Ecology and management of Invasive Species

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Dr. K. Sivakumar
Wildlife Institute of India
Dehradun
ksivakumar@wii.gov.in

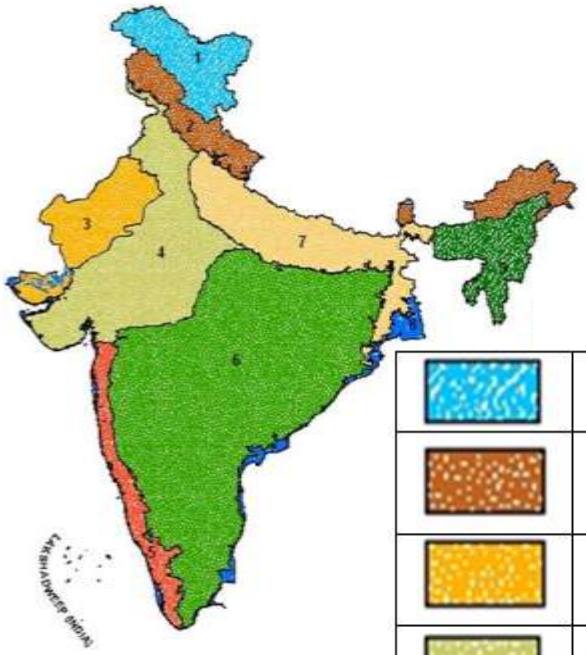
Biodiversity Wealth of India

- The confluence of three major realms - the Indo-Malayan, Eurasian and Afrotropical

- 26 recognized endemic centres for flowering plants
- 30% of the world's recorded flora
- 7.31% of the global fauna

- 103 National Parks
- 536 Sanctuaries
- 67/26 Con. Reserves/Com. Rs
- 7 World Heritage sites
- 18 Biosphere Reserves

Threats to Biodiversity



1: Trans-Himalaya	Livestock pressure, Tourism, Exotic plantations, Medicinal plants & NTFP extraction, Poaching, Human-animal conflict, Border strife, Climate change.
2: Himalaya	Climate change, Deforestation, Invasive species, Medicinal plants & NTFP extraction, Fire, Land use change, Development & urbanisation, Mining, Hydropower development, Tourism, Pollution & eutrophication.
3: Desert	Invasive species, Land use change, Livestock pressure, Human population pressure, Mining, Border strife.
4: Semi-Arid	Land use change, Mining, Livestock pressure, Poaching.
5: Western Ghats	Deforestation, Invasive species, Exotic plantations, Encroachment, Mining, Medicinal plants & NTFP extraction, Livestock pressure, Poaching, Fire, Pathogen load & disease transmission, Climate change.
6: Deccan Peninsula	Deforestation, Invasive species, Development & urbanisation, Mining, Conflict (insurgency), Pathogen load & disease transmission.
7: Gangetic Plain	Deforestation, Invasive species, Development & urbanisation, Mining, Land use change, Pollution & eutrophication, Livestock pressure, Human population pressure.
8: Coasts	Climate change, Pollution, Development & urbanisation, Mining, Tourism, Aquaculture, Invasive species.
9: North East	Deforestation, Agriculture (shifting cultivation), Mining, Hydropower development, Hunting, Conflict (Border strife and insurgency), Climate change.
10: Islands	Climate change, Invasive species, Development & urbanisation.

Chital in Andamans

Invasive Species Facts

India has an estimated 18,000 plants, 30 mammals, 4 birds, 300 freshwater fishes and 1100 arthropods that are invasive and degrading environment.

Many fresh water and marine algae including species of *Kappaphycus*, causing extensive damage to the ecosystems and affecting aquatic biodiversity adversely in India.

- Of the eight worst invasive fish species in the world, five species are present in India.

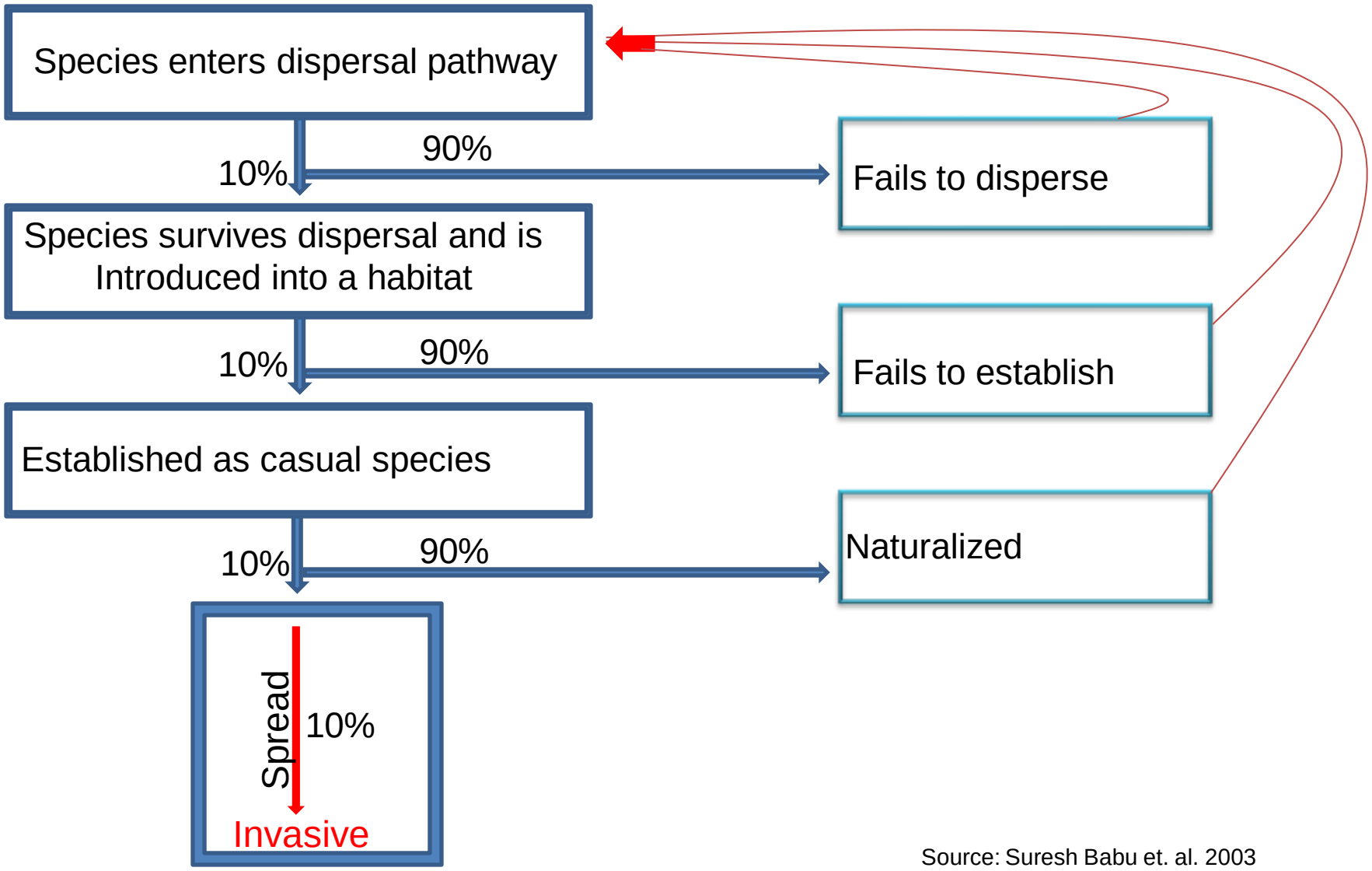
- Several mammalian herbivores introduced to Andaman and Nicobar Islands from the peninsular India.

- Satellite images indicate vegetation degradation due to invasive herbivores in the Andaman Islands

Invasive species

IAS are also commonly referred to as invasive, aliens, exotics or non indigenous species. IAS are species, native to one area or region, that have been introduced into an area outside their normal distribution, either by accident or on purpose, and which have colonized or invaded their new home, threatening biological diversity, ecosystems and habitats, and human well-being.

Are all Alien Species Invasive?

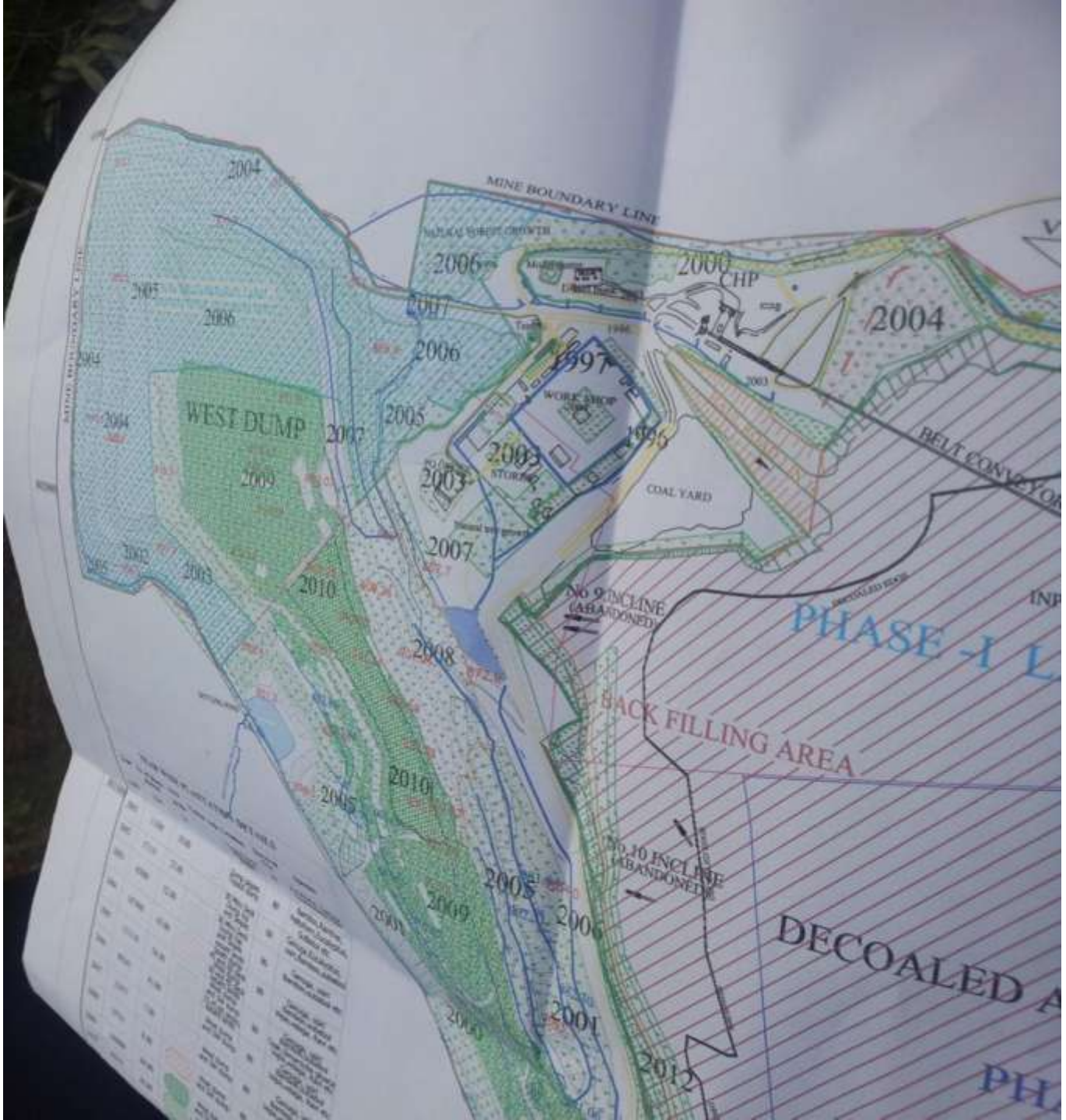


Source: Suresh Babu et. al. 2003

Melghat Story

Shifting of 2 Villages in Progress.

3 villages have been successfully relocated out of 29 villages to be relocated.

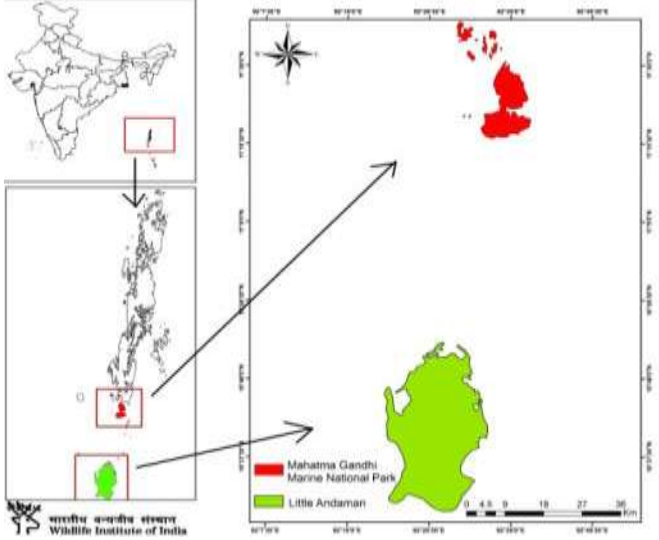

MINE BOUNDARY LINE
WEST DUMP
2004
2005
2006
2007
2008
2009
2010
2001
2012
CHP
WORK SHOP
STORES
COAL YARD
BELT CONVEYOR
No 9 INCLINE (ABANDONED)
No 10 INCLINE (ABANDONED)
BACK FILLING AREA
PHASE -I
DECOALED A
PH

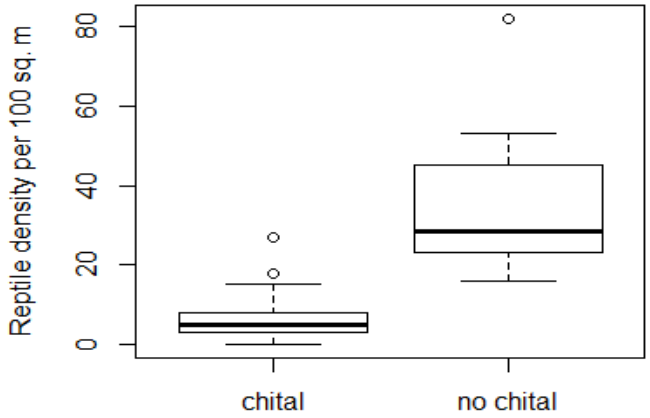
List of Species planted on the OB Dumps

1	Acacia Planiferans
2	Adina cardifolia
3	Aegle marmelos
4	Albezia odoratissima
5	Azadirachta indica
6	Bombox ceiba
7	Dalbergia latifolia
8	Dendrocalamus strictus
9	Emblica officinalis
10	Ficus benghalensis
11	Ficus carica (Medi)
12	Ficus mollis
13	Ficus mollis
14	Ficus religiosa
15	Hardwikia binata
16	Inga dulce
17	Madhuca indica
18	Mytragyna parvifolia
19	Mytragyna parvifolia
20	Pongamia pinnata
21	Pterocarpus marsupium
22	Pterocarpus santalinus
23	Simarouba gluca
24	Sterculia urens
25	T. chebula
26	Tamarindus indica
27	Terminalia.bellarica (Tani)

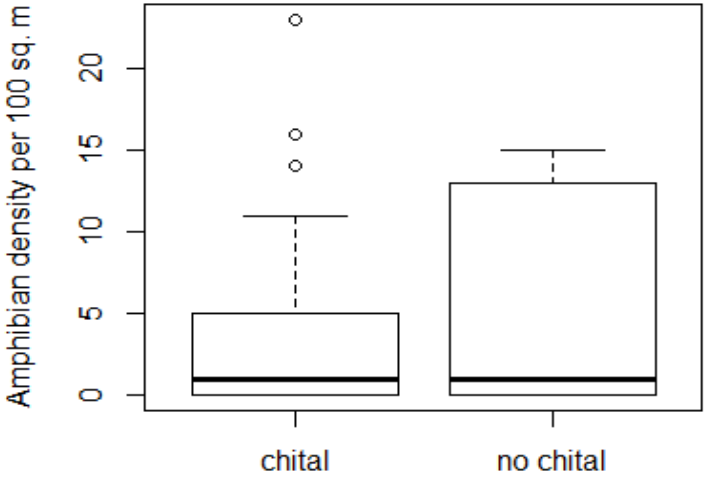
- **Most Invasive Alien Species are post Columbian introductions**

- **Many of the Aquatic Invasive Species were introduced as ornamentals**





A box plot illustrating the difference in reptile density per bound plot between islands with and without chital (F= 40.75, $p < 0.001$ (significant), Effect size (η^2) = 0.58) in Andaman Islands. Island without chital showed higher reptile density per bound plot



A box plot illustrating amphibian density per bound plot in islands with and without chital in Andaman Islands. No difference between these two categories of islands was observed (F = 0.35, p = 0.559, Effect size (η^2) = 0.01).

Ecology

- New World countries (America etc) more invaded than Old world countries (Europe, Africa etc). (New World countries were highly exposed with invasive and anthropogenic pressure).
- Invasive richness increases with species richness.
- Multiple biome regions, temperate agricultural and urban sites are among the most invaded biome.
- Desert and savannas are among the least invaded biome.
- Islands in Europe and North America are less invaded than are tropical islands.
- Number of exotic species in nature reserves increases with the number of visitors.

Successful invaders

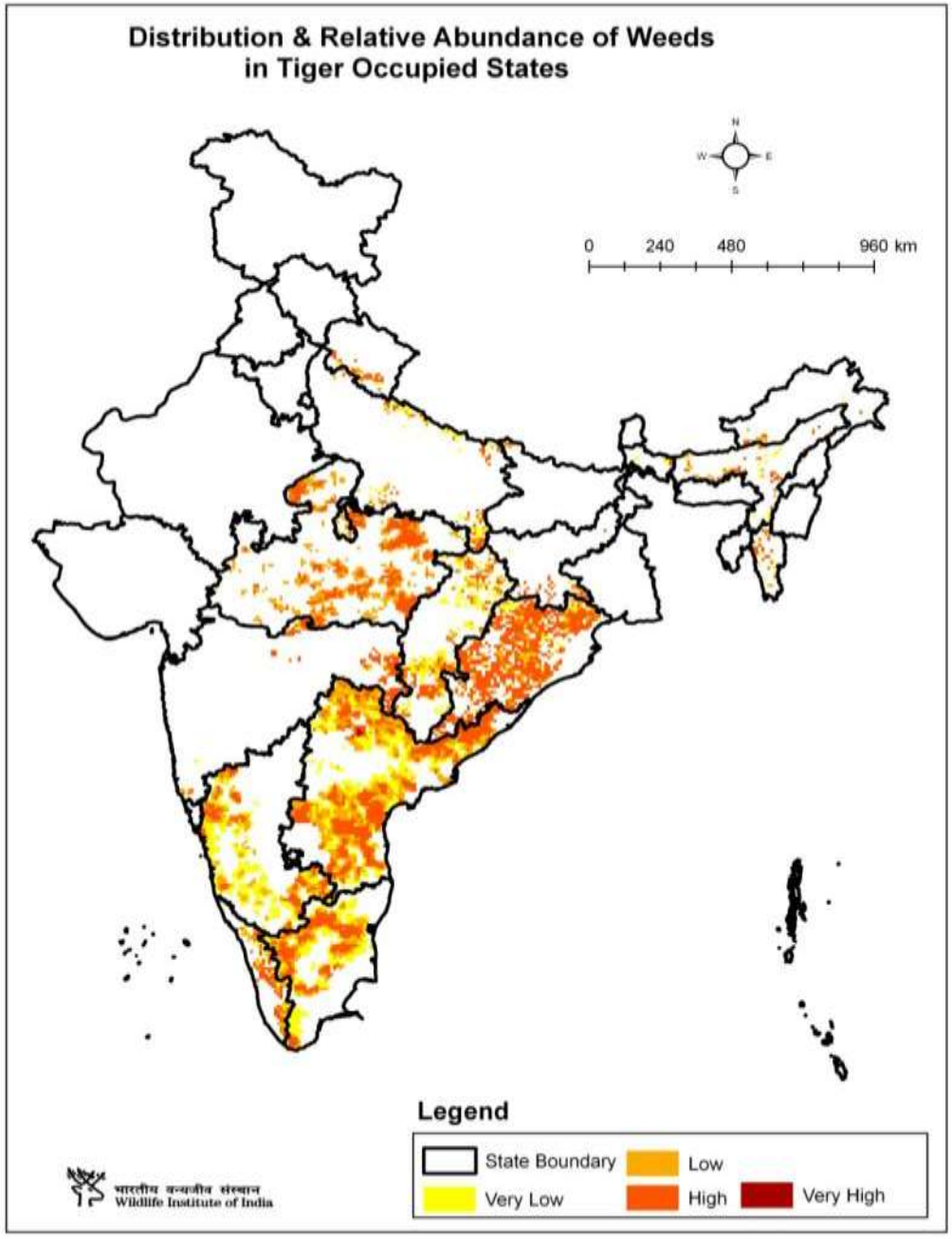
- Large native range
- Abundant in native range (but not always)
- Broad diet (generalist, omnivore)
- prolific breeder
- associated with man
- successfully adaptable in a wide range of environmental conditions

Impacts

- Next to the deforestation (habitat destruction), introduced species are the major threat to the preservation of biodiversity.
- It can profoundly alter ecosystem structure and function.
- E.g. in Western Ghats, Shola grasslands have been modified by with the invasion of aggressive black wattle (*Acacia mearnsii*, introduced here for tannin industry).
- Acceleration of soil erosion rate: Himalayan tahr in South Africa
- Alteration of hydrological cycles: Invasive fungus *Phytophthora cinnamomi* killing Eucalyptus in Australia, increased water table.

Impact

- Large number of species extinct from Islands due to Invasive. In Islands, Amphibians, reptiles and birds are more vulnerable than mammals.
- Predation: e.g. Trout, Cat, Dog, brown tree snake etc.,
- Browsing and grazing: e.g. Goat, Spotted deer, elephant.,
- Hybridization (Genetic contamination): Turtle dove, Egret, pigs, carps,
- Food competition: exotic carp and native carp, sparrows, bulbuls.,
- Nest site competition: Parrot nest site encroached by introduced honeybee
- Introduction of disease: Avian malaria, cholera, pox.


Distribution & Relative Abundance of Weeds
in Tiger Occupied States
N
W
E
S
0
240
480
960 km
Legend
State Boundary
Low
Very Low
High
Very High
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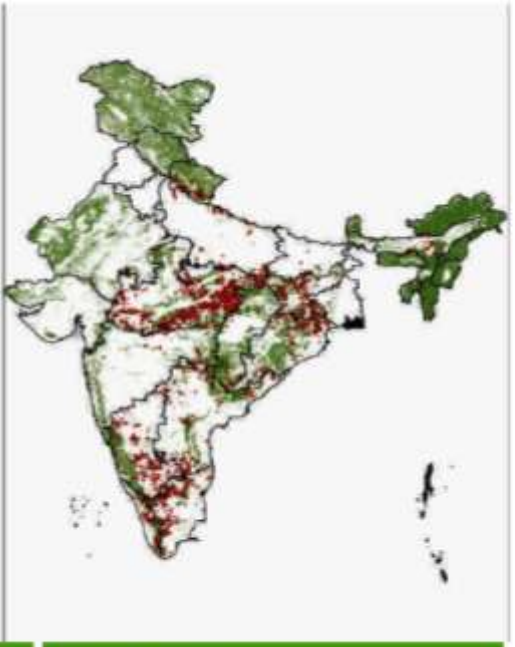
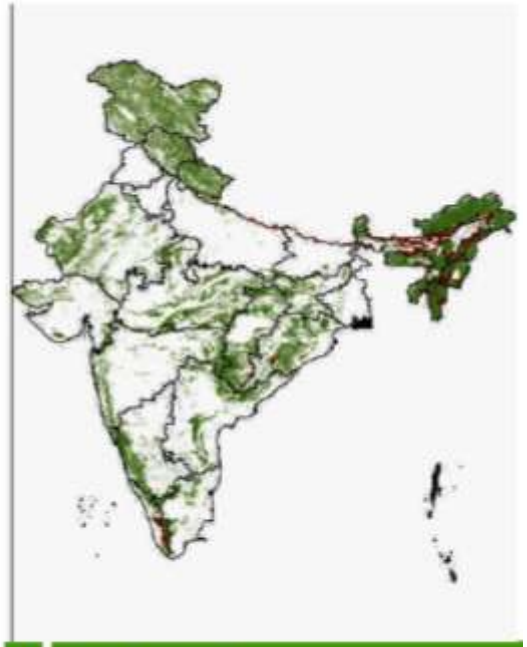
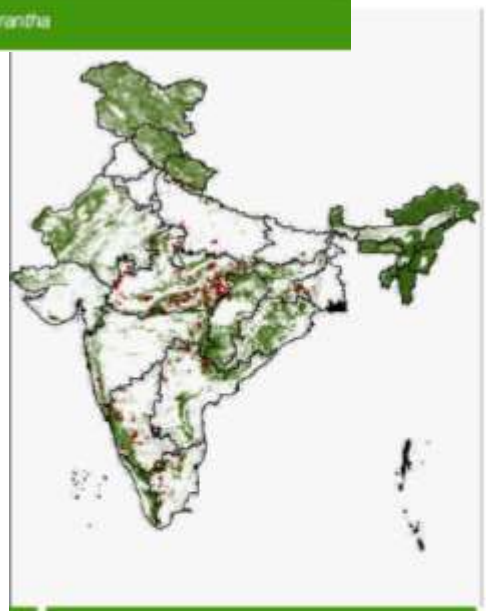
Wildlife Institute of India



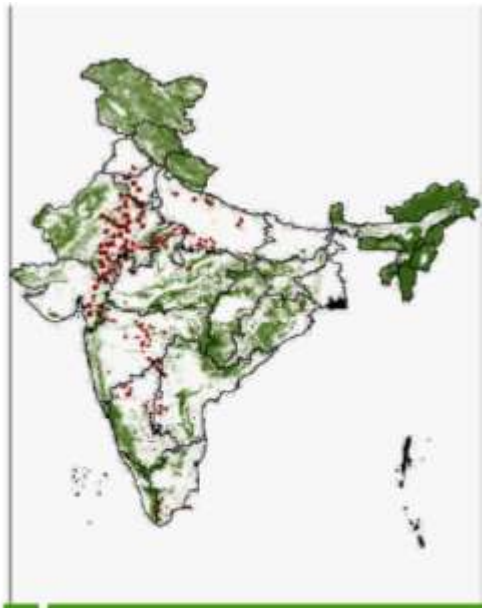
a Lantana camara



b Mikania micrantha



c Parthenium hysterophorus



d Prosopis juliflora

Vegetation cover
Invasive species presence

Kappaphycus alvarezii

The exotic seaweed, Kappaphycus alvarezii **invaded in the reef areas in Gulf of Mannar**

Predation - Crown-of-Thorn Starfish

Acanthaster planci

Management

- Mechanical control
- Chemical control
- Biological control
- Prevention

Existing Methods practiced for the control of *Lantana in forest ecosystems in India and their limitations*

- Slashing/chopping

  Stimulates the shoot buds from most of the nodes below the chopped portions of *Lantana clumps* leading to proliferation of many branches which get interwoven into each other leading to formation of impenetrable thickets

- Burning

Stimulates the sub-terranean meri-stem which produces profuse shoot buds that develop into shoots. The growth rate of new shoots is also enhanced due to burning, it also leads to increase in germination of *Lantana seeds from soil seed bank burning* eliminates competition from native plant species as the native species are not fire-resistant. The alteration of habitat due to burning can promote invasion of *Lantana or secondary invasion of* other weeds if not managed properly

Manual/mechanical grubbing

Manual grubbing, as practiced in India, involves both slashing of branches of *Lantana clumps to be* removed and extensive digging of root system of the slashed *Lantana clumps. There are two major* disadvantages of this method: (i) due to extensive digging below the *Lantana clump, the soil is* extensively disturbed leading to exposure of buried *Lantana seeds to light which leads to gregarious* germination and establishment of seedlings, (ii) regeneration and recoppicing from slashed branches that are fallen on the ground and from the base of uprooted clump; regeneration also takes place from the rooted prostrate branches that might have been severed from the clump while grubbing.

Chemical control

- Impractical to cover vast tracts infested with *Lantana and also not cost-effective, potential hazard*to the native biota and environment.

Biological control

- Limited foraging ability of the insects; variety-specific behaviour of the biocontrol agent, performance of the biocontrol agent is affected by climate, biocontrol agents may also affect native species.

Biological control Experiments

36 insect spp. released in 33 countries to control *Lantana camara*

Cactus moth (*Cactoblastis cactovorum*) introduced from South America into Queensland in 1920s to control prickly pear cactus (*Opuntia* spp.)

Septoria spp. from Ecuador into Hawaii in 1997 to control *Lantana camara*

Puccinia spegazzinii (isolate W 1761) of Trinidad origin imported into India to control *Mikania micranth – under study in Kerala and Assam*

New management strategy On the basis of critical assessment of the biological and ecological attributes of lantana

- **(i) its removal by cut rootstock method,**
- **(ii) weeding of saplings from beneath the trees used for perching by generalist birds that disperse the seeds throughout their home range and from surface drainage channels originating from the area covered by such trees and**
- **(iii) ecological restoration of weed-free landscapes, preferably to the grassland, or forest communities according to the needs of stakeholders to prevent reinvasion of the same species or secondary invasion by another alien species.**

a **b**

a, coppicing zone at the transition between stem base androot.
b, Lantana removed by cutting the rootstock below the coppicing zone.

पारिस्थितिकीय पुनर्स्थापन प्रयोग
ECO-RESTORATION EXPERIMENT

लैण्टाना एवं अन्य विदेशी प्रजातियो को हटाकर देशी प्रजातियो का पुनर्स्थापन

REPLACEMENT OF LANTANA AND OTHER EXOTICS BY NATIVE SPECIES

बोई गई/रोपित प्रजातियॉ (Species Sown/Planted) :-

हरड़ (Terminalia chebula), बहेड़ा (Terminalia bellirica), मदना (Randia Dumetorum), धनेला (Gardenia turgida), बेर (Zizyphus mauritiana), आंवला (Emblica officinalis), पाडल (Sterospermum suaveolens), भिलावा (Semicarpus anacardium), इकदानिया (Bridelia retusa), स्योनक (Oroxylum indicum), अमलताश (Casia fistula), गमहार (Gmelina arborea), सर्पगन्धा (Rauvolfia Surpentina), दूदधी (Wrightia orborea), सालपर्णी (Desmodium gengaticum) , कलीहारी (Gloriosa Cuperba), गिलोह (Tinospora Cordifolia), गजपीपली (Schandops Officinales), इन्द्रायण, आमडा (Spondias pinnata) आदि

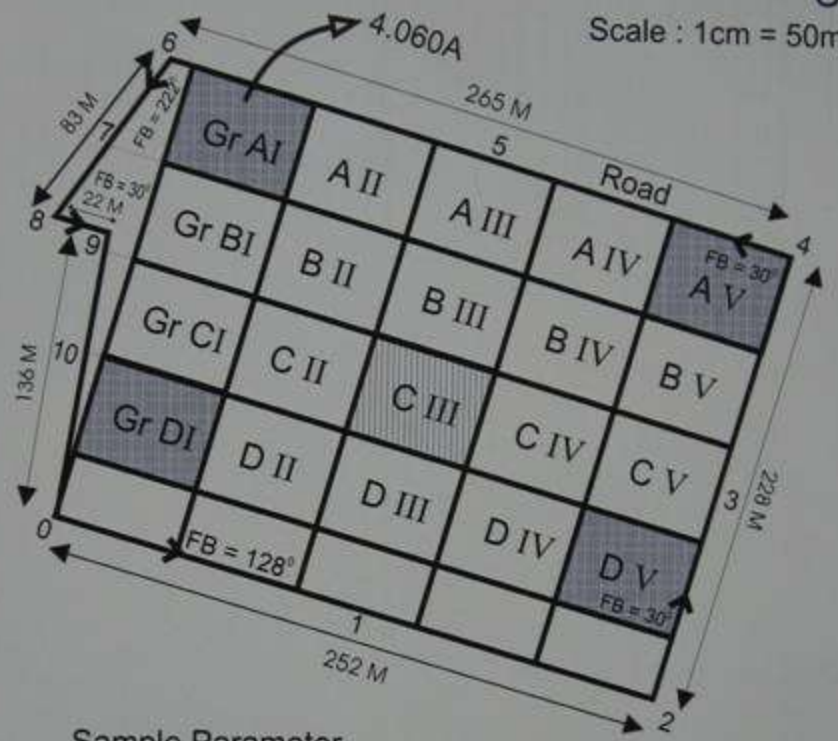
ब्लाक एवं कक्ष संख्या :- चिल्लावाली कक्ष – 1 ए
Block & Compt No. :- Chillawali Compt - 1a
क्षेत्रफल (Area) :- 5.5 Ha.
स्थापना वर्ष (Established) :- 2006-07
रेंज (Range) :- चिल्लावाली (Chillawali)

राजाजी राष्ट्रीय पार्क
वन विभाग, उत्तरांचल
RAJAJI NATIONAL PARK
Forest Department, Uttaranchal

ECO-RESTORATION EXPERIMENT
नक्शा - GRID MAP

N ↑ S

Scale : 1cm = 50mtr



Sample Parameter

Grid No.	pH (1:2)	Soil Texture			
		Sand (%)	Silt (%)	Clay (%)	Soil type (%)
A-1	6.47	7.3	76.4	16.3	Silt loam
A-5	6.48	23.2	56.5	21.3	Silt loam
C-3	6.16	8.5	72.9	20.2	Silt loam
D-1	5.55	6.0	73.8	20.2	Silt loam
D-5	6.18	28.2	55.4	18.4	Silt loam

राजाजी राष्ट्रीय पार्क
वन विभाग, उत्तरांचल
RAJAJI NATIONAL PARK

Lantana eradication in Sukhna Wildlife Sanctuary, U.T. Chandigarh

Restoration & Biodiversity

More than 50% of the forest area in Sukhna Wildlife Sanctuary was highly infested with lantana weed. Lantana camara is one of the most common and worst weed which is perhaps the most obnoxious in the Shivalik hills and the forests around Chandigarh city. It was posing a serious threat to the 'Biodiversity' of our forests. It is a very hardy weed and grows fast in comparison to the indigenous plant species in wildlife sanctuary and other forest area. Wild growth of lantana had choked all natural regeneration in the forests and thus had adverse impact on the biodiversity of wildlife sanctuary. Lantana eliminates all kind of undergrowth and damages the trees also.

Considering the adverse impact of 'Lantana' on the ecology of Sukhna Wildlife Sanctuary and other forest area, Forest Department of Chandigarh Administration had chalked out a 7 year's schedule in March, 2001 to make sanctuary & other forests of U.T. Chandigarh free from 'Lantana'. By 2008-09, the entire Wildlife Sanctuary and other forest area have already been freed from lantana. This is a unique example of the eradication of Lantana from forests. The department has ensured that lantana does not appear again on the site already cleared of it. This has been a very successful project and good results are visible on the ground. The regeneration of indigenous species like Bansa, Ratti, Karipatta, Giloe, Karaunda and other tree species is appreciable. For the last four years, there has been good flowering and fruiting in trees like Ber, Dhak (Palas), Karaunda etc. Good grazing grounds for wildlife have also been developed after removal of lantana and thus, there is overall improvement in the wildlife habitat of the sanctuary. Lantana removal has thus proved to be a great boon to the restoration of floral and faunal biodiversity of Sukhna Wildlife Sanctuary. 'Forest fire' threat to the forests has also been reduced due to removal of lantana.

http://chandigarh.gov.in/green_suk_wild3.htm

Eradication and monitoring of invasive fishes

Invasive African cat fish *Clarias gariepinus* were posing threat to birds and other wildlife especially aquatics of the Park.

Park Management successfully initiated eradication of this species from the Park but it needs to be continued for longer period.

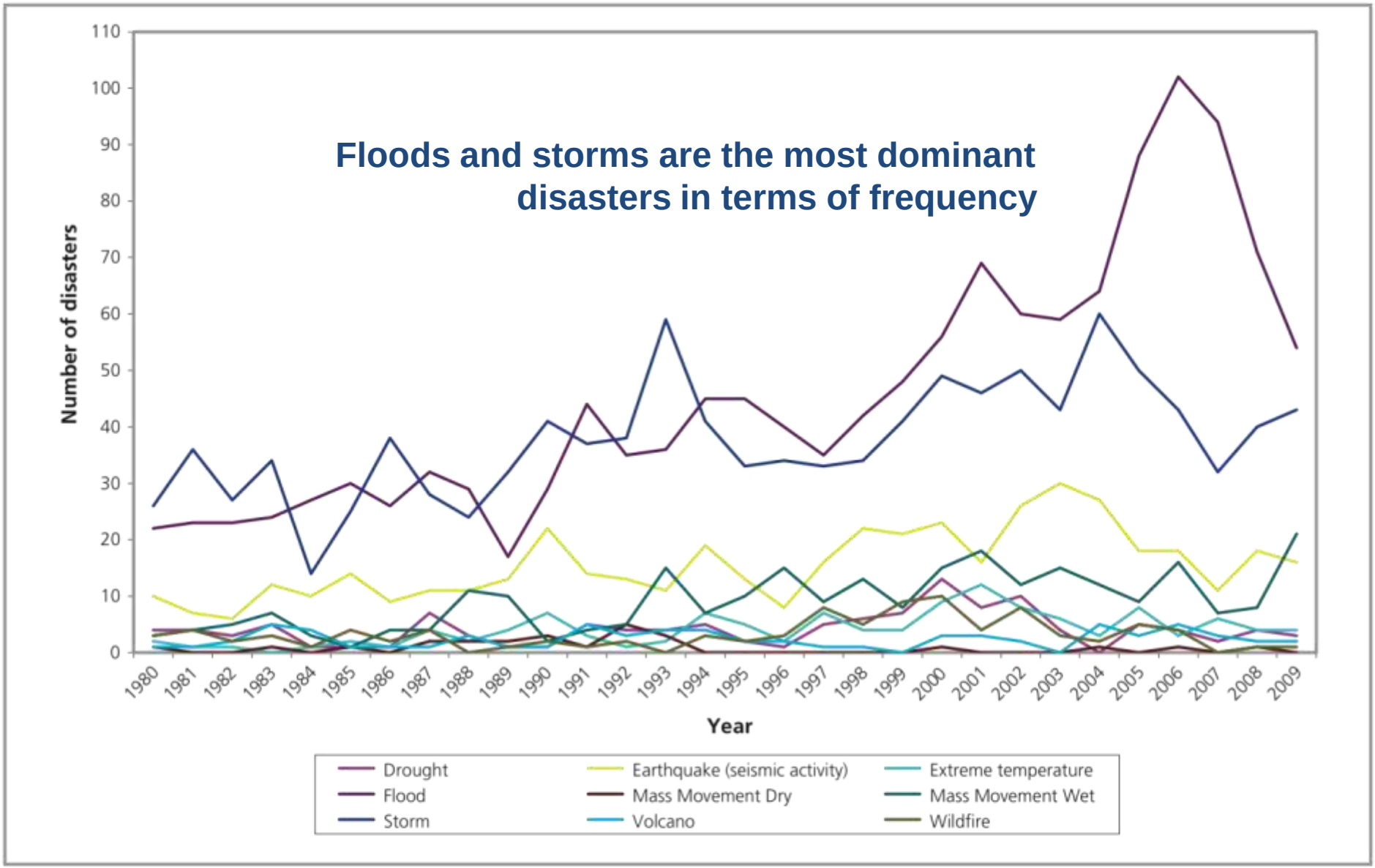
Eradication and monitoring of invasive plants

Management

- Control of Invasive animals:
  - Relocation
  - Fencing
  - Trapping
  - Shooting
  - Containing the population
  - Population control
- National policy on the prevention of invasive animal species.
- IUCN Guidelines (www.issg.org)

Role of floods, cyclones, tsunami in habitat modification

Figure I-2 Number of disasters by type of natural hazard in Asia-Pacific, 1980-2009



Source: ESCAP based on data from EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium

Note: Wind storms are termed hurricanes in the North Atlantic and South Pacific, typhoons in the West Pacific and cyclones in the Indian Ocean.

Impacts of disasters in Asia and Pacific

Table I-6 Top 10 disaster types and their impact, Asia and the Pacific, 1980-2009

Rank		Events	Deaths (thousands)	People affected (millions)	Damage ($ millions)
1	Floods	1,317	128.95	2,676.16	301,590
2	Storms	1,127	384.20	664.03	165,770
3	Earthquakes	444	570.80	109.71	264,530
4	Mass movements – wet	264	14.28	1.36	2,130
5	Extreme temperatures	119	17.51	85.90	18,080
6	Droughts	108	5.33	1,296.27	53,330
7	Wildfires	96	1.06	3.31	16,210
8	Volcanic eruptions	71	17.51	2.36	710
9	Mass movements – dry	20	1.53	0.02	10
10	Insect Infestations	8	0.0	0.00	190

Note: * Damage and loss reported in $millions at 2005 constant prices.

Source: ESCAP based on data from EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium, and data on implicit price deflators in $ from the United Nations Statistics Division National Accounts Main Aggregates Database.

Countries most affected by disasters

Table I-2 Asia-Pacific countries ranked by number of disasters, 1980-2009

Rank	Country	Events
1	China	574
2	India	416
3	Philippines	349
4	Indonesia	312
5	Bangladesh	229
6	Russian Federation	176
7	Japan	155
8	Australia	154
9	Viet Nam	152
10	Iran (Islamic Rep. of)	140

Source: ESCAP based on data from EM-DAT: the OFDA/CRED International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium

Table I-3 Asia-Pacific countries ranked by number of deaths from disasters, 1980-2009

Rank	Country	Deaths
1	Bangladesh	191,650
2	Indonesia	191,164
3	China	148,419
4	India	141,888
5	Myanmar	139,095
6	Pakistan	84,841
7	Iran (Islamic Rep. of)	77,987
8	Sri Lanka	36,871
9	Philippines	32,578
10	Russian Federation	31,795

Source: ESCAP based on data from EM-DAT: the OFDA/CRED International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium

Table I-4 Asia-Pacific countries ranked by number of people affected by disasters, 1980-2009

Rank	Country	Affected (millions)
1	China	2,550
2	India	1,501
3	Bangladesh	316
4	Philippines	109
5	Viet Nam	68
6	Thailand	54
7	Iran (Islamic Rep. of)	42
8	Pakistan	30
9	Indonesia	18
10	Cambodia	16

Source: ESCAP based on data from EM-DAT: the OFDA/CRED International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium

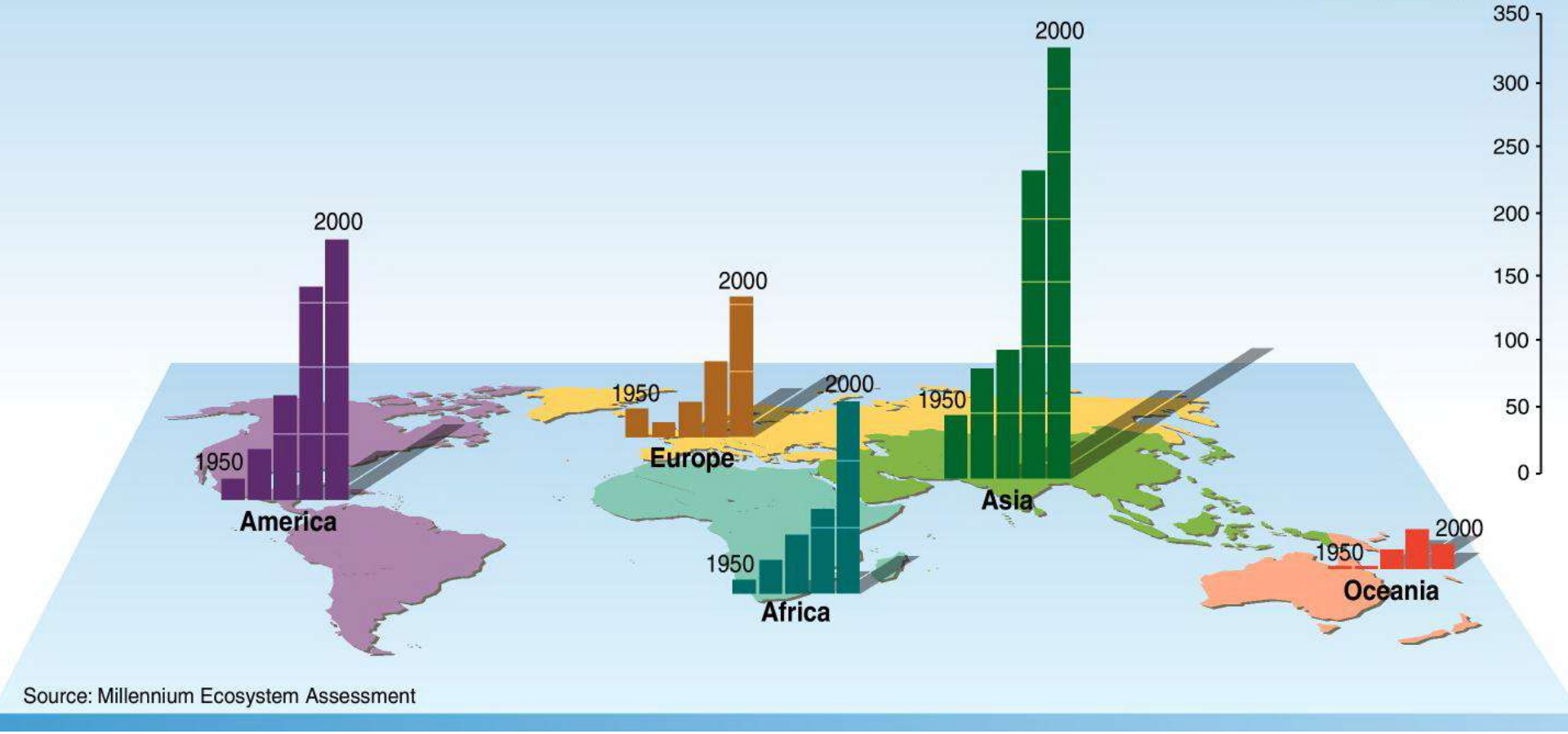
Table I-5 Asia-Pacific countries ranked by economic damage, 1980-2009

Rank	Country	Damage ($ billions)
1	China	322
2	Japan	188
3	India	52
4	DPR Korea	46
5	Turkey	35
6	Australia	34
7	Iran (Islamic Rep. of)	25
8	Indonesia	23
9	Republic of Korea	20
10	Bangladesh	16

Note: Damage data are at 2005 prices

Source: ESCAP based on data from EM-DAT: the OFDA/CRED International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium

Floods



Source: Millennium Ecosystem Assessment

- Disturbance was once viewed largely as an insult to the "balance of nature" and synonymous with habitat destruction.

- Certain forms of disturbance, however, are now held by ecologists and conservation biologists to play a fundamental and creative role in maintaining the natural heterogeneity in environmental conditions that organisms experience through space, time, or both.

- Natural ecological disturbance creates habitats that are used by diverse groups of animals and plants

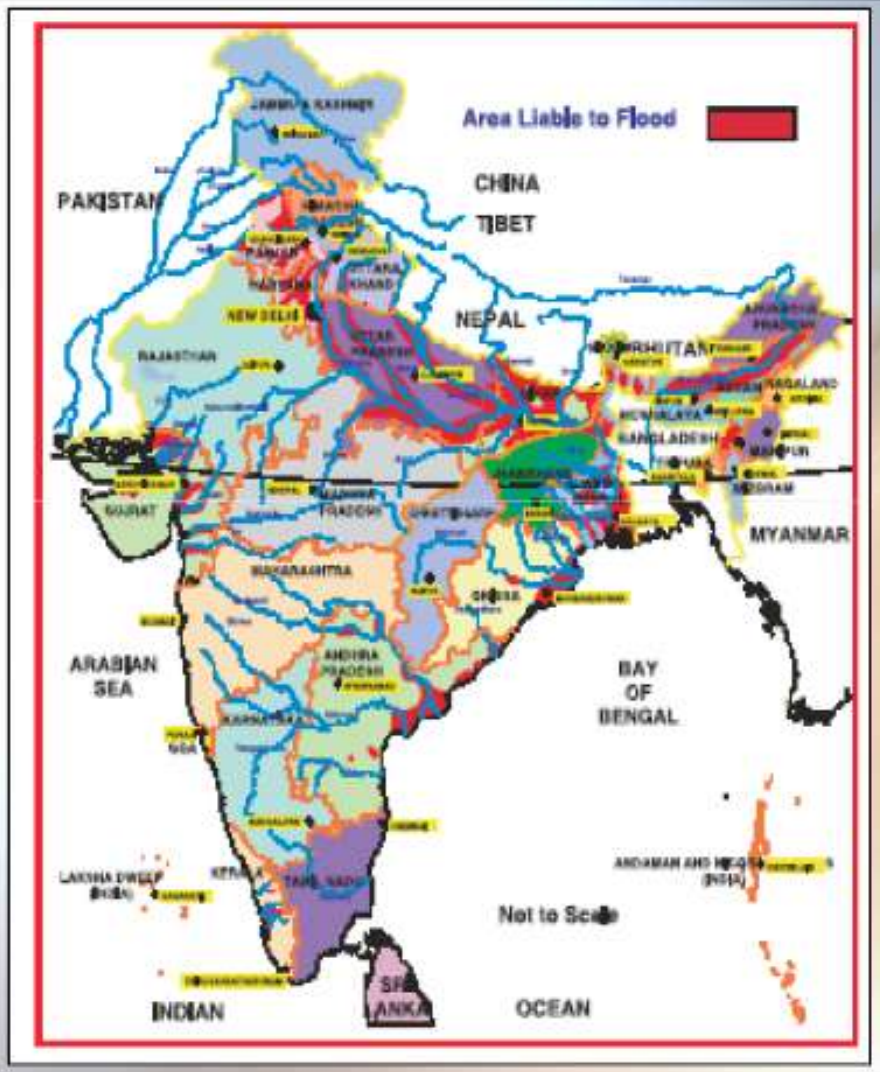
Flood

- Rivers, lakes, estuaries, coastal areas
- Flooding river often represents a beneficial ecological connection between the river and its semiaquatic floodplain, rather than an unpredictable catastrophic disturbance
- Facilitate migration of species
- Inducing factor to maintain the normal life history trait of aquatic animals and plants

Courtesy: Prof A.K. Maitra

FLOOD

Area Liable To Floods



Courtesy: Prof A.K. Maitra

Jammu & Kashmir Flood September 2014

Kaziranga

- The water in the wetlands remains stagnant for almost 8 months in a year. So there is a need for natural replacement of stagnant water by fresh water in those wetlands which is possible by floods. Natural removal of weed and other debris, water hyacinth etc. take place during flood seasons.
  The overall hygiene of the park is maintained in this way naturally through different water current systems caused by the mighty Brahmaputra river and its smaller tributaries.
  Flood also acts greatly against invasion on grassland (more particularly the low grassland) by woody species.

Flood

- The Kaziranga Natioal Park has the largest grassland area left in the region. It stretches about 50 km along the south bank of the Brahmaputra. The annual river floods replenish the wetlands and allow the grassland areas to flourish

- **The Brahmaputra is also the** cause of severe erosion. Satellite data indicates a loss of more than 51 km² between 1967-68 and 1998-99**15 although silt deposition also leads to new land forming in** other areas. Floods have also caused significant animal deaths.

- During major floods in 1998 many animals were drowned; for instance carcases were found of 39 rhinos, 23 wild water buffalo, 19 wild pig (*Sus scrofa) and 15 sambar (Cervus unicolor).* Hog deer (*Axis porcinus) were most seriously affected, with 473 recorded deaths***.** This species was also badly affected by the 1988 floods. Although precise statistics of flood related mortality are not available, there were only 2,900 deer counted in the census of 1991, compared to 10,000 in 1984. The wild pig has seen a similar decline with the census of 1991 counting only 555 individuals compared to a count of 1,645 in 1984

Flood

- Flood control is a major issue for the Government of India, and across the country
- Infrastructure has been developed to protect towns and villages from flooding but not for wildlife habitat (?)
- A comparison of the three recent extreme floods (1987, 1988 and 1998) affecting Bangladesh (from waters of the Ganges, Brahmaputra and Meghna basins) found intense monsoon precipitation was the principal cause of flooding
- There are differences of opinion concerning the significance of land use change and especially the role of deforestation in upstream areas, with some commentators believing this leads to accelerated soil erosion and landslides during monsoon precipitation thus contributing to the floods downstream, whilst others disagree with this interpretation

Flood

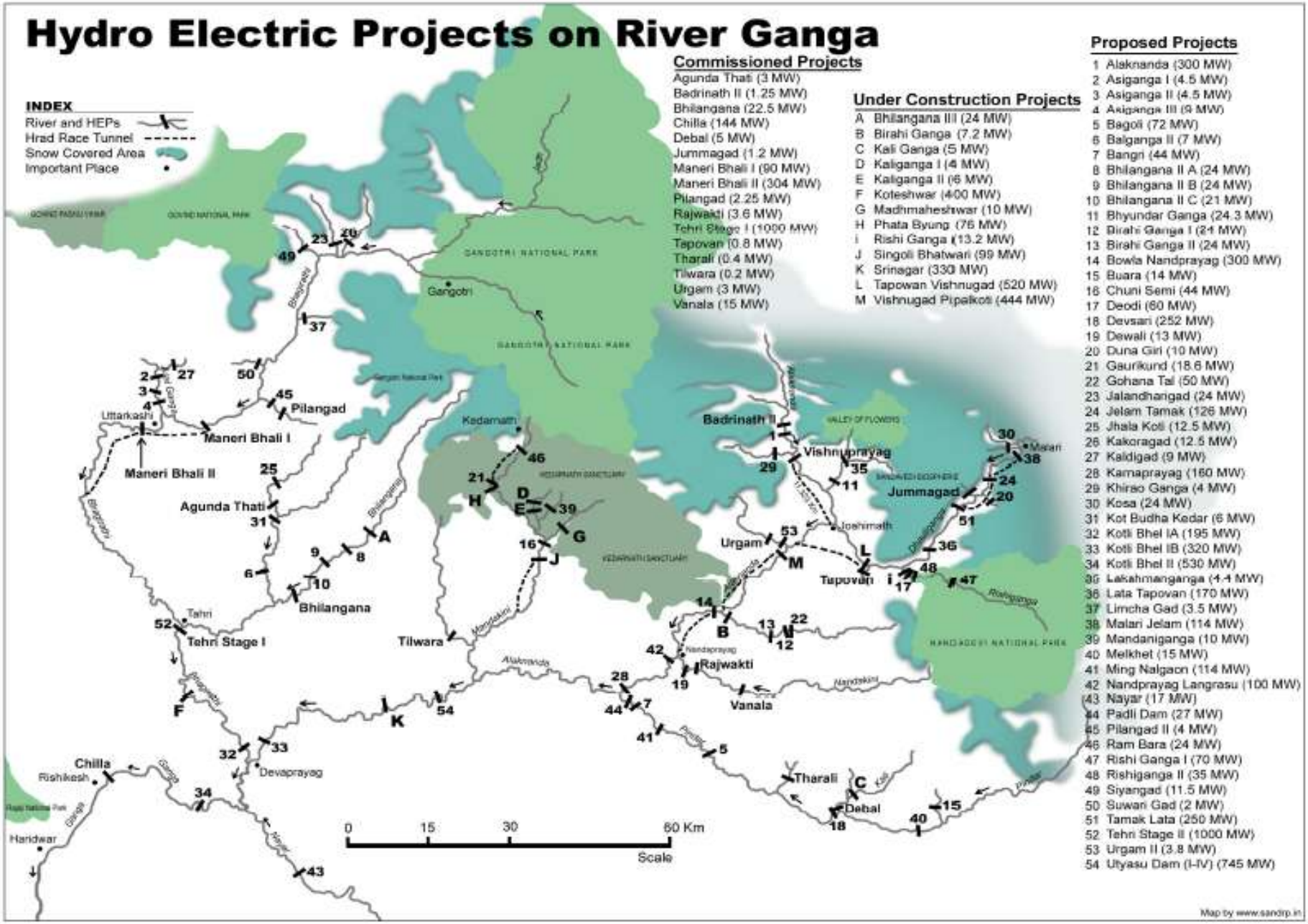
- Unregulated rivers with natural floodplains and flood regimes can serve as benchmarks in attempts to restore natural functioning to altered river systems. Several recent reviews have emphasized the importance of reestablishing natural flow regimes, rather than just minimum flows, in regulated systems

Flood

- Maintaining the connection between the river channel and floodplain is vital for diverse and productive invertebrate assemblages and the higher trophic levels that depend on them.

Flood

- Dams are considered to bring several advantages including power, better irrigation and a reduction in the surges of water that cause flooding. However, from a conservation perspective, reduction in flooding would have enormous impacts on the ecology of Kaziranga. Many of these impacts would be detrimental to an ecology that has adapted over millennia to regular flooding


Hydro Electric Projects on River Ganga
INDEX
River and HEPs
Hrad Race Tunnel
Snow Covered Area
Important Place
Commissioned Projects
Agunda Thati (3 MW)
Badrinath II (1.25 MW)
Bhilangana (22.5 MW)
Chilla (144 MW)
Dehal (5 MW)
Jummagad (1.2 MW)
Maneri Bhali I (90 MW)
Maneri Bhali II (304 MW)
Pilangad (2.25 MW)
Rajwakti (3.6 MW)
Tehri Stage I (1000 MW)
Tapovan (0.8 MW)
Tharali (0.4 MW)
Tilwara (0.2 MW)
Urgam (3 MW)
Vanala (15 MW)
Under Construction Projects
A Bhilangana III (24 MW)
B Birahi Ganga (7.2 MW)
C Kali Ganga (5 MW)
D Kaliganga I (4 MW)
E Kaliganga II (6 MW)
F Koteshwar (400 MW)
G Madhmaheshwar (10 MW)
H Phata Byung (76 MW)
I Rishi Ganga I (13.2 MW)
J Singoli Bhatwari (99 MW)
K Srinagar (330 MW)
L Tapowan Vishnugad (520 MW)
M Vishnugad Pipalkoti (444 MW)
Proposed Projects
1 Alaknanda (300 MW)
2 Asiganga I (4.5 MW)
3 Asiganga II (4.5 MW)
4 Asiganga III (9 MW)
5 Bagoli (72 MW)
6 Balganga II (7 MW)
7 Bangri (44 MW)
8 Bhilangana II A (24 MW)
9 Bhilangana II B (24 MW)
10 Bhilangana II C (21 MW)
11 Bhyundar Ganga (24.3 MW)
12 Birahi Ganga I (24 MW)
13 Birahi Ganga II (24 MW)
14 Bowla Nandprayag (300 MW)
15 Buara (14 MW)
16 Chuni Semi (44 MW)
17 Deodi (60 MW)
18 Devsari (252 MW)
19 Dewali (13 MW)
20 Duna Giri (10 MW)
21 Gaurikund (18.6 MW)
22 Gohana Tal (50 MW)
23 Jalandharigad (24 MW)
24 Jelam Tamak (126 MW)
25 Jhala Koti (12.5 MW)
26 Kakoragad (12.5 MW)
27 Kaldigad (9 MW)
28 Kamaprayag (160 MW)
29 Khirao Ganga (4 MW)
30 Kosa (24 MW)
31 Kot Budha Kedar (6 MW)
32 Kotli Bhel IA (195 MW)
33 Kotli Bhel IB (320 MW)
34 Kotli Bhel II (530 MW)
35 Lakshmanganga (4.4 MW)
36 Lata Tapovan (170 MW)
37 Limcha Gad (3.5 MW)
38 Malari Jelam (114 MW)
39 Mandaniganga (10 MW)
40 Melkhet (15 MW)
41 Ming Nalgaon (114 MW)
42 Nandprayag Langrasu (100 MW)
43 Nayar (17 MW)
44 Padli Dam (27 MW)
45 Pilangad II (4 MW)
46 Ram Bara (24 MW)
47 Rishi Ganga I (70 MW)
48 Rishiganga II (35 MW)
49 Siyangad (11.5 MW)
50 Suwari Gad (2 MW)
51 Tamak Lata (250 MW)
52 Tehri Stage II (1000 MW)
53 Urgam II (3.8 MW)
54 Utyasu Dam (I-IV) (745 MW)
Gangotri
Uttarkashi
Kedarnath
Badrinath II
Vishnuprayag
Joshimath
Jummagad
Urgam
Tapovan
Pilangad
Maneri Bhali I
Maneri Bhali II
Agunda Thati
Bhilangana
Tehri
Tehri Stage I
Tilwara
Nandprayag
Rajwakti
Vanala
Tharali
Dehal
Chilla
Rishikesh
Haridwar
Devaprayag
Mana
GANGOTRI NATIONAL PARK
KEDARNATH SANCTUARY
VALLEY OF FLOWERS
NANDADEVI NATIONAL PARK
0 15 30 60 Km
Scale
Map by www.sandrp.in

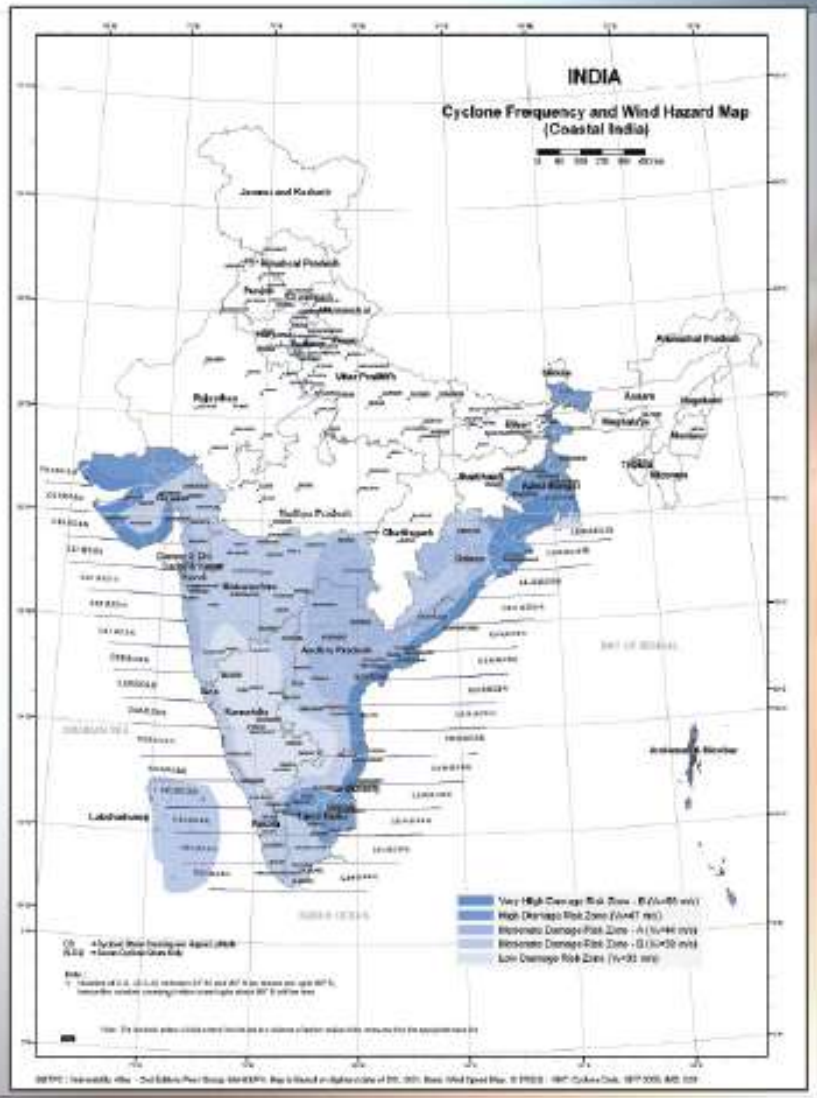
Cyclone

- **All habitats may get affected. Coastal, Grasslands, Deserts and Flood plains are most vulnerable.**
- **Large-scale natural disturbances, such as tropical cyclones, have regularly affected coral reef ecosystems which, as a result, are adapted to these occasional but severe constraints.**
- **In their pristine state, coral reefs have the necessary resistance and resilience to overcome and recover from such disturbances.**
- **However, the recent increase in human-induced disturbances on reef ecosystems has driven a global decline of coral reefs worldwide affecting both reef habitats and their associated biological assemblages.**

Cyclone

Cyclone Frequency and Wind Hazard Map

(Coastal India)



Courtesy: Prof A.K. Maitra

Cyclone

- **Using historical data, it was found that the probability of cyclone increased in 50 years because of sea-level rise, it was emphasized the importance of understanding how the ecological niche of species evolves under the influence of climatic controls over time.**
- **The frequency of climatic extremes is often more or equally important than their mean value in shaping the range of species.**
- **The challenge is offered by the macroecological approach that considers the relationships between climatic and species patterns on large-scales.**

- A cyclone is classified as a tropical depression, tropical storm or hurricane depending on its lifetime-maximum wind speed when it affected a particular coastal region. Since nesting and tropical cyclone seasons typically do not overlap, juveniles fledge before the storms arrive and subsequently are able to seek inland protection with the adults during the storms.

- However, tropical cyclones modify the beach profile by redistributing sand from the dunes to new forefront areas, and creating ephemeral pools and large overwash fans that significantly increase both breeding and brood-rearing habitats.

- The open sparsely vegetated habitats created by cyclones are the preferred habitat by nesting Snowy Plovers. Dune sands show equivalent chemical and granulometric properties of the eroded sand in the pre-cyclone beach.

Precautionary Measures

- Wildlife Rescue Centre
- Disaster Management Team

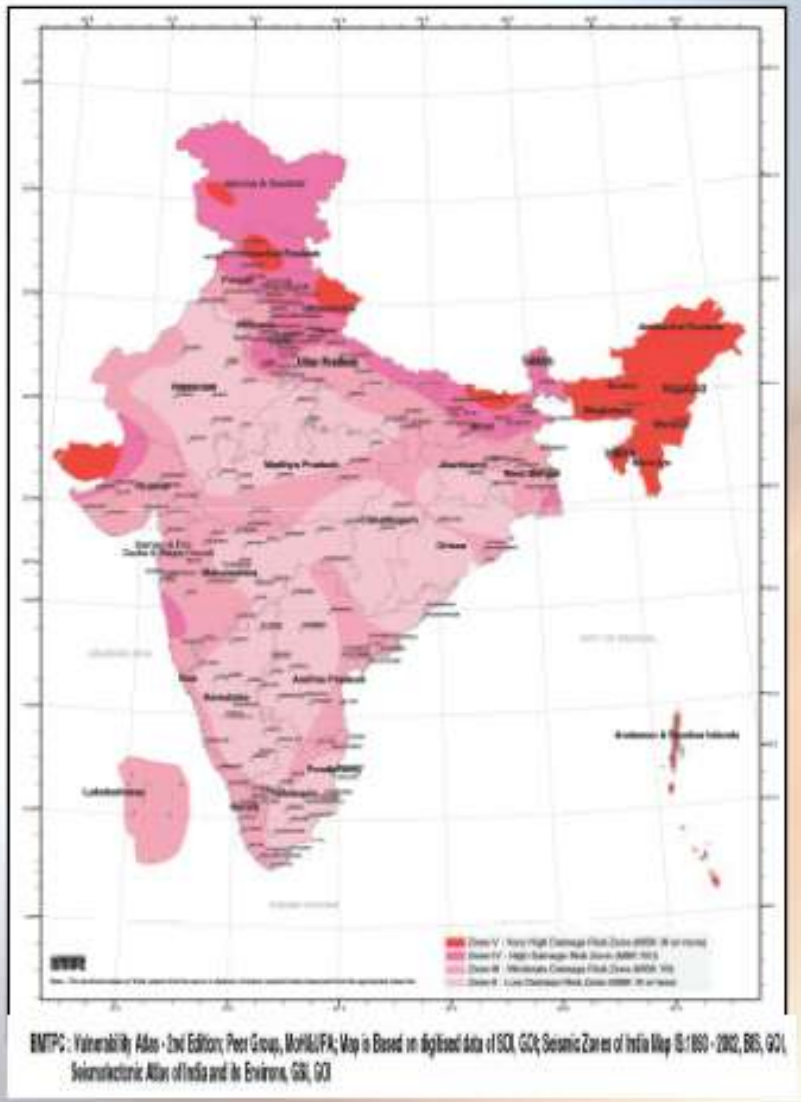
Tsunami

- Affects coastal and river banks
- Affected Andaman & Nicobar Islands, Tamil Nadu and Kerala coasts
- Mangroves, corals, seagrass and costal litoral habitats were most affected
- Megapode, dugong, sea turtle etc affected most

EARTHQUAKES

Seismic Zone Map of India

(IS:1893, 2002)

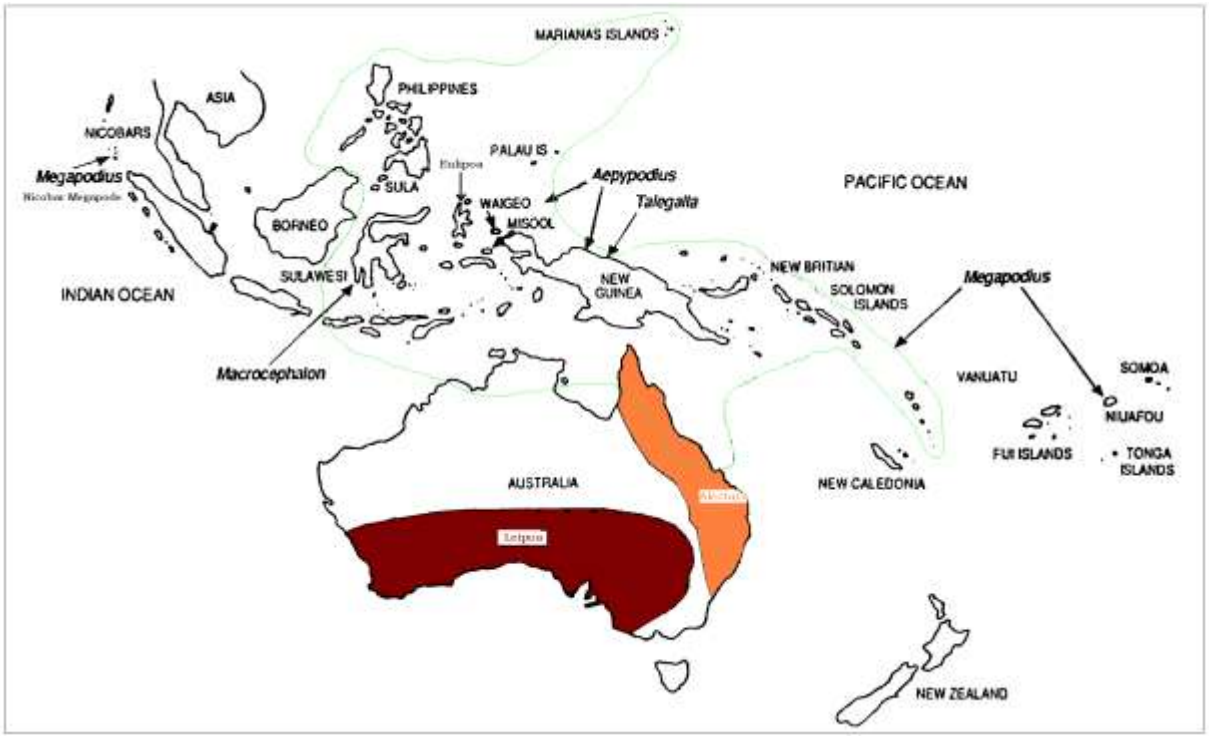


BMTPC : Vulnerability Atlas - 2nd Edition; Peer Group, MoH&UPA; Map is Based on digitised data of SOI, GSI; Seismic Zones of India Map IS:1893 - 2002, BIS, GOI, Seismotectonic Atlas of India and its Environs, GSI, GOI

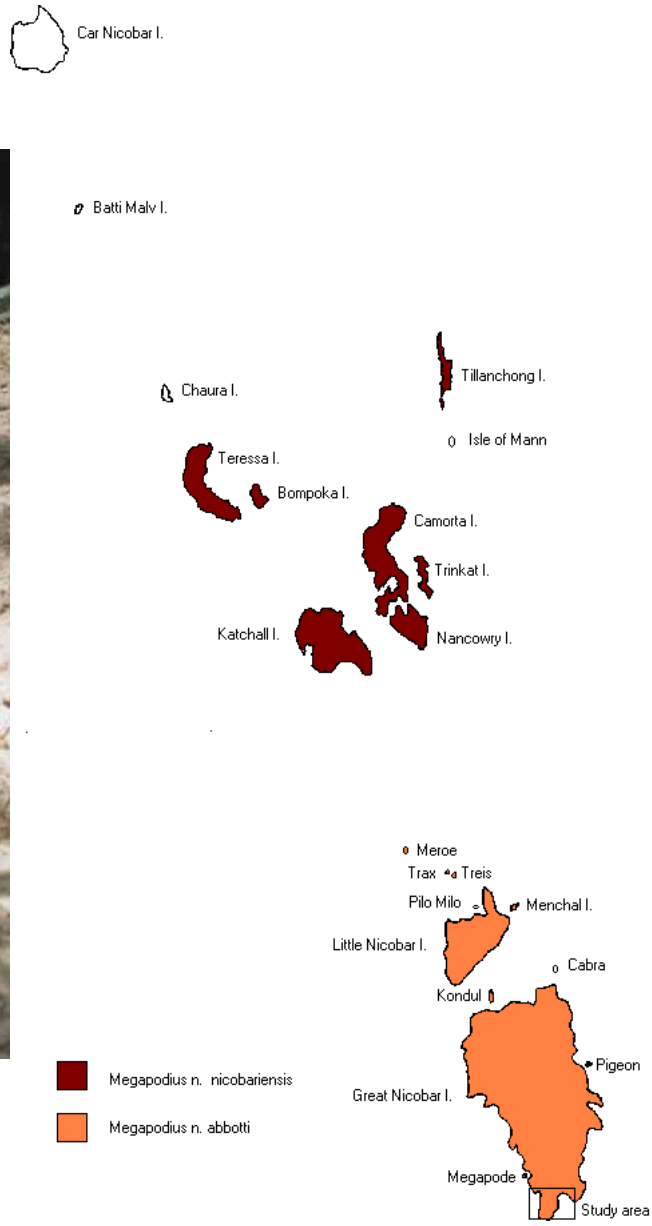
Courtesy: Prof A.K. Maitra

Impact of tsunami on habitat of Nicobar Megapode *Megapodius nicobariensis*

- The family Megapodiidae consists of 22 species.



The Nicobar Megapode



Mound nests

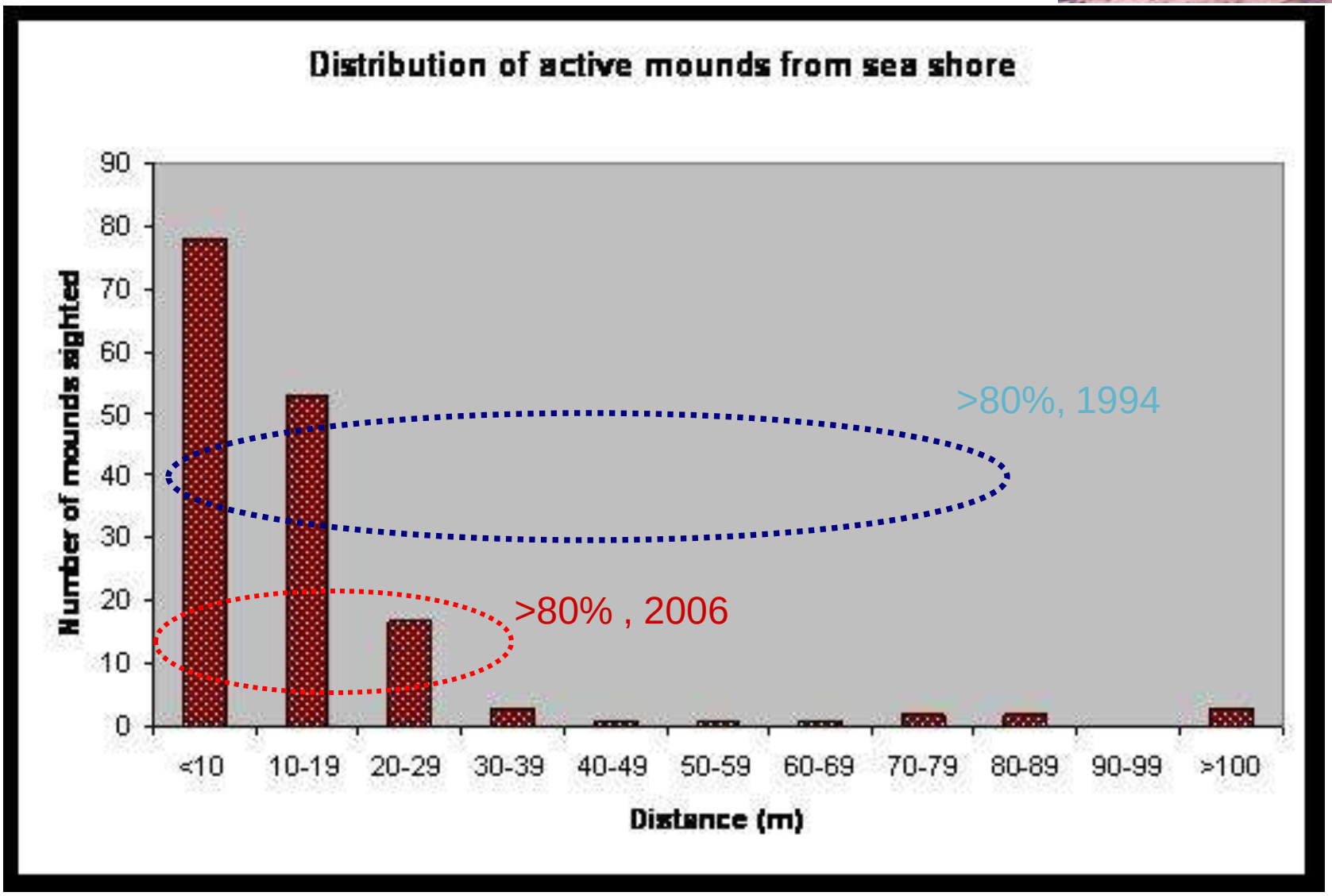
Chick hatching out from a mound

Habitat

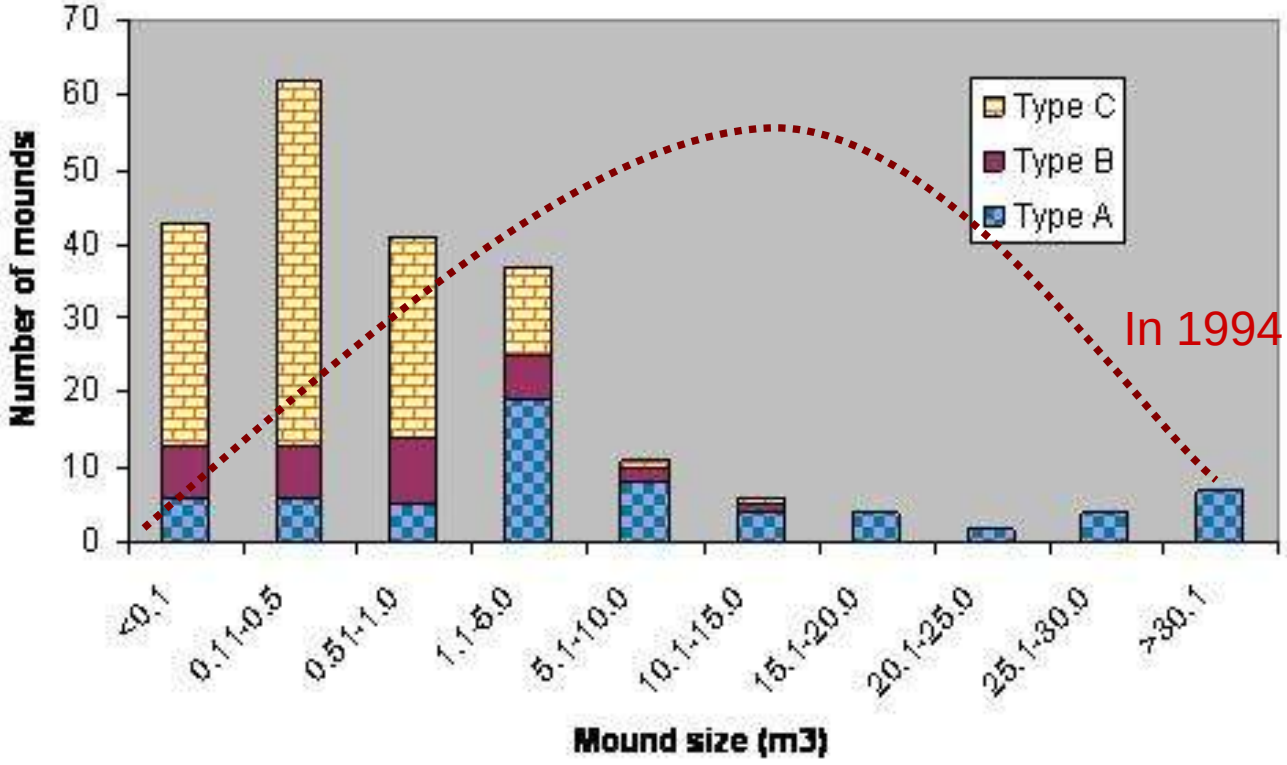
Important findings
Coastal Habitats adversely impacted

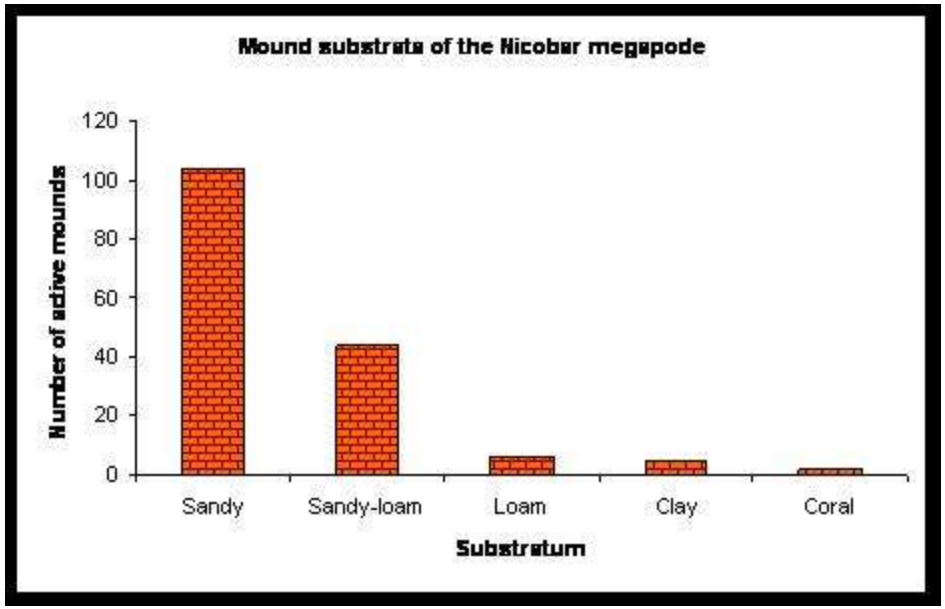
Before and after tsunami

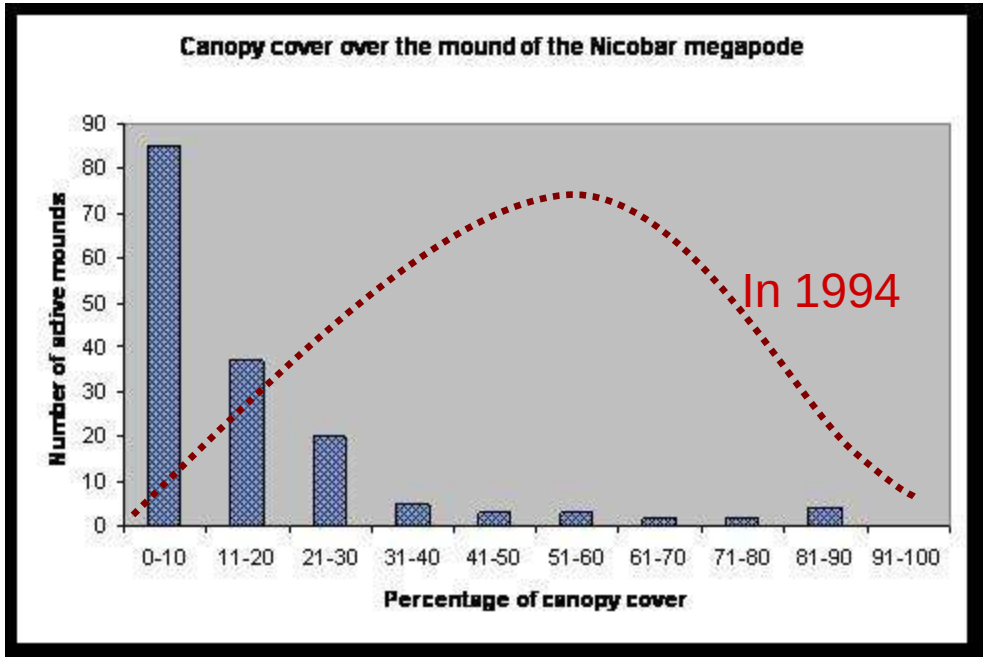
Mound distribution before and after tsunami



Various mound types and mound sizes of the Nicobar megapode




Mound substrata of the Nicobar megapode
Number of active mounds
120
100
80
60
40
20
0
Sandy
Sandy-loam
Loam
Clay
Coral
Substratum

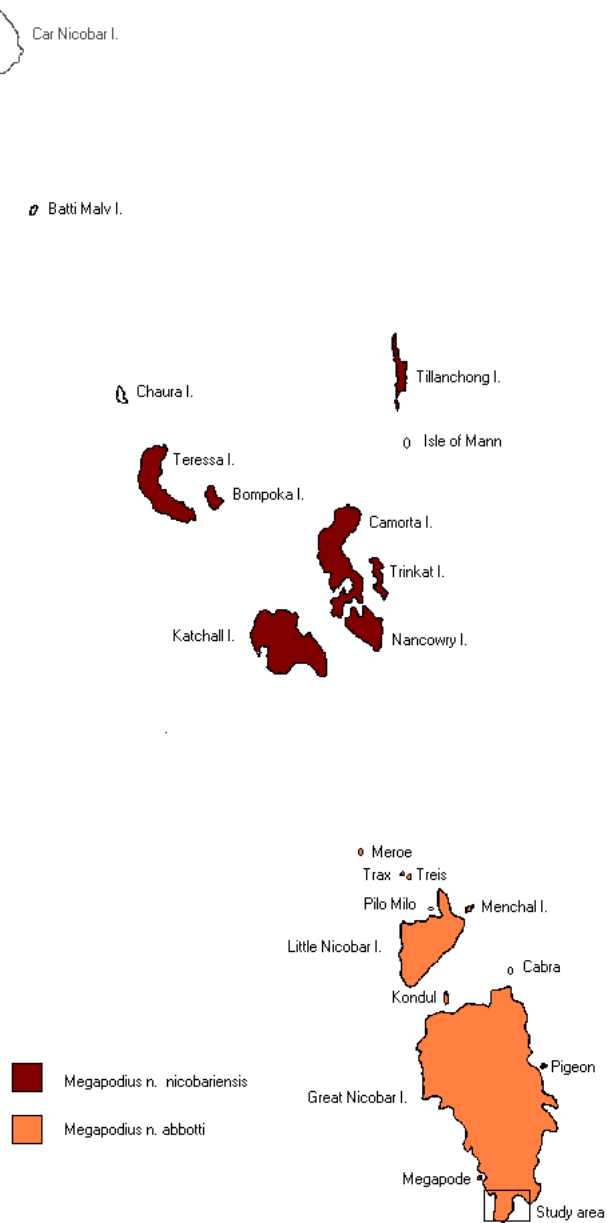

Canopy cover over the mound of the Nicobar megapode
Number of active mounds
90
80
70
60
50
40
30
20
10
0
0-10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81-90
91-100
Percentage of canopy cover
In 1994

Recommendations

- Management of habitat
  - Restoration of habitat on the west coast of Great Nicobar
  - Check on plantation works
  - Removal of invasive species (offer from UK-WPA)
  - International shipping project is not advisable

Review on Existing PA Network for the Nicobar megapode:

- Add the entire west coast and southern part of Great Nicobar to existing PAs
- Proposal for Little Nicobar and Nancowry group of islands 'Conservation Reserves'



Hunting and egg collection:

- ***Food for guns (offer from Germany – detail proposal needs to be developed)***
- ***Awareness programme through the tribal Chiefs.***
- ***Prohibition of air guns in PAs and in proposed Conservation Reserves.***

Strengthening Wildlife Protection

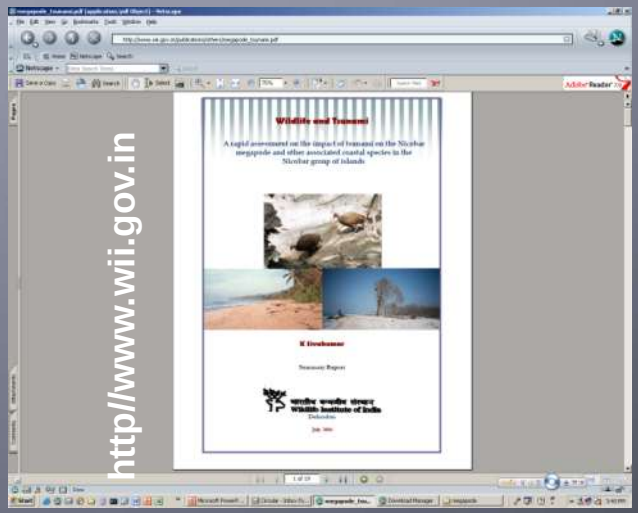
- **Re-establishment of infrastructure**
- **Establishment of 'Wildlife monitoring cum anti-poaching camps'**
- **Recruitment of staff**
- **Strengthening infrastructure for wildlife protection and patrolling.**
- **Independent ACF for Nancowry group of islands**
- **Incentives for staff who posted in anti-poaching camps**


Weekly News Roundup
TRINet
Tsunami Rehab Information Network
Weekly News September 4, 2006
This week's news round up is organized under various headings as follows.
Click on the item to go directly to the section you would like to read.
General
Tsunami Warning
Livelihoods
Housing and Infrastructure
Women
Children
Elderly
Other Countries: Indonesia, Sri Lanka, Thailand, Malaysia, Maldives
General
The Nicobar megapode, a ground-dwelling bird in some ways resembling the ill-fated dodo, has had a tough decade--and the Asian tsunami of 2004 has made matters worse. The Wildlife Institute of India has surveyed the bird's habitat and found that the population has declined by about 70% over the past dozen years. Earlier this year, India's premier wildlife institute conducted a status survey of endangered species in the Nicobar Islands east of Sri Lanka, which were severely affected by the tsunami. The researchers found evidence of only 800 breeding pairs of the megapode. Worse, says institute scientist K. Sivakumar, Megapode Island, which was declared a wildlife sanctuary for the birds, has been totally submerged. Sivakumar believes that if local tribes can be made aware of the problem, the bird population, which is mainly threatened by habitat destruction, could bounce back.


The Statesman


Science


Down To Earth


http//www.wii.gov.in
Wildlife and Tsunami
A rapid assessment on the impact of tsunami on the Nicobar megapode and other associated coastal species in the Nicobar group of islands
K Sivakumar
Summary Report
Wildlife Institute of India

Thank You