Training program on

‘Building urban climate change resilience’

Organized by TERI, Goa

' Rehabilitation of sand dunes as an adaptation measure for arresting coastal erosion'

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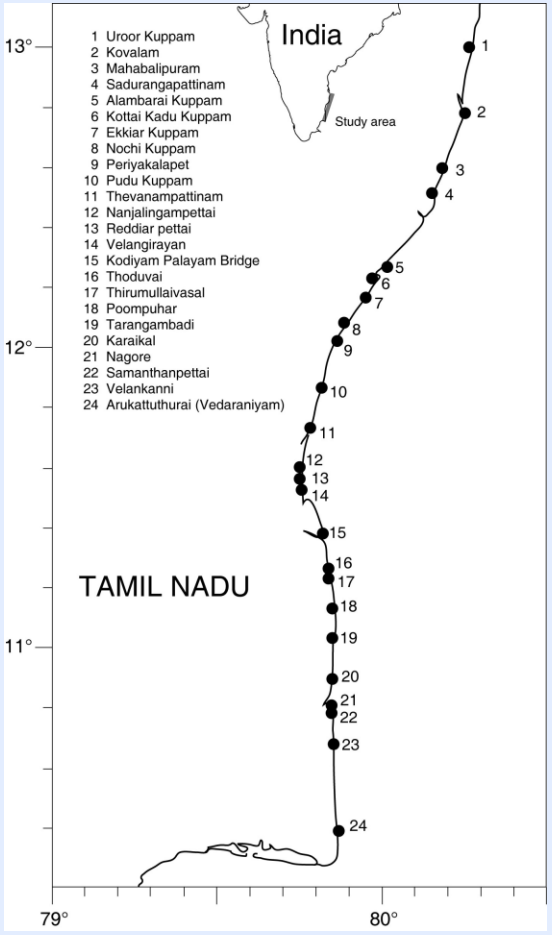
Member, GCZMA

23 January 2015

Main Components Of This Presentation

- Role of sand dunes as natural defense
- Validity of sand dunes as buffer zones
- (Examples from Tamil Nadu coast)
- Human impact on sand dunes
- Examples of dune building initiatives
- Implications of dune restoration



The December 2004 tsunami
RUN-UP HEIGHTS and INUNDATION LIMITS

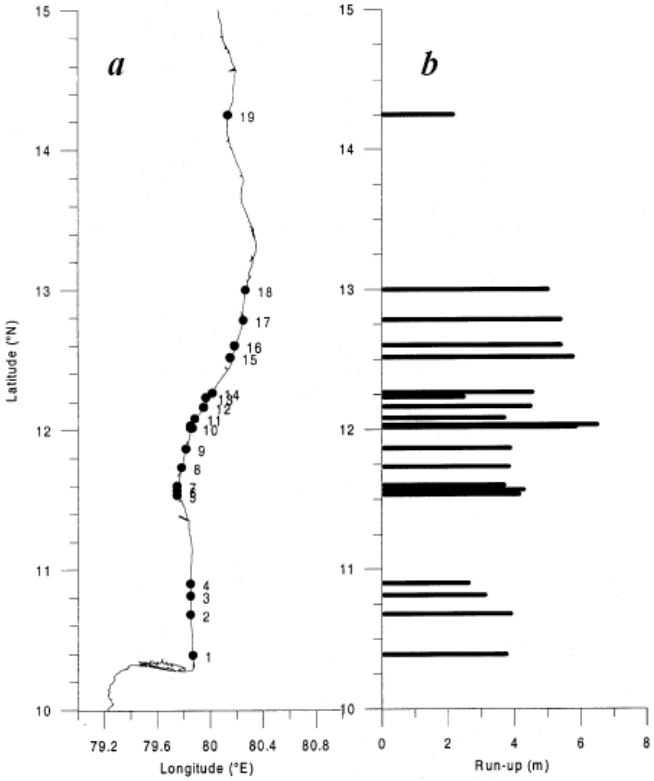


Figure 4. Plot showing (*a*) location and (*b*) run-up height.

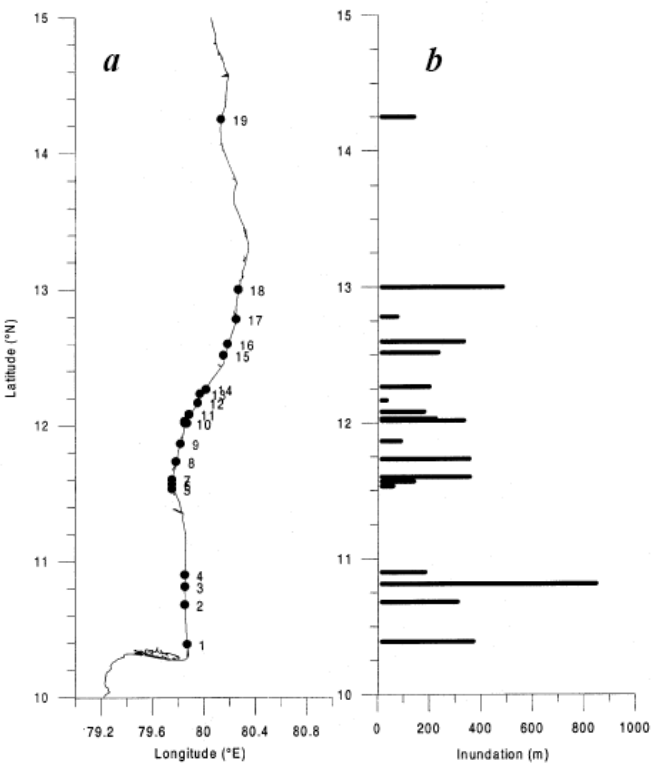


Figure 3. Plot showing (*a*) locations and (*b*) inundation limits.

Sheltered Coasts – Built-up Coasts
- Response to December 2004 tsunami -

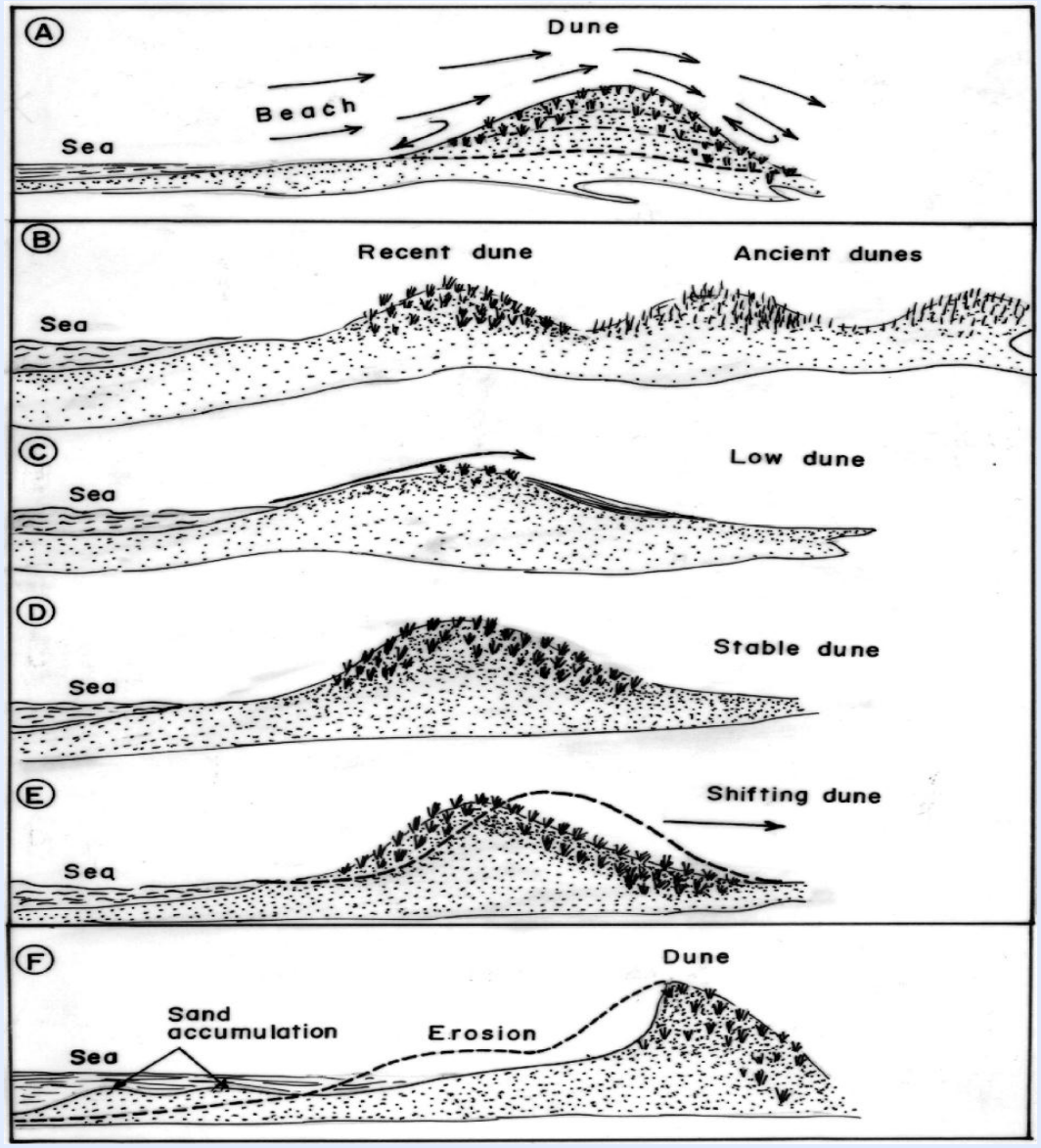
- Beaches backed by dunes
- Luxuriant vegetation with creepers and bushes
- Natural protection
- Natural elevation
- Undisturbed dune fields
- Nominal human intervention

- Leveled / razed dune strips
- A variety of houses, dwellings, huts on and along the dune line
- Lack of natural protection and elevation
- Dune systems have borne the maximum brunt of human actions

Sand dunes - definition

- **Sand dunes are geological landforms formed by the action of wind**
- **The main prerequisites for the formation of sand dunes are wind, sand and vegetation**
- Wind plays the most important role; its direction, frequency, duration and speed displace and transport fine dry sand
- The vegetation plays a key role in dune formation as these objects act as wind breakers due to which wind is forced to drop sand along its path.
- **Vegetation thus traps and stabilises moving sand.**
- The first step in the formation of a dune, by plants tolerant to salt, is a berm which is an accumulation of sand brought up by the waves on the beach at a point just above the highest high tide
- The berm swells due to the eolian import of sand. Thus these small sand mounds which form, finally develop into a continuous chain of sand dunes.
- These eolian bedforms can be symmetrical, several meters in height and can vary in size from place to place.
- **The evolution of a coastal dune system strictly depends on the quantity of sand brought in by winds and the sand removed by tides and littoral currents.**

Geological evolution of coastal sand dunes
(the most impacted of all landforms)



Role of coastal sand dunes

- Nature’s first line of defense
- Serve as sand “banks”
- Sources of beach nourishment
- Dissipate wave energy
- Maintain coastal equilibrium
- Protect coasts from erosion
- Ecological storehouses
- Features of coastal stability
- Guard against sea level rise
- Shield mankind from forces of the ocean

Role of dune vegetation

- Dune vegetation acts as sand binders
- Dune plants contribute towards stability of dunes
- Dune flora protects coasts from erosive forces
- Vegetated dunes arrest wind blown sand
- A vegetated dune implies ecological balance

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Management

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An environmental perspective of the post-tsunami scenario along the coast of Tamil Nadu, India: Role of sand dunes and forests

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Available online 22 May 2007

Abstract

An endeavor to feel the pulse of a coast devastated by a powerful oceanographic event is made. Results of field investigations along Tamil Nadu seaside revealed that the tsunami of December 2004 demolished dwellings within strips ranging from 6 to 132 m (average width, 41 m) from the dune, and flooded up to 862 m (average, 247 m) from the shore. The event damaged sand dunes, ripped dune vegetation, created new water bodies and shattered high value assets. Comparatively, casuarina forests performed remarkably. Uprooting of trees was exclusively restricted to a frontal strip ranging from 5 to 25 m (average width, 14 m) nearest to the shore where the maximum wave run-up was 6.5 m above sea level. Sand dunes in general, and casuarina forests in particular, posses an innate capacity to dissipate powerful waves. This inference is supported by (a) negligible over wash along belts characterized by high dune complexes, (b) intact villages shielded by dense forests as well as sand dunes, and (c) maximum destruction of open beach front influenced by intense human activity. In this context, the coastal regulation zone (CRZ) Notification of 1991 offers sufficient scientific validity to be endorsed. However, post-tsunami ecosystem management initiatives lack a scientific basis. Therefore, a coastal hazards policy, that considers adaptation, dune restoration and forested buffer zones, is a sustainable long-term option for Indian coasts.

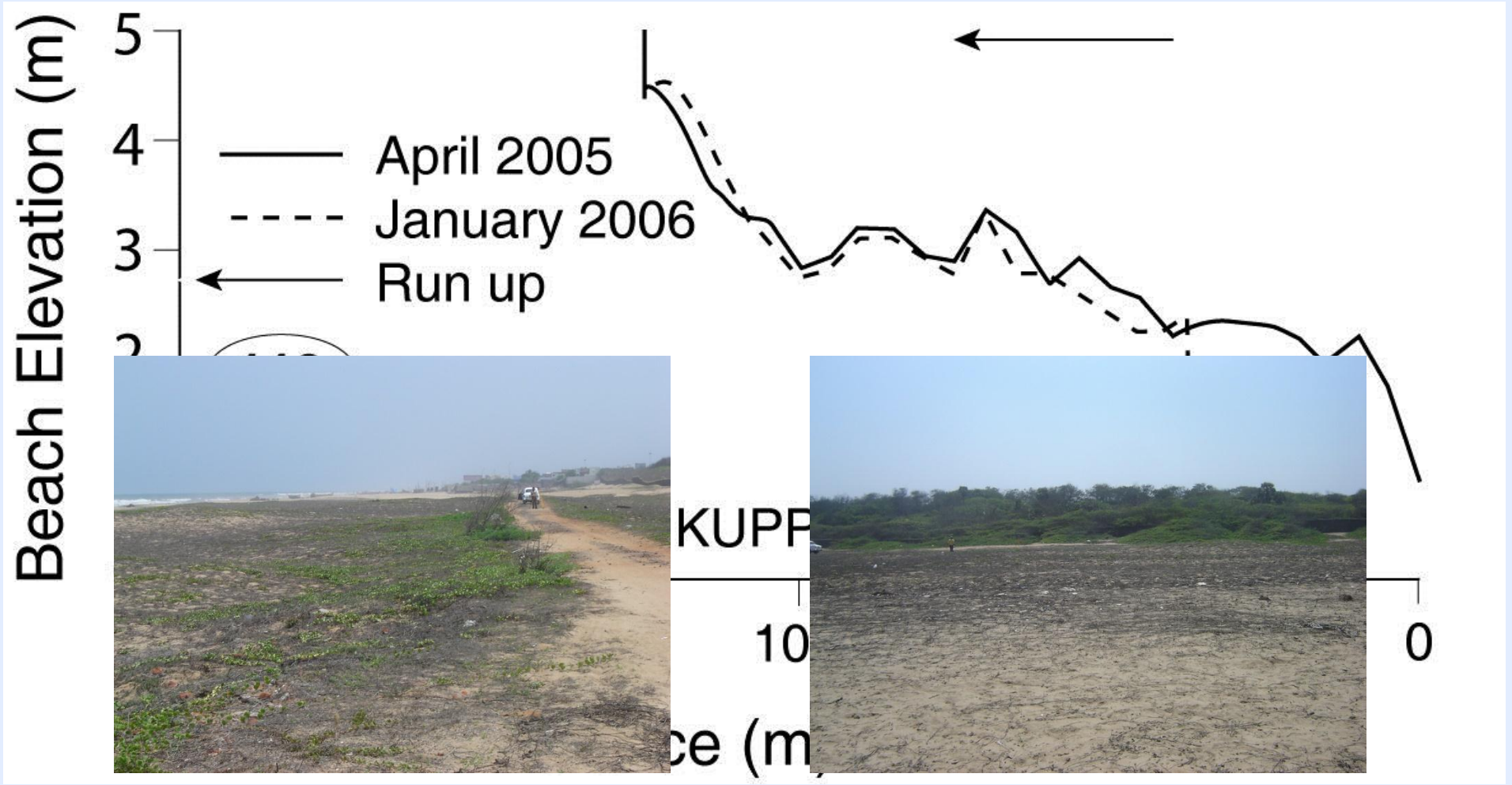
Keywords: Tsunami; Coastal regulations; Sand dunes; Coastal vegetation; Natural hazards; Tamil Nadu; India

Role of sand dunes - tsunami

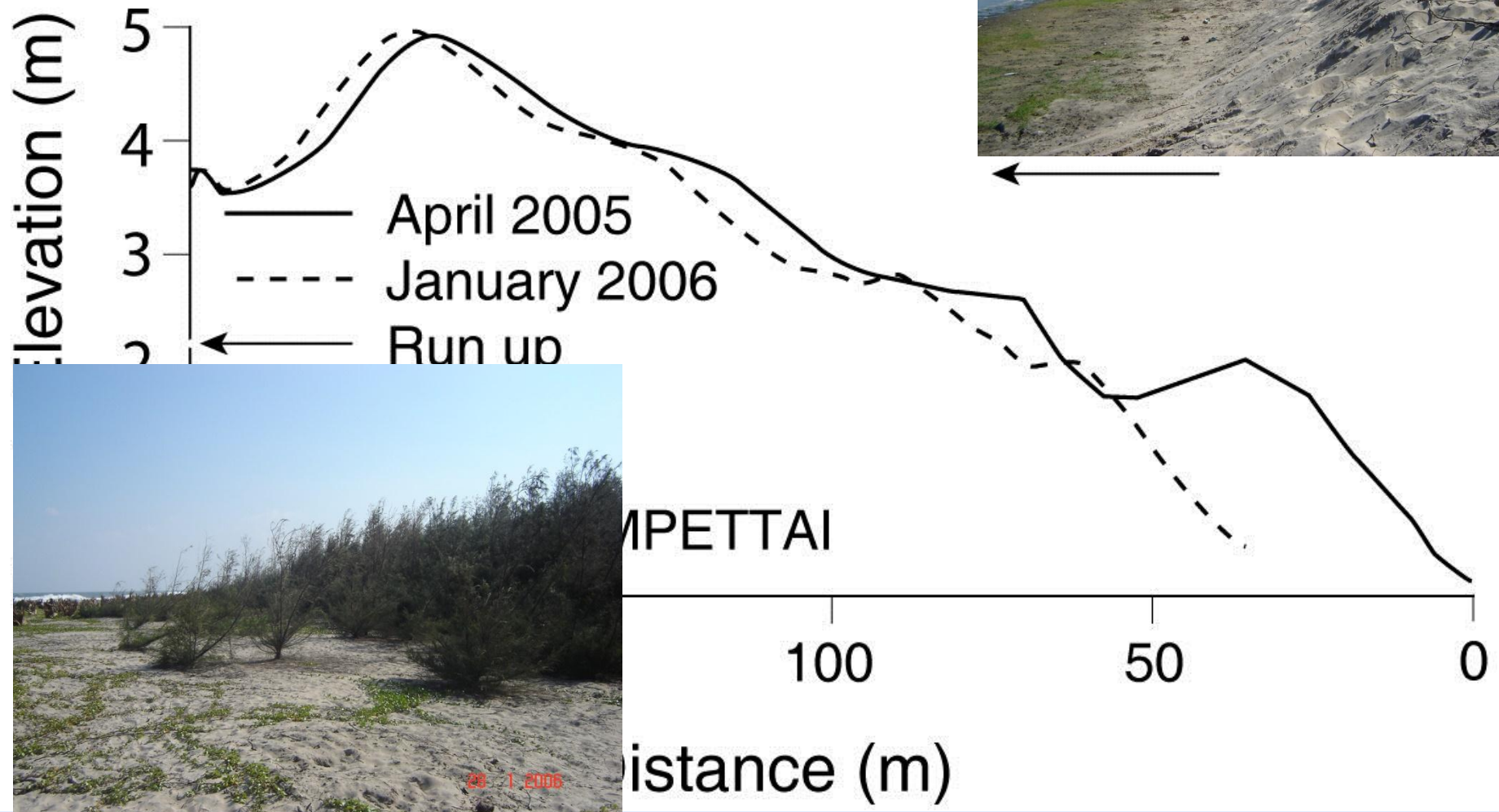
- Dunes served as natural buffers / protection
- Dwellings behind dune belts are all safe
- Steep beaches neutralized wave run-up
- Flat beaches were overshot by tsunami
- **Therefore, coastal dunes posses an innate capacity to attenuate energy from violent waves**
- Flattened dunes, gaps in dune ridges and roads facilitated over wash and tsunami up-rush

The following cases will confirm the natural buffer capacity of sand dunes

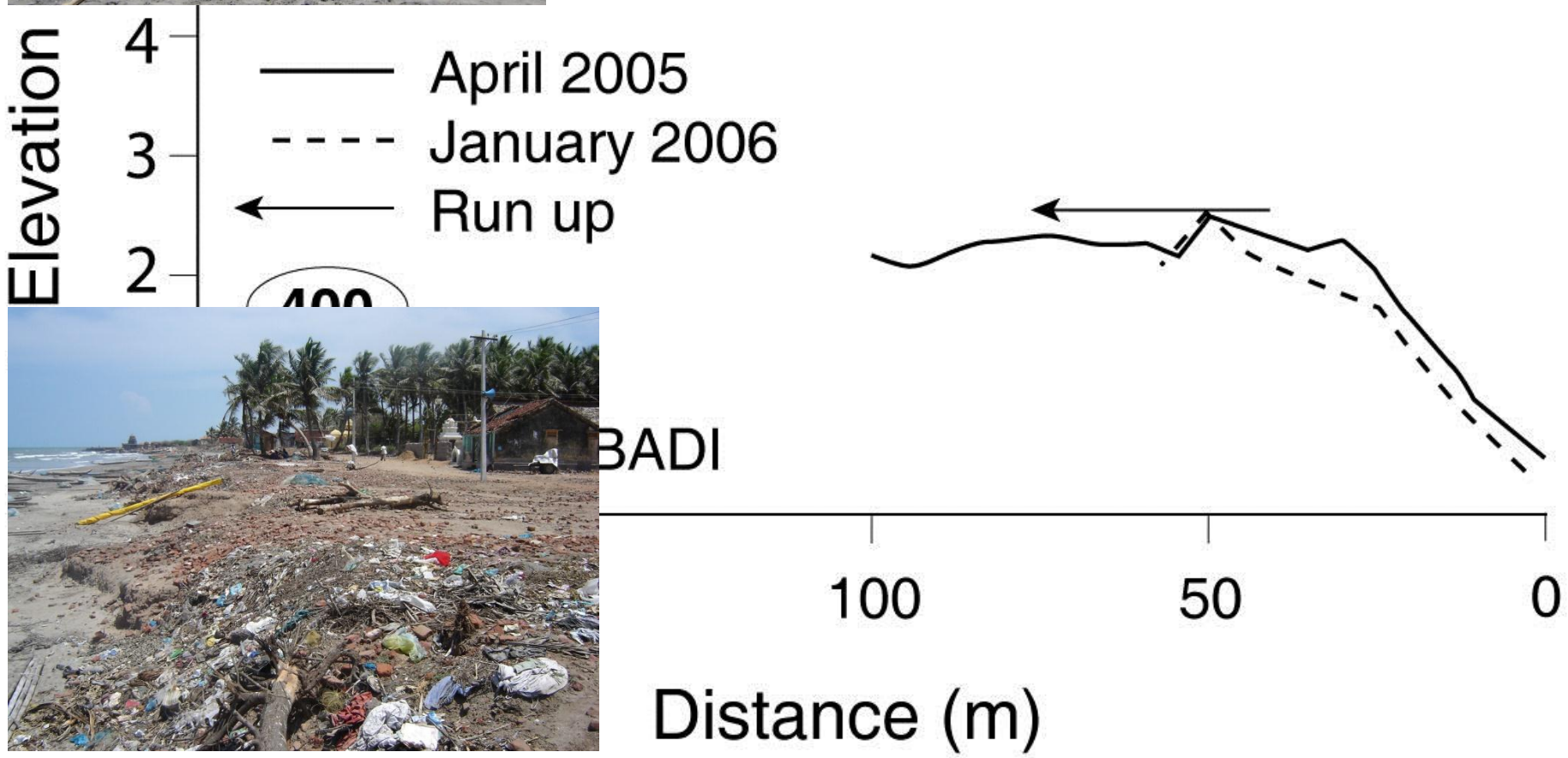
Ex. 1: Natural buffers such as high dunes lined by trees attenuated tsunami up-rush; inundation was minimal; damage to property was nil



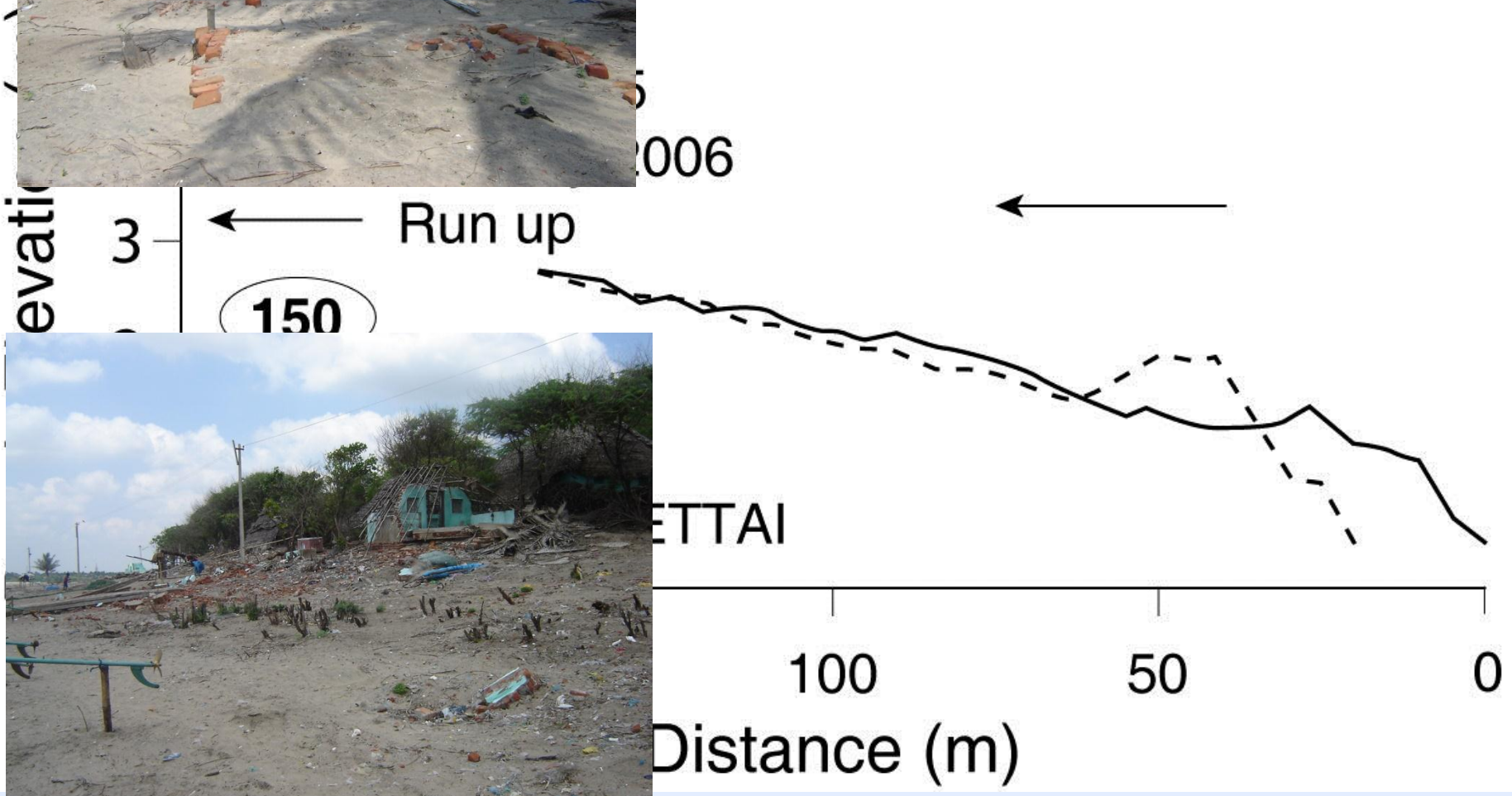
Ex. 2: Natural landforms saved life an
behind high <u>vegetated</u> dunes are all intac
gaps on dunes however facilitated ma



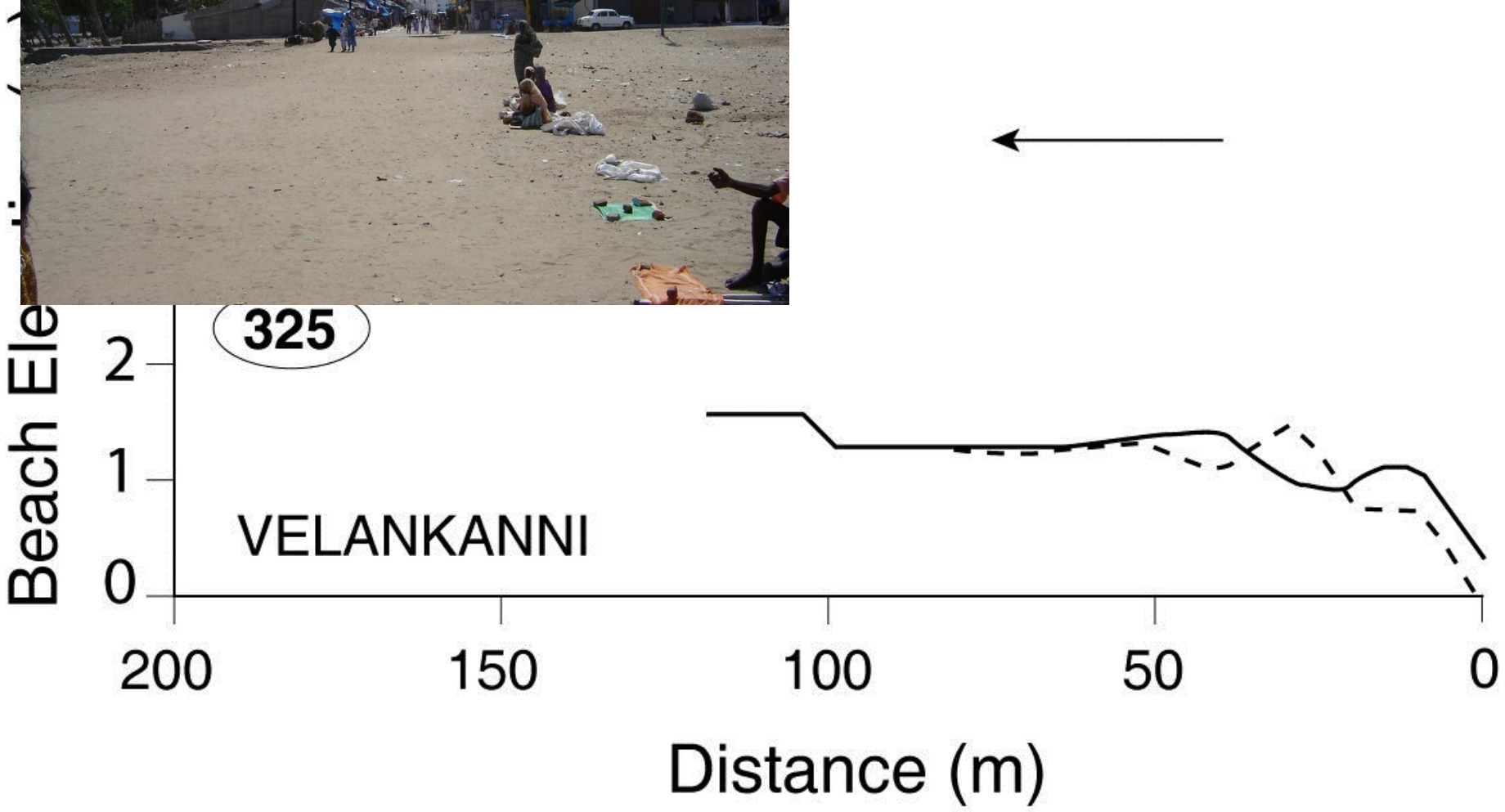
ural protection is the cause of disaster; all
each were smashed; loss of life was heavy;
served as a pathway for tsunami water



minimized tsunami up-rush; all huts /
each also blocked high waves, but
s behind dunes remained intact



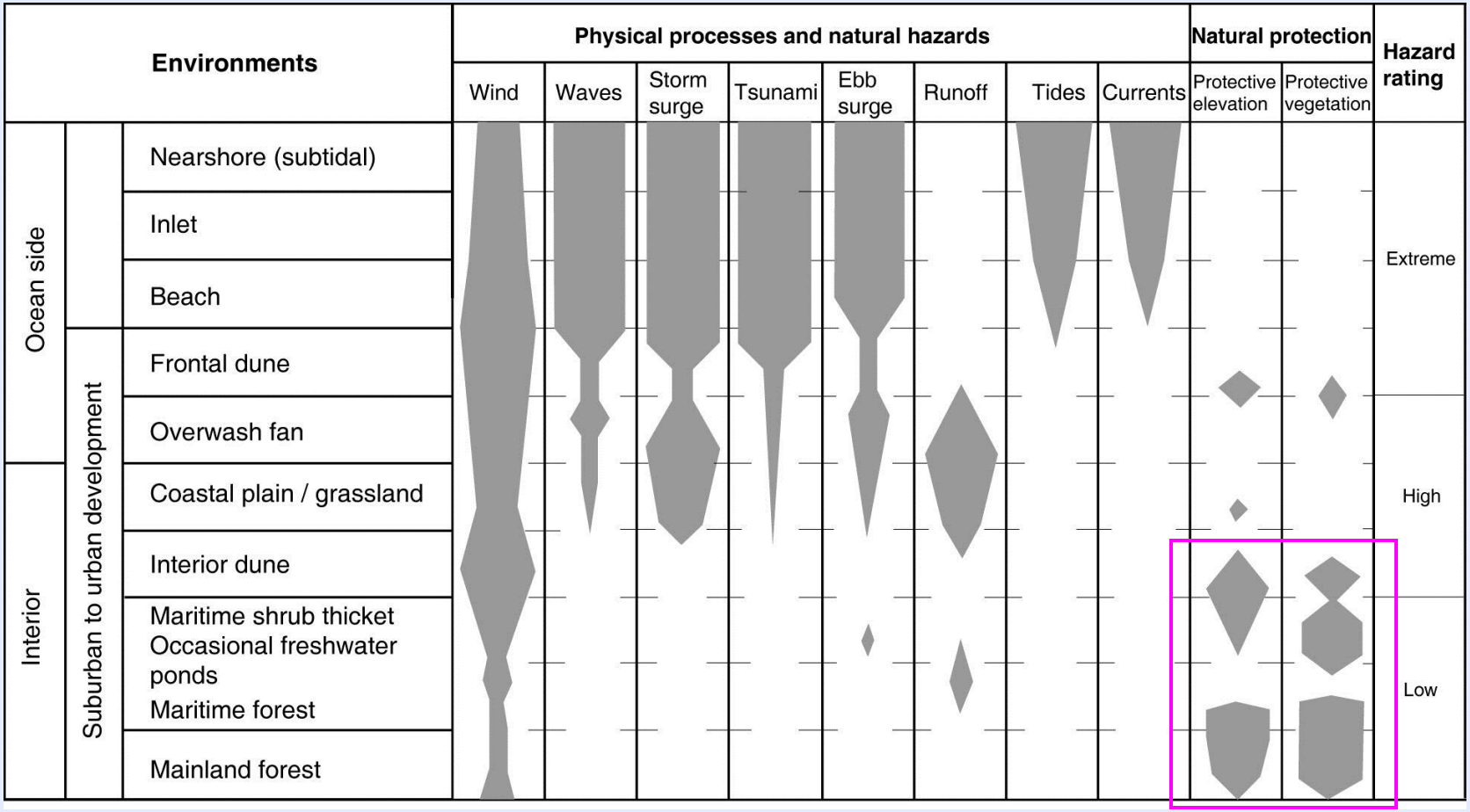
ver-use; tsunami waves
each; road facilitated
900 people perished



Sand dunes - tsunami

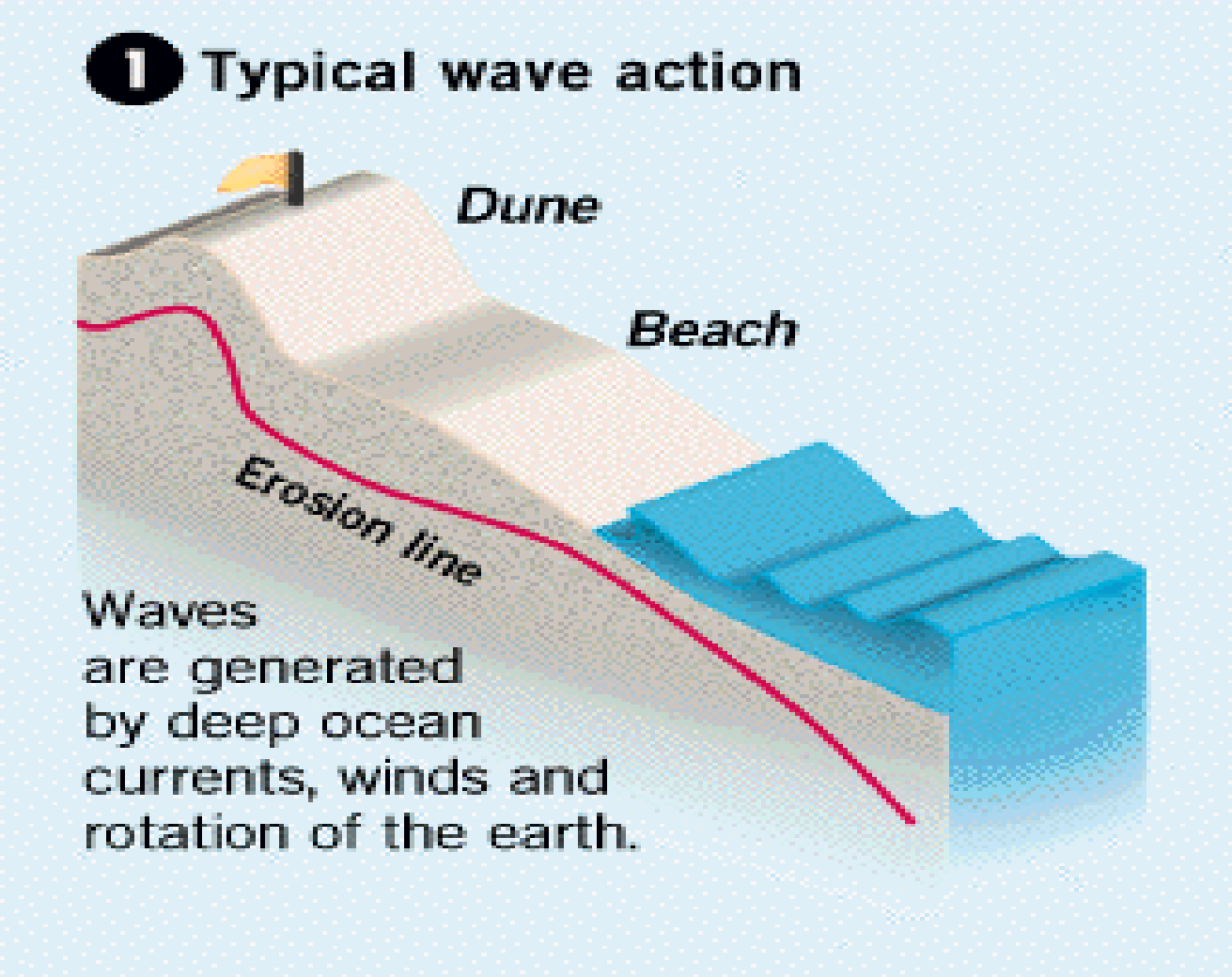
- **Dwellings demolished within strips of 6 to 132 m (Av. 41 m)**
- **Uprooting of Casuarina trees within strips of 5 to 25 m (Av. 14 m)**
- **Flooding recorded up to 862 m (Av. 247 m)**
- **Maximum damage to beach fronts influenced by human activity**
- **Negligible over wash in belts with high dune complexes**
- **Intact villages shielded by dunes or dense forests**
- **Protection offered by natural coastal landforms has sufficient scientific validity**

Coastal Hazards and Natural Protection:
Thickness of hatched portions indicates intensity of or protection from oceanographic forces



[Source: Mascarenhas, 2006]

Wave dissipation by coastal sand dunes



1. Since sand dunes are ecologically sensitive, these ecosystems are protected by law

2. Coastal sand dunes are classified as CRZ I

3. Dune strips are No Development Zones

CRZ I

- **ECOLOGICALLY SENSITIVE ECOSYSTEMS**
  - Mangroves, sand dunes, reserve forests, coral reefs, marine parks, spawning grounds, wildlife habitats, heritage sites, areas likely to be inundated due to sea level rise
  - Inter-tidal areas (HTL-LTL)

CRZ II

- Areas that have already been developed up to or close to shoreline
- Developed areas are those that are substantially built up with infrastructure
- Areas within municipal limits or designated urban areas

CRZ III

- Areas that are relatively undisturbed
- Areas not classified as CRZ I or CRZ II
- Coastal zone of rural areas (developed / undeveloped)

CRZ IV

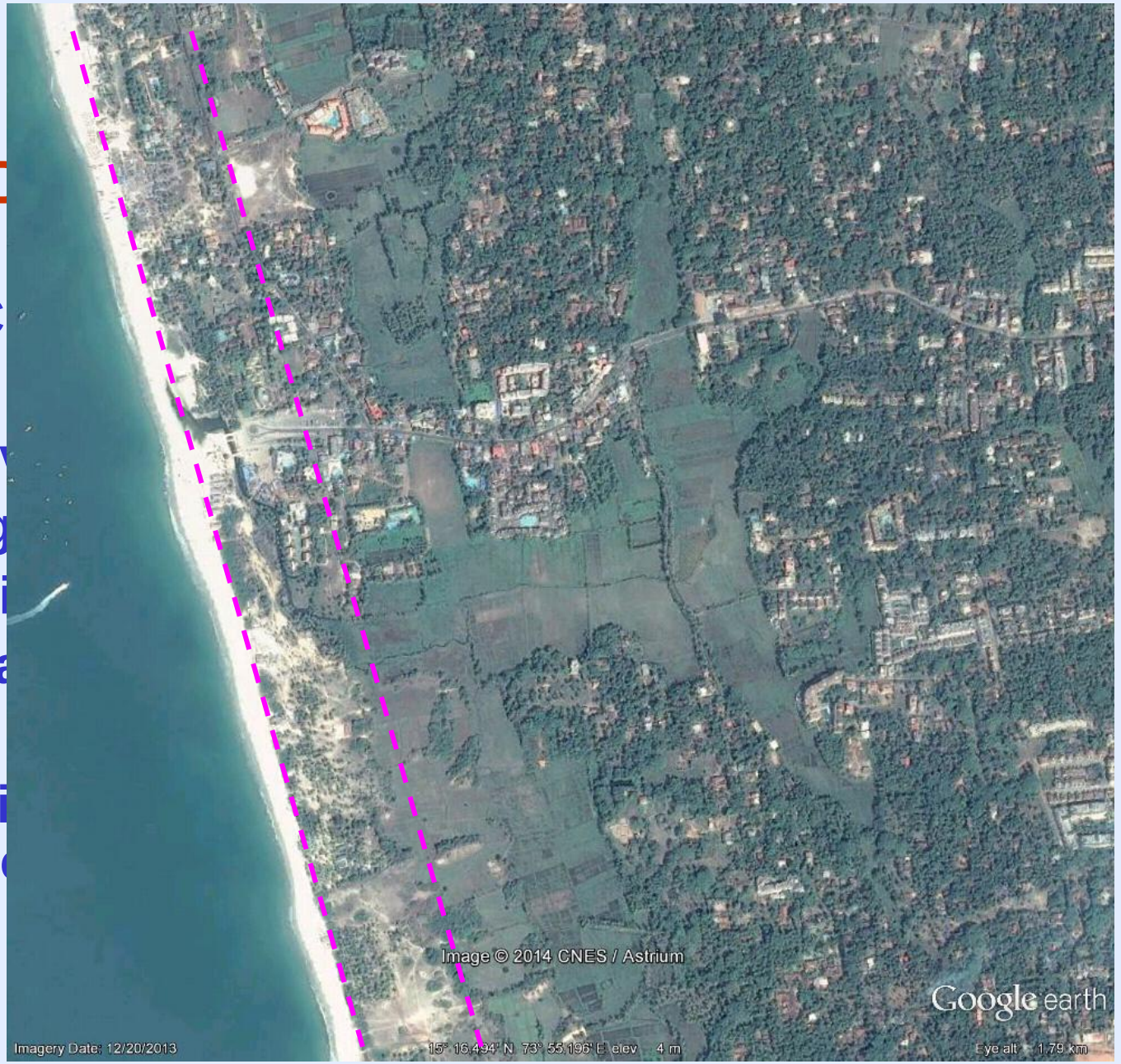
- Water area from the Low Tide Line to twelve nautical miles on the seaward side
- Also comprises the water area of the tidal influenced water body from the mouth of the water body at the sea up to the influence of tide.

No D

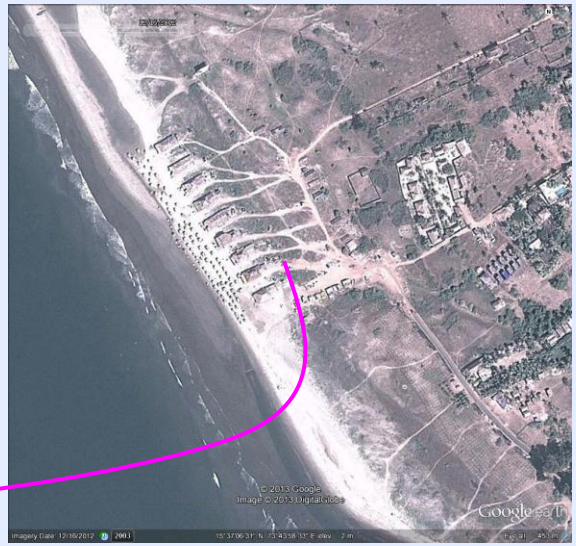
OPEN SEA C

- **CRZ I, sea**
- **CRZ II : dev**
  - **building**
  - **renovati**
- **CRZ III, sea**

- **CRZ IV - Ri**
  of river or



Choose a beach



CRZ news

(August 2014)

480 'CRZ violations' reported from April 2012 to June 2014

TEAM HERALD

PANJIM: As many as 480 cases of alleged coastal regulation zone (CRZ) violations have been reported from April 2012 to June 2014.

MINISTER'S REPLY

While three face action, in some cases reply to show cause notices are awaited while some are pending before the inquiry committee under Goa Coastal Zone Management Authority (GCZMA).

This was informed by Environment Minister Alina Saldanha on the Floor of the House of the ongoing Assembly session, who stated that "action has been initiated into all the complaints received pertaining to alleged violations of CRZ notification 2011".

It may be recalled that the minister was under severe criticism from Opposition as well as ruling legislators for failing to take action against the violators.

Replying to a question tabled by Congress legislator Atanasio Monserrate, the minister said that as many as 480 complaints of violations of CRZ were received by GCZMA from April 2012 till June 2014.

The maximum number of violations was reported in the tourism-rich talukas like Bardez - 237, Pernem-86, Salcete-58, Tiswadi-43, Canacona-28 and Mormugao 21.

Bicholim (3) and Ponda (4) reported the least violations.

These violations include illegal construction of residential houses, commercial projects like hotels, shacks, restaurants, additional roof or rooms to the existing structures, illegal construction of retaining walls, destruction of mangroves and others.

Of the total 480 cases, around 136 show cause notices have been issued, the report of which is still pending and remainders have been sent to expedite the same. A whopping 335 cases are pending before the GCZMA inquiry committee for action.

The GCZMA which enforces the provisions of the CRZ notification, 2011 issued by the Union Ministry of Environment and Forests (MoEF), has in last two years, issued stop order in three cases, one each in Bardez, Tiswadi and Salcete.

There are total six cases in litigation, pending before National Green Tribunal (NGT), High Court and district court.

- 1 violation every 200 m of coast!
- There are as many not reported!
- Maximum violations per unit km!

Titan in a Titanic pose: Chief Minister Manohar Parrikar spreads his hands wide to a query raised by Porvorim MLA Rohan Khaunte on flyover towards NH-17.

Severely criticised for failing to give concrete answers

TEAM HERALD

With Alina coming in for sustained criticism, for failing to give concrete answers, Chief Minister Parrikar had to jump into the fray in a bid to protect his minister

PANJIM: The Goa Assembly on Thursday witnessed fireworks, after Forest and Environment Minister Alina Saldanha, came in for sustained criticism, for failing to give "concrete" answers to questions raised on the Coastal Regulation Zone (CRZ) violations, such that Chief Minister Manohar Parrikar had to jump into the fray in a bid to protect his minister. Parrikar announced that Goa Coastal Zone Management Authority (GCZMA), being a statutory authority, questions related to it would not be tabled in the House from the next Assembly session onwards, further incensing MLAs.

The announcement triggered off chaos as Congress MLA Aleixo Reginaldo Lourenco and Independent MLA Vijai Sardesai objected strongly, stating that the "government should shut down the Assembly if it wants to allow questions as per their (ministers') wishes".

Sardesai, who had raised question on CRZ violations, sought to know what steps the GCZMA has taken against these violations. He was supported by ruling MLAs -- Michael Lobo and Nilesh Cabral, who questioned the environment minister over the denial of beach access to locals by some restaurant and hotel owners.

To this Alina replied, "GCZMA is the authority dealing with taking action against illegal constructions by the hotel units in the area and not to carry out survey to identify whether the access is denied or not".

Alina's reply failed to satisfy legislators, and in a bid to defend herself she said that "being a Minister she could not keep minute details of each CRZ violation case." This agitated the legislators further.

As the situation slowly spiraled out of control, the Chief Minister intervened saying that the "GCZMA is a statutory body appointed by the Central government and apart from its administrative functioning, State government has no role to play" and "since State is not in total control of it, no assurances or firm answers can be given. Also we cannot issue directions to GCZMA."

BIG FIGHT

Alina, in her reply to one of the question raised by Congress MLA Digambar Kamat said that a total of27 cases of CRZ violations have been brought to the notice of GCZMA, out of which 17 cases were pending before the inquiry committee headed by retired civil court judge. Another three cases, in which demolition order were issued were challenged before the National Green tribunal (NGT), two cases have been referred back by NGT; in two cases demolition has been done; in one case demolition is pending and one has been stayed by the Supreme Court.

Earlier, bringing to the notice of the House that 26 CRZ violations had taken place in Morjim, Mandrem coastal areas, Sardesai sought to know what action was initiated against two restaurants - Sunset Ashram and Hotel Blue Waves, both allegedly in violation of the CRZ and one constructed on a turtle nesting site. The Minister in reply said that the GCZMA inquiry committee is inquiring into the Sunset Ashram case, while the demolition order issued to Hotel Blue Waves has been stayed by NGT.

The Fate of NDZ

- **Reduce no development zone to 100m: Parulekar**
- TNN | Jan 18, 2015, 03.00 AM IST
- comments
- Panaji: In a controversial move, the Goa government has sought to reduce the no development zone (NDZ) line in the CRZ notification to 100 metres instead of the present 200 metres from the high tide line (HTL) to allow for "development of tourism infrastructure along the beach".

Goa tourism minister Dilip Parulekar in a letter has requested Union tourism minister Mahesh Sharma as a follow up to his recent meeting explaining that the present NDZ has left large stretches of land unutilized along Goa's 105-km long coastline.

He explained that prior to independence, the NDZ was defined as 90 metres from the HTL.

Also, the Swaminathan committee report has recommended review of the blanket NDZ provision in the CRZ notification, Parulekar said, adding that in some foreign tourist destinations like Maldives and Thailand, "construction of hotel properties is permitted in lagoons and within the continental shelf area."

Parulekar has also requested that the CRZ provision which forbids cooking of food on the beach be reviewed.

Requesting for central financial assistance under different schemes of the tourism ministry, Parulekar has proposed that pending utilization certificates may be adjusted against future installments which Goa is eligible to receive.

Speaking to the media, GTDC chairman Nilesh Cabral, said that Goa has to return Rs 14-crore in unutilized funds to the Centre. These funds were received by the previous Congress government, Cabral said.

Parulekar has also requested for central financial assistance for marketing and promotion activities in tourism. He pointed out that in 2013-14, Goa received 93% of the charter flights to India.

Parulekar has asked for provision for direct incentives for charter operators that maintain a high load factor and bring in additional flights. Such practices are followed by countries like Egypt, Parulekar said, adding, "Such an incentive is required very urgently as this year alone there has been a drop in charter arrivals in Goa by almost 40%".

The tourism minister has also urged that countries like UK, China, Poland, France, Portugal, Czech Republic and all Scandinavian and CIS countries be allowed the e-visa facility. He has also requested the e-visa fees be reduced. Parulekar sought for separate immigration counters at Dabolim airport for handling e-visa arrivals to reduce the processing time.

No Cabinet decision to relax CRZ, NDZ: Alina

TEAM HERALD

PANJIM: Differing with a recent statement by the pro-tourism lobby within the government, Environment Minister Alina Saldanha, said that the State Cabinet has not taken any decision seeking relaxation for the Coastal Regulation Zone (CRZ) and No Development Zone (NDZ).

"We cannot play with nature as the consequences can be severe and we will have only ourselves to blame" Saldanha said.

At a press conference recently, the pro-tourism lobby within the government had said that they had petitioned the Centre that it take cognizance of the Swaminathan report and relax the CRZ and NDZ norms in certain areas of the State's 105 km long coastline.

The environment minister opined that the existing 200 mts NDZ was most beneficial to the State and to the interest of various stakeholders.

"This was the wisdom of our ancestors which has kept the NDZ CONTINUED ON PAGE 10

No Cabinet decision to relax CRZ, NDZ: Alina

intact till date and is maintained for the protection of the water bodies, their biodiversity and indirectly for the protection of mankind," she said. She added that it is a fact that Goa is a popular tourist destination precisely because of its green and beautiful environment.

Saldanha argued that the continuous influx of migrants had made Goa congested and polluted thus reaching a saturation point. There is a decline in tourists visiting the State this year because of complaints of overcrowded beaches, garbage and other factors having no connection whatsoever to the NDZ limits. "Decreasing the NDZ will only increase congestion and further drive away the tourists," Saldanha insisted.

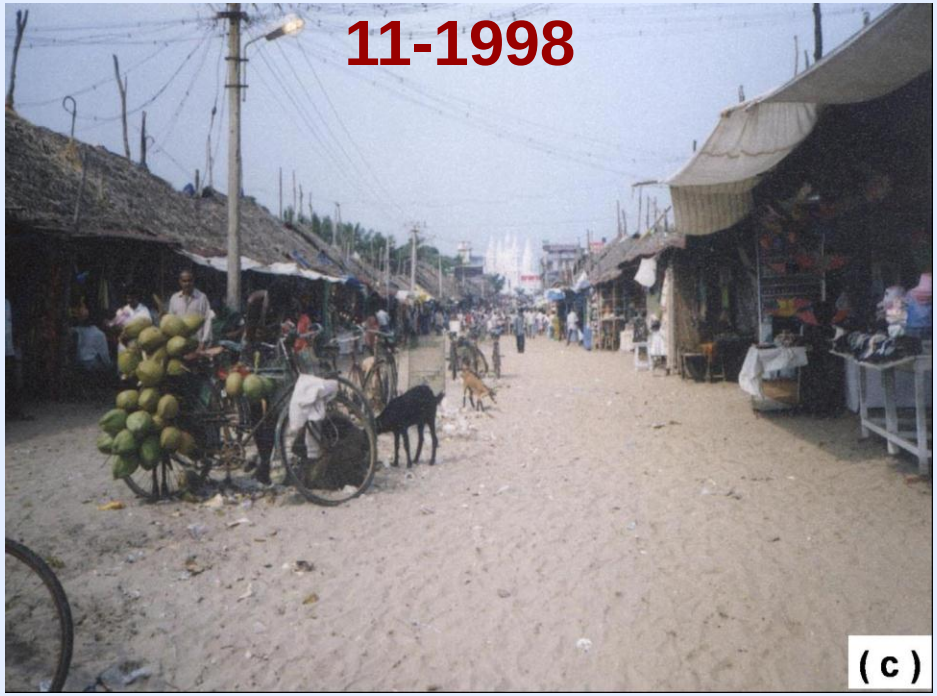
Pointing out that some CRZ rules and regulations allow for necessary tourism related development on the beaches viz in CRZ II between LTL and HTL, community toilets with changing rooms and rain shelters are allowed. The same are also allowed in CRZ III area.

This is, however, not an open permission but will be permitted on a case-to-case basis and therefore urgent tourism needs can be met without decreasing the NDZ, she said.

The environment minister, however, applauded and supported the tourism minister's demand that Airport Authority of India should reduce the exorbitant increase in royalty charges and scrapping of the user development fee imposed on Dabolim airport passengers and for demanding that Dabolim airport be made operational 24 hours a day for all scheduled and non scheduled foreign flights.

"The Navy must provide space for civilian expansion activities of Dabolim airport and shift its clubs and golf course elsewhere for the sake of the tourism industry and the State at large," she said.

Business as usual: Velankanni



Along India's HTL

Kovalam, Kerala (2008) - Palolem, Goa (2013)

Puducherry coast: then and now

1998 : A narrow linear beach along the sea wall

A receding dune and flooding at Morjim
(and at Baga)

Sea level - beach height - dune elevation nexus

Wave uprush on an eroded beach

(High tide Dec2013)

Navhind Times,
17 November 2014

Concern as Baga beach witnesses sand erosion

Lobo to ask WRD, NIO to carry out inspection

Tourists walk through a flooded stretch of the Baga beach caused due to sand erosion. Joseph Pinto | NT

NT NETWORK

CALANGUTE: Baga beach in the north has become another coastal stretch to be affected by sand erosion. Locals including the fishermen, shack owners and water sports boat operators have expressed concern over the damage the beach has suffered and called for immediate measures.

Calangute MLA Michael Lobo said it is a serious matter and that the National Institute of Oceanography should look into it and come out with a solution.

He said he will ask the water resources department to carry out inspection of the beach along with NIO officials so that a solution is arrived at to protect and preserve the beach.

Albert Fernandes, former sarpanch of Calangute, pointing that a retaining wall has washed away due to erosion, said villagers had witnessed such a situation some years back during tsunami and anyone visiting Baga will see the difference in the beach now.

Jose Fernandes, president of traditional fishermen at Baga, said that due to sand erosion it becomes difficult for the fishermen to navigate their boats along the creek.

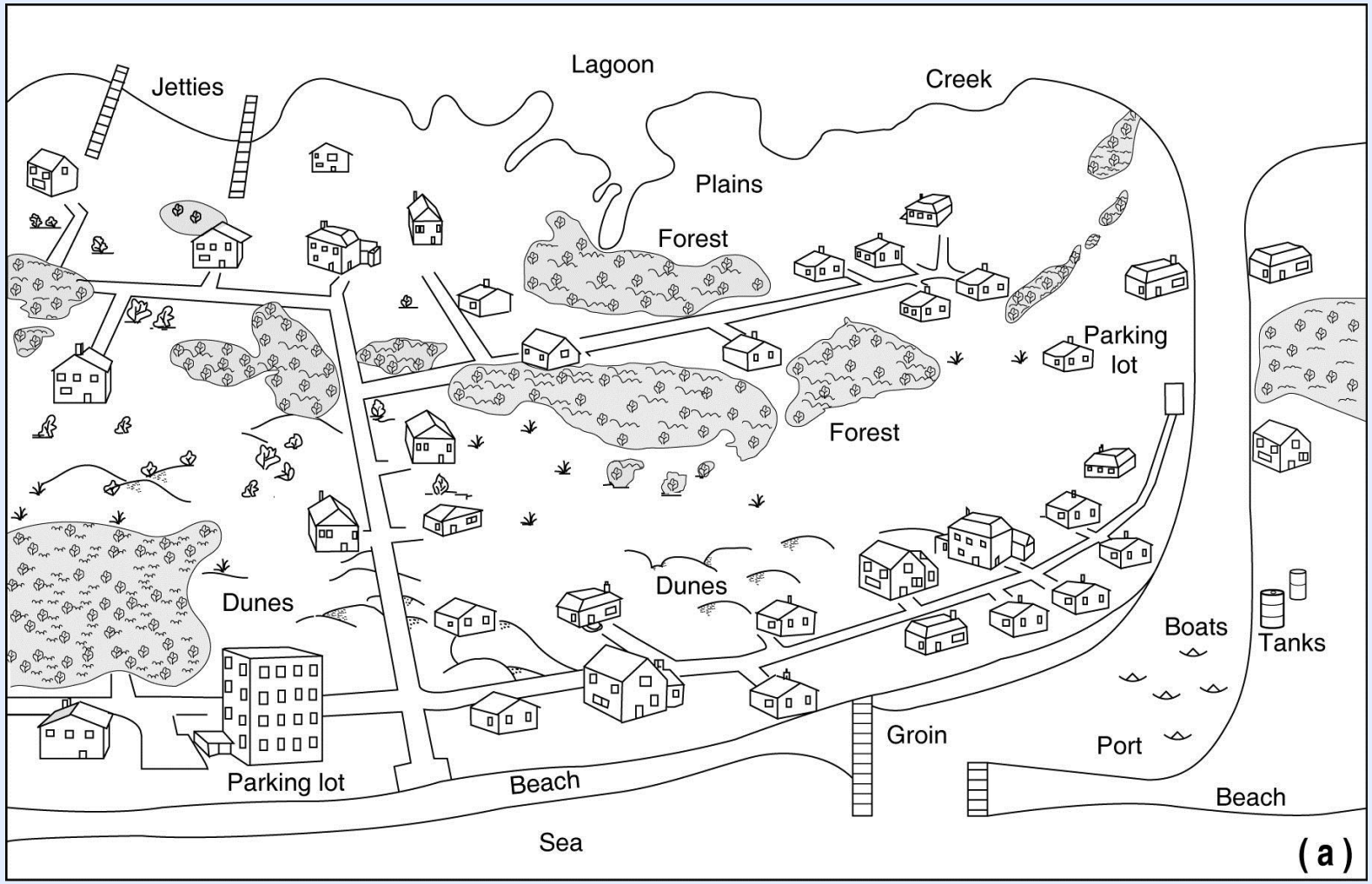
Peter Carvalho, owner of a shack, said the stones that are seen on the beach are of the old retaining wall that had washed away many years ago.

Ronnie Fernandes, who runs water sports business, said that "due to sand erosion we have to operate our boats 80 meters from the beach and tourists have to wade through water during high tides to reach the boats."

CAN DAMAGED COASTS BE REPAIRED?

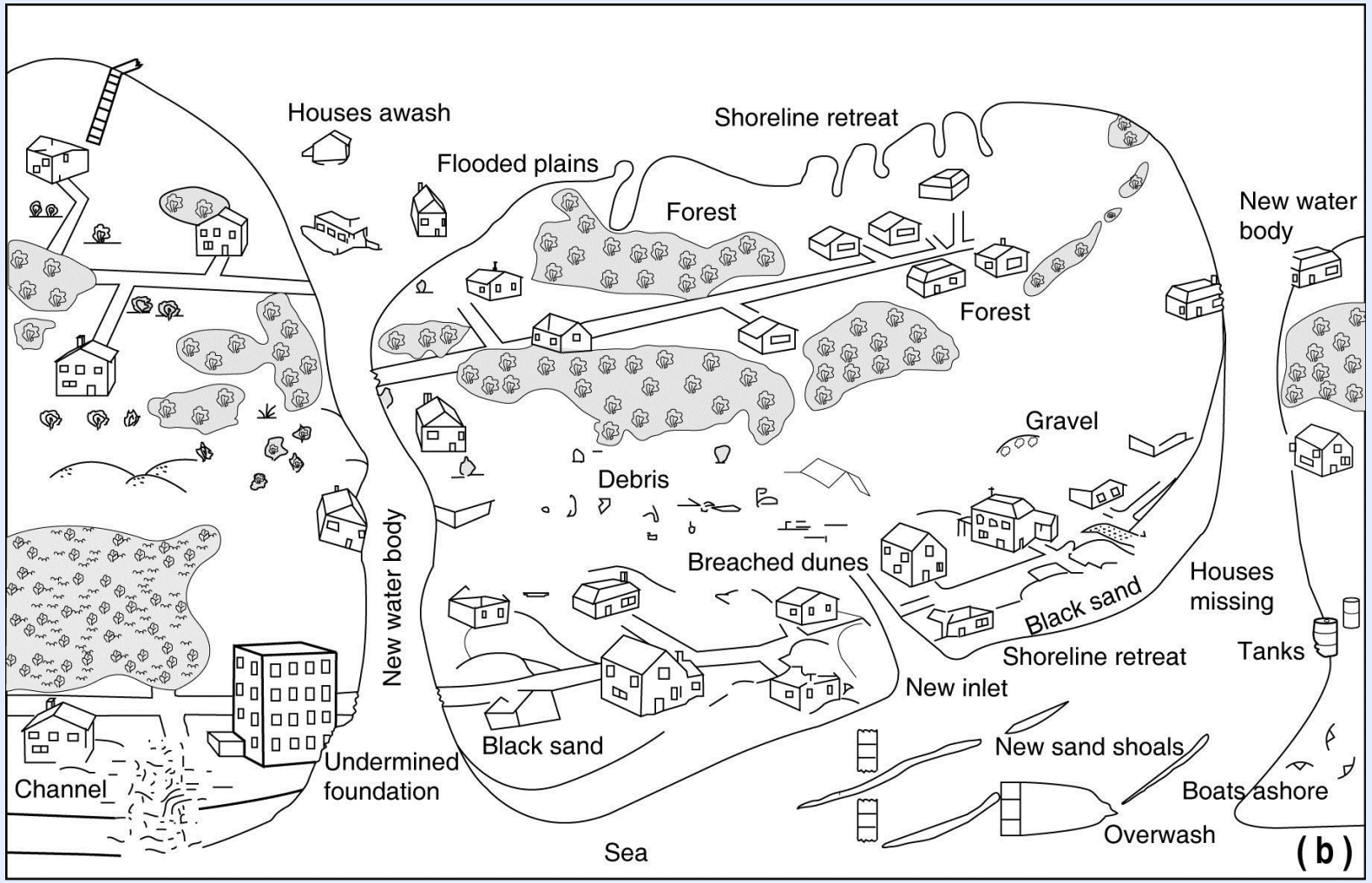
- Is it possible for a breached sand dunes to come back to life?
- Is it possible to rejuvenate coastal flora?
- Is it possible to stabilize a beach – dune system?
- IT IS TIME THESE ASPECTS NEED TO BE CONSIDERED
- THAT IS WHAT COASTAL RESTORATION AND CONSERVATION IS ALL ABOUT

Scenario 1: A human altered coast- dunes are leveled, forests are cleared, dwellings too close to water line, setbacks lacking

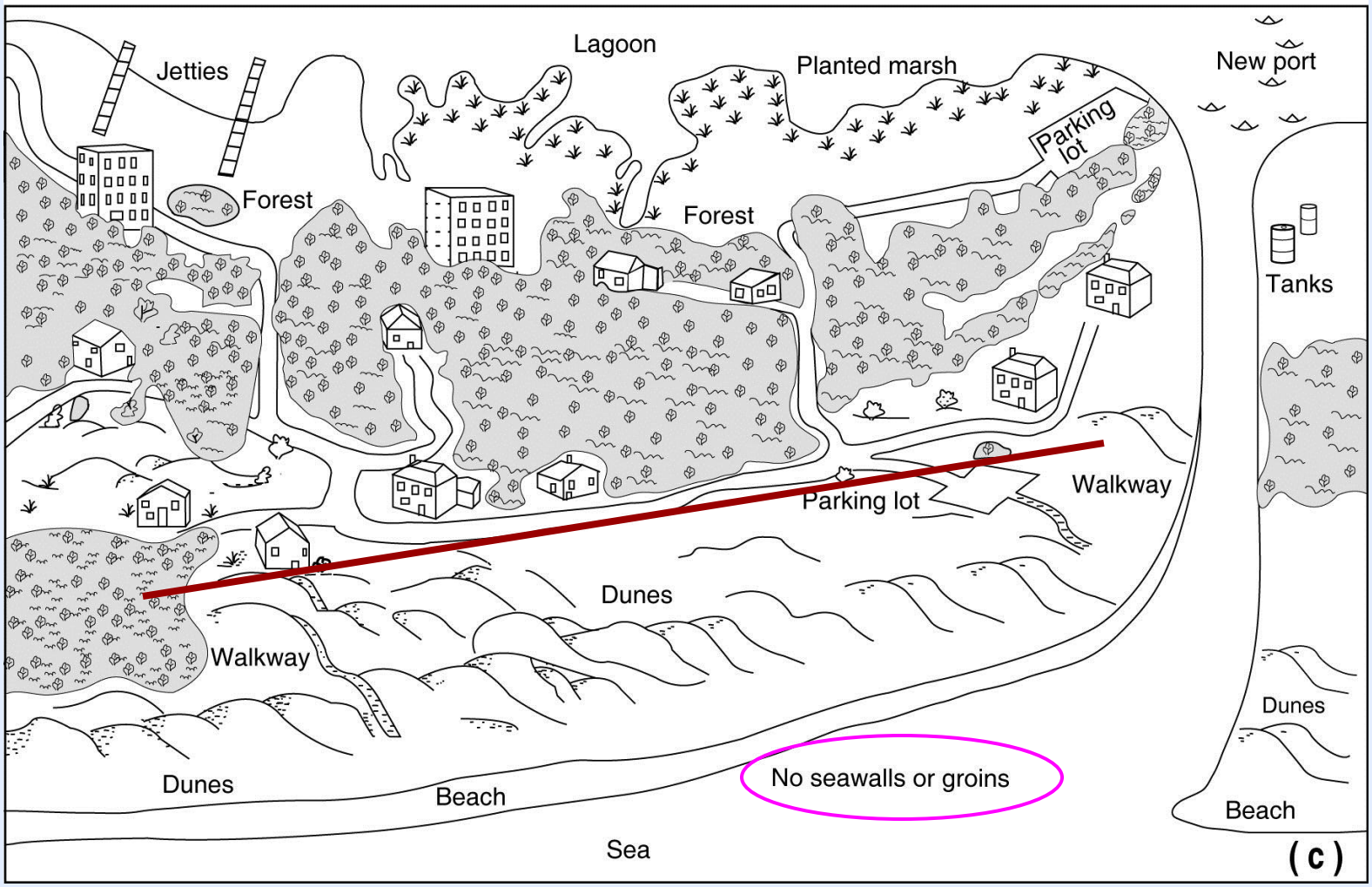


The 2004 tsunami: Kalutara beach, Sri Lanka

Scenario 2: Drastic landform changes after extreme events – breaching of dunes, formation of new water bodies, demolition of sea front structures, uprooting of sea walls



Scenario 3: Restoration of a damaged coast – dunes are rebuilt, forests are extended, roads are redesigned, buildings are relocated, adequate buffer zones are designated



A dune restoration experiment at Miramar

- **A dune building initiative, attempted for the first time in the country**
- **A technique to re-create lost / damaged dunes using scientific backup**
- **Creation of a new landform that forms naturally but fashioned artificially**
- **An example of science – scientist – administration – policy can interact**
- **A purely coastal management oriented program**

Techniques – dune restoration

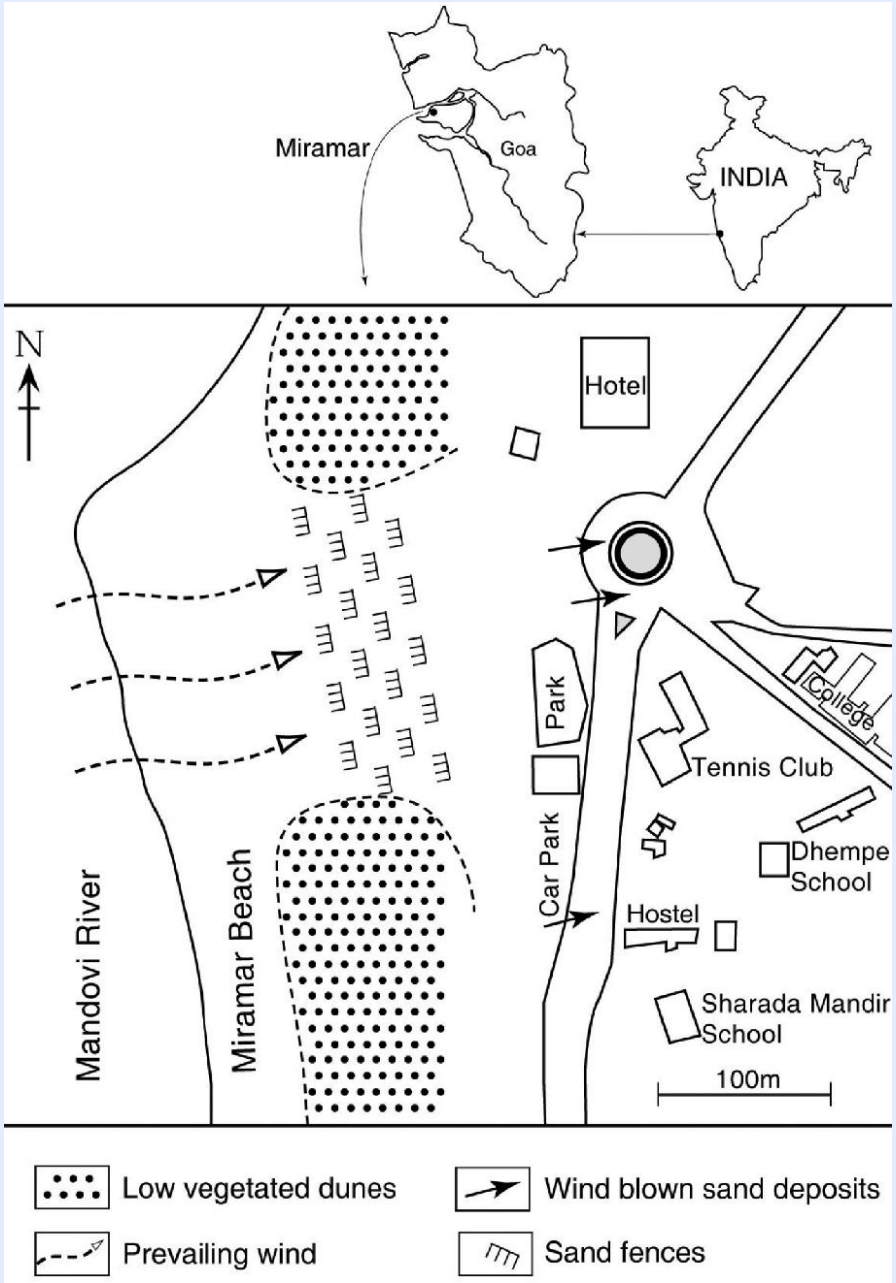
SOFT OPTIONS

- Use of sand fences
- Artificial beach nourishment
- Bio-restoration

Sand fences : an environment friendly option to arrest sand movement and restore coastal dunes

- Linear fences perpendicular to wind direction is the only scientific option
- Fences to be fixed ONLY on dry beach
- Single fences to be 1 m high, 15 m long, with 3 - 5 m spacing, made of waste wood strips
- About 4 to 5 rows of parallel fences appear ideal (on available open, barren sandy space)
- Fences should have adequate spacing of at least **5 cm** between vertical strips

A 160 m STRIP OF DEGRADED SAND DUNES AT MIRAMAR



The problem at Miramar

Wind blown sand creates traffic hazards

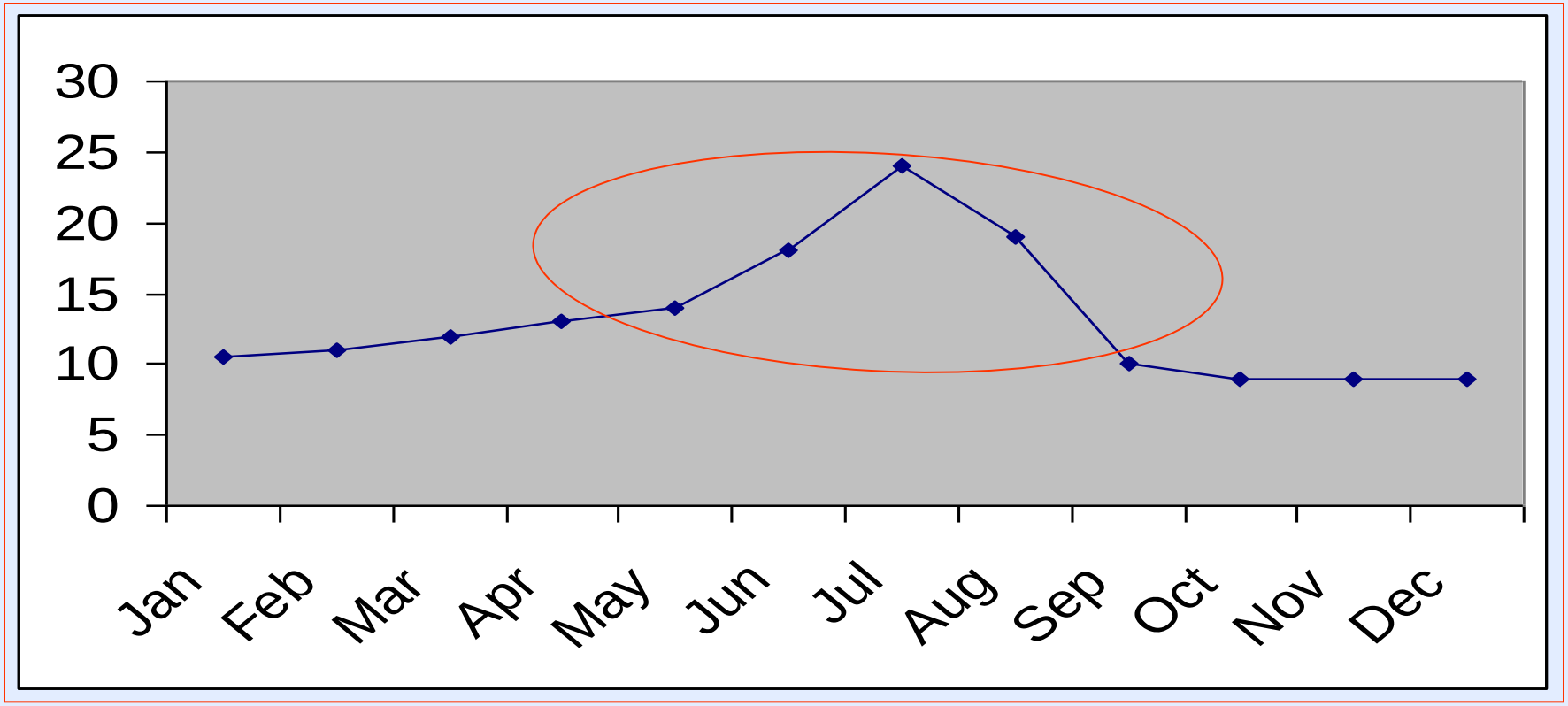
02 July 1998

17 June 2004

Winds at Miramar

<u>Wind direction:</u> Dominantly West (and Northwest)

<u>Wind speed:</u> Yearly average is 9 to 14 km/h; often increases to >25 km/h during monsoons



Causes of Eolian Sand Transport

The process:

- **Human interference on dunes**
- **Uprooting of dune plants**
- **Creation of bare dunes**
- **Production of loose sand**
- **Sand is rendered mobile**
- **Sand moves at wind speed >16 km/h**
- **Blowing of loose sand inland**
- **Observed wherever large dune areas are flattened or opened**
- **Large scale process at Miramar and Colva**

Major Episodes

02 July 1998

Traffic island covered by sand

Wind speed ~25 km/h

16-17 June 2004

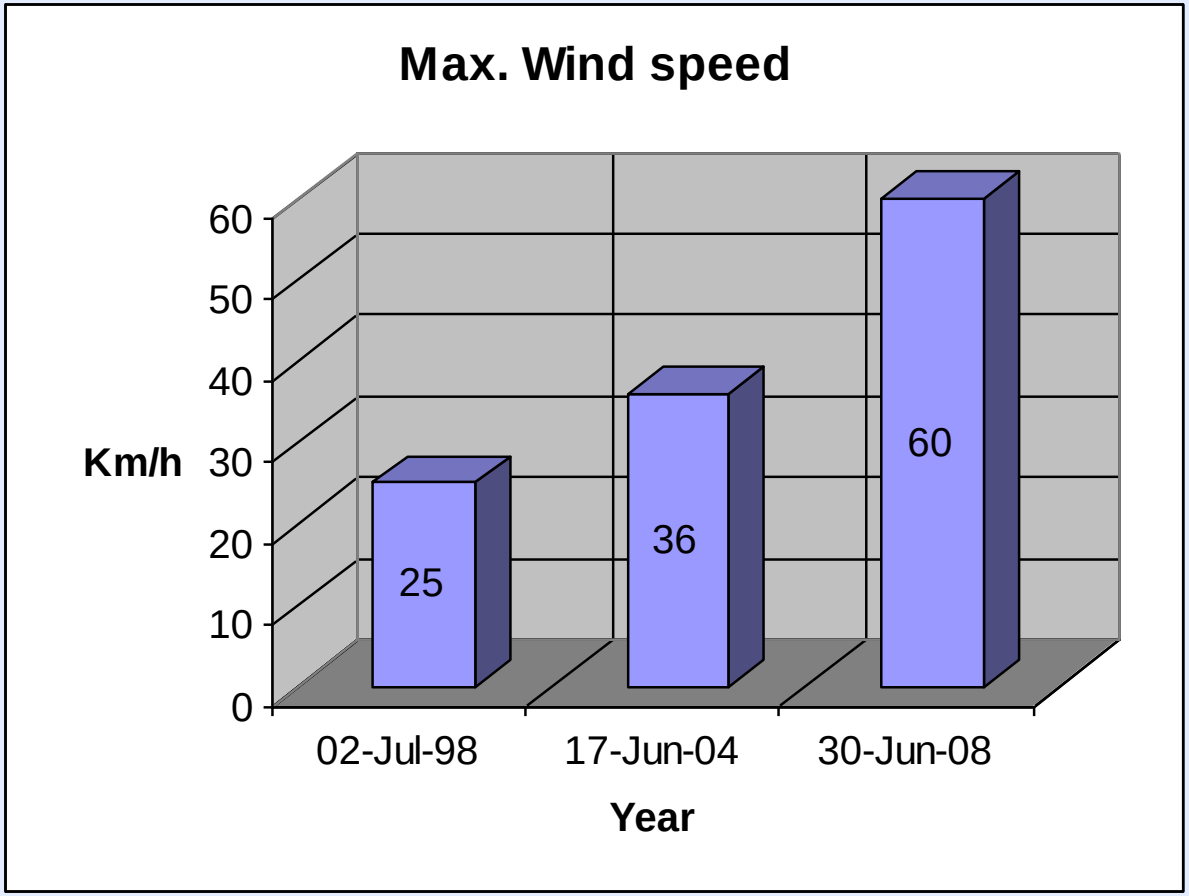
Large amounts of eolian sand on road

Wind speed 36 km/h

29-30 June 2008

Wind speed ~60 km/h

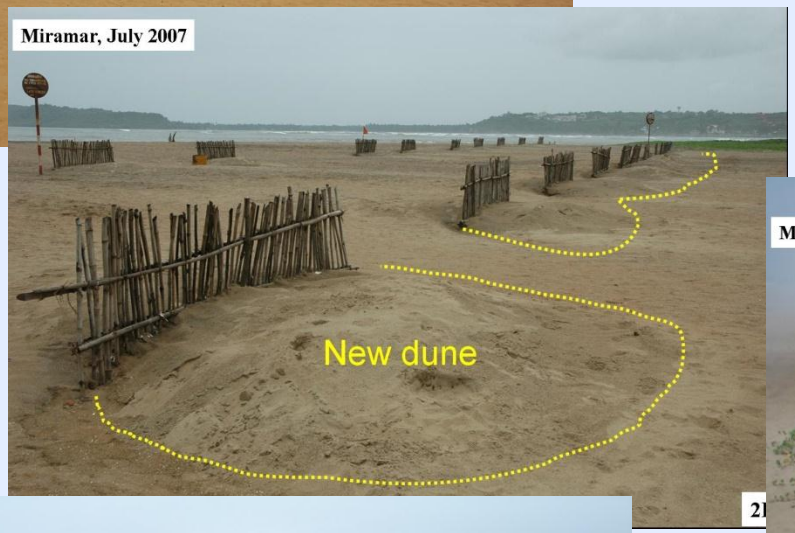
Max. Wind speed, Goa coast



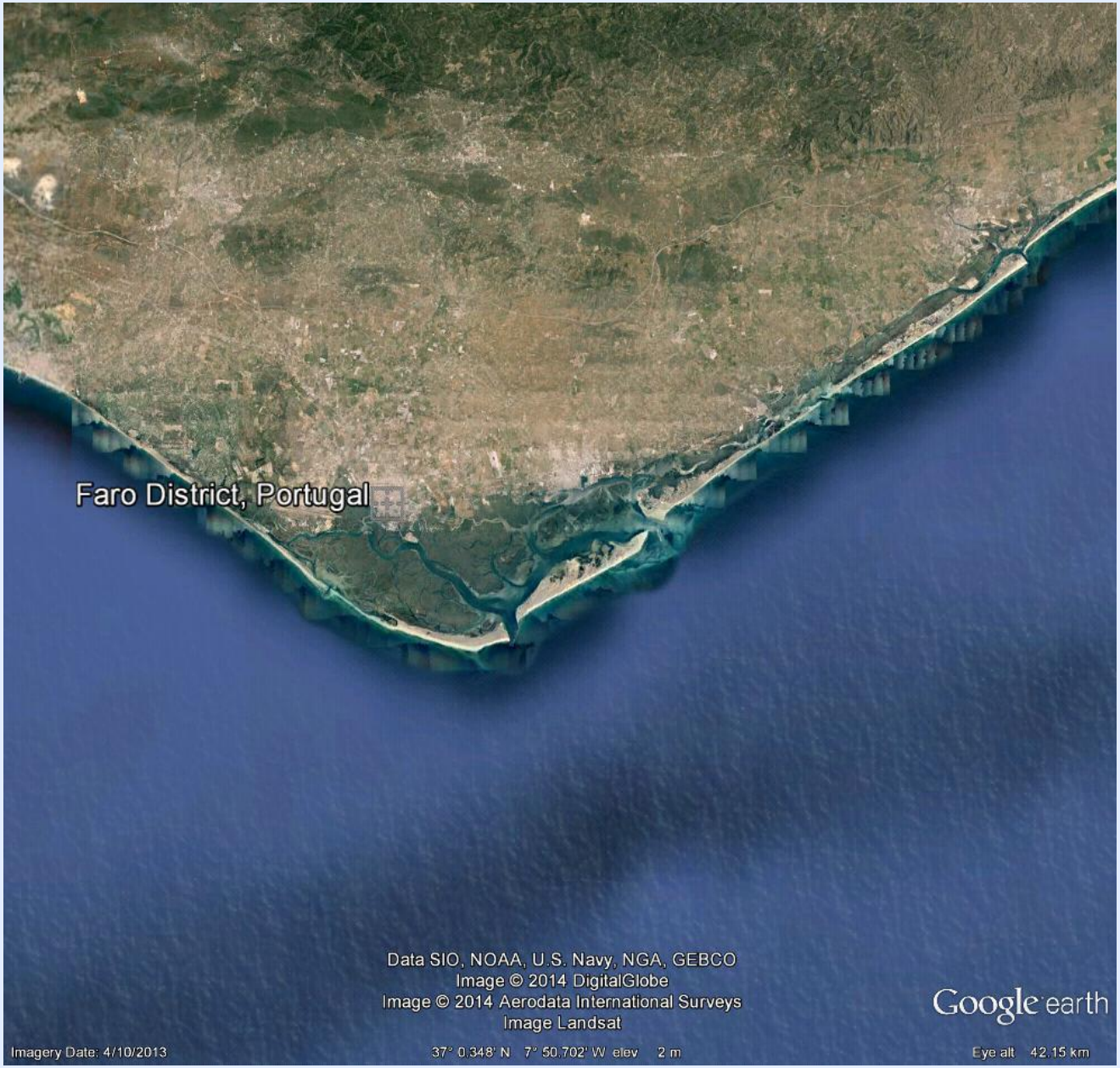

Method to reduce sand movement
Fences
Wind
NEW
DUNE
© 2006 Europa Technologies
Image © 2006 DigitalGlobe
Google
Pointer 15°28'57.85" N 73°48'32.38" E
Streaming 100%
Eye alt 2587 ft

Dune formation : chronology

- Partly restored dune line over time -



Protected dune systems in southern Portugal



Examples of sand fences and a dune walkover

Algarve, Portugal, May 2007

Google image of 1 km long sand fence, Faro beach, Portugal

France


Imagery Date: 10/16/2012 42°39'53.93" N 3°02'00.96" E elev 1 m
Google earth
Eye alt 136 m
Imagery Date: 10/16/2012 42°39'52.74" N 3°01'56.39" E elev 1 m
Google earth
Eye alt 382 m
Google earth
Eye alt 10.77 km

A New Proposal For Dune Restoration

A request to TERI

- Coastal sand dunes have borne the maximum impact from anthropogenic activities
- Coastal sand dunes are Nature's natural line of defense and have to be preserved at all costs
- Artificial sand dunes was never attempted in India; can be tried wherever possible
- Sand fences can be employed as an environment friendly technique to trap wind blown sand
- Plantation of dune species has rarely been attempted
- Restoration of coastal dunes can be adopted wherever these features are damaged due to human interference or natural processes

That’s All, Folks