well-being of coastal ecosystems is inherently connected to the success of nearby communities. Therefore, protecting and rehabilitating these ecosystems is crucial for achieving sustainable development locally (ZEMA Annual Report, 2021) [55].

In light of the dependence on coastal ecosystem services, the limited number of studies concerning these global problems, especially in coastal areas such as Zanzibar, the extent of coastal damages, and the alarming degradation observed, there is an urgent need for extensive habitat restoration efforts across Zanzibar. This current research seeks to assess the impact of environmental degradation on the coastal ecosystem and seeks to provide empirical knowledge on practical ways to overcome coastal ecological challenges for sustainable coastal environmental health in Zanzibar for future use. The study addresses two research questions: What specific forms of environmental degradation are most prevalent in the coastal ecosystem in Zanzibar and their impacts on ecological health? How can practical strategies be developed and implemented to mitigate the effects of environmental degradation on the coastal ecosystem of Zanzibar?

2. Literature Review

- **Main Threats to Costal Ecosystem Restoration**

The marine environment along the coasts and islands of Zanzibar is undergoing considerable damage, largely due to human actions. Key factors contributing to this degradation include unchecked tourism growth, rapid population increases in coastal areas, overexploitation of fisheries resources, use of harmful fishing techniques like dynamite fishing, excessive clearing of vital mangrove forests to obtain wood and other forest resources, and discharge of untreated sewage and solid waste from urban zones into the ocean, adding pollutants and excess nutrients. Major threats inflicting damage comprise deforestation of mangroves, unsustainable fishing methods like blasting reefs with explosives, pollution from various sources, and global consequences of climate change.

- **Deforestation**

Deforestation, or the clearing of natural coastal vegetation like mangroves, is a pervasive threat facing coastal habitats globally. Approximately 35% of mangrove forests globally are estimated to be affected due to deforestation for timber, coastal development, conversion to aquaculture, and over-harvesting of wood for fuel (Hamilton & Friess, 2018; Valiela *et al*., 2001) [16, 46]. Deforestation directly removes important habitats for fisheries species, degrades water quality from increased runoff, and amplifies erosion and storm vulnerability with the loss of coastal vegetation buffer zones (Ellison, 2000) [9].

In coastal regions including Zanzibar, over 50% of historical mangrove cover has been cleared through expanding coastal development, timber extraction, and conversion to salt pan operations since the early 20th century (Semesi, 1998; Burgess *et al*., 2013) [37, 3]. This deforestation around coastal villages has led to declines in the availability of wood products, the loss of fishery linkages to mangroves as critical juvenile habitats, an escalating erosion issue, as well as risks from flooding during extreme weather. This rampant deforestation threatens coastal habitats like mangrove forests and coral reefs, hampering ecosystem restoration efforts. For example, evidence shows increased turbidity and nutrient loading near heavily deforested areas, which stifles coral and seagrass growth (Mirera and Mwashote, 2010) [24]. Furthermore, the loss of forest cover has disrupted vital ecological connectivity between various coastal and inland ecosystems. Mangroves link to offshore coral reefs, seagrass meadows, intertidal mudflats, lagoons, and terrestrial forests through the transfer of nutrients, sediments, and critical mobile fauna (Nagelkerken *et al*. 2015) [27]. Disrupting this connectivity through deforestation negatively impacts all connected ecosystems.

Restoring forest cover and ecological linkages are thus vital, complementary goals supporting coastal habitat restoration initiatives underway in Zanzibar, like mangrove reforestation and coral gardening. For instance, restoring fringe mangrove belts enhances coral reef resilience by filtering land-based pollution and supplying coral reefs with mangrove-derived nutrients (Jordán-Dahlgren *et al*., 2021) [20]. However, the major driver behind deforestation in Zanzibar continues to be clearing land for unsustainable agriculture such as rice paddies. Strengthening protected area management and promoting community stewardship of forests are critical to curbing ongoing deforestation and enabling successful coastal restoration.

Table 1: Illustrates Production of Forest Products (Value - TZS Million), between 2015-2021

Forest Product	Unit	2015		2016		2017		2018		2019		2020		2021	
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Beam	M^3	2,325	261	2,457	276	2,369	266	2,244	252	1,721	193	1,450	171	1,422	160
Building Poles	M^3	3,372	48	3,442	49	3,304	47	4,438	63	3,115	44	3,255	81	3,098	103
Medium Poles	M^3	3,451	224	3,138	204	3,031	197	3,182	207	2,790	181	2,878	216	2,956	237
Firewood	M^3	18,573	929	19,532	977	23,114	1,156	26,569	1,328	32,189	1,609	27,496	1,553	25,813	1,807
Withes	M^3	2,830	871	1,742	536	1,716	528	2,311	711	2,149	661	1,930	418	2,046	1,023
Charcoal	Tons	2,005	1,203	2,046	1,227	1,957	1,292	1,880	1,241	1,766	1,166	1,809	1,302	1,805	1,264

Source: Zanzibar Statistical Abstract, 2021

○ Pollution

Pollution from land-based sources like sewage effluent and agricultural runoff laden with sediments, nutrients, and contaminants poses major risks to coastal habitats in need of better management. Pollution and nutrient over-enrichment from coastal development pose a key risk to coral reefs globally, with estimates indicating over 60% of reefs are facing risks of increased algal growth that can outcompete and smother corals (Burke *et al*., 2011) [4]. Pollutants also drain into and accumulate in mangroves as well as seagrass beds, having detrimental impacts.

In Zanzibar and other semi-enclosed seas, inadequately treated sewage discharge has caused extensive eutrophication, with nitrogen and phosphorus inputs from hotels and urban settlements exceeding sustainable thresholds by up to 30 times (Eriksson *et al*., 2002) [10]. This has been linked to red tide algae blooms, loss of seaweed farming production, and damage to coral reefs. Runoff from farming fertilizers is another concern (Mmochi *et al*., 2002) [25].

Mangroves forest and seagrass meadows habitats are also at high risk from coastal pollution. These habitats act as nutrient filters, trapping excess nutrients and contaminants from land runoff before they reach coral reefs (Valiela *et al*., 2001) [46]. However, this exposes mangroves and seagrasses to dangerous contaminant accumulation and eutrophication threats in their own right. Pesticides, heavy metals, and other toxins can bioaccumulate up the food chain, while nutrient over-enrichment fuels algal overgrowth on leaves and seagrass blades (Ralph *et al*., 2006) [35]. The resulting habitat degradation and loss of fishery production can impact human livelihoods and food security.

To this end, strategies are urgently needed to control coastal pollution through improved sewage treatment, agricultural management, and runoff reduction. Initiatives like the UNEP Global Program of Action can coordinate international efforts on a global framework for marine pollution reduction (UNEP, 2022) [44]. Locally, investments in solutions based on nature like constructed wetlands could filter pollutants while providing co-benefits like carbon sequestration and ecotourism opportunities (Vymazal, 2021) [48]. With proactive policies and responsible environmental management, the ongoing pollution crisis facing coastal habitats can be addressed.

○ Destructive Fishing

Destructive fishing practices have significant global implications, posing threats to marine ecosystems and fisheries sustainability. According to the Food and Agriculture Organization (FAO), over 30% of global fish stocks are either overexploited or depleted due to factors like destructive fishing methods such as poison, blust fishing, and bottom trawling (FAO, 2018) [11]. Bottom trawling, for instance, is a widespread practice that causes extensive habitat damage by pulling cumbersome nets across the ocean floor, impacting both target and non-target species (Pauly *et al*., 2003) [32].

The use of illegal and unregulated fishing methods further exacerbates the issue. A study by Sumaila *et al*. (2019) [41] estimates that the economic losses resulting from such practices amount to tens of billions of dollars annually, affecting both developed and developing nations. Additionally, Bycatch refers to the accidental trapping or catching of species that were not the intended target remains a serious concern. The Global Ocean Commission reports that approximately 40% of the worldwide catch comprises non-target species, leading to population declines and ecological imbalances (Global Ocean Commission, 2014) [13].

In the case of Zanzibar, this practice not only captures large amounts of fish but also destroys supporting marine habitats like seagrass meadows and coral reefs ecosystems (Troni *et al*., 2021) [42]. This poses a significant threat to restoring and conserving Zanzibar's sensitive coastal ecosystems. For example, one study estimated that 2 kg of explosives can destroy around 1000 m2 of coral reef in Zanzibar (Wager, 2004) [49]. The explosives and reef debris also kill organisms like molluscs, echinoderms, and other reef dwellers. This completely devastates the habitat and leaves nothing behind to support ecosystem restoration.

According to the study done by Muhando and Rumisha (2008) [26], there is extensive evidence that blast fishing has decimated over 75% of local coral reefs, driving the loss of essential fisheries habitat as well as tourist revenue in Zanzibar. The practice has dramatically reduced fish catches and catch diversity over time, necessitating extensive bans and enforcement.

In fact, the chemicals linger on the dead reef framework, inhibiting new coral recruitment and growth and blocking ecosystem recovery (Rajasuriya *et al*., 1996) [34]. These destructive practices have already damaged over 50% of Zanzibar's coral reefs (Obura *et al*., 2017) [30]. The loss of reef habitat also impacts coastal protection, tourism, fisheries, and livelihoods-things reef restoration aims to bring back. But continued destructive fishing constrains all recovery efforts and investments in restoration projects like coral gardening (Bos *et al*. 2014) [2]. Strict enforcement of blast and other fishing bans is urgently needed, coupled with the engagement of local communities in restoration initiatives, if Zanzibar is to achieve meaningful coastal ecosystem restoration.

Table 2: Approximate Fish Capture Amounts in TZS (Millions) from 2015 to 2021, Categorized by Fish Species

Fish Type	2015		2016		2017		2018		2019		2020		2021	
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value
Spine foot	1,114	4,855	1,243	4,570	1,252	5,491	1,300	6,783	1,313	6,870	1,398	7,408	2,246	14,206
Parrot fish	1,901	7,292	1,612	5,346	1,931	8,664	1,896	9,496	1,906	9,766	2,038	10,372	1,729	8,689
Emperors	2,324	9,188	2,396	9,958	2,422	11,347	2,574	13,459	2,623	14,162	2,767	14,700	3,074	20,051
Groupers	1,949	8,595	1,955	7,830	2,005	9,175	2,105	10,967	2,228	11,686	2,263	11,978	853	5,407
Goat fish	2,733	10,221	2,634	11,016	2,747	12,514	2,711	13,604	2,794	14,320	2,915	14,858	1,258	7,359
Surgeon fishes	2,910	10,657	2,719	10,517	2,723	11,977	2,654	12,626	2,707	13,466	2,853	13,790	1,431	6,615
Mullets	1,744	7,250	1,513	5,862	1,532	6,537	1,577	8,084	1,606	8,027	1,695	8,829	136	1,031
Anchovies	2,140	8,116	2,160	7,225	2,187	9,095	2,237	9,459	2,672	11,000	2,405	10,331	13,433	43,590
Sardine	1,046	4,534	1,098	4,114	1,191	4,905	1,097	4,812	1,158	5,255	1,179	5,256	1,431	5,591
Mackerels	1,344	5,443	1,454	5,183	1,550	6,183	1,597	8,216	1,608	8,243	1,717	8,974	2,398	13,694
Travellys	1,546	6,372	1,600	6,029	1,623	7,261	1,601	8,359	1,757	9,300	1,721	9,130	1,447	8,763
Yellow fin tuna	2,670	10,009	2,599	10,699	2,612	13,051	2,636	14,001	2,674	14,527	2,834	15,292	2,597	15,504
Sword fish	1,659	6,691	1,691	6,980	1,701	8,321	1,746	9,210	1,799	9,651	1,877	10,059	1,202	7,588
King Fish	1,013	4,428	1,103	4,397	1,196	5,987	1,214	6,414	1,301	6,928	1,305	7,005	1,066	7,399
Barracuda	1,674	6,676	1,689	5,875	1,700	7,800	1,713	9,022	1,746	8,924	1,842	9,854	1,123	6,256
Sharks/Rays	1,956	7,395	1,613	5,568	1,726	7,686	1,660	8,002	1,668	8,299	1,785	8,740	1,476	7,728
Octopus/Squid	976	4,496	1,003	4,793	1,024	6,503	1,097	6,607	1,107	7,019	1,179	7,216	2,065	14,454
Lobsters	1,929	7,662	1,907	12,652	1,928	12,658	1,933	18,478	1,944	18,622	2,078	20,182	136	918
Others	1,476	6,006	1,905	7,540	2,007	8,946	2,097	10,414	2,117	10,581	2,254	11,374	8,010	42,306
Total	**34,104**	**135,886**	**33,892**	**136,154**	**35,057**	**164,099**	**35,441**	**188,011**	**36,728**	**196,647**	**38,107**	**205,350**	**47,111**	**237,148**

Source: Zanzibar Statistical Abstract, 2021

○ Global Climate Change

Anthropogenic climate change represents a severe and mounting threat to coastal habitats like mangroves, coral reefs, and seagrass ecosystems. Rising sea levels, elevate ocean surface temperature, acidification, and intensifying storm activity associated with climate change are directly impacting the health and viability of many coastal ecosystems (Harley *et al*., 2006; Wong *et al*., 2014) [17, 53]. Mangroves, for instance, have been identified as highly vulnerable to climate impacts, with projected sea level rise likely to outpace accumulation rates in many areas (Gilman *et al*., 2008) [12].

Global climate change poses a severe threat to restoring degraded coastal ecosystems like mangroves, seagrass meadows, and coral reefs across the Zanzibar Islands. Rising temperature of the ocean surface, ocean acidification, and extreme weather events are stressing coastal habitats and reducing ecosystem resilience (Darling *et al*. 2019) [6]. According to the studies, over 90% of shallow-water reefs around Zanzibar have already suffered some bleaching from heat stress between 1998 and 2005 (Obura, 2005) [29]. Chronic bleaching diminishes coral growth and reproduction, which are critical for reef recovery. Ocean acidification also threatens calcifying organisms like corals by weakening reef structures. Additionally, Zanzibar's coastal mangroves are highly vulnerable resulting in an elevation of sea level, which could permanently submerge up to 50% of mangrove cover by 2100 (Ellison, 2015) [8].

More intense storms and rainfall due to climate change exacerbate coastal erosion and flood risks for Zanzibar's low-lying coastal communities. The loss of protective coastal vegetation cover like mangroves due to clearing for development expands erosion and storm impacts inland. This infrastructure damage and community displacement stress limited public resources also needed for ecosystem restoration projects.

Climate change mitigation to control emissions is thus urgent to slow further warming and acidification, which will otherwise outpace the recovery capacity of degraded coastal habitats (Irish *et al*. 2010) [19]. Additionally, Zanzibar must expand its protected coastal areas, like marine parks, while making coastal development climate-resilient to support ecosystem restoration amidst accelerating climate change impacts.

Based on the reviews of pre-existing works and the gaps found, therefore, this paper addressed the following two study inquiries: What practical and alternative measures can be proposed to promote and achieve a healthier coastal environment in Zanzibar? As well as how Zanzibar's environment is affecting its coastal ecosystems and what challenges it creates for sustainability.

3. Theoretical Framework

The social-ecological systems (SES) model perspective serves as an integrative lens for examining the interconnected dynamics between coastal communities, governance institutions, and threatened ecosystems in Zanzibar, mapping cross-scale linkages from local resource users to national policies. In particular, the SES framework helps diagnose the drivers of habitat degradation, including lagged human responses and governance limitations that enabled open access resource exploitation without environmental monitoring, as well as sewage infrastructure failures degrading water quality. Equally, the Social-Ecological Systems (SES) approach identifies key areas where community-led management strategies can strengthen the resilience of interconnected systems (Andersson *et al*. 2014) [1]. This includes activities such as involving communities in planning rules and initiatives like restoring mangroves, as well as advocating for policies that consider local circumstances. In essence, the SES method helps understand how social and ecological factors influence each other, guiding restoration efforts that are effective both environmentally and economically and capable of adapting to future challenges.

4. Methodology

The library method refers to the strategic approach to research, utilization of existing code libraries or frameworks to streamline and enhance study. It enhances efficiency by integrating pre-built functions, saving time, and ensuring consistency in data analysis or other processes (Wang, F. & Wan, A. 2021) [50]. By employing the library method, researchers can harness the wealth of information available in libraries and online databases to conduct a comprehensive and well-informed study. This current study employed the library method since this approach is well-documented in academic literature, with scholars emphasizing its role in promoting best practices, minimizing errors, and enabling researchers to focus on the distinctive aspects of their work.

5. Results Presentation

- **Priorities for Coastal Restoration**

In addressing the urgent need for coastal restoration, it is imperative to identify and prioritize key areas for intervention. This entails understanding the multifaceted obstacles confronted coastal ecosystems globally and developing strategic approaches to mitigate their degradation. By focusing on these priorities, we can open the doors for effective and sustainable coastal restoration initiatives that safeguard the invaluable ecosystems vital for both environmental balance and human well-being.

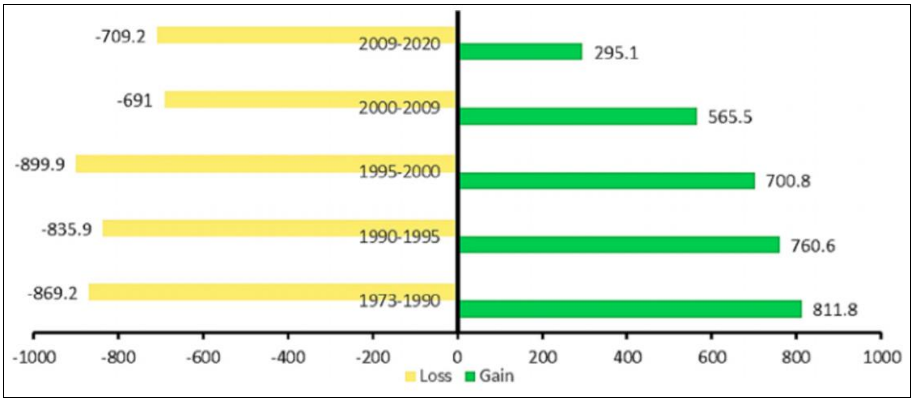
- **Mangrove Forests**

Mangrove forests are a critical priority ecosystem for coastal restoration efforts. In the areas between tides on tropical and subtropical coasts, mangroves provide vital services including reducing coastal erosion, protecting shorelines from storms and flooding, filtering pollutants, storing high levels of carbon, serving as essential breeding grounds for commercially valuable fisheries, and harboring high levels of biodiversity (Sloan & Bodin, 2012) [39].

However, over 35% of mangroves worldwide have been lost since 1980 (Hamilton & Friess, 2018) [16]. The primary causes of mangrove degradation include clearing for the development of the coast and aquaculture, over-harvesting for timber and fuelwood, pollution, changes to hydrology through diversion of freshwater flows, and increasing damage due to rising sea levels from climate change (Ellison, 2000; Duke *et al*., 2007) [9, 7].

In many coastal regions like Zanzibar, mangroves have been over-exploited by local communities for wood chips, charcoal, timber, and poles, leading to substantial deforestation (Semesi, 1998) [37]. This has increased erosion and storm damage risks and threatened important fishery linkages to mangroves as critical juvenile habitats.

Mangrove replanting and restoration programs are major priorities across regions like Zanzibar to re-establish the services provided by intact mangrove ecosystems. Common restoration techniques include directly planting or seeding mangrove propagules, as well as creating appropriate hydrological conditions and tidal flows across a site for the natural recolonization of mangrove vegetation (Kodikara *et al*., 2017) [21]. Educational programs are also needed for local communities on sustainable utilization and instituting protected conservation areas for long-term mangrove persistence against future development encroachment.



Source: Mohammed *et al*. (2023)

Fig 1: Illustrates the Mangrove forest's alterations coverage (both loss and gain in hectares) from 1973 to 2020 in Menai Bay, Zanzibar

- **Seagrass Meadows**

Seagrass meadows are vital coastal ecosystems in need of prioritization for restoration efforts. Forming critical nursery and feeding grounds for diverse marine life, seagrass beds stabilize sediments, filter pollutants from runoff, store high levels of carbon, and prevent coastal erosion (Unsworth *et al*., 2019) [45]. More than 20% of the largest fisheries in the world depend on seagrasses at some stage of life (Nordlund *et al*., 2016) [28].

However, seagrasses have significantly decreased worldwide, with an estimated 30% of the known seagrass extent lost since 1879 (Waycott *et al*., 2009) [51]. Seagrass meadows are dwindling because of harmful fishing methods that disturb sediment, pollution, excessive nutrient runoff from farming, dredging activities, changes to inlets affecting currents and flooding, and the effects of climate change such as warmer water temperatures.

In Zanzibar and other coastal regions, large seagrass losses of over 33% coverage have occurred near populated areas and watersheds with inadequate wastewater treatment (Gullström *et al*., 2002) [14]. Efforts to restore damaged seagrass beds involve activities like planting seagrass shoots, managing water flow to minimize sedimentation, redirecting runoff to control nutrient levels, and establishing protected zones with fishing gear restrictions (van Katwijk *et al*., 2016) [47]. For seagrasses to reestablish self-sustaining meadows, water quality conditions must be ameliorated alongside replanting and protective measures tailored to local community engagement and support.

Table 3: Total Area and Percentage of Seagrass Cover per Site, 2006-2019

Site	Area included in mapping (km^2)	Total area of seagrass cover (km^2), 2006	Percentages of seagrass cover, 2006	Total areas of seagrass cover (km^2), 2019	Percentages of seagrass cover, 2019	Percentages change from 2006 - 2019
Chumbe Island	0.57%	0.27%	48.11%	0.22%	39.08%	-18.76%
Chwaka Bay	59.12%	36.69%	62.06%	3046%	51.52%	-16.98%
Fumba	6.72%	3.29%	49.00%	3.09%	45.91%	-6.30%
Jambiani	20.49%	5.83%	28.47%	6.01%	29.34%	+3.07%
Nungwi	6.47%	1.25%	19.30%	1.00%	15.47%	-19.86%

Source: Purvis, D. & Jiddawi, N. 2021

- **Coral Reefs**

Coral reefs are biodiversity hotspots of critical importance for restoration efforts. Found in shallow tropical waters, coral reefs support over 25% of the world's marine species (Plaisance *et al*., 2011) [33] and provide ecosystem services valued at over $375 billion annually, including fisheries, tourism, and coastal protection (Costanza *et al*., 2014) [5].

Coral reefs span approximately 284,300 square kilometers across the globe (Spalding *et al*., 2001) [40]. They are found in over 100 countries and territories, located in tropical and subtropical regions primarily between 30°N and 30°S latitude (Burke *et al*., 2011) [4]. Around 75% of coral reefs worldwide are located in only 15 countries, with Indonesia, Australia, the Philippines, and Mexico having the largest total reef areas globally (Spalding *et al*., 2001) [40].

However, coral reefs are confronting unprecedented declines globally from climate change-driven bleaching events, ocean acidification, destructive fishing practices, pollution and runoff, tourism overuse, and coastal development (Pandolfi *et al*., 2003; Hughes *et al*., 2017) [31, 18]. It is approximated that over 19% of the original extent of coral reefs worldwide has already been lost (Wilkinson, 2008) [52], with 75% of the remaining reefs rated threatened according to the IUCN Red List Index (Burke *et al*., 2011) [4].

Coral reefs in coastal areas such as Zanzibar have experienced extensive degradation from human activities. According to Muhando and Rumisha (2008) [26], over 75% of coral reefs in these regions are rated as having high or very high levels of degradation. Major contributing factors are blast fishing practices using explosives that damage reef structures, the clearing of mangrove forests, which act as nurseries and shelters, and pollution from urban settlements along the coast as well as industrial activities.

This severe reef deterioration over the past decades has led to significant declines in local fish catches and the loss of species that rely on healthy corals. A study done by McClanahan *et al*. (2009) [22] found that fish catches in a Zanzibar village declined by over 65% between 1980 and 2006 due to coral loss and habitat changes. In addition, the decline in reef quality and productivity has meant a loss of tourism revenue, given that snorkeling and diving in coral ecosystems can generate millions of dollars for coastal economies. Coastal erosion issues may also arise with the loss of natural breakwaters from coral formations.

Extensive restoration efforts for damaged reefs are thus urgently needed along Zanzibar and Tanzania's coastline to support local ecosystems, fisheries, and communities. Methods may include installing base structures to enable new coral growth, cultivating and replanting coral fragments in nurseries, protecting fish spawning aggregations, and addressing key land-based pollution sources that impact water quality (Saleh & Camarena Gómez, 2016) [36]. Integrated coastal zone management that includes the rehabilitation of degraded reefs can help reverse past damage and support the resilience of these invaluable marine ecosystems.

6. Discussion

a) Sustained Community Participation

Sustained community participation is paramount for the success of coastal restoration initiatives. It goes beyond short-term engagement, requiring ongoing involvement from local residents, businesses, and organizations. This sustained participation ensures that the restoration efforts are not only initiated but also maintained and adapted to changing circumstances. Community members are essential for monitoring the progress of restoration projects, providing valuable insights into their effectiveness, and identifying potential challenges or opportunities for improvement.

In the lens of social-ecological systems (SES) model offers a framework for understanding the interconnectedness between social and ecological aspects of a system. In the context of habitat restoration and community participation, the SES model emphasizes the importance of engaging local communities in the restoration process. By involving community members, the model recognizes that human behaviors and social dynamics play a vital role in ecosystem health and resilience. Community participation fosters a feeling of proprietorship and stewardship, encouraging individuals to take responsibility for protecting and sustainably using restored coastal environments. This involvement can manifest through volunteer activities, such as monitoring and maintaining habitats. Additionally, community members can advocate for supportive policies, regulations, and funding to ensure ongoing restoration efforts receive the necessary support. By integrating community participation within the SES model, the reciprocal relationship between social and ecological components is acknowledged, underscoring the significance of sustained engagement in habitat restoration. Through active participation, community members become co-managers of restored ecosystems, contributing to their long-term resilience and the success of restoration initiatives.

Furthermore, sustained community participation enhances the ability of coastline communities in the face of environmental threats and climate change. By actively engaging in restoration initiatives, residents become more knowledgeable about coastal ecosystems and the potential impacts of human activities. This increased awareness can result in alterations in behavior, such as reducing pollution or implementing sustainable land use practices, which ultimately contribute to the long-term health and vitality of coastal areas. Additionally, strong community networks built through participation in restoration projects can facilitate collective responses to natural disasters, helping communities recover and adapt more effectively in the aftermath of events like hurricanes or storm surges.

b) Importance of Regional Coordination for Community-Based Coastal Restoration Efforts

The importance of regional coordination for community-based coastal restoration efforts cannot be overstated. While individual communities may initiate restoration projects within their local areas, the interconnected nature of coastal ecosystems necessitates collaboration and alignment on a larger scale. Regional coordination allows for the pooling of resources, expertise, and data across districts and even national borders, maximizing the efficiency and impact of restoration initiatives. By working together, communities can address common challenges such as habitat loss, water quality degradation, and erosion in a more holistic and strategic manner.

Also, Regional coordination in habitat restoration efforts aligns with the social-ecological systems (SES) framework by recognizing the interdependency between social and ecological components. By enabling communities to leverage each other's strengths and shared experiences, regional coordination fosters social learning within the SES. Through knowledge exchange and the adoption of best practices, participating organizations enhance their capacity to plan and implement effective restoration projects, addressing both social and ecological dimensions. This collaborative approach encourages innovation and the application of scientifically sound techniques tailored to the unique characteristics of each coastal region, reflecting the adaptive nature of SES. Furthermore, by facilitating communication and collaboration among stakeholders, including government agencies and non-profit organizations, regional coordination promotes greater transparency and accountability in decision-making processes, aligning with the governance aspect of the SES model.

Moreover, regional coordination is essential for achieving ecosystem-scale impacts and long-term sustainability. Coastal ecosystems are dynamic and interconnected, with the health of one area often influencing the well-being of neighboring habitats. By coordinating restoration efforts at a regional level, communities can address larger-scale ecological processes such as habitat connectivity, species migration, and nutrient cycling. This comprehensive approach not only enhances the ability of shoreline ecosystems to environmental stressors but also supports the recovery of threatened or endangered species and the maintenance of essential ecosystem services such as coastal protection, fisheries support, and carbon sequestration. Ultimately, regional coordination is key to maximizing the effectiveness and success of community-based coastal restoration initiatives in achieving lasting ecological and socio-economic benefits.

c) The Coastal Restoration Efforts, Community-Based Approaches, and the Importance of Long-Term Support

Coastal restoration efforts have emerged as crucial responses to the severe threats facing coastal ecosystems globally. These ecosystems, including mangroves, salt marshes, and coral reefs, provide vital services such as shoreline protection, carbon sequestration, and support for biodiversity. However, pressures from industrialization, pollution, overexploitation, and global warming posing an increasing threat to ecosystems. As a result, many coastal areas have experienced significant habitat degradation, leading to loss of biodiversity, reduced resilience to natural disasters, and diminished socio-economic benefits for coastal communities.

To address these challenges, community-based approaches to coastal restoration have gained traction as effective strategies for engaging local stakeholders and leveraging their knowledge, resources, and expertise. Community-led initiatives empower residents, businesses, and organizations to take an active role in maintaining and restoring coastal ecosystems, cultivating a feeling of proprietorship and stewardship among participants. By involving communities in the planning, implementation, and monitoring of restoration projects, these approaches not only enhance the ecological effectiveness of interventions but also contribute to the socio-economic well-being of coastal communities. Moreover, community-based approaches often incorporate traditional knowledge and practices that have been transmitted over several generations, enriching restoration efforts with valuable insights into local ecosystems and their dynamics.

However, the success of community-based coastal restoration initiatives hinges on long-term support from governments, funders, and other stakeholders. Sustainable funding, technical assistance, and policy frameworks are essential for ensuring the continuity and scalability of restoration efforts over time. Long-term support enables communities to overcome challenges such as funding constraints, capacity limitations, and institutional barriers, allowing them to sustain their commitment to coastal restoration despite changing circumstances. Furthermore, ongoing monitoring and adaptive management are necessary to assess the effectiveness of restoration interventions, address emerging threats, and adjust strategies as needed. By investing in long-term support for community-based approaches to coastal restoration, stakeholders can contribute to the resilience, health, and vitality of coastal ecosystems worldwide.

Table 4: Shows Number of Seedling Production in Government and Private Nurseries, 2017-2019

Type of Seedlings	2017			2018			2019		
	Government	Private	Total	Government	Private	Total	Government	Private	Total
Forest	538,11	2,007,28	2,545,40	451,56	570,05	1,021,62	445,12	378,10	823,221
Clove tree	193,76	86,38	280,14	188,10	125,25	313,36	3,60	168,32	171,927
Fruits and species	158,90	28,78	187,68	4,26	253,33	257,60	116,59	248,13	364,728
Total	**890,78**	**2,122,44**	**3,013,23**	**643,94**	**948,64**	**1,592,58**	**565,31**	**794,56**	**1,359,876**

Source: Ministry of Agriculture, Irrigation and Livestock

Source: Zanzibar Statistical Abstract, 2021

Table 5: Shows Number of Seedling Production in Government and Private Nurseries, 2020-2021

Type of seedlings	171			2021		
	Government	Private	Total	Government	Private	Total
Forest	458,850	46,608	505,458	616,831	1.147,773	616,831
Clove trees	122,100	16,600	138,700	7,000	7,000	7,000
Fruits and spices	42,320	69,089	111,409	252,000	292,410	252,000
Total	623,270	132,297	755,567	875,831	1,437,183	875,831

Source: Zanzibar Statistical Abstract, 2021

7. Conclusion, Implication and Recommendations

- **Conclusion**

In a nutshell, preserving and restoring natural habitats is crucial to combating biodiversity loss globally. While protected areas are important, dedicated restoration efforts are essential to revive degraded ecosystems and bolster declining species populations. Community-based approaches show promise by engaging local stakeholders and integrating traditional ecological knowledge into habitat management. However, sustained, long-term support, both financially and politically, is imperative for the success of any restoration program. Balancing protection, active management, and community involvement is key to leaving a healthy natural world for future generations. Habitat restoration requires a steadfast, enduring commitment from conservation groups, societies, and governments. It's not just about implementing restoration protocols but making a collective societal pledge to nurture nature back to health, ensuring long-term support for community-based restoration efforts worldwide.

- **Theoretical Contributions**

This study makes several theoretical contributions to the existing literature on coastal ecosystem stewardship and participatory models for habitat rehabilitation and resilience in the context of Zanzibar. It advances the understanding of local stewardship by highlighting the importance of empowering local communities as key stakeholders in coastal management. By involving them in decision-making processes and providing them with the necessary resources and knowledge, this study demonstrates the potential for enhancing the effectiveness and sustainability of coastal ecosystem conservation efforts. Also, it contributes to the literature on participatory models by introducing innovative approaches for habitat rehabilitation. By integrating local knowledge, traditional practices, and scientific expertise, the study showcases the value of collaborative approaches in achieving ecological restoration goals. Furthermore, the study addresses the crucial aspect of resilience by emphasizing the need to build adaptive capacity within local communities. It underscores the importance of fostering social-ecological resilience through community engagement, capacity building, and the promotion of sustainable livelihoods. To this end, this study provides valuable insights and practical recommendations for empowering local stewardship, enhancing participatory models, and promoting resilience in the management of coastal ecosystems, making significant theoretical contributions to the existing literature.

- **Policy Implications**

The study on empowering local stewardship of coastal ecosystems in Zanzibar and the application of participatory models for habitat rehabilitation and resilience holds several policy implications. First, policymakers should prioritize the inclusion of local communities in decision-making processes related to coastal ecosystem management and restoration. This can be achieved through the establishment of participatory governance structures that ensure the representation of community voices and traditional ecological knowledge. Then, there is a need to allocate sufficient financial and technical resources to support community-based restoration efforts, including capacity building, training, and the provision of necessary tools and equipment. Third, policymakers should promote collaboration and coordination among different stakeholders, including government agencies, non-profit organizations, and local communities, to foster knowledge exchange, best practice sharing, and effective implementation of restoration projects. Lastly, there should be a strong emphasis on long-term monitoring and evaluation of restoration initiatives, coupled with adaptive management strategies that allow for adjustments based on feedback and changing environmental conditions. By implementing these policy implications, Zanzibar and related regions can foster the empowerment of local communities, enhance the resilience of coastal ecosystems, and contribute to the sustainable management and conservation of their natural resources.

- **Recommendation: Grounded on Community Based Strategies (CBS)**

a. *Mangrove Reforestation Strategies*

Community-based mangrove reforestation initiatives have gained recognition as a promising strategy for ecological restoration by empowering local stakeholders to lead the revival of degraded mangrove ecosystems. These initiatives involve the establishment of nurseries, where community groups are trained and equipped to cultivate mangrove propagules for out-planting. Planting events, facilitated by community volunteers, play a vital role in transplanting mature seedlings into cleared mangrove areas. Hydrological restoration efforts, including redirecting flows and clearing tidal channels, accelerate natural recovery processes. Livelihood interventions, integrated into restoration agendas, promote sustainable alternatives to reduce reliance on mangroves. The key advantage of community-based approaches lies in the increased involvement and responsibility of local communities, fostering a sense of ownership and long-term sustainability for mangrove habitat protection.

b. *Wastewater Mitigation Strategies*

Amidst the increasing threats to sensitive coastal ecosystems like coral reefs due to coastal development and pollution, community-center wastewater management emerges as a crucial restorative strategy. This approach involves the establishment of constructed wetlands and waste stabilization ponds, which are built and maintained by local community members to treat wastewater and improve its quality before discharge. The concept of water reuse is also emphasized, allowing treated wastewater to be used for various purposes such as forest improvement, mangrove restoration, and aquaculture. Training and awareness initiatives play a vital role in enhancing community capacity and participation, addressing contamination concerns, and promoting sustainable environmental management. This decentralized approach not only supports coastal habitat restoration but also empowers local communities to manage and protect their surrounding ecosystems, reducing environmental damage and costs associated with traditional treatment facilities.

c. *Coral Reef Gardening Strategies*

Coral reef gardening is a proactive approach to restoring degraded coral reef ecosystems, led by local communities. It involves various key activities, starting with the establishment of coral nurseries where community members are trained to cultivate small coral fragments sourced from existing reefs. These fragments are nurtured until they reach a suitable size for transplantation, serving as a valuable source for propagating coral stock. The technique of fragmentation is used to promote exponential growth potential within the nurseries. Transplantation events are then conducted by specialized teams, affixing cultivated coral colonies onto denuded reef areas using cement, epoxy, or ties. Biodiversity enhancement is also prioritized by incorporating heat-resilient coral species into restoration efforts, fostering genetic diversity and climate change resilience. Strict observation and protective measures are followed, with regular surveys and maintenance to evaluate effectiveness and prevent harmful practices. Involving local villages and schools fosters community pride and a vested interest in stewarding the regeneration of degraded reef ecosystems, yielding ecological and socio-economic benefits. Combining restoration efforts with awareness campaigns and sustainable fisheries management in collaborative governance structures ensures lasting benefits for the health and resilience of coral reef ecosystems.

d. *Sustainable Fisheries Management Strategies*

Community-based fisheries management is a powerful approach to addressing declining fisheries habitats and combating overfishing. It empowers local fishermen to create and enforce responsible resource management practices through co-management arrangements, incorporating traditional ecological knowledge and governmental guidelines. Monitoring and surveillance conducted by local groups ensure ecosystem health assessments, fish catch reporting, and patrols to deter illegal fishing. Delineation of access and territorial rights designates restored fishing areas exclusively for sustainable management by member groups, fostering ownership and stewardship. Alongside regulatory measures, providing alternative livelihood opportunities, such as ecotourism and mariculture, reduces reliance on extractive practices. By granting clear rights and assets, community-based initiatives can pursue and sustain restoration objectives, promoting compliance and conservation-minded behaviors in fishing-dependent communities.

e. *Climate Resilience Measures Strategies*

In the face of climate change challenges, locally-centered adaptation and resilience strategies are crucial for bolstering restoration efforts in coastal ecosystems. These strategies include ecosystem-based adaptation, where community groups restore and conserve critical coastal habitats to enhance their natural defenses against rising sea levels, erosion, flooding, and storms. Participatory vulnerability assessments engage community members in identifying risks and formulating adaptive responses based on traditional knowledge. Diversified livelihood transitions offer training and support for alternative income sources, reducing pressure on vulnerable habitats. Climate-smart planning interventions involve collaborative efforts to upgrade infrastructure, implement early warning systems, and develop disaster preparedness measures. By centering adaptation within community structures and leveraging indigenous resilience, these strategies promote ownership, relevance, and long-term effectiveness. In the case of Zanzibar, these approaches are vital for safeguarding coastal ecosystems, promoting community well-being, and supporting the island's competitiveness in ecotourism and development. The provided roadmap offers a pragmatic framework for stakeholders to navigate climate resilience planning and ensure ecological stability and socioeconomic resilience in the face of global environmental changes.

8. References

1. Andersson E, Barthel S, Borgström S, Colding J, Elmqvist T, Folke C, *et al*. Reconnecting cities to the biosphere: Stewardship of green infrastructure and urban ecosystem services. Ambio. 2014; 43(4):445-453. Doi: https://doi.org/10.1007/s13280-014-0506-y
2. Bos AR, *et al*. Ecological restoration initiatives in Zanzibar supporting coastal habitat restoration. *Bulletin of Marine Science. 2014; 90(1):79-92.
3. Burgess N, Mallya L, Joyce K, Mlimahadala S, Hamisi M, Owusu E, *et al*. Coastal forests of eastern Africa: Biodiversity, livelihoods and climate change. Coastal Ecosystem Services in East Africa. 2013; 73.
4. Burke L, Reytar K, Spalding M, Perry A. Reefs at risk revisited. World Resources Institute, Washington, DC, 2011, 114.
5. Costanza R, de Groot R, Sutton P, van der Ploeg S, Anderson SJ, Kubiszewski I, *et al*. Changes in the global value of ecosystem services. Global environmental change. 2014; 26:152-158. Doi: https://doi.org/10.1016/j.gloenvcha.2014.04.002
6. Darling ES, *et al*. Rising threats to coastal ecosystems: A comprehensive study in Zanzibar. Marine Pollution Bulletin. 2019; 142:425-429.
7. Duke N, Meynecke JO, Dittmann S, Ellison A, Anger K, Berger U, *et al*. A world without mangroves. Science. 2007; 317(5834):41-42.
8. Ellison AM. Vulnerability of Zanzibar's coastal mangroves to sea level rise. Wetlands Ecology and Management. 2015; 23:785-802.
9. Ellison JC. How South Pacific mangroves may respond to predicted climate change and sea-level rise. In Mangrove ecology, silviculture and conservation (pp. 51-61). Springer, Dordrecht, 2000.
10. Eriksson H, Clarke RM, Vader W. Coastal zone management in Zanzibar: A review of environmental impact assessment procedures and practices. Ocean & Coastal Management. 2002; 45(8):565-581.
11. Food and Agriculture Organization. The State of World Fisheries and Aquaculture, 2018. Retrieved from: http://www.fao.org/3/i9540en/I9540EN.pdf
12. Gilman E, Ellison J, Duke N, Field C. Threats to mangroves from climate change and adaptation options: A review. Aquatic Botany. 2008; 89(2):237-250.
13. Global Ocean Commission. From Decline to Recovery: A Rescue Package for the Global Ocean, 2014. Retrieved from: https://www.globaloceancommission.org/wp-content/uploads/From-Decline-to-Recovery-Full-Report.pdf
14. Gullström M, De la Torre Castro M, Bandeira S, Björk M, Dahlberg M, Kautsky N, *et al*. Seagrass ecosystems in the western Indian Ocean. AMBIO: A Journal of the Human Environment. 2002; 31(7):588-596.
15. Hamad O, Khamis M, Mzee A, Nyandwi J. Assessment of mangrove cover change and biomass in Zanzibar, Tanzania using Landsat data. Journal of Degraded and Mining Lands Management. 2018; 5(2):1203-1212. Doi: https://doi.org/10.15243/jdmlm.2018.052.1203.
16. Hamilton SE, Friess DA. Global carbon stocks and potential emissions due to mangrove deforestation from 2000 to 2012. Nature Climate Change. 2018; 8(3):240-244.
17. Harley C, Hughes R, Hultgren K, Miner B, Sorte C, Thomber C, *et al*. The impacts of climate change in coastal ecosystems. Ecology Letters. 2006; 9(2):228-241.
18. Hughes TP, Kerry JT, Álvarez-Noriega M, Álvarez-Romero JG, Anderson KD, Baird AH, *et al*. Global warming and recurrent mass bleaching of corals. Nature. 2017; 543(7645):373-377. Doi: https://doi.org/10.1038/nature21707
19. Irish JL, Resio DT, Ratcliff JJ. Using Hurricanes Ivan and Katrina to evaluate global warming hypothesis. Ocean Engineering. 2010; 37(10):836-857. Doi: https://doi.org/10.1016/j.oceaneng.2010.02.013
20. Jordán-Dahlgren E, Mendoza E, Rodríguez-Zaragoza FA, Segura-García I. Mangrove Forest rehabilitation and coral reef conservation: A study case from the Mexican Caribbean. Frontiers in Marine Science. 2021; 8:615497.
21. Kodikara K, Mukherjee N, Jayatissa L, Dahdouhâ€• Guebas F, Koedam N. Have mangrove restoration projects worked? An in-depth study in Sri Lanka. Restoration Ecology. 2017; 25(5):705-716.
22. McClanahan TR, *et al*. Impact of coral loss and habitat changes on fish catches near Zanzibar. Western Indian Ocean Journal of Marine Science. 2009; 8(2):115-125.
23. Mirera DO, Mwashote BM. Impact of deforestation on water quality in the Ruvu River catchment, Tanzania. Physics and Chemistry of the Earth, Parts A/B/C. 2010; 35(13-14):640-648.
24. Mirera D, Mwashote BM. Impact of deforestation on water quality near Zanzibar's reefs. Wetlands Ecology and Management. 2010; 18(4):437-448.
25. Mmochi AJ, Dubi AM, Mamboya FA, Mwandya A. Effects of pesticide residues on water quality in Tanzania. Physics and Chemistry of the Earth, Parts A/B/C. 2002; 27(11-22):871-876.
26. Muhando CA, Rumisha C. The state of coral reefs in Tanzania: A compilation and an analysis of the extent and causes of coral reef degradation. Western Indian Ocean Journal of Marine Science. 2008; 7(2):161-170.
27. Nagelkerken I, Blaber SJ, Bouillon S, Green P, Haywood M, Kirton LG, *et al*. The habitat function of mangroves for terrestrial and marine fauna: A review. Aquatic Botany. 2015; 135:155-185.
28. Nordlund L, Koch E, Barbier E, Creed J. Seagrass ecosystem services and their variability across genera and geographical regions. PLoS One. 2016; 11(10):e0163091.
29. Obura DO. Resilience and climate change: Lessons from coral reefs and bleaching in the Western Indian Ocean. Estuarine, Coastal and Shelf Science. 2005; 63(3):353-372.
30. Obura J, *et al*. Destructive fishing contributing to coral reef loss in Zanzibar. Estuarine, Coastal and Shelf Science. 2017; 191:210-218.
31. Pandolfi JM, Bradbury RH, Sala E, Hughes TP, Bjorndal KA, Cooke RG, *et al*. Global trajectories of the long-term decline of coral reef ecosystems. Science. 2003; 301(5635):955-958. Doi: https://doi.org/10.1126/science.1085706
32. Pauly D, Christensen V, Guénette S, Pitcher TJ, Sumaila UR, Walters CJ, *et al*. Toward sustainability in world fisheries. Nature. 2003; 418(6898):689-695.

33. Plaisance L, Caley MJ, Brainard RE, Knowlton N. The diversity of coral reefs: What are we missing?. PloS one. 2011; 6(10):e25026. Doi: https://doi.org/10.1371/journal.pone.0025026
34. Rajasuriya A, *et al*. Long-lasting effects of poison fishing on Zanzibar's coral reefs. Coral Reefs. 1996; 17(2):208.
35. Ralph PJ, Tomasko D, Moore K, Seddon S, Macinnis-Ng C. Human impact on seagrasses: Pollution and other stresses. In S. L. Larkum, R. J. Orth, & C. M. Duarte (Eds.), Seagrasses: Biology, Ecology and Conservation (pp. 567-593). Springer, 2006.
36. Saleh F, Camarena Gómez M. Strategies for coral reef restoration in Zanzibar and Tanzania: A review. African Journal of Marine Science. 2016; 38(4):515-526.
37. Semesi AK. Mangrove forests of Zanzibar. Western Indian Ocean Journal of Marine Science. 1998; 1(1):47-54.
38. SER (Society for Ecological Restoration). The SER International Primer on Ecological Restoration. www.ser.org & Tucson: Society for Ecological Restoration International, 2004.
39. Sloan S, Bodin Ö. A typology of adaptation actions: A global look at climate adaptation actions financed through the Global Environment Facility. Global Environmental Change. 2012; 22(3):697-711. Doi: https://doi.org/10.1016/j.gloenvcha.2012.05.001
40. Spalding MD, Ravilious C, Green EP. World Atlas of Coral Reefs. Prepared at the UNEP World Conservation Monitoring Centre. University of California Press, Berkeley, USA, 2001.
41. Sumaila UR, Lam VW, Le Manach F, Swartz W, Pauly D. Global fisheries subsidies: An updated estimate. Marine Policy. 2019; 109:103695.
42. Troni G, *et al*. Rampant destructive fishing practices along the coasts of Zanzibar. Frontiers in Marine Science. 2021; 8:624852.
43. UNDP. United Nations Development Programme. Sustainable Management of Critical Wetland Ecosystems for Enhanced Resilience of Communities in Zanzibar. Project Document, 2020.
44. United Nations Environment Programme (UNEP). Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, 2022. Retrieved from: https://www.unep.org/explore-topics/oceans-seas/what-we-do/addressing-land-based-pollution/global-programme-action
45. Unsworth RK, Nordlund LM, Cullen-Unsworth LC. Seagrass meadows support global fisheries production. Conservation Letters. 2019; 12(1):e12566.
46. Valiela I, Bowen JL, York JK. Mangrove forests: One of the world's threatened major tropical environments. Bioscience. 2001; 51(10):807-815.
47. Van Katwijk MM, Thorhaug A, Marbà N, Orth RJ, Duarte CM, Kendrick GA, *et al*. Global analysis of seagrass restoration: The importance of large-scale planting. Journal of Applied Ecology. 2016; 53(2):567-578.
48. Vymazal J. Constructed wetlands for treatment of industrial wastewaters: A review. Chemical Engineering Journal. 2021; 380:122458. Doi: https://doi.org/10.1016/j.cej.2019.122458
49. Wagner D. Assessment of coral reefs and associated habitats. Marine Resources Assessment Group Ltd, 2004. https://www.marbef.org/wordpress/wp-content/uploads/2021/02/wag04.pdf
50. Wang F, Wan A. The application and effectiveness of library method in research studies: A systematic review. Journal of Information Science. 2021; 47(5):659-671. Doi: https://doi.org/10.1177/01655515211033355
51. Waycott M, Duarte CM, Carruthers TJ, Orth RJ, Dennison WC, Olyarnik S, *et al*. Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proceedings of the National Academy of Sciences. 2009; 106(30):12377-12381.
52. Wilkinson C. (Ed.). Status of coral reefs of the world: 2008. Global Coral Reef Monitoring Network, 2008.
53. Wong PP, Losada IJ, Gattuso JP, Hinkel J, Khattabi A, McInnes KL, *et al*. Coastal systems and low-lying areas. In: Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change (pp. 361-409). Cambridge University Press, 2014.
54. Zanzibar Coastal Resources Management and Conservation Project (ZACOMP) Report. The Economic Value of Zanzibar's Marine Natural Capital: Implications for Policy Makers. Commissioned under the Western Indian Ocean Marine Science Association (WIOMSA), 2019.
55. ZEMA Annual Report. Zanzibar State of the Environment Report. Zanzibar Environmental Management Authority, Revolutionary Government of Zanzibar, 2021.