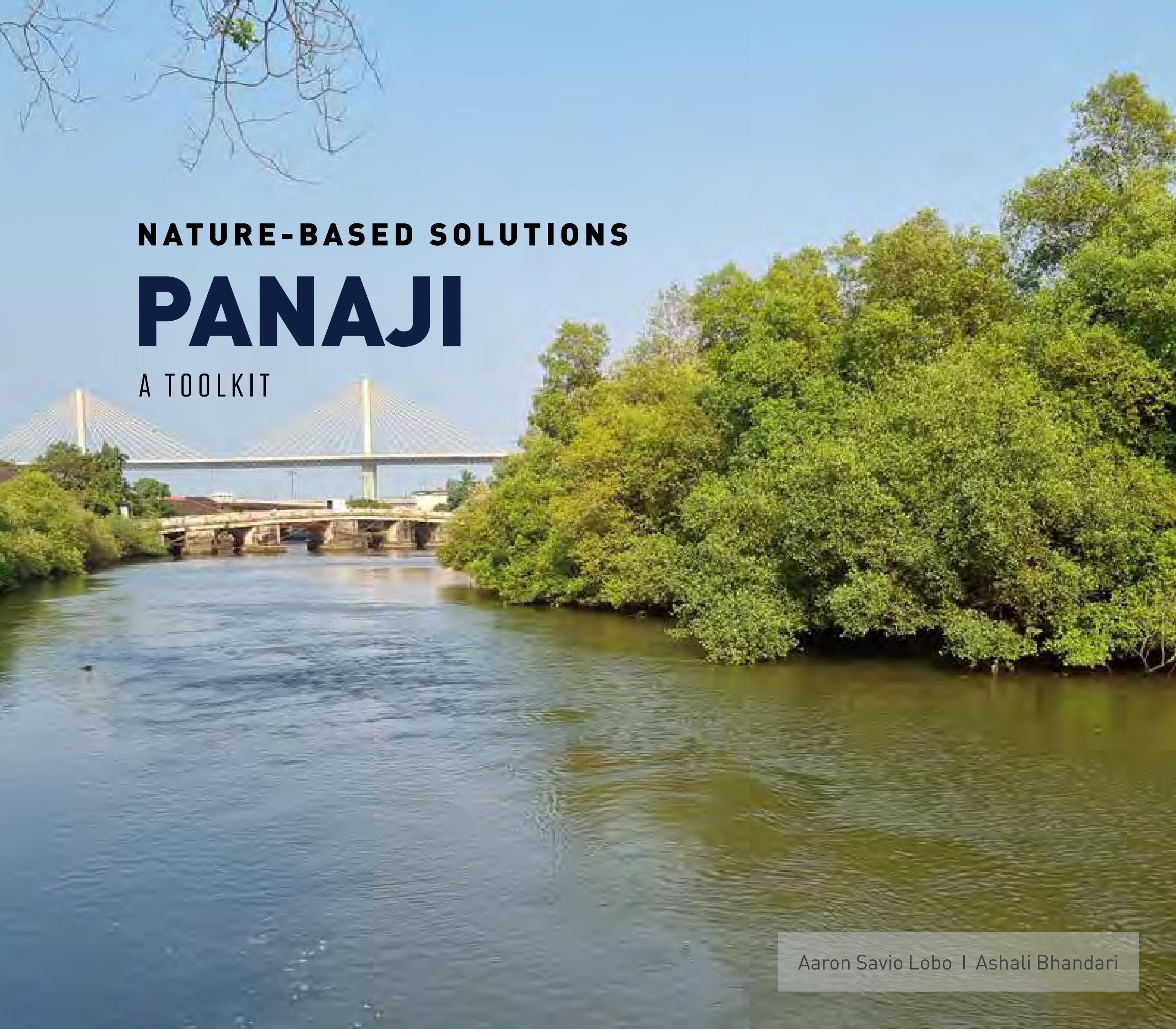
NATURE-BASED SOLUTIONS

PANAJI

A TOOLKIT



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Project Urban Living Lab

Imagine panaji

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PANAJI

FROM MARSHLAND TO CAPITAL CITY

Panaji, is strategically located on the riverine island of Tiswadi. It is bounded by the Mandovi river in the north, the Zuari river to the south, both flowing west into the Arabian Sea. To the east and separating Tiswadi from the mainland is the Cumbarjua canal, which connects the Mandovi to the Zuari.

Panaji became Goa's capital less than 200 years ago in 1843. The land that was transformed/ engineered into the city was largely marshland, with a few fishing villages scattered along the banks of Mandovi. It is said that that Panaji gets its name from the word Panaz, which translates to an area that gets waterlogged (Gomes, 2005).

Beginning from the latter half of the nineteenth century, wetlands were reclaimed to expand the land of the city. This was done by developing an intricate system of drains and also creating soak spaces in the city. Open areas in the form of the wetlands, agricultural lands and gardens/ parks were created or preserved as places where the water finds its way and can be absorbed.

In addition to this, considerable effort was made to keep the two tidal creeks, the St Inez and Ourem creeks, free flowing into the Mandovi river to allow them to absorb and help drain the city of excess water. The bank walls of the St. Inez creek were reinforced with locally available laterite and the channels of both were kept clean to allow for the free flow of water, which also enabled them to support the transport of goods and services.

All planning for the city during that period had to be done keeping the forces of nature, particularly those of water in mind. The Count of Linhares bridge – causeway, commonly referred to as the Ribandar causeway was built over the flood plains of the Mandovi river using pilings of locally available timber. This 3.2 km causeway which connected Ribandar to Panaji was constructed between 1633 – 1634 currently happens to be the longest causeway in Asia. It was built at a height over the river, taking into account tides and increase in the water level even during the monsoons. Most importantly it had a continuous series of wooden arches below to allow for the free flow of water between the Mandovi river on one side and the human modified agroscapes (Khazan lands) on the other. Thanks to this, the mangroves, the khazan lands and the associated services they provide continue to thrive to this day.

The city's growth in the recent decades has led to the decline of these wetlands and open spaces, compromising its ability to deal with floods. The Fontainhas creek which was a smaller branch of the Ourem creek no longer exists and the clogging of the St. Inez creek with solid waste has all been responsible for the increase of floods in the city.

Considering the idea that the city literally grew from the marshes, Panaji is particularly vulnerable to the effects of climate change. The increasing use of hard infrastructure coupled with the diminishing soak areas will only exacerbate flooding in the future. Today, the Tiswadi island as a whole is considered highly vulnerable to effects of climate change. Any plan for the future development of the city should keep in mind the crucial needs for these open spaces and wetlands, which were very much part of the plans when the city was conceived.


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NATURE-BASED SOLUTIONS

FOR PANAJI'S CHALLENGES

Nature-based Solutions (NbS) are actions to protect, sustainably manage and restore natural or modified ecosystems, which address Societal challenges (e.g. climate change, food and water security or natural disasters) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits (IUCN, 2020).

Like many Indian coastal cities, Panaji was built by reclaiming large tracts of coastal wetlands including mangroves, mudflats, low lying agricultural lands (khazan lands) and freshwater bodies.

Over the years and particularly in the recent past there has been an expansion in the urban settlements to accommodate the city's growing needs. This has largely been carried out using impervious grey infrastructure, which has come at a huge cost to these ecosystems, the unique species that inhabit them and the many services they provide, resulting in the erosion of the city's resilience to cope with climate induced shocks and stresses.

It is more crucial than ever before that urban planners and managers recognize these ecosystems as a way to bolster the city's resilience to extreme climatic events.

It is also equally important that management of these urban ecosystems are based on sound ecological principles – Nature-based Solutions, so that they continue to provide the services they once did. For example: flood buffers, carbon sinks etc (Cohen-Shacham et al., 2016).

This toolkit is a quick guide to the city's Nature-based Solutions, the threats these ecosystems face and to provide the necessary steps to conserve and / restore them if degraded. It has been designed for a wide range of stakeholders including city planners (Town and Country Planning Department), managers (Dept. of Forests), regulators (Coastal Zone Management Authority), students and anyone who might be interested in the restoration process.

CLIMATE CHANGE

AND INDIAN COASTAL CITIES

Climate change is no longer a distant possibility but a current reality that can be seen through rising temperatures, changing seasons and more intense and frequent extreme events. Climate change has become one of the most important challenges of this century for policy-makers, public administration, industry, and civil society. It is now an overarching development parameter, which affects most sectors in all countries, and not the least, in coastal cities, including in India.

In India, the future of the 130 towns and cities , including some of country's most populous and fastest growing metropolises, along the coast depends on sustainable, resilient and integrated planning approaches that can adapt to the consequences of forecasted impacts of climate change for the various localities of coastal cities of India (Sharma, 2015).

A fundamental shift in urban development is required because anthropogenic drivers like extraction of natural resources, changing land use patterns, rapid population growth and encroachment into natural areas are now exacerbating cities' already existing risks to climate change by disrupting ecological processes and the way that natural assets function. For example, if urban planners seek to change the land use of an area from marshland to urban functions, they often unwillingly reduce the area's ability to absorb rainwater as the area transforms from pervious to impervious surface. This makes the area more likely to flood during a high rainfall event. Urban planning in India must abolish the duality of nature and development to reduce and avoid climate risks by leveraging and integrating the value of nature. More specifically, it is required to recognize that natural elements and processes can contribute to adapting to the impacts of climate change and to restore and maintain ecological balances.

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CLIMATE RISKS

IN INDIA'S COASTAL CITIES

The risks of climate change in coastal settlements in India have manifested in the form of both slow onset disasters and extreme events. These risks negatively impact the health and well-being of coastal communities, disrupt livelihoods and urban economies, result in loss of life and damage property and infrastructure.

This chapter will cover the types of risks coastal Indian cities face as well as the intersectional urban challenges that Panaji faces due to these risks.

SLOW ONSET DISASTERS

1 SEA LEVEL RISE (SLR)

As the population of India's coastal cities continues to grow and the value of infrastructure and other urban assets in these areas increases, SLR poses a threat to cities social and economic health. SLR will negatively impact resource-based livelihoods such as fishing and farming, as it increases salinity in coastal water bodies. It also poses a threat to property and infrastructure, causing damage and requiring a larger expense on maintenance of existing development.
In Panaji, SLR impacts ground water management practices, the city's ability to manage disasters and the local economy:

GROUND WATER MANAGEMENT

Poor ground water management practices contribute to how cities experience Sea Level Rise: "over abstraction of groundwater at rates faster than it can recharge is one of the main contributors (approximately a quarter) for SLR".

DISASTER MANAGEMENT

SLR reduces Panaji's ability to cope with extreme events like pluvial and/or fluvial flooding, because SLR increases the height of high tide, reducing the city's natural drainage capacity during a flood event.

ECONOMY

The value of infrastructure and assets in coastal areas exposed to SLR in growing in Panaji. Therefore, SLR poses a threat to the city's social and economic health. SLR will negatively impact resource-based livelihoods such as fishing and farming, as it increases salinity in coastal water bodies. It also poses a threat to property and infrastructure, causing damage and requiring a larger expense on maintenance of existing development.

2 WATER SCARCITY AND DEGRADED WATER QUALITY

The depletion of freshwater from coastal aquifers poses a challenge to many coastal states in India. As the groundwater table levels fall below mean sea level, salt water enters coastal aquifer systems, rendering groundwater resources impractical for use. Other anthropogenic influences, such as the discharge of

High Levels of untreated sewage enter the St. Inez Creek at Camrabhatt

© Aaron Savio Lobo

untreated effluent and industrial waste discharge into water bodies, contaminate surface and groundwater supplies. These challenges, along with changing precipitation patters impact and reduce the availability of potable water in coastal cities in India.

Urban planning in Panaji can impact the degree to with which the city experiences water scarcity:

WATER SUPPLY

Unchecked urban expansion and increasing impervious cover in soak spaces in Panaji can reduce the recharge capacity of the aquifer as monsoon rains are unable to replenish the groundwater adequately. This also results in reducing water table levels and increases the risk of salinity intrusion. Poor waste management and sewerage practices in the city can further contribute to the contamination of surface and groundwater supplies in and around the city.

3 COASTAL EROSION

India lost 33% of its coastline to erosion between 1990 and 2016 (Kankara et al., 2018) and due to climate change, coastal erosion is likely to occur at accelerated rates in the future (Rajasree et al., 2016). Coastal erosion results in loss and damage to coastal property, land and infrastructure. This results in higher costs for coastal cities to ensure regular operations and maintenance of critical infrastructure. Real estate markets and tax revenue from the same may also be jeopardized in the future depending on the rate of coastal erosion. Cities may be inclined to rely on engineering solutions to combat erosion, such as dykes, seawalls and groins. However, these also require high maintenance costs and result in the blockage of sand movement, impacting other stretches of beach.

In Panaji, coastal erosion exacerbates the city's exposure to disasters and also impacts the local economy:

DISASTER MANAGEMENT

Coastal erosion in and around Panaji due to anthropogenic and climate-induced factors results in less natural protection from storm surges and coastal flooding.

ECONOMY

Coastal erosion results in loss and damage to coastal property, land and infrastructure. This results in higher costs for coastal cities like Panaji to ensure regular operations and maintenance of critical infrastructure. Real estate markets and tax revenue from the same may also be jeopardized in the future depending on the rate of coastal erosion. Furthermore, communities whose livelihoods are resource dependent, for example fishing communities, are likely to be adversely impacted by coastal erosion as well.

Coastal erosion is leading to the loss of important beach habitat as seen here at Galgibag Beach, South Goa

4

POOR ECOSYSTEM HEALTH/ DEGRADED NATURE IN CITIES

India's coast supports rich biodiversity through a variety of ecosystems such as estuaries, mangroves, reefs, mudflats etc. Urbanization in these areas threatens these habitats as high land values result in the destruction of nature for human settlement. Coastal cities are also often sites of trade and development of ports and other large-scale infrastructure is developed at the expense of ecosystem health. Finally, many forms of industry commercially exploit these ecosystems.

In Panaji, degraded ecosystems adversely impact the city's coping capacity to disasters and the quality of life for residents:

ECOSYSTEM SERVICES

From alleviating urban heat to sequestering carbon to managing storm water flows and supporting a range of livelihoods, nature elements in Panaji provide a plethora of ecosystem services to benefit urban dwellers. The destruction of natural ecosystems due to urbanization pressures threatens the ability of nature to provide these benefits and reduces the quality of life in cities.

Urban flooding is a recurring problem in the coastal city of Mumbai

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EXTREME EVENTS

5

URBAN FLOODING

Indian coastal cities are at risk of coastal, fluvial and pluvial flooding. Coastal flooding occurs when extreme tides and poor weather conditions result in the inundation of land. Fluvial flooding takes place when river flows exceed the natural capacity of the river. In coastal areas, this is likely caused due to high rainfall and not snow/glacial melt. Pluvial flooding occurs due to severe rainfall events. Urban flooding impacts human health and wellbeing, local economies and may result in infrastructure damage. Climate change is likely to increase the frequency and intensity of urban flooding.

Panaji is at risk of coastal, fluvial and pluvial flooding. Poor urban planning and disaster management exacerbate the risk of floods in the city:

STORM WATER DRAINAGE

Both planned and unplanned urban development has resulted in the increase of impervious surface across urban areas and the drainage network in Panaji hasn't been extended to keep up with urban growth. Impervious surfaces also increase runoff speed, which has implications for the quality of flood water as well as poorly constructed infrastructure that may be dislodged due to high runoff speeds. Development Control Regulations (DCRs) and Master Plans often do not consider the local geography, terrain and ecology; thus, development often impedes natural water flows and encroaches on water bodies, resulting in more urban flooding.

DISASTER MANAGEMENT

Panaji does not have an urban flood or city-wide disaster management plan. Plans are often created at the district level and coordination between district authorities and city authorities is poor, resulting in loss of life, damage to property, epidemics and adverse economic impacts from flooding.

6 CYCLONE AND STORM SURGE

Cyclones can produce extreme wind, rainfall and result in storm surges and flooding and wind damage upon hitting land. This can result in human injury and loss of life, property and infrastructure damage and have health and economic implications post the event and during response and recovery. Storm surges usually accompany cyclones upon hitting land, they are an extreme rise in sea levels that are measured as the variance from the predicted astronomical tide. They are caused primarily by strong wind conditions that push seawater onshore. In India, cities on the shores of both the Bay of Bengal and the Arabian Sea have experienced cyclones in recent years.

Cyclone Tauktae in 2021 resulted in severe flooding across Panaji and beyond disaster management, cyclones are likely to have economic impacts in the city. Panaji must rethink spatial planning and disaster management to address this:

SPATIAL PLANNING

As the frequency and intensity of cyclones are expected to increase in the Arabian Sea, cities like Panaji need to rethink development and building practices to adapt to storm surges and high wind speeds. Form based zoning codes, water sensitive urban design practices and contextual building codes can help mitigate damages that occur due to wind speed and storm surges. Furthermore, it may be needed to prohibit new constructions low-lying areas and areas close to the shoreline.

ECONOMY

Cyclones can have long lasting consequences on resource-dependent livelihoods such as agriculture due to salinity intrusion. They also perpetuate cyclical poverty as they damage infrastructure and property, which communities have to pay to repair. There are also health implications as water and vector borne disease outbreaks are common post facto.

DISASTER MANAGEMENT

Panaji is under-equipped to manage a cyclone. Plans are often created at the district level and coordination between district authorities and city authorities is poor, resulting in loss of life, damage to property, epidemics and adverse economic impacts from flooding.

7 HEAT WAVE

A heat wave is defined as a condition of air temperature which becomes fatal to the human body once exposed. In coastal cities, this is when the actual maximum temperature is greater than 37 degrees Centigrade and the maximum temperature departure is more than 4.5 degrees C than normal for at least two days. Cities in coastal districts, especially along the East Coast of India, are particularly susceptible to the impacts of heatwaves due to high humidity. As many urban residents in Indian cities reside in densely-built, crowded settlements with little ventilation, unreliable access to water and minimal green space, heat waves have profound and long lasting health impacts, that include dehydration, heatstroke or exhaustion and can even result in death.

Panaji is not currently at risk for heat waves but this is a condition that impacts other coastal cities in India.

SUMMARY/ CONCLUSION

While many coastal cities in India are at risk from one or multiple of these climatic risks, Panaji is uniquely positioned as it faces multiple climate risks. This guidebook/ toolkit will focus on addressing these risks in the city of Panaji through the implementation of Nature-based Solutions

NATURE-BASED SOLUTIONS

PANAJI´S ASSETS

Panaji´s past growth through the reclamation of the Mandovi floodplains, the low lying nature of the city and the projected increased risk of extreme events along the West coast leaves the city vulnerable to the impacts of climate change.

Despite the growth of the urban sprawl which is projected to increase and spill over to the surrounding villages of Taleigao, Merces, Santa Cruz and Chimbel, there still exist extensive areas in Panaji that are protected by law from infrastructure development. These ecosystems include mangroves, sand dunes, the khazan agricultural lands and fresh water bodies.

Together, these ecosystems represent the city´s safety net in the face of climate change not only buffering it from extreme events, but also to safeguard the city´s food and water security in the long term. It is crucial that these assets are identified and protected as functional ecosystems, so that they continue to deliver the benefits they once did.

This toolkit provides a quick overview of these important ecosystem assets (Nature-based Solutions) in the city of Panaji. It also provides a brief list of the threats they face, and a rationale for ecological restoration of these areas if degraded.

MANGROVES

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KHAZAN AGRICULTURAL LAND

© Nameeta-Ann Menezes

SAND DUNES

© Nameeta-Ann Menezes

FRESH WATER POND

© Aaron Savio Lobo

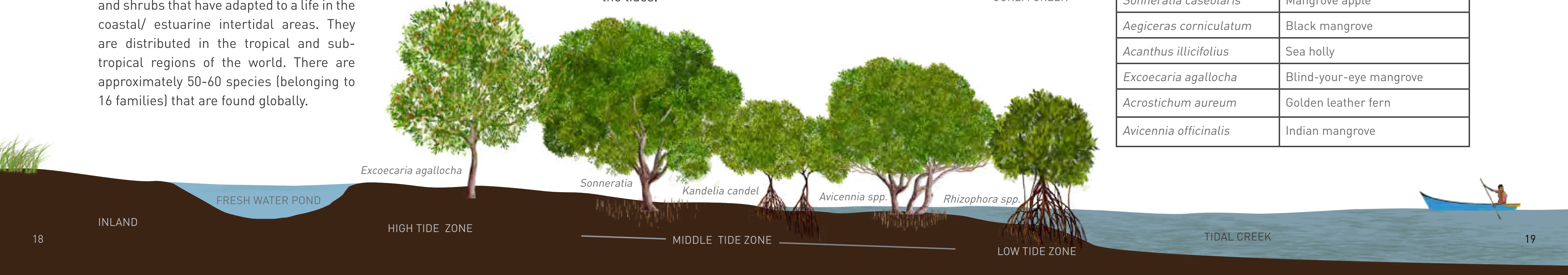
A view of the mangrove fringed Ourem creek

MANGROVES

Mangroves refer to a diverse group of trees and shrubs that have adapted to a life in the coastal/ estuarine intertidal areas. They are distributed in the tropical and sub-tropical regions of the world. There are approximately 50-60 species (belonging to 16 families) that are found globally.

Mangroves grow at or above mean sea level, which include areas which get partially/ completed submerged because of the tides.

MANGROVE ZONATION ALONG THE OUREM CREEK



In a given area, mangrove species distribution is influenced by tidal elevation, flooding regime, salinity and substrate, with different species having a variable tolerance to salinity and flooding.

MANGROVE SPECIES RECORDED IN GOA

(Source: Dhargalkar et al., 2014)

SPECIES	ENGLISH NAME
Rhizophora mucronata	Red mangrove
Rhizophora apiculata	Tall-stilt mangrove
Bruguiera gymnorrhiza	Large-leafed orange mangrove
Bruguiera cylindrica	White Burma mangrove
Ceriops tagal	Indian mangrove
Kandelia candel	Narrow-leafed Kandelia
Lumnitzera racemosa	White-flowered black mangrove
Avicennia marina	White mangrove
Sonneratia alba	Mangrove apple
Sonneratia caseolaris	Mangrove apple
Aegiceras corniculatum	Black mangrove
Acanthus illicifolius	Sea holly
Excoecaria agallocha	Blind-your-eye mangrove
Acrostichum aureum	Golden leather fern
Avicennia officinalis	Indian mangrove

Mangroves have been often viewed upon as wastelands, and often in a derogatory way referred to as swamps/ wastelands. There is now overwhelming evidence demonstrating just how ecologically rich these ecosystems are. They host a diversity of species that have adapted to thrive in these unique ecosystems. Mangroves support a unique diversity of flora and fauna and particularly serve as important nurseries for a high diversity of marine species.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Mud crab *(Scylla serrata)*


© Aaron Savio Lobo

Men fishing at Neogi nagar sluice gates along the Ourem creek


© Aaron Savio Lobo

Linhares wetlands used for solar salt production


© Aaron Savio Lobo

Pearlspot
(Etroplus suratensis)

In Panaji, mangroves are currently mainly restricted to the Calapor-Ourem creek and in small portions to the St. Inez creek. They also occur along Poiem's, which are the brackish waterways integral to Goa's khazan ecosystem. An extensive mangrove swamp can be seen growing in the Linhares wetlands. This area which lies besides the famous Ponte Linhares causeway, was built in 1633 and connecting old Goa to the city of Panaji. It is well known for the production for solar salt, which has been carried out for a large number of years. This is an extremely important green soak area for the city of Panaji buffering it flooding brought about by both tidal fluxes and monsoon waters.

KHAZAN AGRICULTURAL LANDS

The Khazan system of farming is unique to Goa and is carried out by reclaiming low-lying saline estuarine wetlands (mainly mangroves) for paddy cultivation - a practice that dates back centuries (Sonak, 2014). To do this, these communities constructed bunds (walls) to prevent salt water from entering the fields.

To control the flow of tidal waters, the constructed openings in the bundhs and fitted them with sluice gates. The Bunds were constructed using locally available clay, laterite and other material. These gates acted as one way valves, allowing the water from the main backwaters enter the specially dug channels (Poiems) that circumvented the fields.

These channels would fill in with the oncoming tide bringing with them fish, crab and shrimp, the gates automatically shutting when the water level was equal on both sides. This prevented the water from overflowing into the fields, used to grow paddy, which has a low tolerance to salt. This said Korgutis an indigenous salt tolerant variety of rice grown in Goa's Khazan lands.

When the tide receded, the sluice gates would open outwards automatically allowing the water from the poiems to drain out. During this time a bag net is set at the sluice gate to catch fish that had entered in earlier. In this system, everything had a place - while well managed khazan lands would not have mangroves growing within them, they were allowed to continue to flourish along the outer banks of the bund and the banks of the backwater or the estuary because their significance for artisanal fisheries as fish nurseries was well understood. Every bit of space was precious and used efficiently - the bunds themselves were used to grow a variety of vegetables. The Khazan system allowed for the farmer and the fisher to harmoniously coexist and was key to sustaining, what is considered Goa's staple - Fish, Curry and Rice.

Open sluice gate

Shut sluice gate

Bhendi (Lady's fingers) growing along the bundhs

Khazan paddy field

Khazan lands lying fallow being colonized by mangroves because of breaching of the bundhs and salt ingress

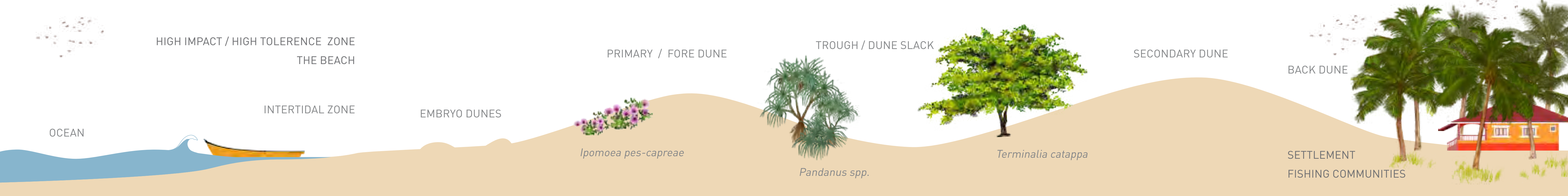
Flooded agricultural lands in Talegao lying fallow are now taken up by invasive water weeds *(Pistia stratiotes)*

THREATS

A general decline of agriculture in the state, which has been primarily driven by out migration, the rising costs of labour and large expanses of these agricultural Khazan lands lying fallow. Lack of maintenance of the bundhs, which are one of the main physical feature of the Khazan lands have resulted in their degradation, leading to the ingress of salt water and has rendered these fields unsuitable for paddy cultivation.

It is interesting to note that this lack of maintenance due to the decline in farming and saltwater ingress is leading to the growth of mangroves in fields.

As the city grows a large proportion of the Khazan lands in the areas surrounding Panaji viz. St. Cruz and Calapor-Merces are now lying fallow and are increasingly being used for development of real estate with several linear infrastructure projects bifurcating these khazan lands.



SAND DUNES

Sand dunes are a low cost natural barrier to winds and waves. In reality, they are considered to be an effective and cheaper coastal barrier than hard – concrete coastal protections such as tetrapods, pylons and the like. They are of particular significance to coastal cities where they help protect coastal infrastructure from strong winds, storm surges and floods. Sand dunes support a diversity of flora, collectively referred to as dune vegetation *(eg. Ipomoea pes-capreae, Vitex trifolia)*. This vegetation, helps bind the sand together, build dunes (a slow and gradual process) and thus helps prevent coastal erosion.

It is easy to disregard sand dunes as piles of sand, but they are complex ecosystems in their own right. They have a life cycle of their own, with young dunes (embryo and primary) forming at the beach front and the more mature dunes further away from the sea, with several stages in between. In general the stronger the winds, the higher are the dunes, with the wind facing side having a gentle slope while the landward/ sheltered side having steeper slopes. The dunes are separated by dips between them called "Dune slacks" or troughs. These slacks generally have a high freshwater table, also being located in a sheltered zone and support their own unique ecologies, characterized by species such as the Screw pines *(Pandanus spp.)* and other riparian vegetation that grow near freshwater.

Intertidal Zone

Beach morning glory *(Ipomoea pes-capreae)*

Screw pine *(Pandanus spp.)*

Fishing Community Settlement

While traditional coastal/ fisher communities have long appreciated the presence of sand dunes *(locally called Ude)* as barriers to protect their homes, fishing boats and nets, most are generally unaware of their importance. This is why these important eco-systems should receive the awareness and protection they deserve.

In contrast to mangroves and khazans, sand dunes have not received the necessary attention. This is an irony of sorts because Goa's tourism, which is predominantly beach tourism rests on the presence of healthy dunes. Although protected by law, the Coastal Regulation Zone Act 1991, sand dunes do not have a management authority that has been mandated with their protection. This is unlike mangroves that are protected by the Department of Forests. They have thereby gone through a rapid degradation because of unplanned coastal development.

In Panaji, sand dunes can be found along the Miramar beach which lies along the southern bank of the Mandovi river mouth. This beach stretches for ~4.5 km from Miramar to Caranzalem. It is the only beach stretch with sand dunes in the city and of particular significance also because of the fact that it is located at the mouth of one of Goa's major rivers. Although the sand dunes of Miramar continue to persist to this day, they are a shadow of their former glory.

The Dr. Jack Sequeira road runs parallel to this entire coastal stretch for approximately 3.09 km connecting Miramar to Caranzalem and Dona Paula. The road runs through an area which were once mature dunes. On the other side road which is now characterized by high rise apartment complexes and hotels particularly in the Caranzalem area, were once low lying agricultural lands, characterized by an abundance of freshwater.

Coastal infrastructure development impacted by coastal erosion in Arambol, North Goa

THREATS

COASTAL INFRASTRUCTURE DEVELOPMENT

Despite Goa's beaches and sand dunes being offered a high level of protection since 1991 (CRZ), the coast has seen rapid infrastructure development even since then. A new study reported that from 1991 to 2019 the built-up area along Goa's coast increased from 19.6% to 40.3% (as a percentage of the total area) within the 500 m buffer and from 15.12 to 36.79% within 200 m buffer. This includes permanent residential houses, resorts and temporary shacks. This infrastructure development is by far the greatest threats to Goa's coastline and the destruction of these sand dunes can result in a huge loss of services that these ecosystems provide.

TRAMPLING

The embryo and the primary dune unlike the intertidal zone cannot withstand trampling, which negatively impacts both the flora and fauna of the sand dune ecosystem. Trampling kills vegetation particularly on the embryo dunes, which are the youngest dunes and mark the first phase in the dune development. Here pioneer sand binding species establish themselves and are able to stabilize the dune with their long roots, which are prevented from doing so if subjected to continuous trampling.

LINEAR INTRUSIONS – PATHWAYS THAT BREAK DUNES

Traditionally there were few pathways that ran from the homes of the fishing community to the seashore that were drawn between the dunes. Since the construction of the Dr. Jack Sequeira road, the number of these paths cutting through the dunes has greatly increased over the recent years. These seemingly benign pathways bifurcate and break the continuity of the dunes and can impact the sensitive dune ecosystem greatly.

AUSTRALIAN PINE *(Casuarina equisetifolia)* PLANTATIONS

The plantations of this exotic (non-native) species has led to the flattening of dunes in several parts. The pine needles take a while to decompose and coat the floor below preventing the regeneration of other dune vegetation and thus hinder the formation of dunes.

Pathways cut through the sand dunes affect sensitive dune vegetation
along the Miramar beach

Australian pine *(Casuarina equisetifolia)*

POLLUTION

Being located at the mouth of the Mandovi estuary, the Miramar beach receives a high level of flotsam, not just in the form of organic waste, but large quantities of non-biodegradable marine debris, particularly plastic litter. Recently Goa's beaches have also witnessed increasing frequencies of tar ball (semi-solid blobs of oil) pollution, having increased dramatically since 2015, with 2021 being the worst year on record so far, with approximately 30 tonnes of these tar balls being cleaned up from the beaches in the month of September 2021 alone. Miramar was amongst the worst affected. Besides being an imminent health hazard, these tar balls threaten the ecology of a large diversity of organisms that exist in the intertidal zone and are also likely to impact coastal fisheries and threaten our food systems. In addition, pollution events such as these, mainly impact the intertidal zone, which is the one most commonly used areas for recreation and generally more resilient to anthropogenic pressures (for eg. trampling) as compared to the dunes. Pollution events in the zone if not dealt with in a timely manner are likely to shift pressure to the more sensitive dune areas.

GUIDELINES FOR DUNE RESTORATION USING SAND FENCES

(Source: Mascarenhas, 2009)

A relatively inexpensive, environment friendly and effective method for dune restoration was piloted at the Miramar beach in 2007 using sand fences. This method is particularly useful for beaches where the sand dunes are completely flattened due to excessive trampling.

- The fences must be around 1m in height and built from evenly spaced bamboo or wooden vertical slats connected with twisted wire.
- Fences must be placed parallel to the shoreline and perpendicular to the prevailing wind direction.
- The fences must be placed as far landward as possible, along or slightly beyond the frontal embryo or primary dunes, to allow for the recreational use of the beach.
- Public access should be maintained in a zig zag fashion, at a 45° angle with the fence line.
- Signboards to raise awareness about the dune and restoration activities must be installed.

Sand dunes support a diversity of flora, collectively referred to as dune vegetation. This vegetation, helps bind the sand together, build dunes (a slow and gradual process) and thus helps prevent coastal erosion.

Five rows of 1 m high sand fences made of bamboo at Miramar beach, installed on 15 April 2007

The second row of fences successfully trapped large quantity of wind blown sand

Over time, dunes increased in height (70 cm), with notable 'ipomoea' vegetation, as observed in August 2008

FRESHWATER BODIES

One of the most limiting factors for any coastal city is the availability of freshwater sources, which is key to urban resilience. Despite being surrounded by saline backwaters of the Mandovi river, Panaji is blessed with an abundant supply of freshwater. This is thanks to the monsoons but also to the forest-cloaked hill slopes and the lateritic plateaus (soak areas) of Altinho and Nagali, crucial to recharging the aquifers of the wells located in the foothills.

Fresh water pond are a common feature in agricultural lands and are used to irrigate the winter crops

In the 19th century two natural springs supplied the city with potable drinking water. They were refurbished into fountains, with specially constructed channels (veios), from which water was led by a trough (goteira) dug in a subterranean bed near a passage provided with sluice gates (ventiladores) to a tank from where it would be supplied through various openings to different parts of the city (Pinto, 2016). Both these fountains viz. Fonte Phoenix and Fonte Boca de Vaca still stand to this date. In addition, most homes in the city had access to their own wells, which would meet the residents daily needs.

Today most of the city´s domestic water supply comes from the Opa water works complex, a water treatment plant built in 1957, although it has gone through several modifications since then. The fact that the citizens of Panaji are supplied with treated water disconnects them from the declining status of their fresh water bodies in the city. As a result many of the freshwater bodies are in a state of neglect.

Fountain of Boca de Vaca

THREATS

SOLID WASTE AND SEWAGE

While the city has a well-functioning solid waste treatment plant, it´s water ways, particularly those of the St. Inez creek (freshwater only in its upper reaches) continue to be dumping grounds for solid waste and sewage. These are mainly from domestic sources, but also include construction debris etc.

INVASIVE AQUATIC WEEDS

Nutrient runoff in the form of raw sewage and fertilizers from the field is leading to the eutrophication of these water ways, leading to the decline of dissolved oxygen. This results in toxic algal blooms and a proliferation of invasive water weeds including Water Hyacinth *(Eichornia crassipes)*, Water lettuce *(Pistia stratiotes)* and the Giant Salvinia *(Salvinia molesta)*. This floating vegetation clogs water ways, blocks sunlight needed by other aquatic plants and algae to carry out photosynthesis, resulting in the deoxygenation leading to its stagnation. This provides an ideal habitat for the breeding of mosquitoes and the spread of vector-borne diseases, whose incidence have been increasing in the city in the recent past.

Untreated sewage entering the Ourem creek in Mala

These weeds can also negatively affect biodiversity including fish and other aquatic life living below the floating vegetation. They also pose a threat to various vulnerable and threatened species which includes the smooth-coated otter *(Lutrogale perspicillata)*, the Mugger or marsh crocodile *(Crocodylus palustris)* and a diversity of waterfowl that inhabit Panaji's wetlands. These invasive species can also greatly affect the ecosystem services that these wetlands confer including their buffering ability to urban floods.

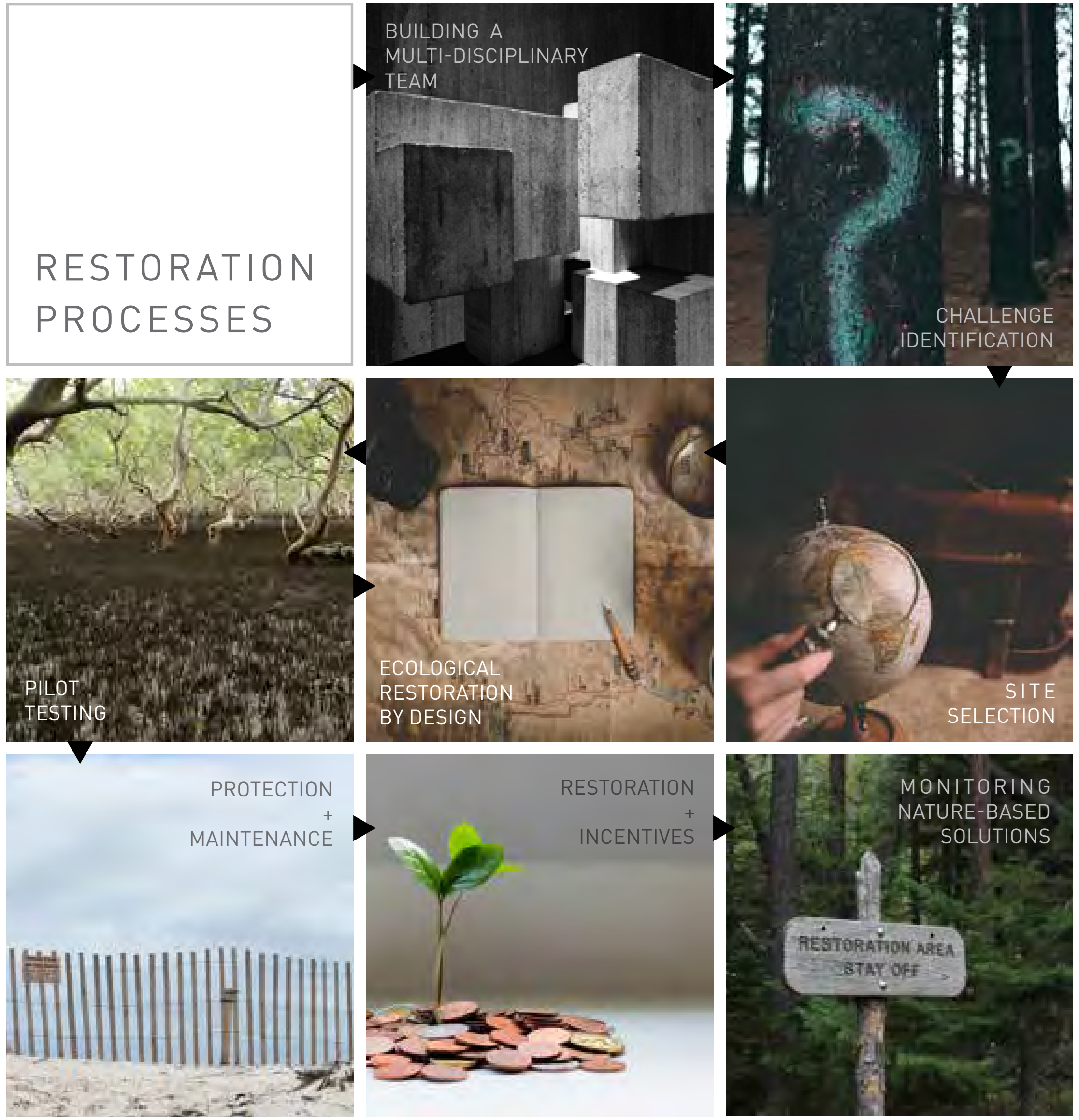
Panaji's wetlands account for high levels of biodiversity including vulnerable species like the smooth-coated otter seen in the St. Inez creek

SALT WATER INGRESS

Hyper abstraction of freshwater in several parts of the city, the lack of maintenance of the Khazan lands (particularly the bundhs) and the shrinking of sand dunes is leading to the ingress of saline water into several wetlands, ponds and wells in Panaji and its surrounding villages.

Nature-based Solutions, which in the case of Panaji include actively farmed khazan agricultural lands with well-maintained embankments and sand dunes, can act as barriers preventing the ingress of saline water. They thus safeguard and enhance the availability and quality of water for agriculture and human consumption. This can also preserve the integrity and intrinsic value of these ecosystems. It is thus always important to locate an NbS within the larger urban landscape, ensuring better connectivity between the various NbS types.


MAP OF
PANAJI'S
NATURE-BASED SOLUTIONS
Mandovi River
St.Inez Creek
Ourem Creek
Legend:
Khazan Fields
Mangroves
Salt Pans
Gardens (soak spaces)
Beach and Sand Dunes
Casuarina Plantation
CCP Boundary
0
1km



RESTORATION PROCESS

It is important to understand that the active conservation of natural ecosystems of concern should always take top priority. Restoration should only be considered a complimentary activity and never a replacement to the active protection/ conservation.
Where possible, it is often advisable to follow a Passive restoration approach. Sometimes by simply reducing/ eliminating the stressors that are responsible for degradation and allowing for enough recovery time for natural regeneration to take its course. For eg. when it comes to restoration of mangroves in degraded sites in Goa, clearing up choked tidal channels and restoring the original hydrological regime can help allow mangroves to take root and may naturally restore the ecosystem.

STEPS FOR IMPLEMENTING NATURE-BASED SOLUTIONS (NbS)

1. BUILDING A MULTI-DISCIPLINARY TEAM
2. CHALLENGE IDENTIFICATION
3. SITE SELECTION
4. ECOLOGICAL RESTORATION BY DESIGN
5. PILOT TESTING
6. PROTECTION & MAINTENANCE
7. RESTORATION & INCENTIVES
8. MONITORING NATURE-BASED SOLUTIONS

1 BUILDING A MULTI-DISCIPLINARY TEAM

The implementation of NbS within cities requires both domain and local expertise. This requires building a multi-disciplinary team that can work on different aspects of implementing NbS. While the following list is not exhaustive, these are the potential types of team members required to implement NbS in coastal cities:

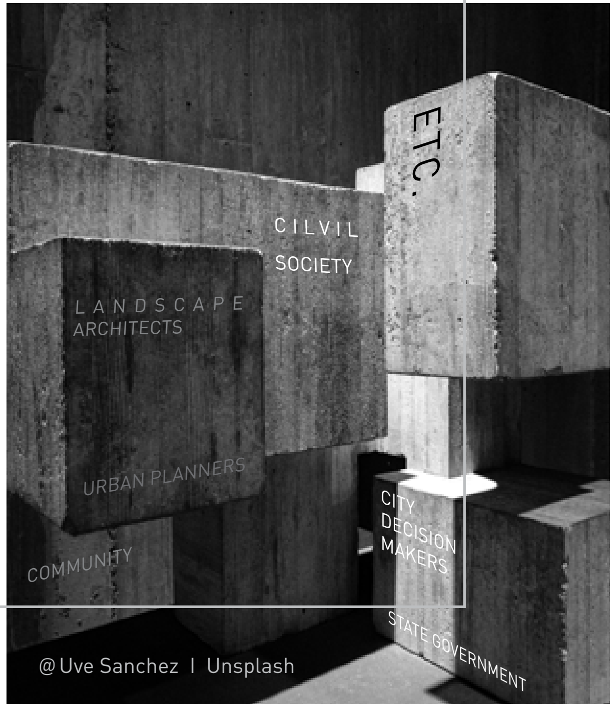
• Urban planners to understand the institutional and legal frameworks around site selection and challenge identification. Urban planners with skills in GIS and stakeholder engagement processes can help support with mapping and community processes.

• City level decision makers and state government actors from relevant departments (eg. Coastal Zone Management Authority, Forest Department) must be part of the advisory process to facilitate the relevant permissions and ensure longevity of the project.

• Landscape architects can support in the design of NbS

• Ecologists play an essential role in determining the species and process for restoration. They also play a role in monitoring and evaluation. Working with local domain experts is also important in understanding the context of the site and local knowledge about the ecosystems that can be used in the design of the intervention

• Civil society organisations within the city and local communities must be part of the process to ensure their challenges are heard and societal benefits are achieved.



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2 CHALLENGE IDENTIFICATION

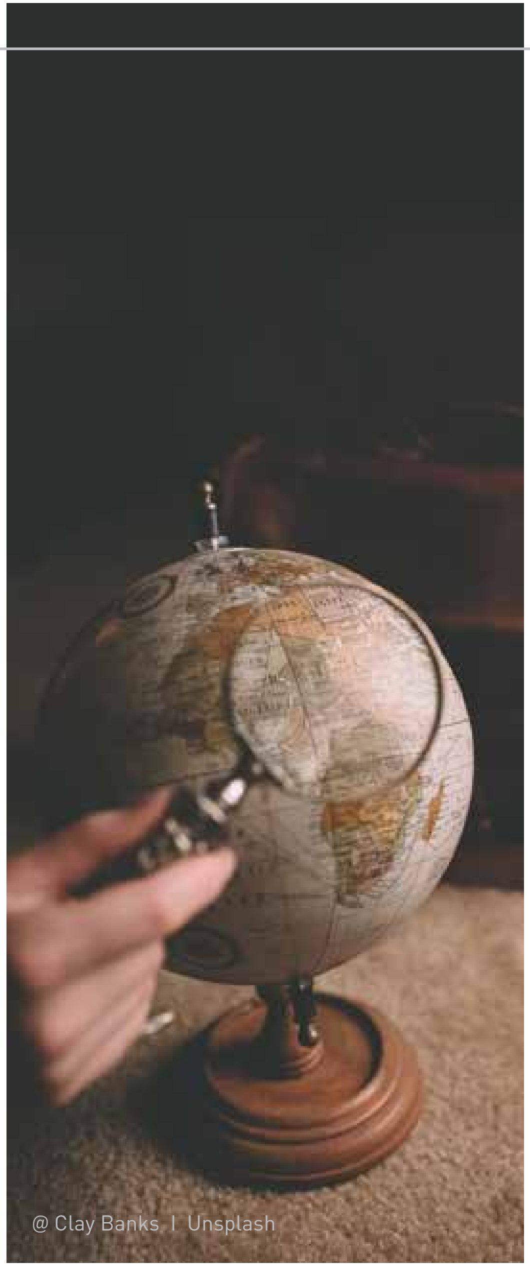
Nature based Solutions (NbS) are an opportunity to both address ecological and societal challenges in Indian cities. Given the variety of climate risks Indian cities face, both as extreme events and slow onset disasters (Pg. 8 - 15), it is essential to understand the local context so that NbS can be selected and implemented accordingly. Community engagement within and across neighborhoods must be conducted to understand the scale and impact of climate risks within a city. These should be carefully mapped and overlaid on local ecology which include the NbS assets. Long term projections on how these risks are likely to intensify in the future given local development trends, demographic transitions and climate change can help create the right context for implementation.

3 SITE SELECTION

NbS must be implemented with local communities and within a defined area to ensure longevity and success. Based on the local challenges that have been prioritised and the overlaps with local assets spatially, sites can be considered for implementation of NbS.

Recognise that few ecological systems exist alone, and are connected to each other either physically or by biological/ environmental links. Site selection should take this into account explicitly, making sure the larger ecosystem is considered (eg. a watershed). There are chances the site's ecosystem may be impacted by the implementation of NbS and this must be considered to ensure there are unforeseen impacts within the larger system.

The local context must be understood to ensure NbS can be implemented on a specific site. This entails reviewing tenure and ownership history of the site, the institutional and legal frameworks that govern the site such as land use, development control regulations, coastal zone regulations etc. to facilitate smooth implementation, and understand community issues (if any) around the site.



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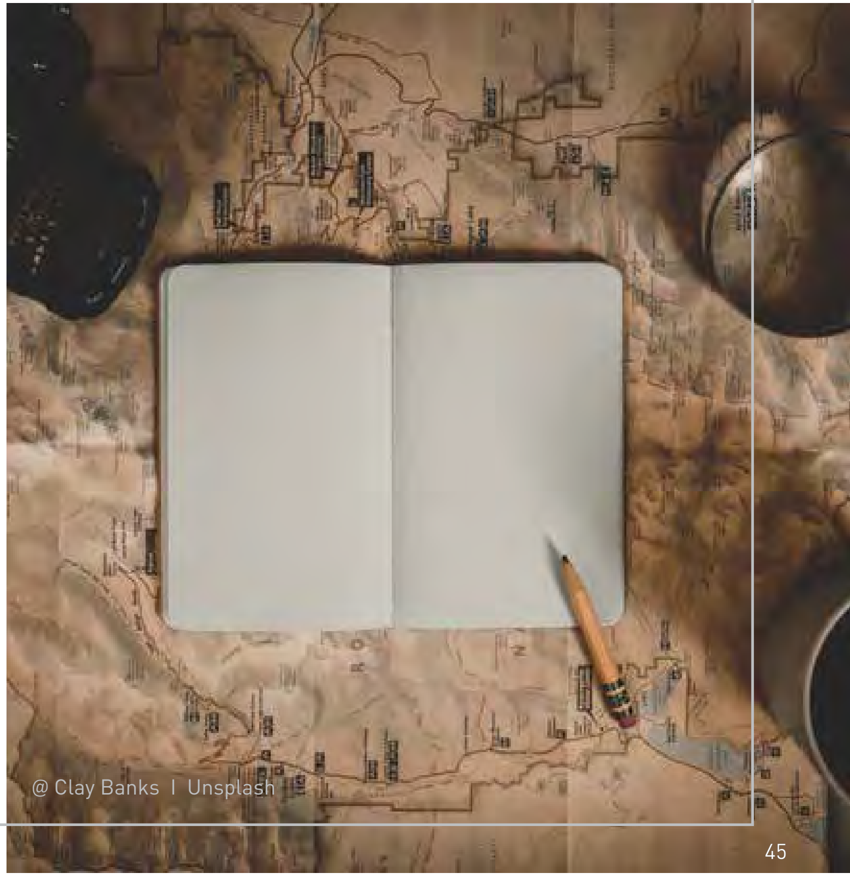
4 ECOLOGICAL RESTORATION BY DESIGN

Ecologists and landscape architects must design solutions that will restore ecosystems and address the societal challenges identified in step two. When restoring an NbS site, it is important to follow ecological principles that would boost biodiversity and ecosystem function, but also maintain/ enhance the services these ecosystems provide. In an urban context, this could include the improved ability of the areas to absorb flood waters, the protective function of sand dunes against strong winds, increasing carbon sequestration through ecological restoration of mangroves etc.

It is important to choose species native to the area and tolerant of specific site conditions. The planting of exotic species such as Australian pine *(Casuarina equisetifolia)* as bioshields should be avoided. Similarly one should avoid monocultures (single species stands), as done in the case of the red mangrove *(Rhizophora mucronata)* and Australian pine. Such plantations compromise biodiversity, affect ecological function and can often do more harm than good. They also often negatively affect ecosystem services that otherwise functional ecosystems would confer.



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5 PILOT TESTING

When planning the implementation of a NbS at a new site or the restoration of a degraded site, it is crucial to pilot the intervention in a small area, before launching a large scale restoration effort. This helps understand if a planned intervention is likely to work or not. Restoration can be expensive and pilot testing can help in the judicious utilization of resources when implementing a specific NbS.

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6 PROTECTION AND MAINTENANCE

Upon the completion of the implementation of NbS, various measures must be taken to protect the restoration site. It is important that every intervention site is marked with appropriate signage. This is particularly important in the case of the largely neglected sand dunes where restoration efforts may be less obvious. Dunes are more vulnerable to trampling than other NbS assets such as mangroves. When it comes to maintenance, most sites are able to regenerate themselves if left to their own accord i.e. simply by removing the pressures that brought about the degradation in the first place.

7

RESTORATION AND INCENTIVES

To ensure the longevity of the intervention/ NbS, it is worth considering how to combine the restoration process and activities with incentive programs for communities living near the site or those who are involved in safeguarding or restoring NbS. In Indian coastal cities it is often the poorest communities that suffer the worst impacts of climate change despite contributing least to its causes. Many of them include fishers and farmers who typically reside in low lying areas and near waterways, making them particularly prone to the effects of urban flooding and other climate driven disasters. These communities are well aware of the benefits these ecosystems provide and are often already working to safeguard them, so that they continue to deliver ecosystem services. Through judicious stewardship of ecosystems like mangroves that they depend on for their food and livelihood, they have an important role in C sequestration which would otherwise be released if these ecosystems were degraded. Incentivizing existing activities could help build long-term support for NbS. Incentives could include Cash for Work schemes, Loan collaterals, Restorative aquaculture activities, Blue carbon activities etc. These incentives need, however to be carefully evaluated for the possible flow-on social and economic changes they could bring to the community.

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8

MONITORING NBS

A robust monitoring framework must be developed with the team and the local community to include relevant ecological and social indicators to monitor the site beyond the implementation stage of the NbS. This should include specific targets and timelines that should be observed as the ecosystem is restored. This should also be linked to the restoration and incentives program designed in step 7 to ensure incentives are being distributed on the basis of progress. Monitoring should be consistent and fixed over time, potentially with annual reports and case studies. Any monitoring programme should pre-planned strategies for what step should be taken if targets are not being met, conditions are worsening, unexpected consequences of the NbS are encountered or to deal with natural/other disasters. This would help with a dynamic and adaptive management of NbS.

There should also be a communication strategy between the team members involved in the restoration process and the community. The feedback obtained can help domain experts and managers make the necessary checks and tweaks to ensure that the NbS meets it´s optimal potential.

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