

Sustainable Land Use Planning for Tourism Development in protected landscapes of a Coral Atoll A Case of Minicoy Island, India

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Abstract: *Together with the neighboring habitats of lagoons, reefs, seagrasses, seaweeds, mangroves, coastal dunes, and the reef islands, coral atolls rank among the most biologically productive, fragile and diverse of all natural ecosystems. The atolls function as breeding, spawning, breeding and feeding grounds for a multitude of organisms while providing several other functions such as shoreline protection, erosion regulation, food provision, climate regulation and livelihood opportunities for subsistence. Supporting about half a billion people around the world with its goods and services, these atolls indubitably constitute unique socio-ecological landscapes with the islanders. And yet, irresponsible and indifferent human activities are consistently undermining these fragile ecosystems and the benefits they provide. Every year, millions of tourists visit the reefs to enjoy the myriad of marine life, making coastal tourism one of the fastest-growing marine-based economic activity worldwide. And yet, despite their conservation status, many established and premium coral reef related tourist destinations, are already under threat due to unregulated physical development, unwarranted tourist behavior, overcrowding, physical damages, increasing pollution levels and a threat to the cultural identity of the native population. Although the national goals offer a vision of holistic sustainable development, lack of cross-sectoral approach in policy making, planning and implementation at the local level are often the reason for such unwarranted development impacts.*

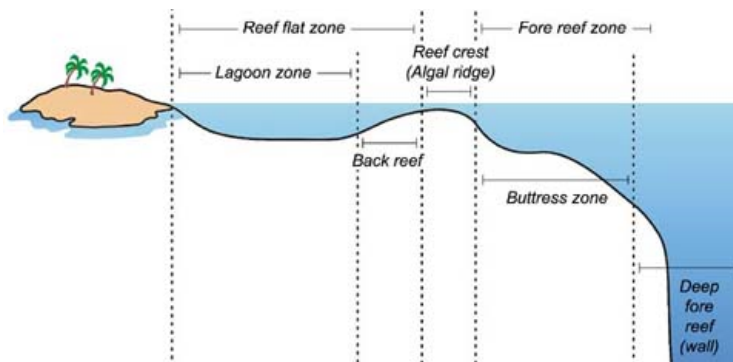
This article presents an insight into the use of sustainable land-use planning as a tool to integrate the ecosystem values into local development and tourism planning of Minicoy Island, Lakshadweep Islands, in a flagship project of NITI Ayog, Government of India. The Government envisions Minicoy Island – an inhabited coral atoll – as a self-sustained ecotourism destination, where tourism would generate local employment and propel maritime economic growth while ensuring the conservation of its ecological richness. Review of the local policies and regulations dealing with conservation and tourism planning revealed significant gaps essential for healthy coexistence of development activities and ecological processes. The paper reflects some of the initiatives undertaken to overcome these gaps. Detailed land suitability-based land-use zoning was undertaken to preserve the pristine areas from any anthropogenic effects inherent with development, and steer unavoidable development activities to less sensitive ecological landscapes. The notable feature of the project was the formulation of ecosystem-based development control regulation to guide tourism development, which was drafted carefully after examining the functioning of the landscapes and sensitivity of identified species to various development activities. The project provides a framework for sustainable land-use planning for tourism development in fragile coral atolls and this methodology can be replicated for similar geographies and tailored to site-specific conditions.

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1 Introduction

An atoll is a ring-shaped coral reef, island, or series of islets which surrounds a body of water called a lagoon². Moving inward from the oceans the fore reef zone, reef crest and flat reef zone, back reefs and lagoons are the major divisions the atoll. Together with the lagoons and reefs, these regions are home to diverse habitats characterized with seagrasses, seaweeds, shoreline vegetation covers such as mangroves and sandy beaches while the islands are often flanked with indigenous forest covers or plantations grown by the native residents. Coral communities are dependent on neighboring linked habitats such as adjacent reef flats, seagrass beds and their supporting organisms such as fishes and algae for nutrient supplies while they offer spawning, nursery, breeding, and feeding grounds for various marine organisms. For survival, coral reefs need specific environmental conditions characterized with adequate light, temperature and clear waters (turbid and nutrient-free).

Figure 1 Divisions of the Coral Atoll³



In 2007, one-eighth of the world's population, approximately 850 million people lived within 100 kms of corals and were likely to be reaping the benefits of ecosystem services⁴ provided by coral reefs⁵. Occupying less than one percent of the ocean floor, coral reefs are home to more than twenty-five percent of marine life – truly called as rainforests of the sea⁶. While the reefs along with shoreline vegetation covers such as mangroves possess incomparable medicinal value, they also provide food security and offer livelihood opportunities such as fishing and tourism. According to one estimate, the total annual earnings of coral reefs in the world is \$29.8 billion. Tourism and leisure activities represent \$9.6 billion, coastal protection \$9 billion, fisheries \$5.7 billion and biodiversity \$ 5.5 billion (Cesar, Burke and Pet-Soede, 2003)⁷. Rather the Islands in the atolls, which provide permanent and temporary shelter/refuge to man, owe their existence to the reef-building processes of past millennia⁸. By dissipating the wave energy, these ecosystems act as natural barriers to disasters preventing loss of life

² National Geographic. n.d. *Resource Library | Encyclopedic Entry*. Accessed 2020.

<https://www.nationalgeographic.org/encyclopedia/atoll/#:~:text=An%20atoll%20is%20a%20ring,the%20open%20ocean%20or%20sea.>

³ National Ocean Service. n.d. *Coral Reef Profiles*. Accessed 2020.

https://oceanservice.noaa.gov/education/tutorial_corals/media/supp_coral04b.html.

⁴ The Millennium Ecosystem Assessment report 2005 defined ecosystem services as benefits people obtain from ecosystems and distinguishes four categories of ecosystem services – supporting services, provisioning services, regulating services and cultural services.

⁵ World Resources Institute. n.d. *Number of People Living Near Coral Reefs in 2007*. Accessed 2020.

<https://www.wri.org/resources/charts-graphs/number-people-living-near-coral-reefs-2007#:~:text=One%20Deighth%20of%20the%20world's,within%2030%20km%20of%20reefs.>

⁶ Coral Reef Alliance. n.d. *Saving the World's Coral Reefs*. Accessed 2020. <https://coral.org/coral-reefs-101/coral-reef-ecology/coral-reef-biodiversity/>.

⁷ Conservation International. 2008. *Economic Values of Coral Reefs, Mangroves, and Seagrasses: A Global Compilation*. Arlington, VA, USA.: Center for Applied Biodiversity Science, Conservation International.

⁸ Salm, R.V., John Clark, and Erkki Siirila. 2000. *Marine and Coastal Protected Areas: A guide for planners and managers*. Washington DC: IUCN.

and damage to property/infrastructure and erosion. Additionally, seagrass beds and mangroves maintain water quality and provide building materials whereas sandy beaches function as nesting grounds for species like turtles. Coral reefs remove carbon dioxide from the atmosphere and are thus important for climate change mitigation.

1.1 Tourism Prospects in Coral Islands

Tourism contributes a crucial role in the maritime economy across the world, by attracting investments and driving community development in the destinations. As per World Travel and Tourism Council, while the global economy grew by 3.2% in 2018, Travel & Tourism grew significantly more at 3.9% outperforming all sectors except manufacturing, contributing a record \$8.8 trillion and 319 million jobs worldwide⁹. It is interesting to note that South-Asia posed the highest growth at 7.2%. About one in five new jobs were created by the sector over the last five years. For small islands, the contribution of the sector to its economy is significantly larger. A study done by the United Nations World Tourism Organization states that tourism contributes more than 20% of the GDP in two-fifths of the Small Island Developing States, and tourism has been the key in graduation of island destinations like Samoa, Cabo Verde and the Maldives from the Least Developed Countries status¹⁰. With the emerging trend for maritime and eco-tourism, coral islands are becoming the poster child of nature-based tourism. Coral destinations such as Bahamas and Maldives secure half of their government revenue from tourism. Coastal tourism alone is one of the fastest-growing marine-based economic activity worldwide, estimated at USD 7.4 billion from the coral reef nations alone¹¹.

Nature-based tourism products including **water and adventure sports** is the most popular tourist attractions in these destinations with scuba diving and snorkeling being the most sought out products, along with other water and land sports like game fishing, parasailing, wave surfing, trekking, camping, etc. The islands are often home to endemic marine and avian species and are an excellent destination for turtle and bird watching. There is a growing demand for **conservation tourism** products such as whale, shark and dolphin watching. In the **luxury segment**, coral islands are frequented by **Cruise and Yacht tourists**. The islands are also an emerging destination for **honeymoon, destination weddings and MICE** market. The exotic geography, pristine beaches and the exclusiveness complemented by modern luxury resorts with state of art infrastructure and water/adventure sports offerings make these islands an excellent choice for this niche market. Coral Islands are often home to the indigenous (tribal) population due to their geographical and cultural isolation with rest of the world and are therefore endowed with distinct lifestyle and traditions, providing an unparalleled avenue for **experiential and spiritual tourism**. Local heritage, culture, festivals, rituals, cuisine, endemic medicines and medical practices, crafts, arts and dance forms are some of the popular tourist attractions¹².

1.2 Threats to Coral Atolls and associated ecosystems

Coral reef species, being stenotypic, have a very narrow set of environmental conditions that they can live in¹³. Any change in the set of conditions would potentially affect their survivorship¹⁴. Despite their socio-economic significance and a plethora of ecosystem goods and services offered, coral atolls are abused by the direct and indirect human actions both locally and globally. Climate change is the most significant global threat to coral reefs. Higher ocean temperature, ocean acidification, sea-level rise, increased frequency and intensity of tropical storms induce coral stress, cause physical damage and affect the formation and

⁹ WTTC. 2019. "The Economic Impact of Travel and Tourism."

¹⁰ UNWTO. n.d. "Tourism in Small Island Developing States."

¹¹ Africa News. 2018. *Importance of a Sustainable Blue Economy: Statistics and facts*. Accessed 2020. <https://www.africanews.com/2018/11/26/importance-of-a-sustainable-blue-economy-statistics-and-facts/>.

¹² Data compiled from various travel aggregators such as TripAdvisor and MakeMyTrip

¹³ Hughes, Terry P., et al. 2003. "Climate change, human impacts, and the resilience of coral reefs." *Science*.

¹⁴ Hoegh-Guldberg, Ove, et al. 2007. "Coral reefs under rapid climate change and ocean acidification." *Science*.

stability of carbonate structures. The global costs of coral bleaching are calculated to range from \$20.0 billion (a moderate bleaching scenario) to over \$84.0 billion (a severe bleaching scenario) in Net Present Value (over a 50-year time horizon with a 3% discount rate). The tourism cost is highest with \$10.0 billion to nearly \$40.0 billion losses, followed by fisheries (\$7.0 billion to \$23.0 billion) and biodiversity (\$6.0 billion to \$22.0 billion) (Cesar, Burke and Pet-Soede, 2003)¹⁵. While severe storms and sea-level rise endangers the nesting habitats of turtles (i.e. beaches), changing ocean currents and hotter sands are considered to affect migration patterns and disturb their gender balance¹⁶.

These impacts are exacerbated by local anthropogenic activities carried on the mainland along with the lagoon waters such as overfishing, unregulated tourism activities, deforestation, coastal development, harvest, the introduction of invasive species, coral and sand mining, dredging, etc. Habitat loss, shoreline erosion, algal bloom, extinction of species, sediment resuspension and water quality degradation are some of the aftereffects. Of the threats assessed, industrial and agricultural run-off, coastal infrastructure development, and dredging were determined to have the greatest impacts on seagrasses globally¹⁷. Local threats to sea turtles include poaching, unsustainable fishing practices, plastic disposal, and vessel strikes.

2 About the Project

Minicoy Island, located nearly 400km from Kochi (mainland India), is the second largest and the southernmost island in Union Territory of Lakshadweep, India. The close proximity to Maldives and international trade route (Eight Degree Channel) makes the Island extremely important to the Indian subcontinent from a strategic perspective. The island constituted only 15% (4.8 sq. km) of the lagoon area of 30.60 sq. km. more than half of which was dominated by coconut plantation. With a local resident population of 10,447 people and a density of 2381 population per sq. km. as per the 2011 census, Minicoy is one of the densely inhabited islands in the archipelago.

Geologically, the island is made up of fine coral sand and boulders which have been compacted into sandstone. The presence of coral reefs – a biodiversity hotspot - make these islands ecology very important. The biophysical survey of coral reefs conducted during the 1999-2002 period has indicated the presence of live corals in the ranges of 14% to 24%¹⁸. The calm waters of the lagoon which serves as a home and a nursery for large number of fishes, molluscs, echinoderms, seagrasses, seaweeds, etc. Around 4 species of turtles i.e. Hawksbill, Green, Olive Ridley and Leatherback are found in Lakshadweep where the beaches are used for sporadic nesting. The island has a mangrove belt in its southern region and a few water bodies.

¹⁵ Conservation International. 2008. *Economic Values of Coral Reefs, Mangroves, and Seagrasses: A Global Compilation*. Arlington, VA, USA.: Center for Applied Biodiversity Science, Conservation International.

¹⁶ The sex of sea turtle hatchlings is influenced by the temperature of the sand in which the eggs develop. Climate change can cause increased temperature. Higher temperatures cause the sand to heat up and lead to a higher proportion of female to male hatchlings. One study concluded that it is likely that southern populations of turtles in the U.S. will become ultra-biased towards female populations if temperatures increase by even 1 C. (Source: Oceana. n.d. *Threats to Sea Turtles*.

<https://eu.oceana.org/en/threats-sea-turtles#:~:text=Other%20Threats%20to%20Sea%20Turtles,invasive%20species%20and%20vessel%20strikes.>)

¹⁷ Miami Shark Research. 2015. *Current Threat to Coastal Seagrass Ecosystems*.

<https://sharkresearch.rsmas.miami.edu/current-threats-to-coastal-seagrass-ecosystems/>.

¹⁸ Government of India. 2014. *Integrated Island Management Plan For Lakshadweep Islands*. UT Lakshadweep Administration.

The island community mainly relies upon fishing and other maritime activities for livelihood, followed by coconut farming. Despite the immense potential offered by its vast turquoise blue lagoon along white sandy beaches, tourism development here is at a nascent stage with the island housing a lone 44 bedded tourist resort. The reasons can be attributed to poor infrastructure provision, restricted entries, poor connectivity to international and national markets and absence of marketing and branding efforts. During the year 2015, the total number of tourists to visit Lakshadweep islands were 18,414 out of which 93.63% were domestic tourists. Most popular attractions in Minicoy include water sport activities including scuba diving, snorkeling, kayaking etc. The 130 years old Minicoy lighthouse is popular with tourists offering a panoramic view of the island. The island is also famous for its unique socio-

Figure 2 Location of Minicoy Island in India

cultural heritage.

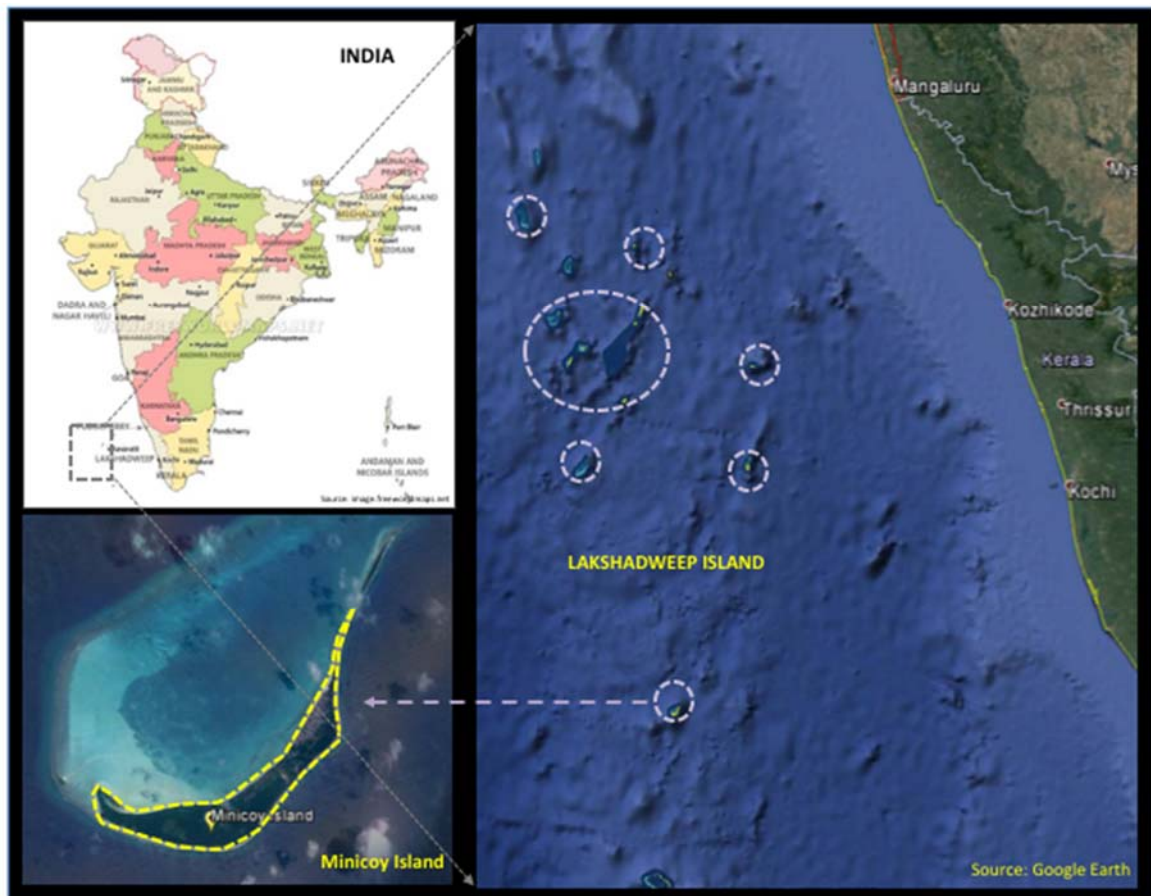


Figure 4 Aerial View of South Western edge of the Island showing the light house, mangroves amidst coconut plantations



Figure 3 Minicoy national fest

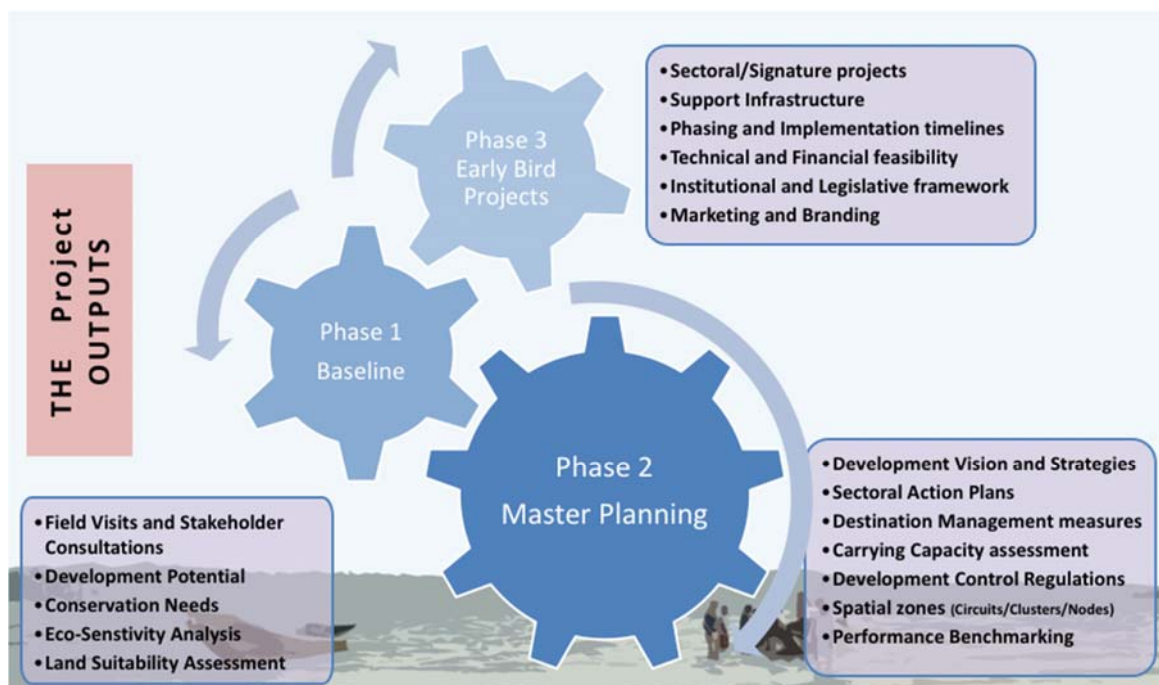


Realizing the immense potential, the Union Govt. launched Holistic Development of Islands Project in 2017 - a flagship project of the Govt. steered by NITI Aayog (the country's policy think tank) that aims to set a sustainable development model for these strategically important, ecologically sensitive group of islands. In the first phase, five islands in Lakshadweep were selected namely Minicoy, Banagram, Thinnakkara, Cheriya and Suheli. The key objective of the project was to establish India's strategic presence in the region by building a holistic maritime base, with emphasis on coastal and maritime tourism. The project, near to completion, has been carried out in three stages as shown below.

The sensitivity and richness of the natural resources that the Island possesses along with the unique socio-ecological ensemble it constitutes, made it even more pertinent to promote sustainable and responsible tourism development, protecting the very resources that set the

Figure 5 Project Phases and Outputs

stage for tourism growth. Tourism products such as Island Water Villas, beach villas, beachfront development, as well as water-based activities such as diving, snorkeling, boating were found conducive for development. The master plan proposes to develop India's first water villa projects in 3 islands of Lakshadweep including Minicoy in PPP mode. Its



geographical proximity to leading coral island destination of Maldives also opens an avenue for cross-border collaboration and attracting cruise tourists.

Master Plan making for a city is a spatial decision-making process which rolls out policies required to attain the desired level of development for that city supported with a land-use plan which assigns land parcels to different uses, development control regulations which helps to create healthy physical spaces, an implementable action plan and monitoring mechanisms. In order to boost sustainable development of tourism industry in Minicoy which has minimal impacts on the regions' ecological processes, it was important that tourism master planning internalizes ecological values in decision-making, policy formulation and its operations. Hence, it was vital to first understand how unregulated tourism, in general, impacts the ecological functioning of coral atolls and what are the possible mitigation measures available. Equally important was to assess whether the existing regulatory frameworks in the Minicoy Island acknowledges these ecological processes, understands how tourism can affect these processes and lays out implementable actions that mitigate these impacts and enable co-existence of these ecological processes to the extent possible. The following section discusses the same.

3 General Impacts of Tourism activities on Ecological Processes of Coral Atolls

Tourism development and operations have multiple impacts on the coral islands/atolls depending upon the type, location and intensity of use. The table below shows the generic impacts of different activities and corresponding mitigation measures as identified through desktop research and consultation with experts. Habitat clearance to make way for tourism infrastructure; physical damage due to tourist behavior or anchoring of boats; shading and artificial lighting which affects predation behavior among the species; water quality deterioration due to run-off from the mainland, boating and construction activities, disposal of waste and pollutants, etc. are some the impacts.

It can be observed that in order to curb the impacts, actions are required at all levels of tourism planning starting from tourism plan making (decision making- formulation of policy and regulations), construction, operations and monitoring. The mitigation measures incorporate regulating permissibility of activities, siting of activities at specific locations; controlling the design, construction and material use and regulating operations and management among others. An important observation here is that activities in a particular location can affect the ecological health of another region.

Table 1 Impacts of Tourism activities on Coral Ecosystems¹⁹

Impacts	Activities				Mitigation Measures
	Overwater structures - villas, docks, boardwalks, marina, jetty, etc.	Boating, navigation	snorkeling, scuba diving	Land-based tourism development (resorts /hotels, beach activities, supporting infrastructure, etc.)	
Reduces penetration of light due to shading which inhibits photosynthesis vital for healthy growth of submerged vegetation such as seagrasses and alters fish behavior affecting predation.	X				Avoid construction of these structures over seagrasses/reefs/vegetated bottom; regulate orientation and window/floor treatment to allow light passage together with height specifications that allows light penetration.
Sediment suspension induced by construction of in-water structures creating turbid conditions which again reduces light penetration	X				Specific construction techniques such as socketing for pile foundation; Construction during reduced currents also restrict spread of excessive sediments to a larger area; use of sediment control traps
Sediment resuspension due to boating activities in shallow areas and near shorelines which again increases turbidity		X			Designate no-wake zones from shorelines; Motorised boating to be regulated at sufficient depths so that dredging is not required and intended boat traffic would have sufficient draft to prevent re-suspension of silt by propellers
Marine Habitat loss (coral reefs, sea grasses, etc) due to illegal mining and removal to facilitate construction, seagrasses have particularly been removed to enhance visual appeal	X				Avoid construction in such areas, habitat restoration measures (either onsite or offsite and either in-kind or out-of-kind, of an area equivalent to the area disturbed or altered), prohibit mining of corals & clearing of habitats
Physical damage of the seabed / underlying habitats due to anchoring, reef walking, diver damage, souvenir collection, boat damage		X	X		Designated boat channels to prevent boat damage; compulsory anchoring areas or compulsory moorings; use of sandbag as temporary anchor; periodic closure to allow recuperation; prohibition or strict control on reef walking; ban

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Blue and Green Tomorrow. 2015. *The Green Blue project – minimising boating's impact on the environment*. <https://blueandgreentomorrow.com/environment/the-green-blue-project-minimising-boatings-impact-on-the-environment/>.
Cari, H., and P. Mackelworth. 2014. *Cruise tourism environmental impacts : The perspective from the Adriatic Sea*. Ocean & Coastal Management.
European Commission. 2007. "Environmental Impacts of Recreational Boating." *DG Environment News Alert Service, Science for Environment Policy*.
European Confederation of Nautical Industries. 2009. "Nautical Activities: What impact on the environment? A life cycle approach for "clear blue" boating."
Islands by Design. 2012. "A review of overwater bungalows: environmental considerations specific to The Bahamas."
NCS Survey. 2016. *The Impact of Recreational Boating On Marine Life*. <https://www.ncs-survey.com/2016/08/19/the-impact-of-recreational-boating-on-marine-life/>.
Salm, R.V., John Clark, and Erkki Siirila. 2000. *Marine and Coastal Protected Areas: A guide for planners and managers*. Washington DC: IUCN.

					shell collection, souvenir collection; Education and awareness generation
Metal leaching from CCA treated wood (chromated copper arsenate- a preservative to delay wood decay) which gets adsorbed by the near-by marine organisms.	X				CCA treated wood to be restricted in the region.
Changes in water circulation and movement especially in shallow, intertidal, low wave and low current regime, may result in scour and alter predator-prey behaviour.	X				Siting of overwater structures to be avoided in regions with low wave or current regime.
Many cleaning chemicals (containing chlorine, ammonia, potassium hydroxide, etc) and antifouling paints used for maintaining hulls have similar impacts as waste disposal.		X			Cleaning of boat hulls in the water to be prohibited to prevent the release of cleaner, paint and solvent into water column
Untreated/treated Waste disposal (solid and liquid) can contaminate the marine water and effect the marine life as nutrient enrichment promotes eutrophication causing oxygen depletion and localised suffocation of aquatic life; Plastic is a threat to turtles.	X			X	Waste to be treated to sufficient levels; promote reuse of sludge; treated Waste to be disposed of carefully in sea away from sensitive habitats as per waste disposal norms; Use of plastics to be banned
Increased run-off from land cleared to build resort/hotels in the mainland to marine waters due to loss of vegetation cover, increased pervious covers, etc can further add the nutrients, pollutants, or sediments.				X	Land disturbing activities should be scheduled to occur during the dry season to prevent excessive storm run-off; promote use of sediment traps; keep building ground coverage to minimum; restrict clearing of vegetation cover
Loss of natural habitats to build resort/hotels on the mainland can also reduce water percolation (further affecting the sustenance of groundwater lens – a crucial resource for the region) and can lead to extinction of species.				X	Siting of accommodation units away from sensitive landscapes maintaining habitat continuum; assign buffers to major habitats Protect water conveyance channels and depressions, prohibit fillings of water bodies, design zero-runoff sites, promote water percolation, restrict pervious spaces
trampling/clearing of beach vegetation, beach soil compaction and armoring of the shoreline affects the habitat provisioning, reduce natural resilience to climate impacts and promotes erosion		X		X	Prohibit clearing of sensitive beach vegetation, Prohibit soil compaction and soil removal
Artificial Lighting on the waters or shores affects prey-predator relationship as well as movement and nesting pattern of specific species like turtles	X			X	Regulate turtle friendly lighting systems and avoid unnecessary lighting

4 Regulatory Gaps

Considering the ecological fragility of the islands and the insular nature of its inhabitants, one of the key components of this project was to understand and assess the existing legislative framework in place to guard/guide the development of these islands. Minicoy Island is a protected landscape regulated through Integrated Island Management Plan (IIMP) under the centrally notified Island Protection Zone notification 2011²⁰, and hence it was all the more important to understand and address any possible gaps to promote sustainable tourism operations while maintaining the ecological processes. Below is a brief insight into the current regulatory regimes for the Minicoy Island dealing with. While Justice Ravindran Committee was constituted by the Apex Court of the nation to address the concerns with IIMPs, the remaining three policies/guidelines are issued by UT Administration of Lakshadweep.

²⁰ IPZ notification 2011 is issued by MoEF&CC, Gol under Environment Protection Act, 1986

Table 2 A Glimpse at the regulations in Minicoy

Regulatory Framework & Implementing Agency	Objectives	Salient Features	Remarks
IIMP - Minicoy ²¹ implemented by Department of Science and Technology, UT Lakshadweep Administration	To conserve and protect the unique environment of coastal stretches and marine areas of Lakshadweep Islands, while promoting sustainable development on scientific principles.	<ul style="list-style-type: none"> IIMP aims to ensure sustainable development of the islands. The plan includes spatial recommendations on development, conservations and preservation zones for the entire island keeping in view the statutory IPZ Notification of 2011. checklist of permitted/regulated activities across these zones The IIMP also takes into account the impact of the proposed development on the livelihood and associated disaster risk. Reservation/identification of suitable locations and areas for the creation of public and semi-public facilities for development of tourism is also briefly discussed IIMP attempts to also document a qualitative baseline for the island, and recommends broad measures to increase livelihood options for the local islanders, while protecting its fragile ecosystems 	<i>IIMP as a “law of the land” has a very strong legal backing. The document acknowledges and aims to address the changing dynamics between human uses of ecological resources and fragility of the coastal ecosystems. The recommendations include spatial zoning maps and delineates zones as conservation, preservation and development, including a checklist of permitted/regulated activities across these zones. Although, the zones are identified, it is not supported with a proposed land/marine use plan for any prospective year, although, it does show locations for selected land-based future projects such as tourism zones. A few physical development control regulations are also included. It does not offer implementation framework/guidelines with respect to construction techniques, materials, safety protocols and O&M. Being the closest document which balances development (including tourism) and ecological protection, it endorses application of carrying capacity thresholds for various activities/resort development and suggests adoption of eco-friendly construction techniques.</i>
Justice Ravindran Committee Report ²² implemented by Lakshadweep administration	To evaluate draft IIMPs of Lakshadweep and suggest measures for improvement and to examine allegations regarding violation of the CRZ and other irregularities	<ul style="list-style-type: none"> The report aimed to bring uniformity among the IIMPs of all islands by standardizing norms such as No Development Zone. Highlights the need for conservation of the corals, lagoons and other eco-systems Endorses carrying capacity based eco – tourism development in uninhabited islands/ uninhabited/ sparsely occupied portions of the inhabited islands. Endorses development of eco resorts and tourist home establishments, whereas discourages homestays due to cultural sensitivity of the islands. Specific details are also included for infrastructure and transport related development for the group of islands. 	<i>The report includes suggestive measures in terms of disaster risk reduction, biodiversity conservation, infrastructure and tourism development. The report includes physical development control regulations aiming to attain orderly development and planned built form. For a holistic understanding and appropriate guidance in the development process, this report must be read in conjunction with IIMP and local byelaws. No spatial prescriptions/zoning is included. The report is silent on capacity building and awareness generation programs although it does highlight the need to engage community in the development process.</i>

²¹ Government of India. 2014. *Integrated Island Management Plan For Lakshadweep Islands*. UT Lakshadweep Administration.

²² Expert Committee. 2014. "Final Report of the Expert Committee: To Oversee the Preparation of IIMP of UT Lakshadweep."

Lakshadweep tourism policy 2020 ²³ implemented by Department of Tourism, UT Lakshadweep Administration	To promote economically viable, environmentally sustainable, socially acceptable and culturally desirable tourism; promote local Economic Development and aims to attract investments from both public and private parties	The policy identifies issues, potentials and constraints for developing tourism in the islands and provide an action plan as follows: <ul style="list-style-type: none"> • Augmentation of accommodation infrastructure <i>within the limits of carrying capacity of each island as well as within the contours of IIMP.</i> • Enhancement in Connectivity • Institutional Upgrading and Monitoring • Engagement with the locals • Diversification of Tourism Products • 	<i>Being a policy document for the entire UT, it gives a very broad policy framework. Again the policy needs to be read in conjunction with other guidelines/regulations for optimum comprehension. It cannot guide any development process in isolation for the policies are suggestive statements. Acknowledging the ecological sensitivity of these coral islands, the document does highlight the need for healthy co-existence between ecological processes & development and the need for carrying capacity based development; however, it does not give any specific/spatial recommendations on the same.</i>
Guidelines for Approval for Development of Eco-Friendly Tourist Resorts in Inhabited Islands, 2017 ²⁴ implemented by Department of Tourism, UT Lakshadweep Administration	To develop quality accommodation in the inhabited islands within the carrying capacity of islands and with eco-friendly structure, having non-conventional sources of energy supply to the extent possible and environmentally waste/sewage disposal.	A number of guidelines with respect to following aspects have been established for setting up Tourist Resorts in the Islands: <ul style="list-style-type: none"> • Registration and Tax related Guidelines • Land and Ownership Guidelines • Area, Infrastructure and Development Guidelines • Employment Guidelines for ensuring livelihood generation for local islanders Utility Guidelines Dealing with green power generation, independent water supply systems and waste treatment systems	<i>Detailed information with respect to permit requirements and steps to be followed are included in the guidelines. It does not give any location specific information. Although, it encourages the use of alternate energy sources, currently the document does not talk about feasible techniques or any suggestive methods, and is silent on operations & maintenance of the resorts. For implementation purposes, the guidelines need to be referred along with the local byelaws.</i>
Guidelines on tourist home establishments ²⁵ implemented by Department of Tourism, UT Lakshadweep Administration	To promote entrepreneurship among the islanders for operating bed and breakfast / tourist home establishments (in accordance with recommendations of Justice Ravindran committee report) for tourists.	<ul style="list-style-type: none"> • The Tourist Home Establishments in Lakshadweep Islands are registered and classified in two categories based on facilities and services they provide Diamond Class and Gold Class • The number of tourist homes to be within the carrying capacity of the islands • The building should not be in the No Development Zone (NDZ) and should be away from the permitted HTL limits • The application procedure for registration of tourist homes have also been explained in the guidelines. 	<i>Predominantly these guidelines only focuses on the approval process for establishment of Tourist Homes and details out the process of licensing. The guidelines endorses use of renewable energy, adoption of pollution abatement technologies, lacks any spatial recommendations and has to be read in conjunction with the local byelaws.</i>






























































































²³ Lakshadweep UT Administration, Government of India. 2020. *Lakshadweep Tourism Policy 2020*. Kavaratti: Government of India Press.




































²⁴ Lakshadweep UT Administration, Government of India . 2017. *Guidelines for Approval for Development of Eco-Friendly Tourist Resorts in Inhabited Islands of UT of Lakshadweep*, 2017. Government of India Press.

²⁵ Lakshadweep UT Administration. n.d. "Guidelines on tourist home establishments."

Upon detail assessment of each of the above regulations, it was recognized that although the current framework does attempt to address the prevalent issues in the island, it still needs to be converged and strengthened further to ensure healthy coexistence of tourism development and ecological processes. A brief appreciation of the above regulations is given as under:

Table 3 Comparative details in the regulations on various aspects of ecological and tourism concerns

Parameters	Justice Ravindran committee R	Guidelines for Eco-friendly resort	Lakshadweep Tourism Policy	Guidelines on Tourist Home Establishments	IIMP MINICOY
 not included;  Included;  Briefly discussed/not sufficiently detailed					
1. Addressing Ecological concerns					
Optimum buffers from sensitive habitats (while project siting)					
Suggestions for eco - sensitive development					
Pollution abatement and monitoring					
Capacity building and awareness generation on ecological concerns/mitigation					
Biodiversity conservation initiatives					
Promoting renewable energy usage					
Marine / land - use zoning					
Turtle safety protocols					
Activity permissibility based on cumulative ecological impacts					
On site habitat protection					
Reduction in resource consumption for tourism development					
Land use/suitability zoning					
Marine Spatial Plan					
Permits and licensing requirements					
Behavioral change guidelines for fishermen and locals (for reducing conflicts with tourism activities)					
Inter departmental coordination and convergence					
2. Tourism Development					
livelihood generation for local islanders					
Guidelines for ecologically responsive tourism operations/activities					

Spatial zoning (and project siting) for tourism development					
Construction guidelines for tourism establishments					
O&M guidelines for tourism establishments					
Permits/licensing for tourist accommodations					
Carrying capacity for tourism activities/establishments					
Skill development for tourism operations					
Material use guidelines					

While the above regulations are largely serving their independent objectives, they still need to be further converged and strengthened to guide the sustainable development of the tourism sector. Most of the current regulations are very broad, offer only schematic guidance, and are generic in nature with only IIMP making spatial recommendations. While most of the regulations dealing with tourism development focus on approval processes and permit requirements, they do acknowledge the need for ecological conscious tourism development. However, specifications are limited to resource consumption and pollution abatement dealing with sectors of energy, water and waste treatments which are universal principles to be followed in any ecosystem and not just in the coral ecosystems.

On the other hand, IIMP (which includes suggestions from Justice Ravindran Committee) is currently the most comprehensive and ready referral for project siting and general development guidance for the island. It is the closest document trying to balance tourism development and ecological protection in the island. Unfortunately, this balance is limited to regulating the permissibility of uses across the identified zones. It is silent over siting principles, controlling the design, construction and material use and regulating operations and management which were essential to curb the impact of tourism development on the islands and ensure the continuity of ecosystem services which a site with its abutting areas provides. The document well identifies and maps the habitats in the area, but the interrelatedness and implications of permitted activities in one area on the other habitats are poorly understood which can be seen from the fact that there is complete lack of turtle safety or lighting protocols, construction protocols as well as the absence of buffer designations along the key habitats such as mangroves, nesting grounds, water bodies, etc. On the other hand, the document was found to be too restrictive in its tourism ambitions by permitting scuba diving and snorkeling only in regions of non-coral reefs.

Apart from guiding the initial development process, a key success factor for sustainable development of such islands is an efficient, transparent, regular, non-biased and technically sound monitoring of all construction and operation activities, which unfortunately is missing from all the regulations.

Considering the above gaps and the established need to strengthen and converge the current legislative regime, this paper next presents some recommendations which were made to provide Minicoy with a set of comprehensive, all-inclusive and yet adaptive set of guidelines, to ensure sustainable tourism development in this culturally and ecologically unique island that resonates well with its ecosystem functioning.

5 Mainstreaming ecosystem processes into Tourism Planning & Development

The coral atolls of Lakshadweep are highly sensitive to environmental changes. While the eco-tourism projects that have been proposed in the islands shall give a tremendous boost to economic development, they can have severe environmental impacts if not carefully regulated. Considering these, as a science-based approach to master planning, three tools were used to mainstream ecosystem processes into tourism plan-making which shall protect the fragile habitats, ensure the coexistence of natural processes within tourism development as well as minimize the impact of tourism development on the ecosystem services.

Detailed Land Suitability-Based Land-Use Zoning: *A Spatial Assessment tool that answers where what is permitted*

A region is a sum of ecological features which renders several functions vital for life's existence and each area has intrinsic suitability for some use. Since, Lakshadweep features the most sensitive ecosystems, it is pertinent to align development activities to the areas of least sensitivity. Environmental Sensitivity Analysis is a spatial tool to identify the natural processes and values which a region possesses, to precede and prescribe the use it can be put to. Sensitivity analysis not only identifies the place intrinsically suitable for a particular use but also helps in prescribing the development guidelines which can simultaneously enable those ecological functions to co-exist. It protects sensitive areas from incompatible and unsustainable land uses. In this method, all basic data including resource values were compiled and mapped –topography, vegetation, hydrology, hazards, wildlife habitat, and land use. These data were reconstituted to reveal a value system. Each data map is assessed to prepare a value map depicting least, moderate and highest sensitivities. Higher the sensitivity of an area for a particular activity, lesser is the suitability for the same. The exercise was used to produce the land/marine use plan and govern siting of specific projects such as water villas.

The difference between this exercise and the once done by IIMP are as follows:

1. Assigned buffers along the critical habitats such as water bodies and mangroves and regulated the activities permitted in these buffers. For example, acknowledging the importance of scarce groundwater resource, it was important that construction of tourists' accommodation units does not restrict the conveyance, treatment and storage of the stormwater. Hence, an adequate buffer around the water bodies was required to ensure bank stabilization, habitat preservation and water quality improvement. The suggested buffers varied from 5 to 10m depending upon the size of the water bodies.
2. Permitted activities like snorkeling and scuba diving in the reefs but subject to conditions.
3. Designated buffers for beaches used by turtles for sporadic nesting. As per expert opinion, generally, different species cover different distances upward on the beach to nest (Olive Ridley covers 10m landward while Green Turtle goes farthest up to 15-20m). While Olive nest in sandy beaches, green turtles uses the natural plantation cover (not the coconut plantation) to nest. Hence, this 20m was recognized as a buffer zone to be spared from construction activities where only non-extractive and non-transformative uses were permitted.

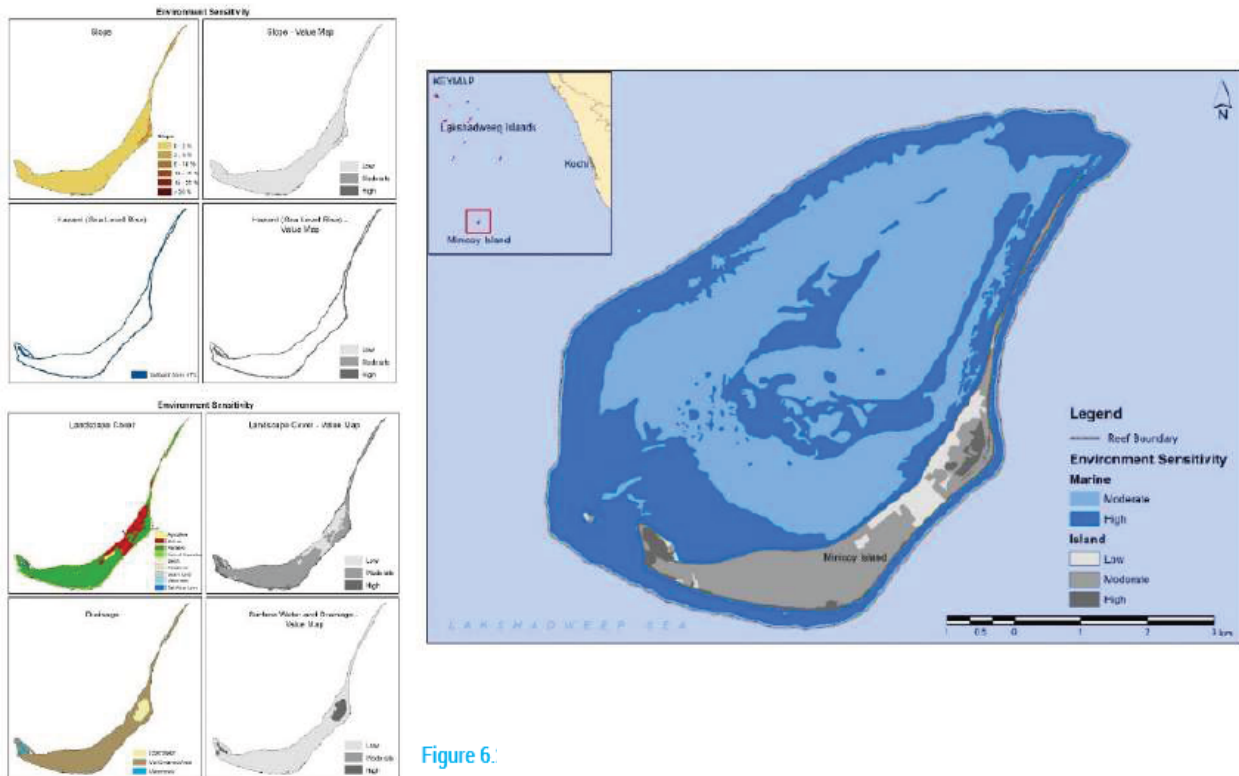


Figure 6.

Figure 6 Environmental Sensitivity Map for Minicoy

Carrying Capacity: A Quantitative Threshold Assessment Tool that answers how much is permitted

The World Tourism Organisation defines tourism carrying capacity as “the maximum number of people that may visit a tourist destination at the same time, without destroying the physical, economic, socio-cultural environment and an unacceptable decrease in the quality of visitors’ satisfaction”. Considering the intricate relationship between tourism growth, resource base and local development, an attempt to establish carrying capacity of these islands becomes an important step while ensuring sustainable and holistic development of the Islands. This is to ensure that the intensity of development does not surpass the ability of the Island to sustain itself as a unique ecosystem, a home to its people and an iconic destination to its visitors. The model devised accommodated three dimensions common to many carrying capacity studies across the world –physical (the maximum number of tourists/locals that can physically fit into or onto a specific area, over a particular time), social (levels of tolerance of the host population, as well as the quality of the experience of visitors to the area) and ecological (any change an ecosystem can withstand without deteriorating it to irreparable damage).

Figure 7 Methodology for Carrying Capacity Assessment



The model computed carrying capacity for individual tourism activities such as boating, beach activities, snorkeling, and scuba diving as well as for tourist accommodation. The ecological parameters internalized in this assessment were corrective factors which took into account the turtle nesting on beaches; sensitivity based spatial zoning which kept sensitive habitats free from development; discounting of environmentally vulnerable areas such as shallow lagoons from suitable areas for boating, etc.

Figure 8 Carrying Capacity of the different Activities

Sr. No.	Activities	Threshold Numbers for Tourists
1	Beach	1069
2	Boating	3654
3	Diving	133
4	Snorkeling	2922
5	Total Keys	180
6	Water Villas (Keys)	103

Ecologically responsive Development Control Regulations: *An Implementation Tool for the above two assessments and to prescribe how to conduct the permitted activities.*

As explained above, the existing regulations do include physical development control regulations to ensure orderly development and maintain physical for, it was also important to reduce the impact of physical development on ecological services such as habitat provision, water cycling, food provision, etc. Hence, additional regulations were formulated to guide siting, design, construction, operation, management, material use and pollution abatement of different activities based on:

- Extensive Site Analysis to understand the underlying ecological processes, existing habitats and species, their dependence on abiotic and biotic components.
- Comprehension of the impacts of tourism development and possible mitigation measures
- Expert opinion
- Study of Similar Regulations: National Guidelines on Overwater structures of Belize; Tourism Bungalow standards of Vanuatu

While many guidelines exist globally, most of them are either centered on the overwater structures or the land-based developments. Among the few which consider both, revolve mostly around the physical development guidelines such as built-form with little ecological responsiveness. While the three tools have been briefly described, the section below presents a closer look at three specific areas where a deeper understanding of the region's ecological processes were used to inform decisions on sustainable tourism planning.

1. Water Villas:

Water Villas - overwater villas built over shallow lagoons – are popular high-end tourist attractions. Just like other overwater structures, poorly planned water villas can be detrimental to the lagoon ecosystems as it blocks light penetration, alters water movement, resuspends sediments, and contaminates the water. India's first Water Villas, proposed as part of this project, was sited based on environmental sensitivity analysis of the lagoons. Bounded by carrying capacity thresholds, a set of DCRs were formulated to arrest the potential negative impacts which were mandated to the private developer through inclusion in the developer's contract/ legal arrangement with the UT administration. Additionally, monitoring committees are also proposed to be established (including eminent subject experts, local representatives and officials from UT administration) to regularly monitor and guide the development process.

Siting of Villas: To reduce the impact of Water Villas on the critical habitats and shoreline processes, globally construction of villas on/near sea grasses, coral reefs or along beaches with mass nesting are restricted. These are allowed in areas with sandy/ muddy bottoms along stable beaches and calmer portions of the lagoon with adequate setback distances from mangroves, reefs atolls and shorelines.

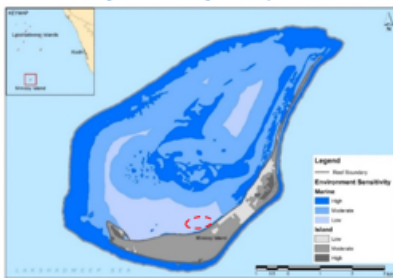
Various parameters such as sensitive habitats, lagoon bathymetry, marine activities and navigation routes, regulatory documents such as IIMPs as well as beach stability were considered to identify sites for water villas in Minicoy. Atolls of the island are characterized by seagrasses, seaweeds, sand sheets, shallow/moderate/deep lagoons, reefs, etc. Among these, the lesser sensitive habitat along the shore are the sand sheets. The sand sheets are the feeding ground for fishes particularly the live baitfish which are caught by the fisherman from these areas. Experts were of the view that the types of live baitfish would be Sprat, Anchovy, Damselfish etc which are planktivorous²⁶ implying that the baitfish habitats are rich with planktons and zooplanktons. While studies reveal that shading impacts the fish behavior and alter predations, some experts were also of opinion that being mobile, most of the fish and their food zooplankton can move out of shaded sites to the adjoining lit areas. Additionally, some advisory like the orientation of the structure i.e. North-South orientation, artificial light underneath the structure during day time, grating etc. were deemed important to be reduce shading effects. Although, site visits and stakeholder consultation with local fishermen revealed that bait fishes are generally not found close to the beaches but farther in the lagoons.

Adequate buffers were recommended to be maintained from shoreline, mangrove covers and reefs to ensure minimum disturbance to these regions.

²⁶ A planktivore is an aquatic organism that feeds on planktonic food, including zooplankton and phytoplankton

Figure 9 Factors Considered to choose ideal site for Water Villas

1. Marine Sensitivity (Based on Location of live corals, sea grass and other flora and fauna)



Source – (PE Global Analysis (D3))

Marine Sensitivity Map for Minicoy



Source – Forest Survey of India (ISSAI data of March 2007)

FSI Coral Reef Map 2007 - Minicoy

2. Lagoon Depth



2. Beachfront Development: Sandy beaches, in general, provide a multitude of benefits: sediment storage and transport; wave dissipation and associated buffering against extreme weather events; dynamic response to sea-level rise; water filtration; storage of water in dune aquifers and groundwater discharge through beaches; maintenance of biodiversity and genetic resources; providing nesting sites or rookeries for turtles; prey for birds and other terrestrial wildlife; scenic vistas and recreational opportunities; and functional links between terrestrial and marine environments (Defeo et al., 2009). Hence, it was important to protect the belt from succumbing to development pressures by designating an appropriate buffer. IIMP identifies 20 m **No-development zone** of 20m from the High tide line where only specific activities such beach activities (but not hotels/resorts) and infrastructure facilities of extreme local/national importance such as jetties were permitted. The reason for identifying the zone was projected sea-level rise. However, as explained earlier, given the role beaches play in providing suitable nesting sites to the turtles, the maximum landward distance a species would cover to the nest was also required to be considered which coincidentally overlapped with 20m NDZ.

Further, it was also important to regulate the use of the beach by the tourists as well as effects which the water villas and beach villas might have on the beach. It was hence important to understand the beach morphology and their roles. In Minicoy, the beachfront was found to consist of three zones of varying depths containing the sand beach area with minimal vegetation, the ground cover zone close to the beach dune and the tree and shrub zone further from it. Different zones were used by specific turtle species to nest and the vegetation cover also played an important role in binding the sand. Hence, management guidelines for each zone were established as shown in the table.

Table 4 Beach Zones in Minicoy

Zone	Plant Species	Role in Erosion Control and Nesting	Development Control Guidelines
Sandy Beach Zone	sandy beach without vegetation cover	Olive Ridley nests in sandy areas which sans vegetation cover	The visitors/ tourists would have access to this zone subject to conditions mentioned below.
littoral vegetation zone	Spinifex littoreus Ipomea crassipes	These vegetation cover the sand and facilitate accretion.	Vegetation needs to be kept intact along the coast line and should not be removed for landscaping or given tourist access. Only bare minimum width of the littoral vegetation should be removed for providing access to the water villa if necessary. Land ward infrastructure can be connected with the water villa by the elevated deck ensuring minimal disturbance to vegetation beneath.
Trees/Shrubs /bushes	Scaveola Taccada Morinda tinctorious Pandanus Odorifer Pemphis acidula	prevents coastal erosion green turtle prefers the Scaevola, Pemphis for nesting	No access to visitors and minimum clearance of vegetation to support necessary infrastructure subject to approval from the authority.

Figure 10 Beach Zones in Minicoy

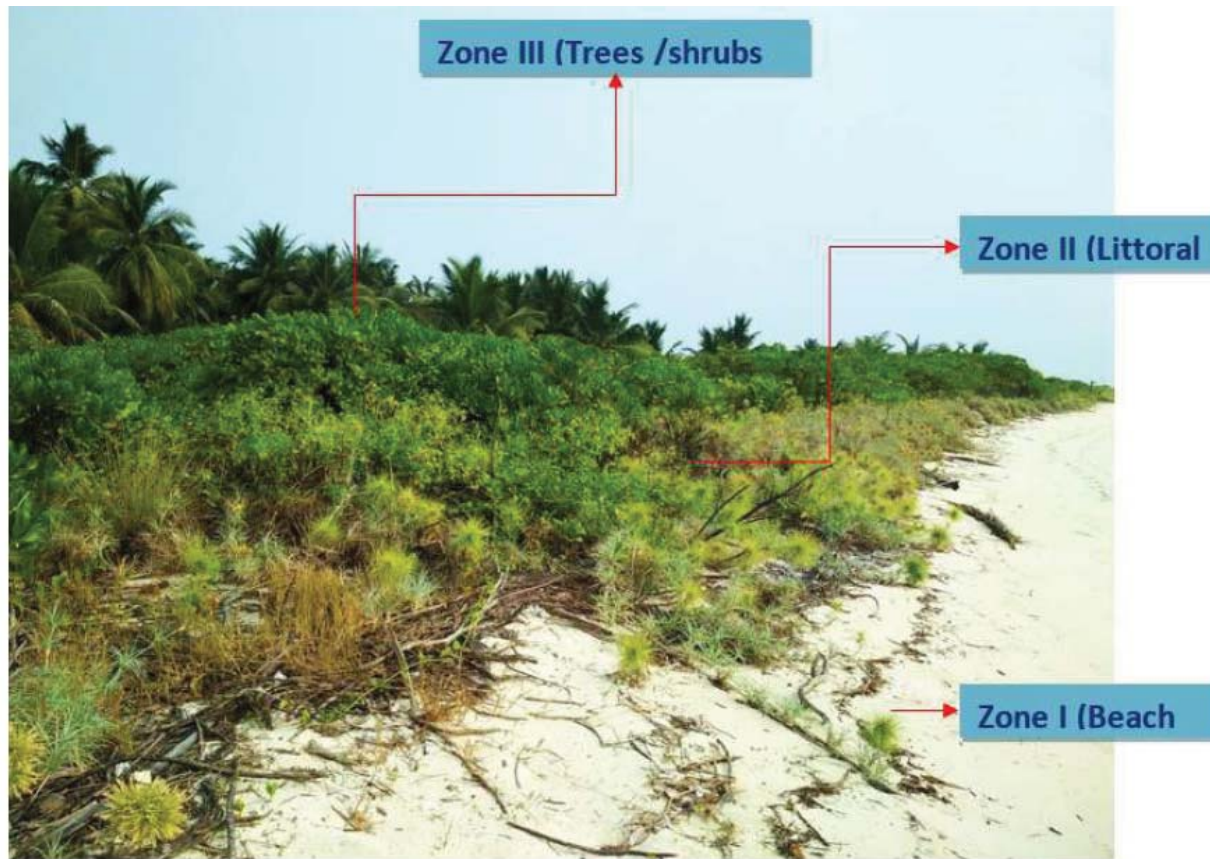
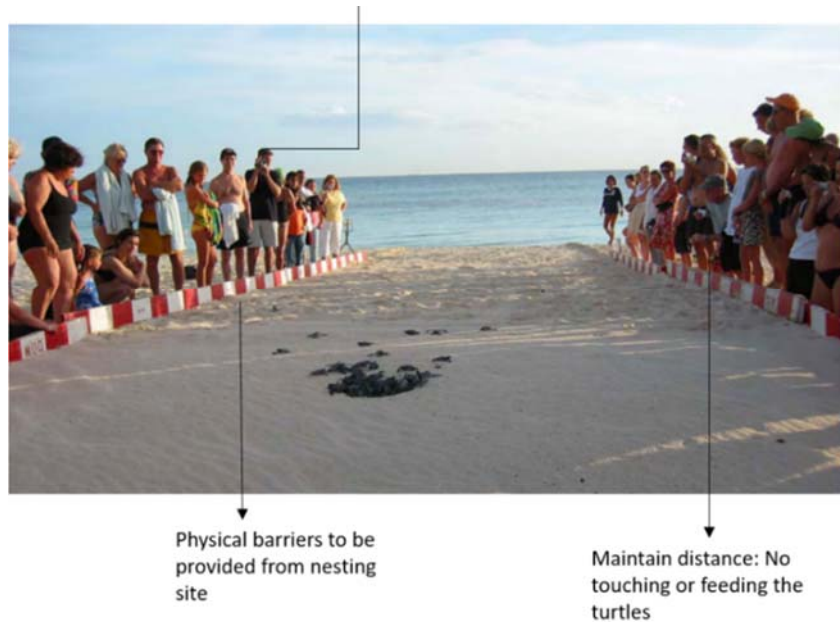


Figure 11 Boardwalks created along the coastal beach witnessing turtle nesting in Miami, the sand dunes and the littoral vegetation zone is fenced and kept out of bounce of tourist.



Management measures were formulated for the villa operators to minimize the project impact on sporadic turtle nesting and their habitats. These included regulating the deployment of beach furniture, designing means to educate tourists, use of display boards to regulate tourist behavior, maintaining buffer from a nesting location wherein tourists shall not be allowed to walk, etc.

Figure 12 Best behavior that shall be followed during hatching

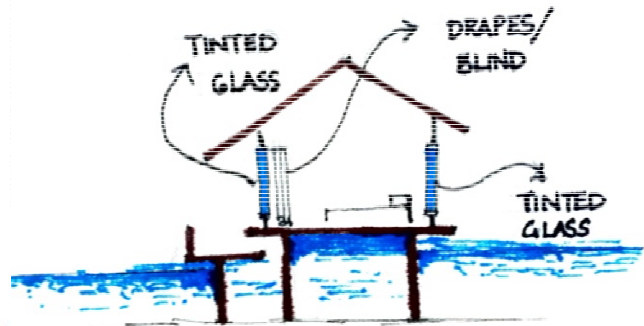
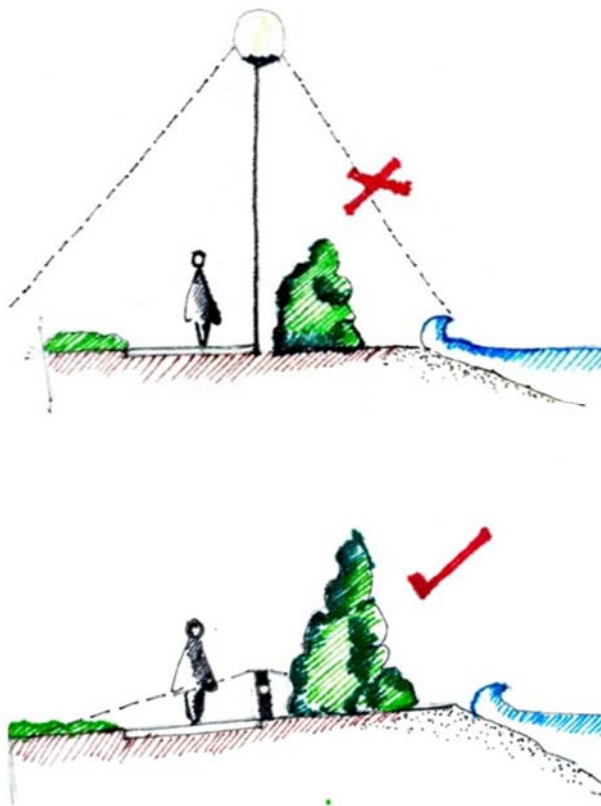


Lighting guidelines were established to control the lighting of beaches, beach villas and overwater structures

to protect nesting turtles and their hatchlings. Artificial lighting of beach dunes or beach vegetation for decoration, usage of metal halides, high-pressure sodium vapour lights, lighting of parking lots, floodlights and spotlights on the beach and bright lights inside the built structures, to name a few can negatively affect the turtle habitats. The hatchlings can get misdirected (move in the wrong direction) or disorientated (unable to orient in one constant direction), which can cause the hatchlings to suffer high levels of mortality due to predation and dehydration²⁷. Also, this can reduce the reproductive success of marine turtles by deterring females (mother turtles) from these nesting beaches. Hence, to minimize any impact on sporadic nesting along the beach, lighting guidelines were made to regulate placement, screening, visibility and types of bulbs (wattage and colour). Further, specific guidelines were made for the water villas. As a part of window treatment, blackout draperies (or heavy, opaque curtains), shade-screens, and/or tinting or using shading film on windows was recommended to be used. Educating the guest to encourage them to close the drapes during sensitive hours was also recommended.

²⁷Choi, Ga-Young, and Karen L. Eckert. 2009. *Manual of Best Practices for Safeguarding Sea Turtle*. Technical Report, Missouri: Wider Caribbean Sea Turtle Conservation Network.

Figure 14 Best and Worst beach lighting practices Figure 13 Methods to block light from water villas



3. **Beyond 20m NDZ:** The project island is bestowed with rich vegetation covers which are home to many species, bind the soils, filter and treat ground water, etc. Protecting the sensitive habitats, the Beach Villas were not allowed on ecologically sensitive habitats like mangroves, salt marshes, mudflats, inter-tidal zone, dunes, and mass turtle nesting beaches; while the resorts and hotels were restricted on water bodies, mangrove forests.

Beach villas were recommended to be suitably located in non-eroding or stable beaches to avoid aggravating the erosion in eroding beaches. As part of the landscaping guidelines, no exotic/invasive species could be introduced in the villas and only native species was mandated. The existing trees and vegetation were encouraged to be incorporated into the landscape and options of replanting was mandated in case of removal. Excessive tree felling for access paths were also discouraged. It was recommended to prefer the wilderness of the region's vegetation communities over manicured landscapes.

6 Conclusion

Each parcel of land in a region is part of larger ecological processes and have specific roles in delivering services and goods. What is important here is to not see these land parcels as discreet entities but understand the inter-relationships & interdependencies. Development practices, although allotted to small land parcels, can affect/destroy their roles and disrupt the entire processes. However, balancing ecological protection and development goals need to look beyond permissibility and prescribing utility guidelines but deeper into the habitat compositions, their interdependencies, ecological goods and services rendered and how development can potentially impact all these. Mainstreaming ecological values into the entire development processes (decision making, policy formulation, development control guidelines, implementation and monitoring) and across project components (design, construction and operations) can mitigate their impact and enable coexistence of the ecological functions. The project provides a framework for science-based master planning for tourism development in fragile coral atolls and this methodology can be replicated for similar geographies and tailored to site-specific conditions.

7 Acknowledgement

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