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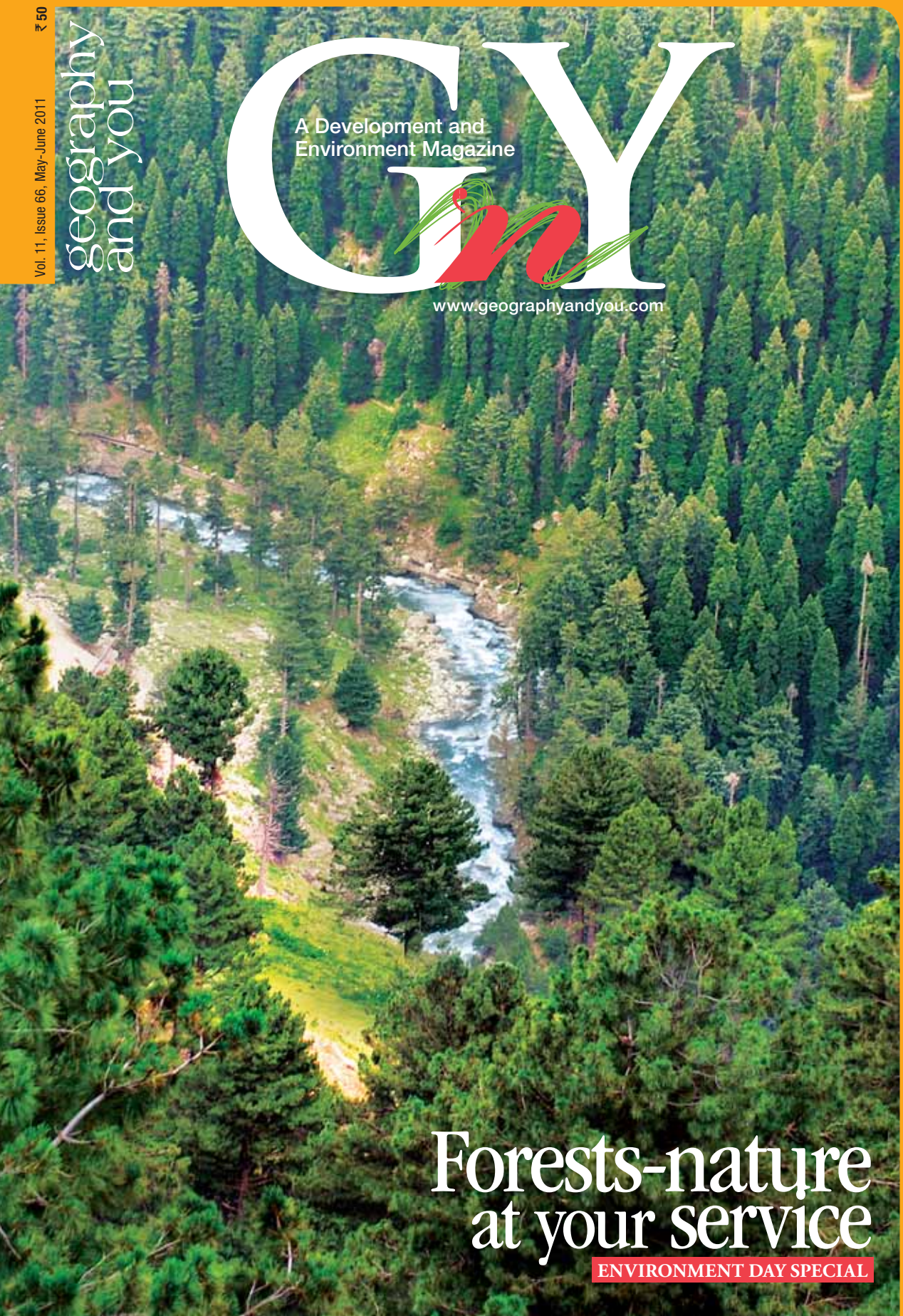


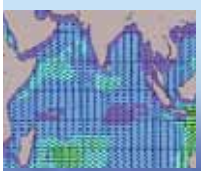
Forests-nature at your service

ENVIRONMENT DAY SPECIAL

Indian National Centre for Ocean Information Services

The Indian National Centre for Ocean Information Centre (INCOIS), an autonomous body under the Ministry of Earth Sciences (MoES) has a vision to emerge as a knowledge and information technology enterprise for the oceanic realm with a focus on the life of nearly 350 million of coastal population and specifically 7 million fishing community. The mission of INCOIS is to provide information and advisory services to society, industry, government agencies and scientific community through sustained ocean observations and constant improvements through systematic and focussed research.

Activity Spectrum



- Potential Fishing Zone Advisory Services
- Ocean and Coastal State Forecast
- Early Warning System for Tsunami and Storm Surges
- Ocean Observing System
- Ocean Modelling
- Satellite Coastal and Oceanographic Research
- National and Regional Oceanographic Data Centre
- Web-based Ocean Data, Information and Advisory Services
- Coastal Geospatial Applications
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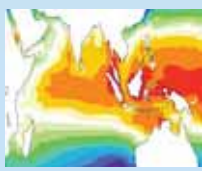


Indian National Centre for Ocean Information Services
(Ministry of Earth Sciences)
Ocean Valley, Pragathi Nagar (BO), Nizampet (SO), Hyderabad-500090

Phone 91-(0)40-23895000/23886000, Fax: 91-(0)40-23895001
e-mail: director@incois.gov.in, URL: http://www.incois.gov.in

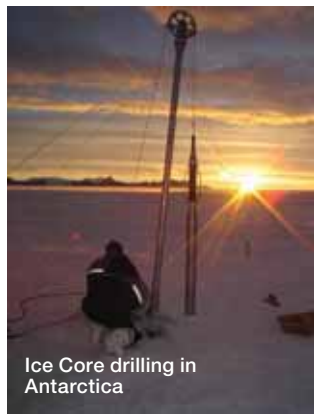
NCAOR

The Indian gateway to polar regions

Maitri - Indian Research Base in Antarctica

Himadri - The Indian Research Base in Arctic

National Centre for Antarctic and Ocean Research (NCAOR) - an autonomous R&D Institution under Ministry of Earth Sciences - is the nodal agency coordinating and implementing the Indian Polar (Arctic, Antarctic and Southern Ocean) Program. It is the only institute in the country that has the capability to raise, archive & process ice cores from polar regions. India has successfully launched 30 scientific expeditions to Antarctica and 5 expeditions each to Arctic and Southern Ocean till now. In the year 2010-11, NCAOR accomplished the first ever Indian expedition to South Pole. Apart from Maitri in Antarctica, India now has a research Base – Himadri – in Arctic. The first phase of the construction of new research base in eastern Antarctica, Bharati, is complete and station is likely to be commissioned in 2012-13. The process for acquisition of a new Ice Breaker Polar Research Vessel is in advanced stage.



Ice Core drilling in Antarctica

Research

- Ice Core Studies
- Polar Limnology
- Remote Sensing
- Climate Change Studies
- Southern Ocean Processes
- Exclusive Economic Zone Survey
- Legal Continental Shelf Mapping
- Environmental Impact Assessment
- Microbial Biodiversity & Biogeochemistry

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- Earth Station - Satellite Link with Maitri
- Ice core processing and repository complex
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- State of the art laboratory and library facilities
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Research Ship in waters near Antarctica

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CLIMATE CHANGE

CENSUS 2011

INDIA OUTDOORS

Editor
Sulagna Chattopadhyay

Associate Editor
Shubhra Kingdang

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Cover Photograph
Summer evening in the alpine pastures interlaced with forested slopes of pine, fir and silver birch, a gurgling brook and myriad birds, indeed paradise on earth - Gulmarg, Kashmir 2011 by Prasad

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Correspondence/Editorial Office
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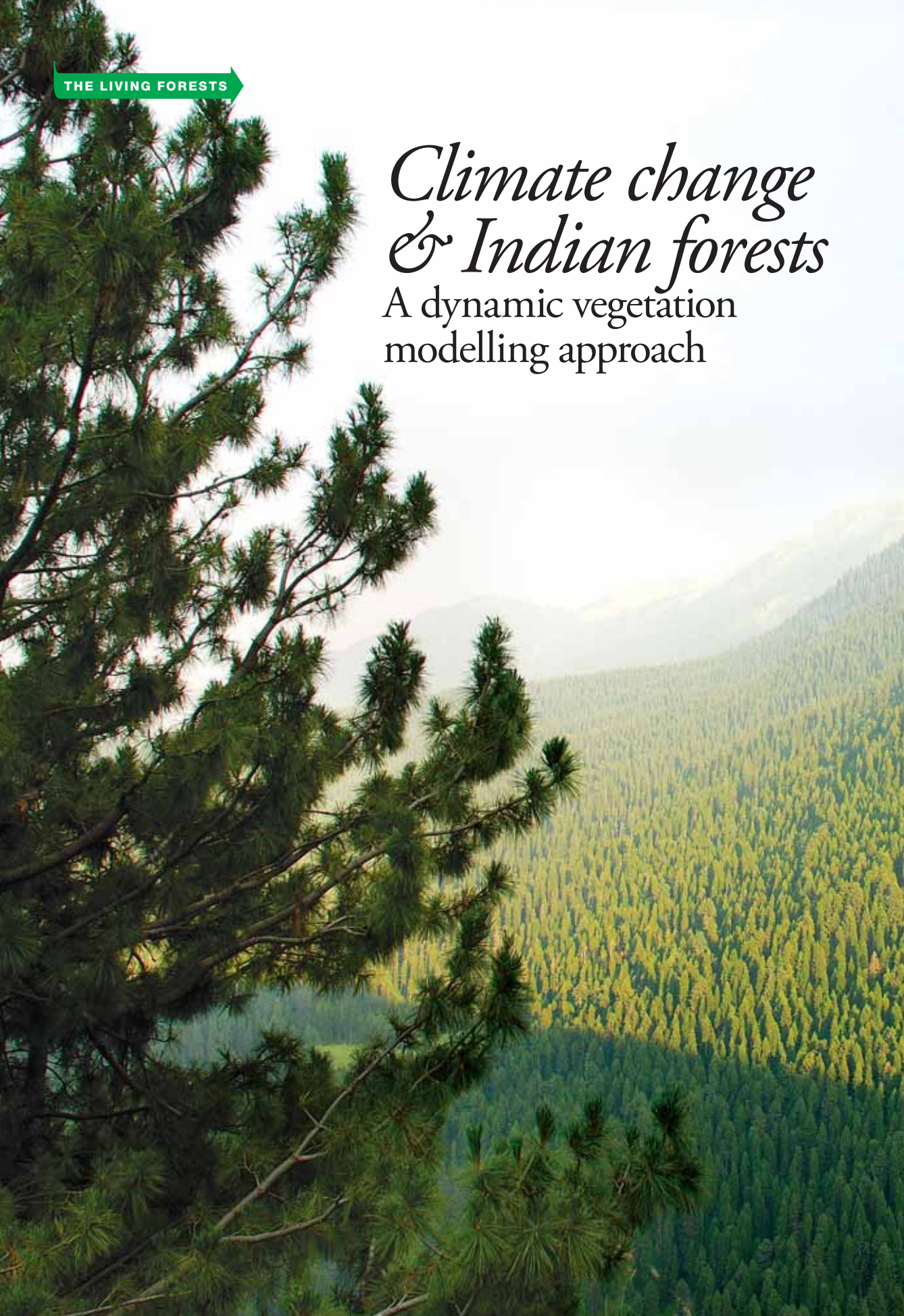
Climate change & Indian forests

A dynamic vegetation modelling approach



An assessment of the impact of climate change on forest ecosystems in India has been attempted in this paper, based on climate projections of the Regional Climate Model of the Hadley Centre and the dynamic global vegetation model IBIS for A2 and B2 scenarios. A forest vulnerability index for India has also been worked out based on the dynamic global vegetation modelling and observed datasets of forest density, forest biodiversity as well as model predicted vegetation type shift estimates for forested grids.

Story **Rajiv K Chaturvedi, Ranjith Gopalakrishnan, Mathangi Jayaraman, Govindasamy Bala, N V Joshi, Raman Sukumar** *and* **N H Ravindranath**

DENSE FOREST CANOPY - GULMARG, KASHMIR

Climate is one of the most important determinants of vegetation patterns globally and has significant influence on the distribution, structure and ecology of forests. Several climate-vegetation studies have shown that certain climatic regimes are associated with particular plant communities or functional types. It is therefore logical to assume that changes in climate would alter the distribution of forest ecosystems. Based on a range of vegetation modelling studies, UN's Intergovernmental Panel on Climate Change (IPCC) 2007 suggest potential forest dieback towards the end of this century and beyond, especially in tropics, boreal and mountain areas.

Assessments of potential climate change impacts on forests in India were based on the BIOME model (versions 3 and 4), which being an equilibrium model, does not capture the transient responses of vegetation to climate change. The recent study (Ravindranath et al. 2006) concludes that 77 per cent and 68 per cent of the forested grids in India are likely to experience shift in forest types for climate change under A2 and B2 scenarios, respectively (refer to page 13 for special report on emission scenarios - SRES). In addition there have been two regional studies, the first focusing on potential climate change impacts on forests in Himachal Pradesh (Deshingkar 1997) and a second in the Western Ghats (Ravindranath et al. 1997). These studies indicated moderate to large scale shifts in vegetation types with implications for forest dieback and biodiversity. The studies conducted for India so far have faced several limitations, e.g., coarse resolution of input data; and, use of BIOME, an equilibrium model with limited capability in categorising plant functional types and dynamic representation of growth constraints.

Impacts of climate change on forests have severe implications for people who depend on forest resources for their livelihoods. India is a mega biodiversity country where forests account for more than one fifth of the geographical area. With nearly 173,000 villages classified as forest villages, there is a large dependence of communities on forest resources. India has a huge afforestation programme of over 1.32 mha per annum, and more area is likely to be afforested under programmes 'Green India Mission' and 'Compensatory Afforestation Fund Management and Planning Authority' (CAMPA). It is thus imperative to assess the likely impacts of projected climate change on existing forests and afforested areas, and develop and implement adaptation strategies to enhance the resilience of forests to climate change.

Status of forests in India

According to the Forest Survey of India (FSI) 'all lands, more than one hectare in area, with a tree canopy density of more than 10 per cent is defined as forest' (FSI 2009). The status of forests and forest management systems contribute to the vulnerability of forests to climate change. The Forest Survey of India has been periodically estimating the forest cover in India since 1987 using remote sensing techniques. In addition to forest cover, FSI has also included the tree cover in its 2001, 2003, 2005, and 2007 assessments.

Indian forests are extremely diverse and heterogeneous. Classification of Indian forest types is available from two main sources - Forest Survey of India (FSI 2001) and Champion and Seth (1968). Due to forest heterogeneity, Forest Survey of India's classification scheme has a pan-Indian 'miscellaneous forest' category (with no dominant species), which accounts for 63 per cent of forest area. This large miscellaneous category makes the FSI classification rather unattractive for further analysis. However, Champion and Seth (1968) classify Indian forests into 16 distinct forest types, prompting us to opt for the Champion and Seth classification for further analysis. The distribution of forest types in India according to Champion and Seth (1968) is shown in Fig 1.

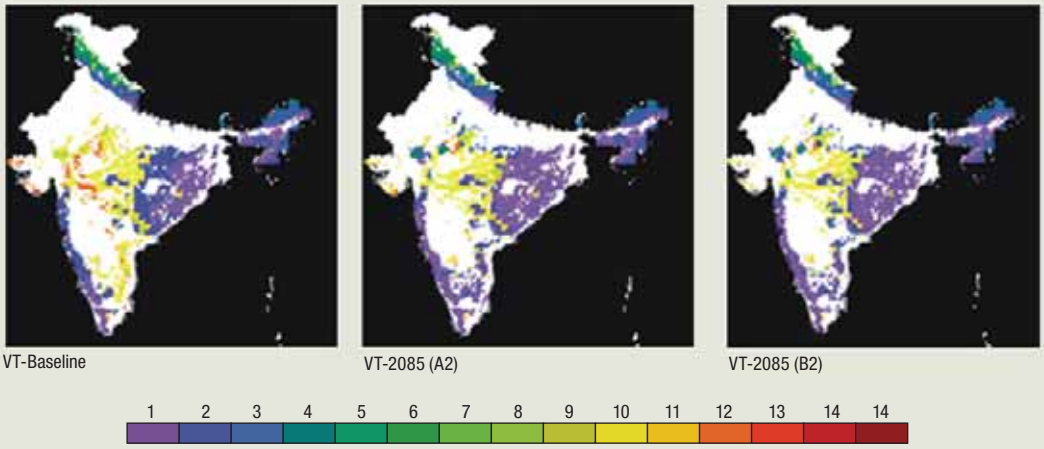
Methods

The impacts of climate change on forests in India are assessed based on the changes in area under different forest types, shifts in boundary of forest types and net primary productivity (NPP). Data sets selected were: (i) spatial distribution of current climatic variables, (ii) similar data for future climate projected by relatively high resolution regional climate models for two different climate change scenarios, and (iii) vegetation types, NPP and carbon stocks as simulated by the dynamic model IBIS V.2 (Integrated Biosphere Simulator).

Vegetation model

The dynamic vegetation model IBIS is designed around a hierarchical, modular structure. The model is broken into four modules - land

Fig 1. Forest type, distribution and extent simulated by IBIS for the baseline case and A2 and B2 scenarios



White areas represent non-forested grids. (VT - refers to Vegetation Types). The numbers refer to the following vegetation types **1:** tropical evergreen forest / woodland, **2:** tropical deciduous forest / woodland, **3.** temperate evergreen broadleaf forest / woodland, **4:** temperate evergreen conifer forest / woodland, **5:** temperate deciduous forest / woodland, **6:** boreal evergreen forest / woodland, **7:** boreal deciduous forest / woodland, **8:** mixed forest / woodland, **9:** savanna, **10:** grassland/ steppe, **11:** dense shrubland, **12:** open shrubland, **13:** tundra, **14:** desert, **15.** polar desert / rock / ice

For analysis, we considered the forested grid points obtained from Forest Survey of India forest type classification 2001. Then, we identified grids where vegetation type (simulated by IBIS) is projected to change under A2 and B2 scenarios compared to baseline scenario (Fig. 2). Approximately 39 and 34 per cent of forested grid are projected to experience vegetation type change under A2 and B2 climate scenarios, respectively. In agreement with earlier studies, we find a trend towards expansion of wetter forest types. Tropical dry deciduous forests currently constitute more than 40 per cent of the Indian forested grids. Our analysis suggests that approximately 47 and 42 per cent of these tropical dry deciduous grids undergo change under A2 and B2 climate change scenarios, respectively, as opposed to less than 16 per cent grids for tropical wet evergreen forests. Tropical moist forests, which constitute 20 per cent of the grid points, appear to be relatively stable with only 38 and 34 per cent of forested grids experiencing change under the two scenarios. However, tropical thorny scrub forest which constitutes 20 per cent of the Indian forested area is projected to experience a larger change with majority of grids (more than 80 per cent) undergoing change under A2 scenario and 50 per cent grids experiencing change under the B2 scenario.

surface module, vegetation phenology module, carbon balance module and vegetation dynamics module. These modules, though operating at different time steps, are integrated into a single physically consistent model that may be directly incorporated within AGCMs (atmospheric general circulation models). For example, IBIS is currently incorporated into two AGCMs namely GENESIS-IBIS and CCM3-IBIS. The model allows an understanding of different light and water regimes - enhancing comprehension of competition for sunlight and soil moisture which determines the geographic distribution of plant functional types and the relative dominance of trees and grasses, evergreen and deciduous phenologies, broadleaf and conifer leaf forms, and C3 and C4 photosynthetic pathways.

Input data

IBIS requires a range of input parameters, primarily climatological and soil characteristics. The main climatological parameters used are: monthly mean cloudiness (per cent), monthly mean precipitation rate (mm/day), monthly mean relative humidity (per cent), monthly minimum, maximum and mean temperature (C) and wind speed (m/s); while the main soil factor used is texture (i.e percentage of sand, silt and clay). The model also requires topographical information.
Observed climatology is obtained from Climatic Research Unit (CRU), while soil data was obtained from International Geosphere-Biosphere Programme (IGBP). For climate change projections, RCM outputs from Hadley centre model HadRM3 were used. The climate variables for future

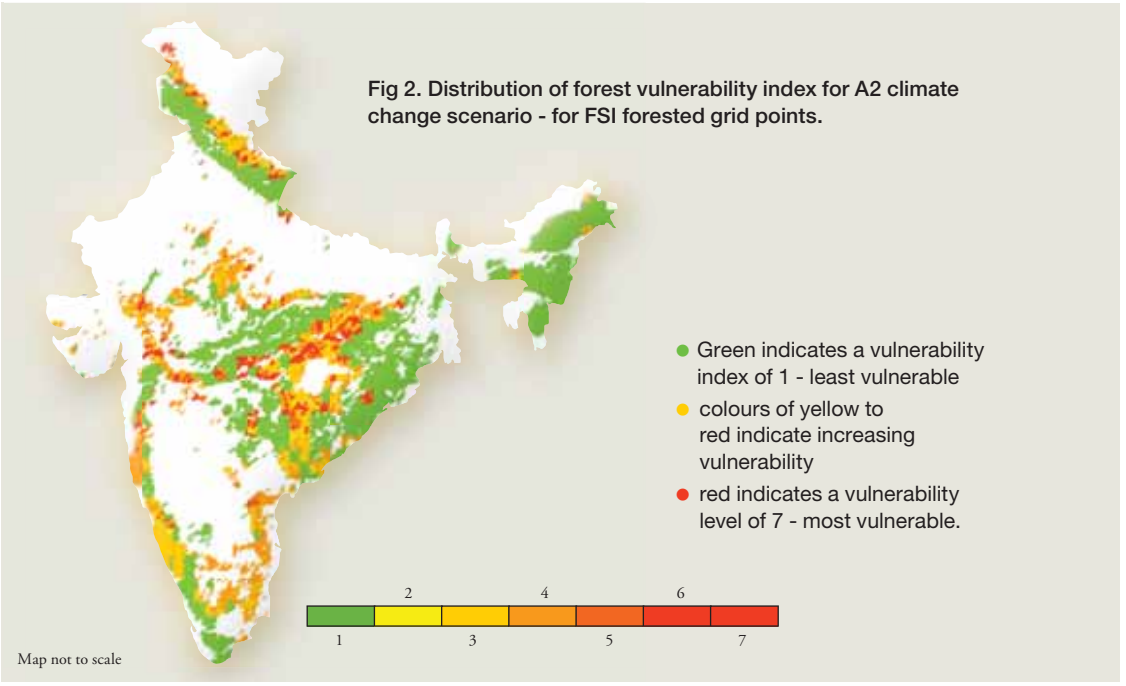


Fig 2. Distribution of forest vulnerability index for A2 climate change scenario - for FSI forested grid points.

scenarios were obtained using the method of anomalies. Briefly, this involved computing the difference between projected values for a scenario and the control run of the HadRM3 model, and adding this difference to the value corresponding to the current climate as obtained from CRU climatology. Climate data operators (CDO) software was used for the data editing and climate data analysis tool (CDAT) for data processing and generation of various maps and plots.

Selection of forested grids

Digitised forest map of India (FSI 2001) was used to determine the spatial location of all forested areas. This map was based on high resolution mapping (2.5 by 2.5 inch), wherein India was divided into over 165,000 grids. Out of these, 35,899 grids were marked as forested grids (along with forest density and forest type). Further, the forest grids were classified into three categories as per forest density: 'very dense forests' with crown density above 70 per cent; 'moderately dense forest' with crown density between 40 and 70 per cent; and, 'open forest' with crown density between 10 and 40 per cent.

Scenarios of climate change

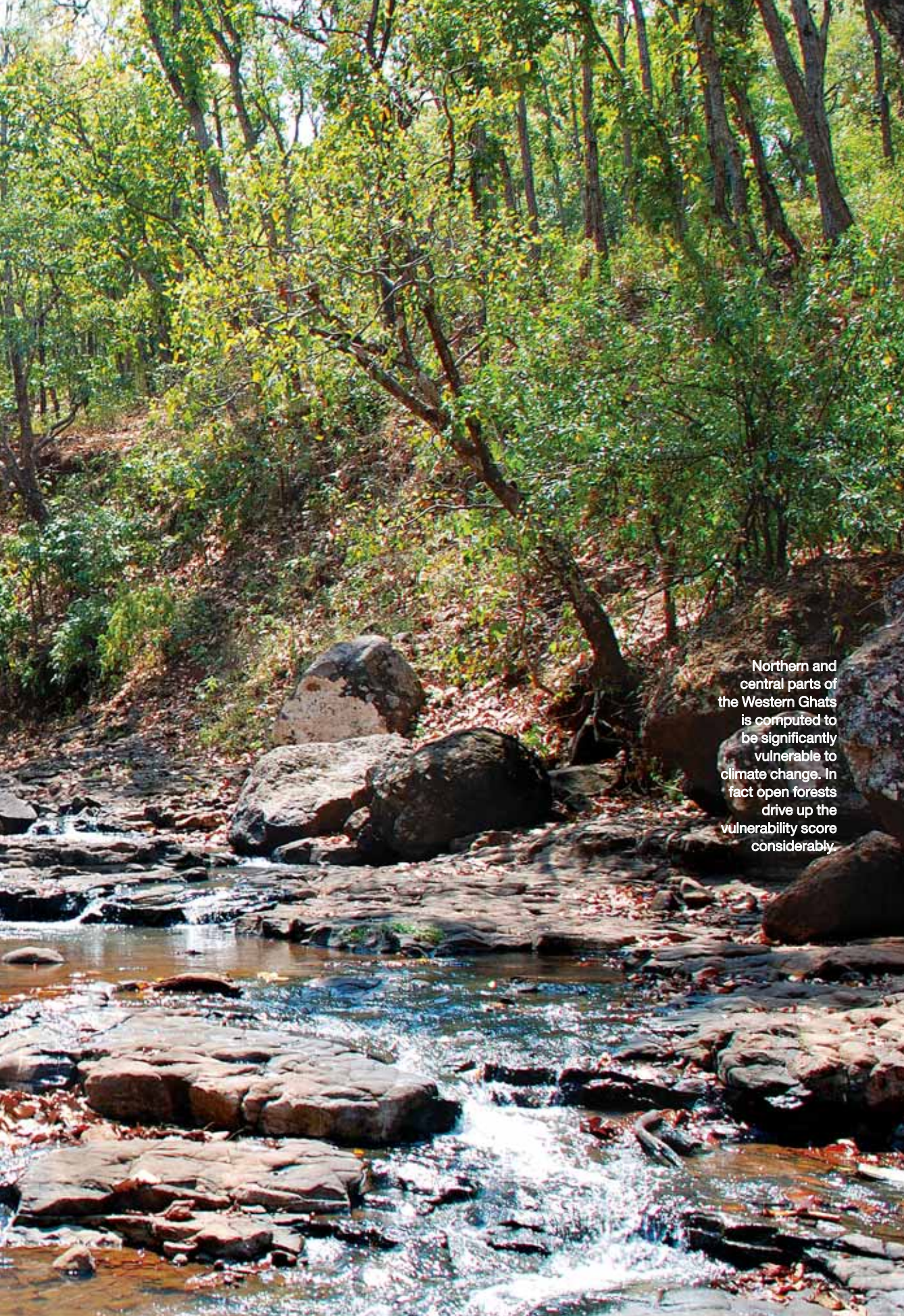
SRES scenario A2 (740 ppm by 2085) is selected as one of the scenarios. However, since a more constrained emission pathway may emerge as a result of global mitigation actions, we also chose B2 scenario (575 ppm by 2085) in this study. The results were then compared with the 'baseline' (also referred to as reference or control case) scenario, which represents the simulation using the 1961-91 observed climatology.

Impacts of climate change on forest types and extents

CHANGES IN THE DISTRIBUTION OF FORESTS

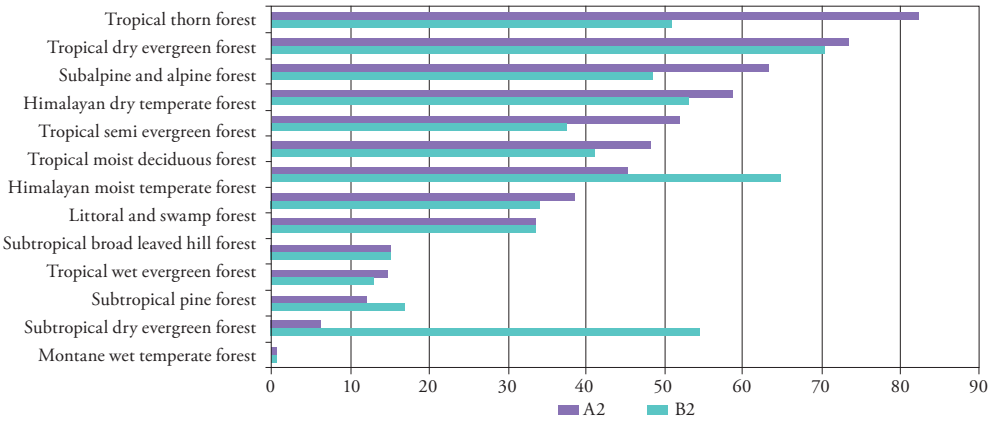
The vegetation distribution simulated by IBIS for baseline, A2 and B2 scenario in the forested grids are shown in Fig 1. It is noticed that there is an expansion of tropical evergreen forests (IBIS vegetation type 1) in eastern India plateau for both A2 and B2 scenarios. The same trend can be observed in the Western Ghats. It is interesting to note that there is almost no vegetation type change in the northeast. Further, there is a slight expansion of forests into the western part of central India. Overall, there is negligible difference between forest extents predicted for the future in A2 and B2 scenarios except that forest expansion is higher in the western part of central India in the A2 scenario. This could be attributed to higher precipitation levels in A2 scenario relative to B2 in this region. One caveat to the expansion trend of forests (like tropical

ACHANAKMAR FORESTS, CHHATTISGARH



Northern and central parts of the Western Ghats is computed to be significantly vulnerable to climate change. In fact open forests drive up the vulnerability score considerably.

Fig 3. Percentage of forest grids undergoing vegetation change by 2085 under A2 and B2 scenarios according to forest types



evergreen) is the assumption that forests are not fragmented, and there is no dearth of seed dispersing agents. In the real world, forests are indeed fragmented, and, seed dispersal may not be efficient in the view of loss or reduction in number of dispersal agents due to human habitation pressures and climate change. As the population of seed dispersing agents decline, predicted forest expansion is not guaranteed.

Vulnerability index for India's forests

Forests in India are already subjected to multiple stresses including over extraction, insect outbreaks, livestock grazing, forest fires and other anthropogenic pressures. Climate change is an additional one. Disturbed and fragmented, forests and monoculture forests are likely to be more vulnerable, to climate change. Therefore, a vulnerability index, Fig 2, has been developed to assess the risk factor of different forest types and regions. The various vulnerability index classes were defined by spatially combining information on forest diversity (monoculture versus natural forest), forest density (an indicator of degradation) and IBIS vegetation type change estimates for the forest grids under A2 scenario. For example, if a particular forest grid had monoculture vegetation, a low forest density (or higher levels of degradation) and if there was a vegetation type shift in the future as predicted by IBIS, then this grid point is given the highest vulnerability index of 7. The analysis thus achieved, points towards nearly 39 per cent of forested grids being vulnerable to climate change in India. The forests in central India are highly vulnerable. There are pockets of vulnerable forests surrounded by non vulnerable regions in that area.

A significant part of the Himalayan biodiversity hotspot that stretches along the north western part of India along the states of Punjab, Jammu and Kashmir and Himanchal Pradesh is projected to be highly vulnerable, mostly attributable to the higher elevation of these regions. Our studies have shown that these regions will experience increased levels of warming.

Northern and central parts of the Western Ghats also seem to be significantly vulnerable to climate change. Northern parts of the Western Ghats contain significant extent of open forests, which drive up the vulnerability score. High values of the index in the central part of the Ghats are likely caused by the negligible precipitation increase over there (with more than 3°C rise in temperature). Forests in the southern part of the Western Ghats appear to be quite resilient as forests in this region are less fragmented, more diverse and they also support tropical wet evergreen forests which, according to IBIS simulations, are likely to remain stable. In the northeast of India, there are relatively few areas that have a high vulnerability index. This low vulnerability index in this regions is because climate is predicted to get hotter and wetter, which is conducive to the existing vegetation types - tropical evergreen forests. GY

The authors are from the Indian Institute of Science, Bangalore. nh.ravi@gmail.com,

The article is an extract of a previously online published work in Springer Science and Business Media BV in August 2010.

THE EMISSIONS SCENARIOS

The Emissions Scenarios is prepared by the Intergovernmental Panel on Climate Change (IPCC) and was published in the year 2000. The emissions scenarios have been used to make projections of possible future climate change.

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid century and declines thereafter, and rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income.

The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily region oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the A1 and B1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels. GY

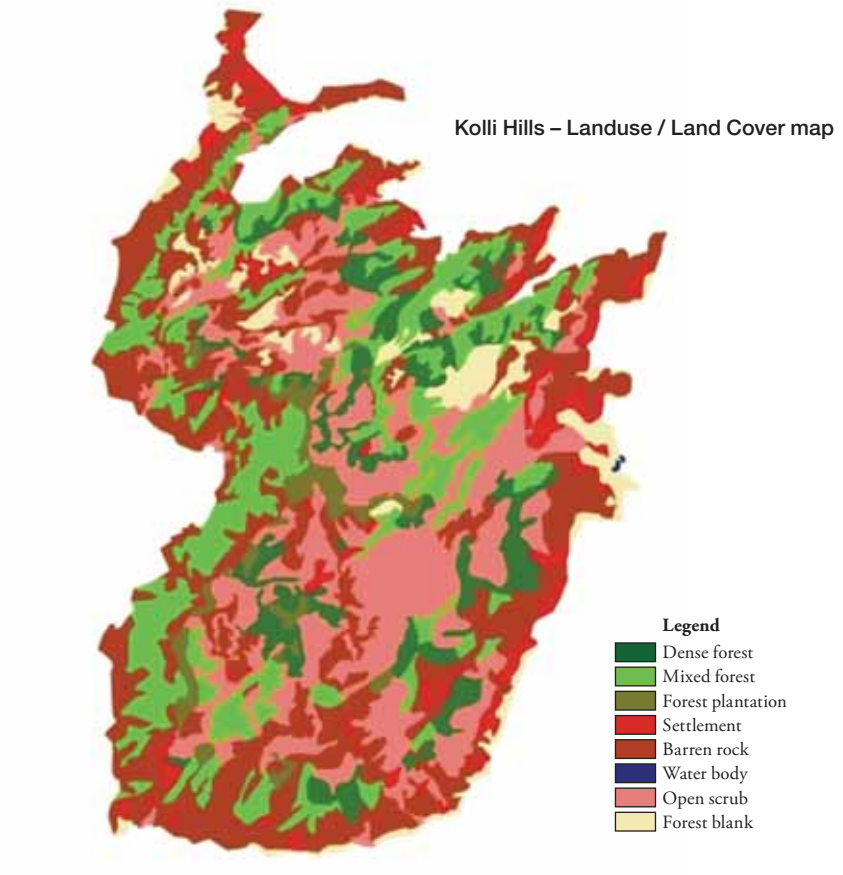
Source: IPCC (2001). CLIMATE CHANGE 2001: THE SCIENTIFIC BASIS. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Edited by: J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, C.A. Johnson (page 63 of the Report; Chapter: Summary for Policy Makers).

Changing *Forest* Carbon

Under elevated CO_2 conditions a possibility of decomposition occurring more than net primary production, leading to a loss of carbon, is predicted in some forest regions. A micro level study undertaken in the small mountain range of Kolli, located in the Namakkal District of Tamil Nadu, points towards a enhanced need to measure carbon stock deterioration amidst the struggle to fend off anthropogenic disturbances.

Story **R Mohanraj and J Saravanan**

Cultivation in streams



Forest ecosystems play a crucial role in global carbon cycles, acting as a sink and a source. Forests form an active carbon pool that accounts for 60 per cent of carbon storage in the earth's land surface. Therefore, dynamics of carbon in forest vegetation and soils are significant in terms of global climate change policy framework. The rate of carbon absorption is greatest in the earliest stages of growth and regeneration, and declines as forests mature. Tropical forests dominate the dialogue in the global carbon flux, and carbon stocks. It is thus such regions that require dedicated research to estimate its carbon sequestration potential. The tropical forests, both moist and dry types, account for approximately 60 per cent of global forests. While covering only 22 per cent of potential vegetation by area, tropical forests

Table 1. Total carbon stock changes in Kolli Hills

in teragram (Tg)

Forest type	Above ground biomass		Soil (up to 0.3m)		Woody debris		Surface litter	
	2009	2010	2009	2010	2009	2010	2099	2010
Evergreen	0.82	1.43	0.83	0.56	0.00019	0.00034	0.00625	0.01602
Deciduous	2.21	1.97	3.12	2.03	0.00052	0.00337	0.01743	0.05333
Mixed	0.97	1.69	0.99	1.28	0.00021	0.00110	0.00716	0.01829
Open scrub	0.43	0.53	0.54	0.46	0.00009	0.00058	0.00286	0.00694
Plantation	0.06	0.06	0.05	0.07	0.00001	0.00003	0.00042	0.00001
Total stock	4.49	5.68	5.53	4.4	0.00102	0.00542	0.03412	0.09459

The Kolli Hills region is important for its plantation products which include coffee, tea, jackfruit, pineapple, black pepper and other spices. Rice and other minor millets form the primary food of the tribal people who inhabit these mountains.

have been estimated to account for 75 per cent of the world's terrestrial net primary productivity (NPP). However, under elevated CO_2 conditions a possibility of decomposition occurring more than net primary production (NPP) leading to a loss of carbon is predicted in some forest regions. In others, elevated CO_2 and N deposition tend to increase NPP more than decomposition, leading to carbon storage. Given the uncertain scenario, a micro level carbon flux examination of different forest types alone can give a clear picture.

The two significant drivers of forest carbon flux are biophysical processes operating at various spatial and temporal scales; and the local anthropogenic disturbances. In addition to this, global climate change and other multiple stressors such as ozone, sulphur and nitrogen depositions also influence the productivity and carbon stock, which has been largely ignored till date in the Indian scenario. Many studies in the nation have pointed out forest degradation and productivity loss due to regional climate anomalies and trends, fires, cultivation, mining, biomass extraction and cattle grazing. The challenge for the scientific and policy making community now lies in identifying the major factor that affect the carbon flux in the forest at micro level.

Study Area

In one such attempt we focussed on carbon stock variations in the Kolli Hills forest regions of Namakkal, Tamil Nadu, covering an area of about 500 km^2. The forest occupies 44 per cent of the total geographical area, agricultural activities take place in 51.6 per cent and other activities occupy less than 5 per cent of the total geographical area. Annual rainfall is between 300 to 750 mm and the soil type varies between red to black clay. The highest point in the region is marked by Kollimalai, 1400 m above sea level, but the general elevation of the Kolli Hills is not more than 1000 m. As per Census 2001, the population residing in the area is about 37 thousand.

As described in classical Tamil literature, under varied nomenclature - Agananooru, Silappathigaram, Manimekalai, Purananuru and Ainkurnuru, Kolli Hills, historically witnessed a good forest cover (75 per cent) which gradually dwindled. However, even today the area is important for its farm products which include coffee, tea, jackfruit, pineapple, black pepper and other spices. Rice and other minor millets form the primary food of the tribal people who inhabit these mountains. Kolli Hills are also well known for their medical herbs and plants.

The Results

Evergreen and semi-evergreen forests in this area occurs in upper plateau region with an elevation of 900 m and above, while the slopes are occupied by deciduous and thorn forests. Land use and land cover analysis showed abundance of different forest cover in the order deciduous > mixed > evergreen > open scrub > plantation with total area under forest cover extending up to 26587.8 ha. Anthropogenic disturbances such as mining, exotic plantation, agriculture extension, shifting cultivation, over grazing, tourism developments and firewood collection occurred at several places. An earlier study also hinted extensive mining activities in Kolli Hills removing about 600 mg of soil per day for cement and aluminium factories.

Our examination for carbon stock was limited to the forest cover that is protected under reserved forests. For comparative assessment, sample studies were also undertaken in the open scrub and plantation forests. Research revealed that the carbon stock is undergoing a gradual change in the forest system both above ground and within the soil. For instance carbon stock in the above ground biomass increased from 4.4 teragram (Tg) in 2009 to 5.68 in 2010, while the soil carbon stock decreased in the same proportion (Table 1), which implies Kolli Hills forest is neither a sink nor source. However, the increase of carbon stock in woody debris and surface litter indicates a possible addition to future soil carbon stock, provided similar biophysical conditions prevail without any anthropogenic disturbances. Periodical examination of this and similar areas is required to reveal if a particular region in the forest ecosystem is undergoing any significant change. Subsequently, the predominant drivers behind the change can also be identified.

The author is Asst. Professor, Department of Environmental Management, Bharathidasan University, Tiruchirappalli.
mohan.bdu@gmail.com

Forests of the Northeast

Over exploitation, habitat loss and fragmentation threaten the biodiversity in the northeast region of India. Serious efforts have to be made by the government as well as the people to protect and conserve the vestiges of virgin forests that still remain in the most forested zone of the country.

Story **Sanjoy Choudhury** and **N Prasad**

The eight states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura - the northeast region of India, constitute one of the 18 recognised biodiversity hotspots of the world. Occupying 7.7 per cent of India's geographical area the northeast contains more than one third of the country's total biodiversity. Of increasing concern is the region's shrinking greenery and degrading ecosystems. Reasons cited for such destruction are:

■ conversion of forests into agricultural land with growing demand for food, ■ reducing cycle of shifting cultivation or *jhum* cycles in most parts of

PHOTO COURTESY: MOEF

the region compounding the loss of forest cover, ■ grazing beyond the carrying capacity of moderate forest cover by large herds of domestic animals, ■ recurrent forest fires, man made and natural, besides destroying vegetation, harden the surface decreasing soil porosity resulting in low rain water infiltration, ■ lumbering for domestic and commercial purposes with increasing industrial expansion, urban growth and rapidly growing human population that damage the natural forests, and ■ multipurpose river projects that require large reservoir area submerging pristine forested tracts.

LOSS OF LIVELIHOOD

The northeast is home to several tribal communities for whom forests have been an invaluable source of livelihood. The tribes traditionally protected the forests. Echoes of continuity in the age old practice may be found still today as 'sacred forests' or 'sacred groves' in Meghalaya, Manipur, Mizoram and Nagaland, the 'sacred landscapes' in Sikkim and the 'sacred hilltops' in Arunachal. Unfortunately such acts of biodiversity conservation is slowly disappearing with conversion from traditional animistic religions to Christianity, western education system, expansion of agricultural activities etc.

STATE OF FORESTS

A review, based on the State of Forest Report 2009, published by Forest Survey of India, reveals some unexpected and contradictory trends in the northeast. Forests represented are classified as very dense with tree canopy density of 70 per cent and above; moderately dense with 40 to 70 per cent canopy density and open with density between 10 to 40 percent. Below 10 per cent it is classified as scrub. For the purpose of this discussion we will restrict our analysis to the first

Hill top agriculture results in rapid erosion and deterioration of top soil

Table 1: Area and percentage of forests in the northeast

Source: SFR, 2009

States	VDF	MDF	OF	FA	GA	% of FA to GA
Tripura	111	4770	3192	8073	10491	76.95
Nagaland	1274	4897	7293	13464	16,579	81.21
Mizoram	134	6251	12855	19240	21081	91.27
Meghalaya	410	9501	7410	17321	22429	77.23
Manipur	701	5474	11105	17280	22327	77.4
Assam	1461	11558	14673	27692	78438	35.3
Arunachal	20858	31556	14939	67353	83743	80.43
Sikkim	500	2161	696	3357	7096	47.31
Total	**25449**	**76168**	**72163**	**173780**	**262184**	**66.28**

VDF: Very dense forest; MDF: Moderately dense forest; OF: Open forest; FA: Forest area; GA: Geographic area

PHOTO: MEGHALAYA BY SANJOY CHOUDHURY

Analysis of moderately dense forests reveals a decline at each stage, with Nagaland topping the list. In fact, the three states of Nagaland, Assam and Arunachal have mapped a decline in every category of forests.

Table 2: Net change from 2005 to 2007 in km²

Source: SFR, 2009

States	VDF	MDF	OF
Tripura	-2 (-1.80)	-46(-0.96)	-52 (-1.63)
Nagaland	-6(-0.47)	-175(-3.57)	-20(-0.27)
Mizoram	0(0)	-133(-2.13)	773(6.01)
Meghalaya	76(18.54)	-26(-0.27)	66(0.89)
Manipur	12(1.71)	-48(-0.88)	364(3.28)
Assam	-3(-0.21)	-95(-0.82)	32(-0.22)
Arunachal	-1(0)	-76(-0.24)	-42(-0.28)
Total change forest type wise	**76(0.30)**	**-599(-0.81)**	**1121(1.57)**

Figure in parenthesis indicates per cent change in area
VDF: Very dense forest; MDF: Moderately dense forest; OF: Open forest; FA: Forest area; GA: Geographic area
Net change data for Sikkim was not available.

three classification as the northeast is known for its resplendent forests.

At the outset forested area of the eight northeast states computed in the Report stands at a whopping 66.28 per cent, much above the target of 33 per cent set by the government of India. Mizoram stands tallest with 91.27 per cent of its area under forests, followed by Nagaland and Arunachal. Understandably, Assam, being the most industrialised state in the area, has the lowest forest cover of 35.30 per cent, which is still higher than the national target.

But this broad picture does not capture the nuances of change that are taking place in the northeast. Delving deeper into the net change matrix of different forest types the degradation is palpable. Dense forests in Tripura are disappearing. In two years, from 2005 to 2007 the decline measured is nearly 2 percent. Similarly in Nagaland, although less, a decline of nearly 0.5 per cent in dense forest cover has been noted. Opposed to this however, is a huge gain of nearly 19 per cent in Meghalaya, offsetting the marked decline in other northeast regions. Analysis of moderately dense forests reveals a decline at each stage, with Nagaland topping the list. In fact, the three states of Nagaland, Assam and Arunachal have mapped a decline in every category of forests. In case of Assam the decline in forest cover is significantly discernible in Kokrajhar, Karbi-Anglong and North Cachar Hills districts. It is also to be understood that forest areas move from one category to the other, but decline of moderately dense forests and increase of open forests may be taken as a proxy variable to demarcate degradation of forests. In totality the northeast has lost 599 km² amounting to nearly 0.8 per cent of moderately dense forest and gained 1121 km² (about 1.6 per cent) of open forests.

STEPS TAKEN BY THE GOVERNMENT

Three factors that primarily threaten the biodiversity of the northeast are over exploitation, habitat loss and fragmentation. Serious public private partnerships efforts have to be made in tandem with governmental interventions to protect and conserve the forests. The National Forest Policy of India, 1998, is now in force. The policy emphasises on increasing the area under forest cover to 33 per cent or one third of the country's total geographical area and to 60 per cent in the hills of northeast India. Also the Forest Development Agency (FDA) is a central agency which provides financial help to the state governments for the planting of trees and

Conversion of forests into agricultural land with growing demand for food and reduced cycles of shifting cultivation in most parts of the region compounds the loss of forest cover in the region.

PHOTO: MEGHALAYA BY SANJOY CHOUDHURY

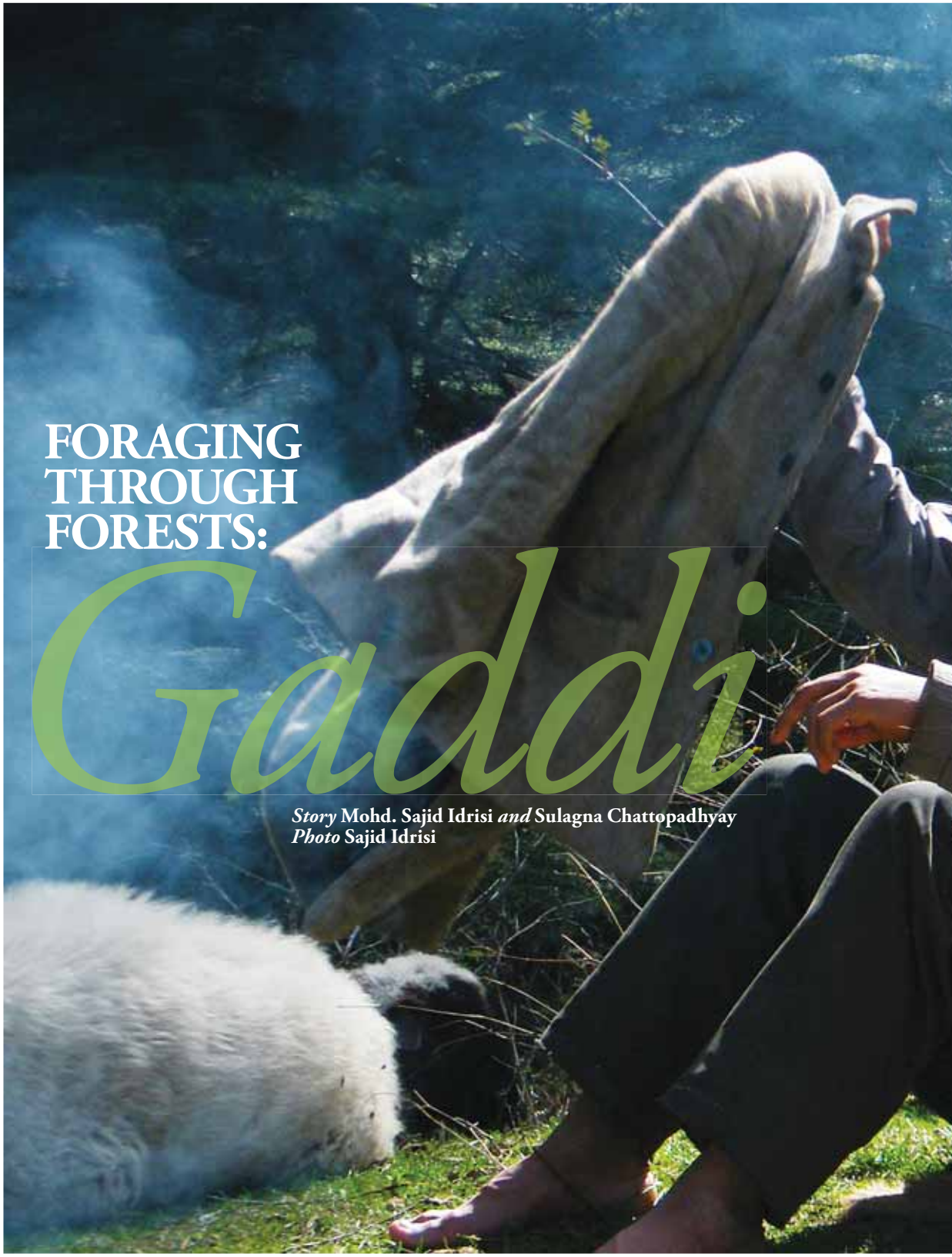
conservation of forest area. The policy of joint forest management (JFM) introduced during the 1980's also encourages participation of local communities in forest management.

In a recent development, the government of Assam has formulated a forest policy, developing a common approach to manage both environment and biodiversity. The new policy is comprehensive and considers all major environmental concerns - flora, fauna, wildlife, soil fertility etc. The policy provides a comprehensive strategy for environmental conservation and improved support system for livelihood of the people living in the fringe areas of forests and thereby seeks to overcome degradation of biodiversity and forest cover.

END NOTE

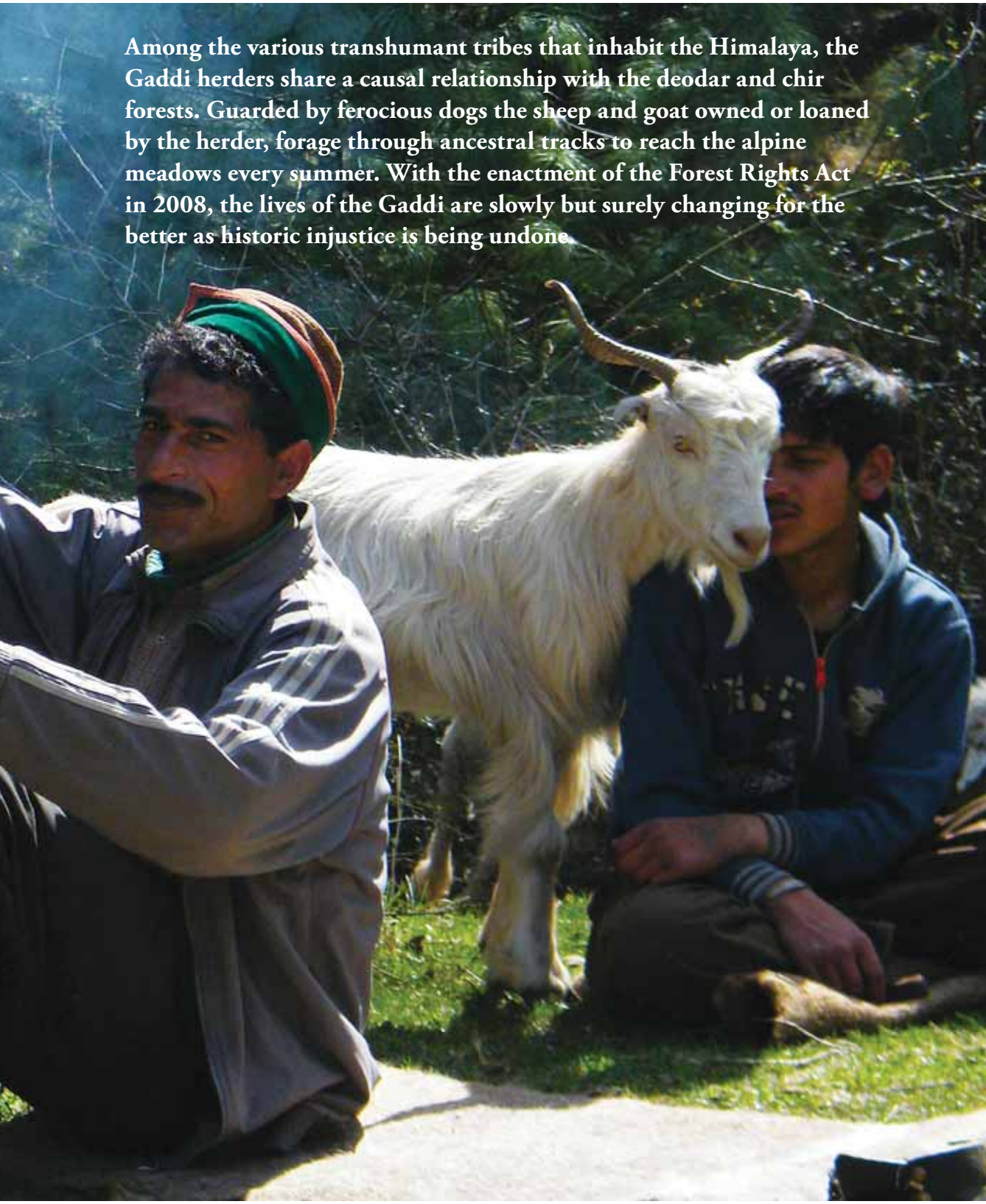
Environmental stability, biodiversity conservation, food security and sustainable development have been widely recognised at many aspects of conservation strategies. Conservation of forest resources would entail management of biosphere reserves, national parks, sanctuaries etc.; regulation of sacred groves; introduction of sustainable afforestation programmes; regulations of community forest management (CFM); possible replacement of areas under *jhum* by alternative economic activities; adoption of ecosystem based forest management to maintain ecological balance; regulation of reforestation in the deforested areas to restore the ecological balance; compulsory plantation projects in educational institutes, youth clubs and communities; watershed management through afforestation programmes; and, provision of alternate livelihoods for forest dwellers of north east India. GY

The Author is Lecturer, Department of Geography, St. Edmund's College, Shillong, sanjoychoudury@yahoo.com



FORAGING THROUGH FORESTS: Gaddi

Story Mohd. Sajid Idrisi *and* Sulagna Chattopadhyay
Photo Sajid Idrisi



Among the various transhumant tribes that inhabit the Himalaya, the Gaddi herders share a causal relationship with the deodar and chir forests. Guarded by ferocious dogs the sheep and goat owned or loaned by the herder, forage through ancestral tracks to reach the alpine meadows every summer. With the enactment of the Forest Rights Act in 2008, the lives of the Gaddi are slowly but surely changing for the better as historic injustice is being undone.

Gaddi, the nomadic sheep herding scheduled tribe of Himachal Pradesh, are among the traditional pastoralists of Himalayas, the others being Gujjar, Bakarwal, Kinnaur, Kauli and Kanet. Environmentalists have long perceived pastoralists' livestock as an enemy to wildlife conservation, even though the livestock may not be that different from wildlife. Plus, increasing evidence is emerging for positive effects of pastoralism on the environment (Ilse Köhler-Rollefson and the Life Network, *Keepers of Genes*). Based on the informal interviews with the Gaddi pastoralists the author met at different locations while undertaking a mammal survey in Himachal, here are some facts that reveal their causal relationship with the forested realms.

LIVESTOCK BASE

Gaddi herders perceive livestock as asset to the community - their livelihood depends on the sale or exchange of animals and their products to obtain foodstuffs and other necessities. With an economy that is today a mix of commercial herding and subsistence cultivation, the Gaddi sell wool, aging female sheep, and male lambs and kids. Goat milk is the principal source of food for the herders, and goat wool is used to make blankets. Gaddi however are semi nomadic tribes, as they do have some form of permanent dwellings unlike other nomadic grazers such as Gujjar and Changpa who migrate with their whole families from one pasture to another. Gaddi communities undertake cultivation within permanent villages located along the migratory route. Up to two crops may be harvested annually, involving a labour intensive intermeshing of the herding and cultivation cycles. (Vasant K Saberwal, *Pastoral Politics*)

Gaddi communities are primarily located in and around four districts of Himachal - Chamba, Kinnaur, Kangra and Dharamshala. By caste they belong to Rana, Rajput, Thakur or Khatri and follow Hinduism. Gaddi herders travel extensively and are believed to cover a distance of almost 400-500 km in one season over an elevational gradient of 13,000 ft with single herd constituting more than 500 sheep and goats. The pastoral cycle of the Gaddi largely depends on the availability of forage during different seasons. They usually inhabit marginal lands on the periphery of settled societies and eke resources in a way not possible by sedentary communities. In summer, they migrate to the alpine meadows of Dhauladhar and Pir Panjal while in winters they forage through the Siwaliks. They migrate during the transitional seasons i.e. autumn and spring, walking longer distances and taking short halts in between.

In the forests the stock survive exclusively by grazing. During the lean season in winter the Gaddi source forage through mutual understanding and reciprocity with the sedentary establishments. Farmers invite the Gaddi herders to pen stock on their farms for the night in lieu of land enrichment through sheep and goat droppings. Hay offered by the farmers for this service ensures the survival of the stock.

GRAZING RIGHTS

The access of Gaddi herders to the forested realms has been and still is an extremely complex issue. The present government policies take off from nineteenth century mindsets, wherein grazing was seen as a hindrance to biodiversity regeneration, culminating into accelerated soil erosion - necessitating a need to debar such activities. In ancient times the Gaddi may have achieved grazing rights from kings and colonisers - some families still exert formal rights and are granted permits to graze specific tracts herded for generations, but today these rights are a contentious issue. The forest authorities have earmarked developmental projects in various areas where the Gaddi herders are prohibited to forage for a stipulated period, say 5 to 7 years. The Gaddi thus tend to group their livestock with relatives, an activity which is again banned by the forest authorities as denser stocks result in enhanced stress on the carrying capacity of the foraging tract. The Gaddi also migrate to the adjacent states of Punjab, Haryana and Uttar Pradesh depending on the need and agreement with state authorities.

ASSERTING TRANSHUMANCE RIGHTS

The Forest Rights Act [Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights)] notified on January 1, 2008,

Literature suggests that there is no scientific evidence to indicate that Gaddi grazing is leading to degradation. Rather, the thought springs from an assumption that degradation is taking place as a natural outcome of grazing.

forged new grounds and brought fresh hopes for the battered Gaddi community. The Act conferred rights over natural resources in order to secure a living coupled with the responsibility of using forest resources sustainably. (Pernille Gooch, *Van Gujjar: The Persistent Forest Pastoralists*) By combining livelihood with use and conservation of natural resources, the Act opens up the possibility of sustainable pastoralism.

On the downside, the Act perpetuates what the colonisers had set up - individual/household permits in lieu of community rights. As sustainability concerns are community driven, perhaps conferring community rights would have been an appropriate option. As of now the Gaddi herders are applying to village/community

With increased technological upgradation, monitoring the movement of Gaddi and other transhumant tribes can be undertaken through GPS and participation interlinked with tangible biodiversity improvement studies.

committees already set up, or are in the process of constituting a village committee.

SUSTAINABLE FORAGING

The Gaddi herders believe that they use the forests and pastures sustainably. Considerable consensus is being built up today citing examples from world over that grazing may be beneficial after all and should be encouraged within reserved forests. In fact pastoralists' livestock can benefit wildlife conservation as there is a long history of coevolution between wild species and livestock. Evicting the livestock from wildlife reserves may lead to an exodus of predators, or result in habitat changes that make it unattractive for wildlife. The Gaddi herders claim that they constitute a responsible disaster mitigation group, especially in the context of forest fires. Their stocks minimise the growth of high grass, thus preventing fires from spreading too far during the hot and dry summers. The Gaddi and many such grazers in the Himalaya also act as sentinels and first responders, warning forest officials of impending or ongoing wild fire danger. In many cases they have also stepped in as volunteers to stop the spread of forest fires.

Gaddi grazers reiterate generations of learning, which emphasises that foraging livestock help stimulate biodiversity more luxuriant and diverse in growth. Also they claim that browsing on young saplings leads to better root development, making the shrub or tree drought resistant.

These herders of Himachal add that their stocks are healthy and disease resistant as the breed, again named Gaddi, have evolved in the wild. With ever increasing selection pressure, the Gaddi provide a crucial counterbalance to the narrowing genetic base of industrial breeds. This important role of pastoralist production systems in maintaining domestic animal diversity needs to be appreciated and fully recognised. Unfortunately, at present pastoralists' livestock face scorn from both ends, with wildlife conservationists denoting stock as 'domestic' animals, thus opposed to wildlife, while animal scientists dismiss them as unproductive.

POLICY INTERVENTIONS

The Gaddi need legally sanctioned and managed access to forest commons to protect the traditional means of conservation of Himalayan flora and fauna. The Forest Rights Act confers access rights, but procedural delays remain. With increased technological upgradation, monitoring the movement of Gaddi and other transhumant tribes can be undertaken through GPS and participation interlinked with tangible biodiversity improvement studies. Research on carrying capacity and changing mindsets of forest and wild biodiversity experts can enhance the role of the Gaddi in establishing sustainable environments. Experiences from other countries should be analysed for their applicability to India and the Gaddi could gain much from exposure to such programmes.

END NOTE

With various employment schemes and other benefits offered by the government, it is odd that the Gaddi have preferred to bear various levels of hardship in order to continue their traditional vocation. But, times are changing - lucrative short term employment schemes in the offing coupled with reduced long term rights to forage are slowly pushing herders out of business. Agriculture now holds more promise, the Gaddi feel and their future depends on the political decisions made by state and central governments.

A more participatory and inclusive approach by the forest authorities in grazing and herders' rights would be effective for long term conservation, management of forest resources and sustainable grazing practices. GY

The authors are Asst. Field Officer, Wild Species Programme, Wildlife Trust of India, Uttar Pradesh and Editor, G'nY respectively. sajididrisi@yahoo.com

GUARDING THEIR FORESTS
BHIL

The Sondwa Block of Jhabua, Madhya Pradesh saw unprecedented commercial exploitation of its forests which upset the fragile hilly ecosystem. The Bhil livelihood was the most affected with dwindling forest resources on one end and the Indian Forest Act on the other which deemed them criminals in their own backyard. In 1983, the Bhil of Alirajpur began organising themselves to protect the forests - their lifeline.

Story **Subhadra Khaperde**

"I felt very angry that after cutting down all our forests to supply timber to the cities, the forest authorities should blame us for the destruction. So I got the women of our village together and started protecting these hills. Now nobody can blame us anymore," said Daheli Bai, a Bhil tribal woman of Attha village in Alirajpur district of Madhya Pradesh replying to a question as to what had prompted them to protect their forests and render them as verdant as they are.

The Sondwa Block of Alirajpur flanks River Narmada and is very hilly, constituting the edge of the Vindhyas, before the river debouches onto the Bharuch Plains in Gujarat. The slopes have thin red soils while narrow strips in the valleys contain black soil of medium depth. This is underlain by basaltic hard rock with poor ground water aquifer characteristics. The average annual rainfall is 900 mm occurring in the monsoon season (mid-June to mid-October). The indigenous people of this region, Bhil, have adapted to this semi arid ecosystem by practising organic agriculture in the valleys and supplementing it with forest produce. Deciduous trees, teak, *sisam*, *anjan* and *salai* and various grasses, shrubs and herbs grow in abundance here. Despite hard rock underneath, the forest cover ensures that there is enough natural recharge of groundwater with the rain percolating through fissures in the rock. Consequently, streams gurgle with fresh water throughout the year.

The reorganisation of states in 1956 and the formation of Madhya Pradesh changed things drastically. Alirajpur had earlier been ruled by a feudal prince, who exerted a loose control over the Bhil. The community mostly lived in tightly knit tribes bonded by customs of labour pooling.

PHOTO: WFS

Under Daheli's guidance, the women of Attha formed groups of five or six and began patrolling the forest to ensure that they were not grazed and root stock regenerated. Thereafter, they made sure that the new trees were not cut.

The Bhil organised themselves to demand their rights - they formed the Khedut Mazdoor Chetna Sangathan to rebuild and protect the denuded forests in about fifty villages of the Sondwa Block, Jhabua.

When the area was handed over to the Forest Department the commercial exploitation of the forests for timber production began.

This upset the fragile hilly ecosystem and with the forests gone and thin soil layers washed away, the natural recharge of the rain was greatly reduced, drying up the streams. Of course, the Bhil livelihood was most affected as the fertility of their lands as well as the supply of forest produce declined drastically. Simultaneously, the provisions of the Indian Forest Act ensured that they were deemed criminals in their own backyard and forced to pay bribes to the forest authorities staff to access forests.

Then in 1983, the Bhil began organising themselves to demand their rights, especially the right to protect the forests - their lifeline. They formed the Khedut Mazdoor Chetna Sangathan (KMCS) to rebuild and protect the denuded forests in about fifty villages of the Sondwa Block. The women of Attha village, under the leadership of Daheli Bai, began the struggle which soon spread to nearby villages. Daheli Bai and her comrade Vesti Bai, travelled upstream along the rivulet that ran through their village to reach the villages of Gendra and Fadtala. They explained that since the stream originated in Fadtala, full benefits of forest protection in terms of greater availability of soil, water and forest produce would only be gained if they all joined hands to protect their forests. The stream in Attha had begun to go dry with heavy deforestation, but in over a decade - early 1990s - the stream became perennial once again.

The uniqueness of this conservation effort is its reliance on the traditional labour pooling custom of the Bhil. Under Daheli's guidance, the women of Attha formed groups of five or six and began patrolling the forest to ensure that they were not grazed and root stock regenerated. Thereafter, they made sure that the new trees were not cut. The grass would be cut only after the monsoons and distributed equally among protecting families to be used as fodder for cattle.

Emboldened with their success, the Attha women then began another conservation activity. The small teams began working in groups on farms of their members to plug the gullies in between the farms with stones so as to catch the soil and some of the runoff. Since the mid 1990s, establishment of hundreds of such gully plugs have led to an increase in productivity and soil profile of many small plots. This practice, too, was replicated in many other villages in Alirajpur.

Adjoining Alirajpur, in the village of Kakrana the winds of taking charge spelt hard decisions. The courageous Bhil posted a permanent member in the forest to sound an alarm whenever poachers arrived. Raija Bai, and her husband Dilu, were the first to take up this challenge and built their hut in the forest. Even today they live there alone with their children.

The villagers of Jhandana, Sugat, and Chameli initially had trouble protecting another forests too - however, after much fighting, they were able to resolve their differences with the help of members of the KMCS. Today, this forest too is resplendent and visible from a long distance.

"Collective action by the community for forest, soil and water conservation is the only sustainable way in which the productivity of fragile ecosystems in hilly, semi arid and hard rock regions of the country can be ensured," opines Rahul Banerjee, who has spent twenty five years in researching and implementing natural resource management projects in the region.

Banerjee, a graduate in civil engineering from the Indian Institute of Technology, Kharagpur, adds, "Growing forests, greater availability of flowing water leading to reduced demand for artificial energy and greater agricultural productivity achieved through organic practices all contribute significantly to mitigating climate change." And when this is done through communitarian collective action, the gains in terms of social justice are an added benefit. GY

Article contribution Women's Feature Services, New Delhi.

TERM Power

Here is an exercise that is intended to introduce you to a gamut of terms related to forests that you know but just cannot define. Pick the right option and check how you fare. The answers are on page 39.

1. CANOPY

a. Shrubs growing on forest bottom
b. Uppermost layer of forest foliage
c. Trees in a forest

2. DECIDUOUS

a. Trees and plants that shed their leaves at the end of growing season
b. Trees and plants that retain their leaves throughout the year
c. Trees and plants that die at the end of growing season.

3. LITTER

a. Freshly fallen leaves on forest floor
b. Animal carcass on forest floor
c. Undecomposed organic debris on surface of forest floor

4. ANGIOSPERMS

a. Flowering plants with seeds dispersed by wind
b. Flowering plants that produce seeds enclosed in fruit
c. Flowering plants with pollen spread by bees

5. AUTOTROPH

a. An organism that eats other organisms
b. An organism that uses energy from sun to digest its food
c. An organism that makes its own food from light or chemical energy without eating

6. CARRYING CAPACITY

a. The maximum number of animals of a given species that can live in an area.
b. The maximum number of plants that can grow in an area.
c. The maximum number of animal species in a given area.

7. DISPERSERS

a. Animals that do not live in herds
b. Animals that spread plant seeds
c. Plants species that are spread out in a forest

Coastal Vulnerability Index

Scientific study of the natural hazards and coastal processes has assumed greater significance after the December 2004 tsunami as the country learnt lessons from the high impact damage to life, property and environment. The nation's want for reliable coastal vulnerability information has created a need for classifying coastal lands and evaluating its hazard vulnerability.

Story **T Srinivasa Kumar**

KAVARATTI, LAKSHADWEEP

Coastal regions of our nation are facing tremendous population and developmental pressure for the last four decades. According to the 1992 estimates of United Nations more than half of the world's population lives within 60 km of a shoreline. In the 1950s there were only two mega cities - New York and London, which notched upto 20 by 1990, and as recent projections predict, it is likely that we have 30 mega cities by 2010 with a population of 320 million. According to United Nations Environment Programme (UNEP) report the average population density in the coastal zone rose from 77 people per sq km in 1990 to 87 in 2000 and was projected as 99 for 2010.

Collectively, this is placing additional demands on coastal resources as well as exposing more people to coastal hazard. About 200 million people were estimated to live in the coastal floodplain in 1990 (in the area inundated by a 1 in 1000 year flood) - it is likely that their number increases to 600 million by the year 2100. Furthermore, global climate change and threat of accelerated sea level rise exacerbate the already existing high risks of storm surges, severe waves and tsunamis. Over the last 100 years, global sea level rose by 1.0 to 2.5 mm/year. Present estimates of future sea level rise induced by climate change, range from 20 to 86 cm for the year 2100, with a best estimate of 49 cm. It has been estimated that a 1 m rise in sea level could displace nearly 7 million people from their homes in India (IPCC WG1, 2001).

Officials and resource managers responsible for dealing with natural hazards need accurate assessments in order to take informed decisions before, during, and after hazard events. Such study or analysis of risk is increasingly being presented with the intention of contributing data to physical and territorial planning specialist as an ingredient within the decision making process.

Disciplines such as geography, physical, urban or territorial planning, economics and environmental management helped to strengthen what is perhaps an applied science approach to disasters. Maps became more and more common due to greater participation of geologists,

geotechnical engineers, hydrologists and other experts. They were able to provide required data for the adequate identification of the danger or hazard zones, according to the area of influence of natural phenomena. Also tools such as GIS have facilitated identification and analysis.

Methodology

Vulnerability may be defined as internal risk of a subject or system that is exposed to a hazard and corresponds to its intrinsic predisposition to be affected, or to be susceptible to damage. In general, the concept of 'hazard' is now used to refer to a latent danger or an external risk factor of a system or exposed subject. Hazard can be computed mathematically as the probability of occurrence of an event of certain intensity in a specific site, during a determined period of exposure. Vulnerability, however may be mathematically expressed as - feasibility that the exposed subject or system may be affected by the phenomenon that characterises the hazard. Risk, therefore is the potential loss to the exposed subject or system, resulting from a combination of hazard and vulnerability. Risk may be expressed in a mathematical form as the probability of surpassing a determined level of economic, social or environmental consequence at a certain site and during a certain period of time.

Although a viable, quantitative predictive approach is not available, the relative vulnerability of different coastal environments to sea level rise may be quantified at a regional to national scale using basic information on coastal geomorphology, rate of sea level change, past shoreline evolution, etc., to estimate the coastal vulnerability index (CVI).

Coastal vulnerability index (CVI) = $\sqrt{[(a*b*c*d*e*f*g)/7]}$

Where
a = risk rating assigned to shoreline change rate
b = risk rating assigned to sea level change rate
c = risk rating assigned to coastal slope
d = risk rating assigned to significant wave height
e = risk rating assigned to tidal range
f = risk rating assigned to coastal regional elevation
g = risk rating assigned to coastal geomorphology

The CVI values are categorised into very high, high, medium and low vulnerability coasts based on the equal interval of the CVI percentile.

This approach combines the coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, and yields a relative measure of the system's natural vulnerability to the effects of sea level rise. The method uses a rating system that classifies the coastal area based on degree of vulnerability - low, medium and high.

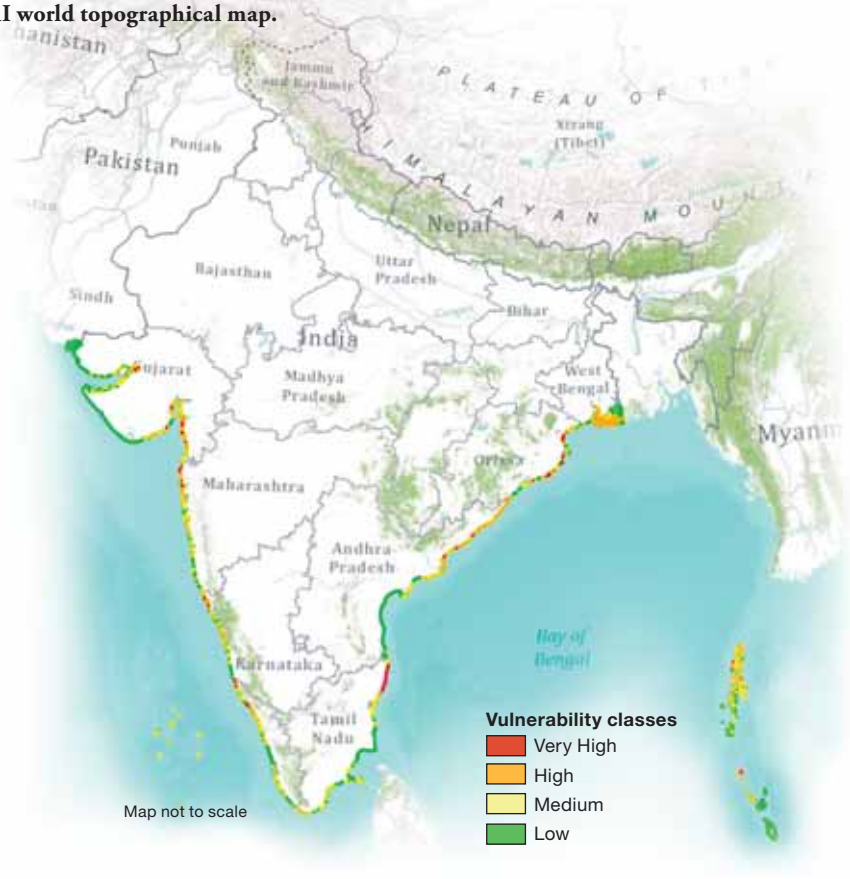
The method of computation of CVI in the present study is similar to that used in Thieler and Hammar-Klose (1999), Thieler (2000) and Pendleton et al., (2005). In addition to the 6 parameters used by earlier researchers, the present study uses an additional geologic process variable, i.e. coastal regional elevation. The seven relative risk variables used are shoreline change rate, sea level change rate, coastal slope, mean significant wave height, mean tidal range, coastal regional elevation and coastal geomorphology. Most of the above parameters are dynamic and require a large amount of data from different sources to be acquired, analysed and processed. Once each section of coastline is assigned a risk value for each variable, the CVI is calculated as the square root of the product of the ranked variables divided by the total number of variables (Pendleton et al., 2005).

Results

This is the first study to look at vulnerability on synoptic scales (1:1,00,000) that covers the entire Indian coastline. The resulting map is shown in Figure 1. The general trend shows that the northern parts of the coastal states: Tamil Nadu, Andhra Pradesh, Odisha, Kerala, Maharashtra, and Goa indicate high and very high vulnerability indices as compared to the southern and central parts of the states' coastlines - Gujarat being an exception. The north south trend is also apparent in the Andaman and Nicobar Islands. Lakshadweep Islands indicate high to very high indices due to the sea level and terrain elevation of the region, with Minicoy recording very high vulnerability index. The Gulfs of Kambhat and Kachchh in Gujarat show very high vulnerability indices, with the inlets of Kachchh showing localised vulnerability. Sunderban in West Bengal shows high and very high vulnerability index in majority of its locations, while the north eastern patches show low vulnerability indices, due to mangroves in slightly elevated regions. It

The vulnerability map indicates that the northern parts of the coastal states -Tamil Nadu, Andhra Pradesh, Odisha, Kerala, Maharashtra, and Goa fall in the high and very high vulnerability zones as compared to the southern and central parts of the states' coastlines - Gujarat being an exception. The north south trend is also apparent in the Andaman and Nicobar Islands.

Fig 1. Coastal vulnerability index along the Indian coast overlaid on the ESRI world topographical map.



has been well documented that the mangroves break waves, dissipating the energy and hence acts as a natural barrier.

The study depicts vulnerable areas as per the seven parameters considered. These maps are therefore not maps of total vulnerability, but of essential aspects constituting overall vulnerability. They depict the problematic regions, and therefore further attention should be directed to these regions to analyse their vulnerability in the context of nested scales and on higher resolution. Use of additional parameters such as cyclone, storm surge and coastal flooding will add an additional dimension to the current study.

The coastal vulnerability maps produced using this technique serve as a broad indicator of threats to people living in coastal zones. This is a objective methodology to characterise the risk associated with coastal hazards and can be effectively used by coastal managers and administrators for better planning to mitigate the losses due to hazards as well as for prioritisation of areas for evacuation during disasters.

The author is senior scientist, Indian National Centre for Ocean Information Services (INCOIS). srinivas@incois.gov.in

Warming in Coastal Antarctic

Scrutiny of instrumental data from Antarctic reveals that the Continent has undergone significant changes in the recent decades, with an increase in atmospheric temperature in most parts. The largest annual warming trends are found in the West Antarctic and Antarctic Peninsula in particular. In contrast, the East Antarctic has experienced little warming. However, recent studies reveal that the warming had affected many sites in the coastal East Antarctic. Importantly, the complexity of Antarctic climate is still poorly understood because of the limited periods of observational data.

Story **Meloth Thamban** *and* **Rasik Ravindra** *Photos* **NCAOR**

Annual scientific research expeditions to the Antarctic by the National Centre for Antarctic and Ocean Research (NCAOR), Goa, utilises its singular environment as a great natural laboratory for scientific investigations that assists the understanding of global environment change. India established its first station in Antarctic at Dakshin Gangotri in 1983, followed by the second permanent station at Maitri in 1989. A third station Bharati is being established at the Larsemann Hills area of East Antarctic.

The present study investigates the fluctuating Antarctic climate system on sub-annual to centennial time scales, with a complex interplay of the ice sheet, ocean, sea ice, and atmosphere. Scrutiny of instrumental data from Antarctic based on the few available records reveal that Antarctic had undergone significant changes in recent decades, with an increase in atmospheric temperature in most parts of the Antarctic continent. The largest annual warming trends are found on the western and northern parts of the Antarctic Peninsula. Contrastingly, interior parts of East Antarctic seems to have experienced little warming or even slight cooling at certain locations. However, the spatial and temporal complexity of Antarctic climate is still poorly understood because of the limited and short periods of observational data.

Analyses of ice core proxy records provide one of the most accurate methods to reconstruct the Antarctic climate change beyond the instrumental limits. Ice core records from polar regions offer continuous and highly resolved proxy records on major atmospheric parameters like temperature, composition and trace gases. Among the various proxy variables used, the stable isotope ratios of oxygen ($\delta^{18}O$) and hydrogen (δD) offer the most critical information on the past changes in temperature. Additionally, glaciochemical parameters like ionic and trace metal composition of the ice cores are extensively used for reconstructing past changes in atmospheric circulation, global volcanism, dust input, sea ice extent/concentration, oceanic productivity, as well as environmental pollution.

ANTARCITC IS WARMING

Considering the importance of chronicling Antarctic environmental change in the context of global warming, Indian researchers have made systematic efforts to retrieve and study ice core records from the coastal regions of East Antarctic. Further to understand the coastal Antarctic variability during the past few centuries with annual to sub-annual resolution, several ice cores have been collected from the coastal sites of East Antarctic. Among these, two ice cores from the central Dronning Maud Land region (IND-22/B4 and IND-25/B5, Fig 2) with reliable chronological constraints were studied extensively for various proxy parameters. While the IND-25/B5 provided

Fig 1. SAM Index

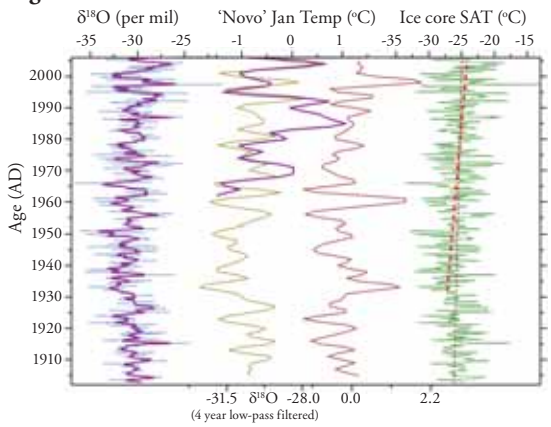
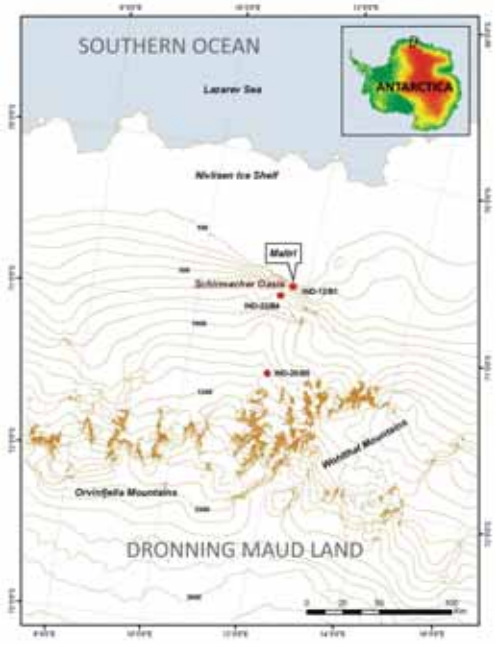


Fig 2. Reconstructed temperature records of ice cores from the coastal regions of Dronning Maud Land, East Antarctic



Findings about warming trends have considerable implications for the coastal Antarctic ice sheet stability and possible sea level changes. On a broader perspective, effects of such enhanced warming could affect the fragile Antarctic ecosystem.

high-resolution records of the past 100 years (1905-2005), the IND-22/B4 core represented the past ~470 years (1530-2002) of climate change in coastal East Antarctic. The considerable variation in $\delta^{18}O$ records on an interannual to decadal scale seems to be associated with changes in low and mid latitude climatic modes. The IND-25/B5 $\delta^{18}O$ record revealed a significant relation to the Southern Annular Mode (SAM) and the El Niño Southern Oscillation (ENSO). Conversely, on a decadal scale, the influence of ENSO diminishes and a significant relationship between $\delta^{18}O$ and SAM is established. Application of the $\delta^{18}O$-temperature relationship in the region to the IND-25/B5 ice core record revealed an average air temperature of -25.5°C during 1905-2005 AD. Compared to this, extended $\delta^{18}O$ records of IND-22/B4 revealed an average temperature of -19.3°C during 1530-2002.

The reconstructed temperature record of IND-25/B5 exhibited an average warming of 1°C for the entire century (1905-2005) with a warming trend of 0.1°C/10 years. The records also revealed a greatly enhanced warming of ~3°C during 1930-2005 (~0.4°C/10 years). The temperature record of IND-22/B4 exhibited relatively more negative $\delta^{18}O$ values during periods of reduced solar activity like the Dalton and Maunder Minima, suggesting significant influence of solar activity on Antarctic climate. The estimated warming trend for this site was ~0.6°C per century, with relatively increased warming during the recent decades.

The reconstructed temperature records of ice cores as well as the available observational data thus suggest that the coastal regions of Dronning Maud Land in East Antarctic are experiencing significant warming in the recent decades. The findings have considerable implications for the coastal Antarctic ice sheet stability and possible sea level changes. On a broader perspective, effects of such enhanced warming could affect the fragile Antarctic ecosystem. Any loss of sea ice due to warming could adversely affect the coastal Antarctic food chain system since any decrease in sea ice algae would affect the krill population, which in turn would affect the Adélie Penguin population.

Ice core drilling in progress at Dronning Maud Land

Our studies while confirming the instrumental record of recent warming at the Novo Antarctic station data, contradict the observed slight cooling at the South Pole Amundsen-Scott Station. Considering such large spatial and temporal heterogeneity in the environmental conditions, the current estimation of temperature trends across the East Antarctic based on extrapolations using few station records needs to be vigorously tested. It is suggested that spatially distributed ice core derived temperature profiles could provide valuable data in filling the large gaps as well as extending the climatic records in Antarctic. GY

The authors are Scientist E and Director, respectively at the National Centre for Antarctic and Ocean Research, Goa.
meloth@ncaor.org

TERM Power RATINGS

1 to 3 Correct - Informed
4 to 5 Correct - Knowledge bank
5 to 7 Correct - Encyclopedia

1. CANOPY

Ans (b); A layer of foliage in a forest stand. This most often refers to the uppermost layer of foliage, but it can be used to describe lower layers in a multistoried stand. Leaves, branches and vegetation that are above ground and/or water that provide shade and cover for fish and wildlife.

2. DECIDUOUS

Ans (a); Plants characterised by a specific growth and dormancy cycle, with certain parts falling at the end of the growing period, as leaves, fruits, etc., or after anthesis, as the petals of many flowers - as contrasted with evergreen which remains verdant throughout the year.

3. LITTER

Ans (c); The loose, relatively undecomposed organic debris on the surface of the forest floor made up typically of leaves, bark, small branches, and other fallen material.

4. ANGIOSPERMS

Ans (b); Angiosperms are flowering plants that produce seeds enclosed in fruit. They are the dominant type of plant today with over 250,000 species. Their flowers are used in reproduction. Angiosperms evolved 125 million years ago and became the dominant plants about 100 million years ago. Angiosperms are divided into the monocots (like corn) and dicots (like beans).

5. AUTOTROPH

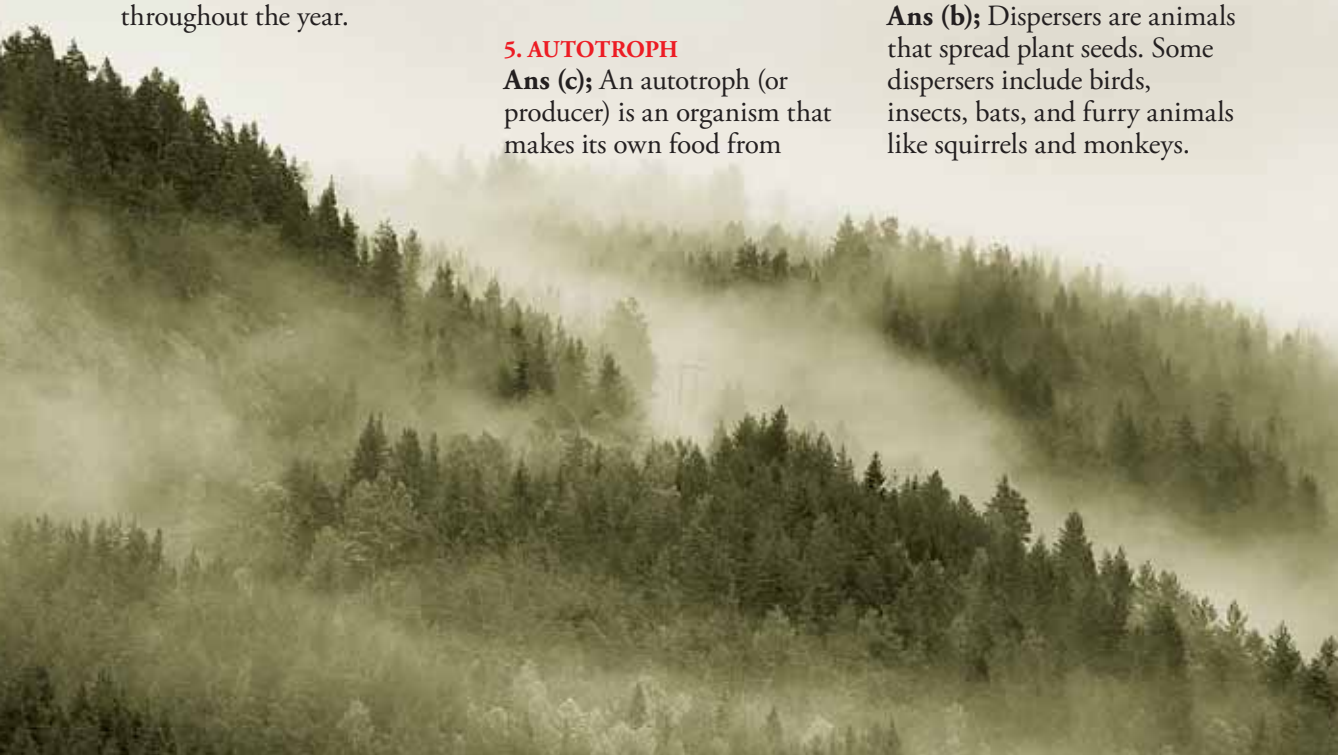
Ans (c); An autotroph (or producer) is an organism that makes its own food from light or chemical energy without eating. Most green plants, many protists (one-celled organisms like slime moulds) and most bacteria are autotrophs. Autotrophs are the base of the food chain.

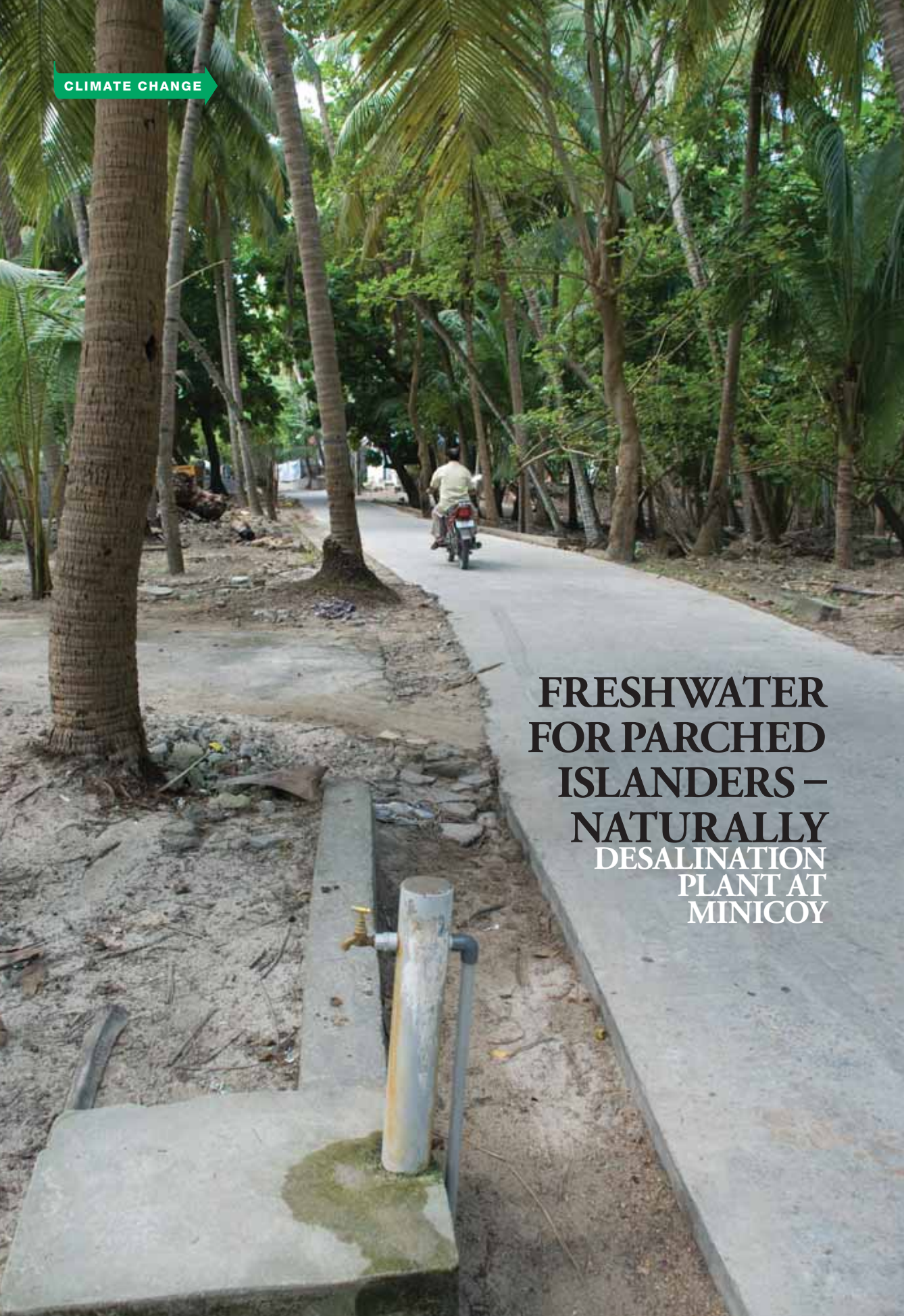
6. CARRYING CAPACITY

Ans (a); The carrying capacity of an area is the maximum number of animals of a given species that can live there. This number is limited by amount of food in that region, by the amount of sheltering area required by the species, and other factors. The carrying capacity of a region is difficult to calculate.

7. DISPERSERS

Ans (b); Dispersers are animals that spread plant seeds. Some dispersers include birds, insects, bats, and furry animals like squirrels and monkeys.





FRESHWATER FOR PARCHED ISLANDERS – NATURALLY

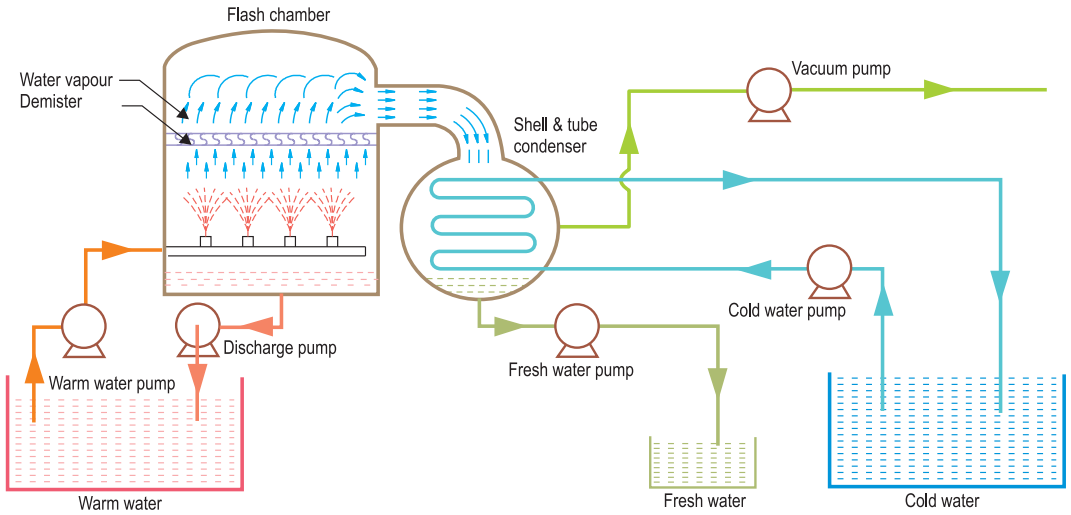
DESALINATION PLANT AT MINICOY

The mismatch between increasing demand and decline in water availability due to overexploitation and climate change is a critical issue for policy makers. Desalination, which is the conversion of seawater to potable water through various physical and chemical methods, has emerged as a potential solution to India's looming water crisis. The most important concern however is cost effectivity of the methodology, type of energy used for desalination and sustainability of the plant.

Story **S V S Phani Kumar,**
M V Ramana Murthy *and* **M A Atmanand**

Rapid urbanisation, population explosion and over exploitation of ground water resources are some of the reasons for the increasing freshwater demand in regions of the country. Coastal and island communities of the nation however, can eke potable water with the use of desalination technologies. Some of the common conventional desalination technologies are reverse osmosis (RO), multistage flashing and multi effect distillation. In RO water from a highly concentrated region is transferred to a region of low pressure. A semi-permeable membrane having pore diameter from 0.5 nm to 1.5 nm separates the two sections. The technology has the limitations - pretreatment of water to protect membranes, higher pumping power proportional to feed pressure, biofouling of membranes, frequent change of expensive membranes, etc., apart from causing ecosystem imbalances through discharged water. Similarly,

Fig. 1 Schematic diagram of low temperature thermal desalination plant using shell and tube condenser



1. View of sump during its tow. 2. Wave activity in the breaker area. 3. An aerial view of Minicoy Plant showing the plant building, bridge and sump

multistage flashing and multi effect distillation plants are economical for higher capacity desalination plants especially when warm water above 60°C can be produced using waste heat from power plants. However, in the Indian context there are very few plants that work with these technologies - since the ultimate cost of desalination would include the cost of the waste heat that is used to take the water to the required inlet temperature. The generation and maintenance of vacuum and the problems of scaling are two technical challenges associated with such technologies.

On the other hand, low temperature thermal desalination (LTTD) process uses naturally available temperature difference in the ocean layers, and provides an option that is completely environment friendly with the added advantage of minimum maintenance. The process entails evaporation of warmer surface sea water at low pressures and condensation of the resultant pure vapour using deep sea cold water available at about 400m below sea level. Simple and easy to maintain, the desalination plant requires just a few components - a flash chamber for evaporation, a condenser for liquefying the vapour, sea water pumps, vacuum system, a long pipe to draw cold water from 400m below sea level, marine structures such as sump, plant building and bridge. The LTTD with ocean thermal gradient is an environment friendly technology as it uses naturally available heat. Fig. 1 shows a schematic diagram of LTTD process.

Desalination Plant for Islanders

Realising the misery of the islanders, Lakshadweep was identified as the most suitable for setting up of the LTTD technology on experimental basis to produce freshwater. Also, for most islands here, a 400m depth is available within 600 to 800 m from the shore. The Ministry of Earth Sciences through the National Institute of Ocean Technology (NIOT) decided to set up a desalination plant at Kavaratti, with a capacity of 1 lakh litres/day in 2005 to provide potable water from the sea and alleviate the scarcity of drinking water faced by the communities. The plant is being operated by local islanders since 2006 and meeting the drinking water requirements of the 10,000 strong local communities for over six years. Studies conducted by a team of doctors have shown an improvement in public health among the beneficiaries with a drastic drop in the water borne diseases.

Minicoy Desalination Plant

Satisfied with the ease of operation, utility and performance of the successful Kavaratti desalination plant, Lakshadweep administration

PHOTO COURTESY: NIOT

approached NIOT to put up similar plants in other islands of the region. Works in Agatti and Minicoy were taken up in the first phase. The plant at Minicoy, was commissioned on 22 April 2011 to mark the Earth Day celebrations.

Challenges

Construction of marine structures that can withstand all weather conditions is the most challenging part of the project. The 400 tonne sump that houses the sea water pumps are initially cast inside the island lagoon, pushed into water, floated and towed about 10 km to the eastern side of the island, for its final installation at the site. The construction of piers of the bridge that connects the sump to the shore was a daunting task considering the fact that the piers in the breaker area experience constant wave action at every 10-15 second period.

The 700 m long HDPE pipe that draws the cold water from 400 m below the sea level is connected to the island through 12 m pieces, welded in the lagoon and towed to reach the site and then deployed to connect one end to the sump and leave other end at about 400 m depth. The pipe is designed to withstand all weather conditions in an oceanic environment. The design of process equipment is optimised to facilitate the ease in construction, transportation and erection in remote islands, while meeting the project requirements of minimal power usage to cut down running costs, compatibility for sea water use and containment of total project cost.

Concluding Remarks

LTTD is a fairly new development with significant scope for cost reduction as the technology matures. The process involves about 1 per cent conversion resulting in zero brine disposal problems, and hence does not interfere with the fragile ecosystem of the area. The discharged cold water that is let out at about 17°C is rich in nutrients and attracts a variety of fish. This results in spin offs like air conditioning for land based plants and mariculture. Considering the projected demand for drinking water in the near future, it is important to promote LTTD for parched coastal and island communities. GY

The authors are Scientist E, Scientist F and Director, respectively at National Institute of Ocean Technology, Chennai. mvr@niot.res.in

Lives at Risk

Where have the baby girls gone?

The 2011 provisional figure for the sex ratio in the age group 0-6 (CSR) is a mixed bag of hope and despair. While on one hand the tempo with which CSRs were becoming skewed in favour of boys over the last two decades has slowed down and the worst areas have shown some improvement, on the other, there is rapid spread of low CSRs to regions well beyond the traditional strongholds known for discriminatory practices towards girls. A combination of factors responsible for such spread demand contextualised short and long term interventions.

Story **Dr Saraswati Raju**

The declining number of girls vis-à-vis boys in the age-group 0-6 in India, commonly known as child sex ratio (CSR), has caught the attention of a wide ranging group of scholars, activists and policy makers in India. The declining sex ratio is a proxy variable for societal apathy towards girls - they are either not allowed to be born or face discriminatory treatment soon after being born to the extent that they perish.

More boys are conceived and are born naturally, but more boys die within first few months – this is the nature's way to keep the balance provided there is no external interventions. The earlier explanations for skewed CSR drew from this observation. That is, it was argued that with the improvement in reproductive health and pre-natal and post-natal child care, fewer boys now die and therefore the initial advantage that the baby boys have continue to remain. Other reasons cited were selective under enumeration of girls and differential mortality between boys and girls. It was soon clear that these explanations were only partially true in accounting for the rapidly falling number of girls.

The temporal data for the sex ratios at birth (SRB), however, showed that over the decades the number of boys born per 100 girls was crossing the normally accepted ratio of 105 boys per 100 girls to touch SRB of 111 baby boys to 100

Sex selective abortions distort the natural process of balancing of child sex ratios. Prior to availability and access to technology, families would still desire sons and would bear several daughters till that desired son arrives. Now with selection of the sex of unborn babies possible, desirable sex composition is being achieved without going into multiple pregnancies.

More boys are conceived and are born naturally, but more boys die within first few months – this is the nature's way to keep the balance provided there is no external interventions.

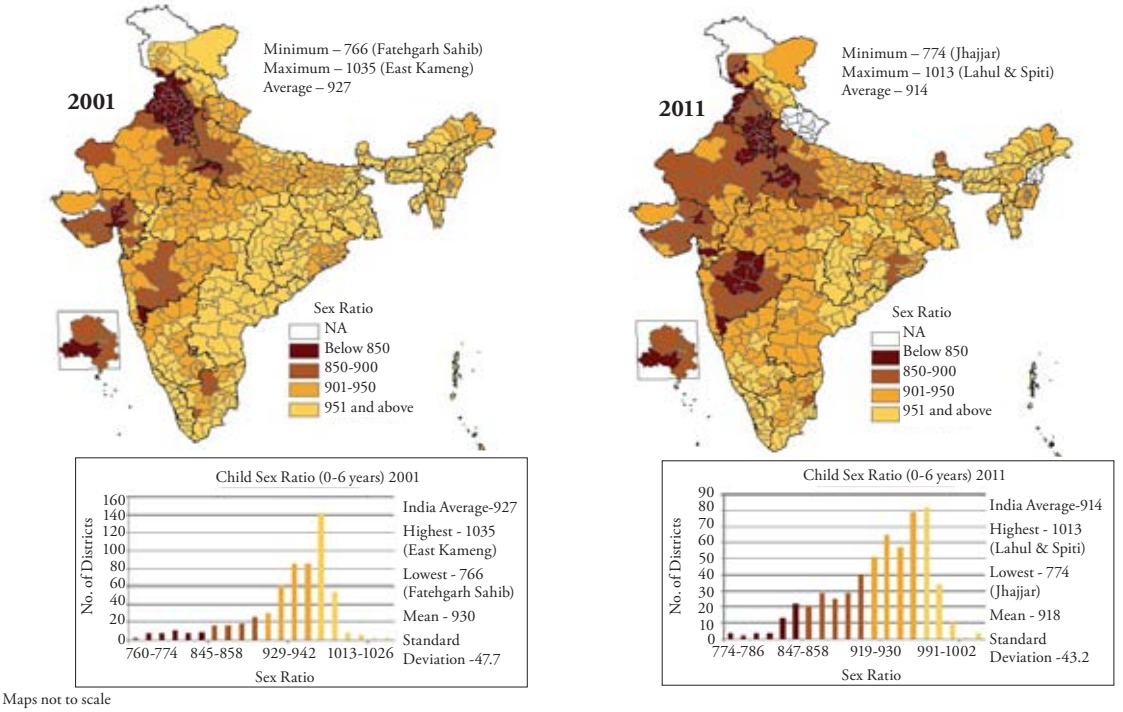
baby girls at the national level albeit with a wide ranging regional differences - from 104.4 in Kerala to 119.5 in Punjab.

Such skewed SRB clearly indicates that the very birth of a baby girl is being manipulated. This has become possible through amniocentesis, a process of taking a sample of amniotic fluid from mother's womb – a technology which was to diagnose babies' chromosomal and other abnormalities including the lungs' condition. Unfortunately, its ability to detect the sex of the unborn baby is what has made a milestone technology an eyesore, particularly in north-western parts of India, to begin with, which have been traditionally characterised by 'son preference'. However, it will be subsequently seen that areas of skewed CSRs are expanding much beyond the 'traditional' strongholds.

Sex selective abortions distort the natural process of balancing of CSRs. Prior to availability and access to the technology, families would still desire sons and would bear several daughters till that desired son arrives. Existing rituals such as the virtue of *kanyadān* and *Raksha Bandhan* would mean that at least daughters were not unwelcome even if not too many. Now that technology makes it possible to select the sex of unborn babies, desirable sex composition of children can be achieved without going into multiple pregnancies.

There are enough evidences to endorse the increasing practice of sex selective elimination of girls through abortions. A recent study in Lancet (May 24th, 2011, available online), which draws upon annual birth histories and child mortality rates for 1990-2005 from three rounds of the National Family Health Survey (NFHS) - a large-scale, nationally representative survey of rural and urban Indian households, found that the

Fig 1. Children under six: How many girls for every 1,000 boys?



Maps not to scale

sex ratio for the second-order births when the firstborn was a girl, fell from 906 per 1000 boys in 1990 to 836 in 2005. This decline amounts to an annual decline of 0.52 per cent. As opposed to this, the second-order births did not show any significant decline in the sex ratio if the first born was a boy. The researchers adjusted for excess mortality rates in girls. Even then the estimated number of selective abortions of girls rose from 0 to 2 million in the 1980s, to 1.2 to 4.1 million in the 1990s, and to 3.1 to 6.0 million in the 2000s.

The study's worst and counter-intuitive observation is that the declines were much greater where mothers had 10 or more years of education as compared to mothers with no education and in wealthier households compared with poorer households. Other studies also suggest the association between worst CSRs and the developmental parameters, not only in terms of conventional indicators of women's enhanced status such as female literacy, higher age at marriage, lower fertility rates, but also in terms of overall development such as urbanisation, poverty levels and per capita income. It is known for example that the district of South Delhi - the most affluent and rich part of Delhi is characterised by the worst CSRs in the State. This trend continues. Moreover, as the following discussion shows, areas which were earlier not in this league are showing increasingly worsening of the CSRs, obliterating the well known regional differences between the north and the south in India, for example.

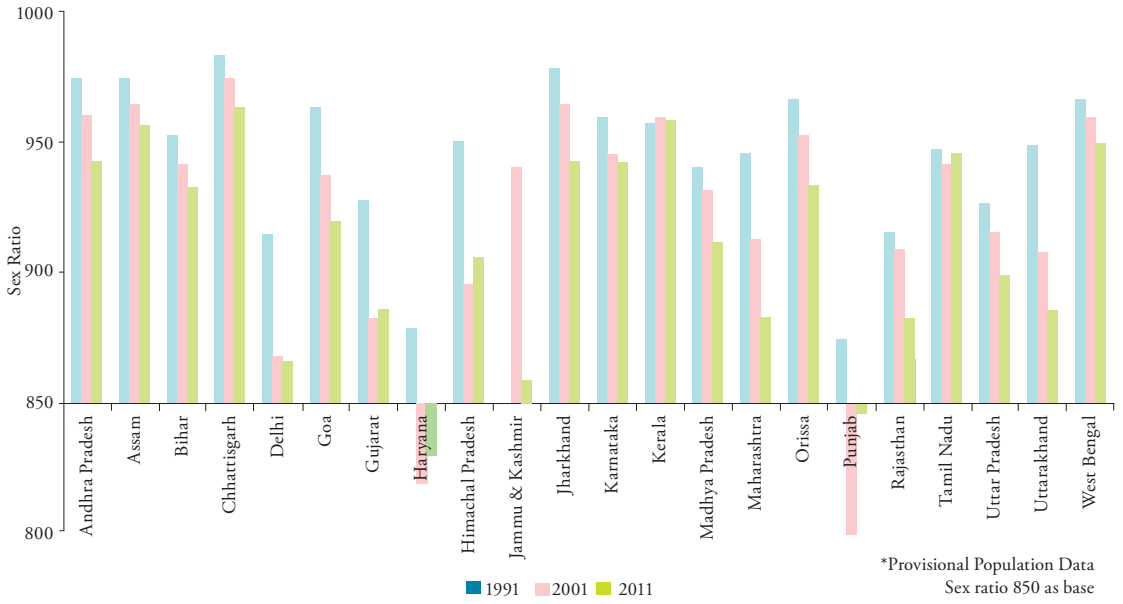
There is consensus now that the skewed SRB in favour of baby boys is what has contributed to the alarmingly worsening of CSRs. This realisation has resulted in several agencies including members of civil society, activists, researchers as well as central and state apparatus becoming concerned about the issue with several corrective measures in place. The Prenatal Diagnostics Techniques (Regulation and Prevention of Misuse) (PNDT) Act and its relatively more stringent implementation is a case in point. Some were hopeful of seeing a turnaround, some were apprehensive, but everybody eagerly waited for the 2011 Census.

The provisional figures for 2011 Census do bring some relief in the sense that the tempo with which the numbers of baby girls were declining has now slowed down – in 1991, there were 945 girls to 1000 boys for India as a whole - five points short of generally accepted CSR of 950 girls per 1000 boys. The 2001 Census had witnessed a sharp decline of 18 points with CSR of 927; the CSR in 2011 is 914 – a decline of 13 points. In addition, some of the worst hit states in 2001 such as Haryana, Punjab, Himachal Pradesh and Gujarat have now gained. However, this 'gain' has its underbelly for even with the improvement, Haryana and Punjab continue to have the dubious status of CSRs below 850 (short by 100 points from a CSR of 950) with the 2011 CSR of 830 and 846 respectively (Graph 1).

More importantly, the 2011 Census shows rapid spread of districts/states with low CSRs – Maharashtra and Uttar Pradesh, Jammu and Kashmir are new entrants (See maps 1 and 2). It is known that in general tribal communities are not discriminatory towards women. 2011 CSR figures seem to defy this. Some of the districts with high tribal population (in the neighbourhood of 30 per cent as per the 2001 Census) such as Rajouri in Jammu and Kashmir, Karauli in Himachal Pradesh and Surat in Gujarat do have low CSRs in 2011. Jalgaon and Ahmadnagar in Maharashtra are no exceptions. According to the Lancet study referred above, between the 2001 and 2011 Censuses more than twice the number of Indian districts has shown declines in the child sex ratio as districts with no change or increases (Table 1).

Not letting a life take full form is inhuman and yet families are deciding to do so – the answer to 'why' is complex and multilayered. Easily available technology, awareness and access have often been held squarely responsible for the declining CSRs. And yet it has to be admitted that a technology cannot function is contextual isolation. For example, the southern parts of India are more advanced in terms of medical technologies and yet, with few exceptions, they do not have low CSRs. Even relatively poorer states in northern parts, i.e. Jammu and Kashmir, Rajasthan and Uttar Pradesh offer contrasting scenes. It does not need much imagination to see the reason. These states, with a possible exception of Jammu and Kashmir, are located in a social space known for undervaluation of women and a strong son preference. The more recent spread beyond has to be located in the contemporary discourse of development whereby more progressive processes such as educational aspirations for girls, rising age at marriage, improved medical facilities and 'small family norm' juxtapose uncomfortably

Fig 2. Comparison of Child Sex Ratio (major states) between 1991, 2001 and 2011*



Placing sex selective abortion as a 'choice' that educated families are making, leaves a gaping hole in the argument – the possibility that it is not a choice. A stricter monitoring of and prosecution of erring medical fraternity and use of sex selective techniques is the need of the hour.

with near universal norm of marriage and moving of daughters in patrivirilocal (parents-in-laws) sites which has meant that investment in daughters has increasingly been seen as a avoidable burden by the families. Further, in the absence of institutional support for old age security, sons are still looked upon as a support system. Placing sex selective abortion as a 'choice' that educated families are making leaves a gaping hole in the argument – the possibility that it is not a choice – it is the age old social conditioning and socialisation process which sees privileging of mothers having male offspring that women and other family members internalise.

The challenges thus do not lie within the four walls of homes. Any serious attempt at curbing the further deterioration in the situation demands a multi-pronged strategy which include affordable and easily accessible old age care and survival support, social sanction for daughters shouldering responsibilities towards their parents, overall secure environment on one hand to a much stricter monitoring of and prosecution of erring medical fraternity and use of sex selective techniques on the other (see, Report on Planning Families, Planning Gender by Mary John, Ravinder Kaur, Rajni Palriwala, Saraswati Raju and Alpana Sagar published in 2008 which is downloadable from the Web). Region Abstract

The 2011 provisional figure for the sex ratio in the age-group 0-6 (CSR) is a mix bag of hope and despair. On one hand the tempo with which CSRs were becoming skewed in favour of boys over the last two decades has slowed down and the worst areas have shown some improvement. On the other hand, however, there is rapid spread of low CSRs to regions well beyond the traditional strongholds known for discriminatory practices towards girls. A combination of factors responsible for such spread demand contextualised short and long term interventions. Specific processes and outcomes require contextualised interventions rather than 'one glove fits all' approach. GY

The author is Professor, Centre for the Study of Regional Development, School of Social Sciences, Jawaharlal Nehru University, New Delhi. saras@mail.jnu.ac.in

Our census Our future...

CENSUS 2011

The new Census has brought in astounding results. To appreciate the nuances of the results, here is a list of terms often used and seldom understood.

Census Fact File

First Census conducted in India: 1872.

Census 2011: 15th National Census of India.

Conducted by: The Office of the Registrar General and Census Commissioner of India, under the Ministry of Home Affairs, Government of India.

Unique feature: Only source of primary data at village, town and ward level.

The census results:
Till the 1991 Census entire data processing took more than 5 years
In the 2001 Census time taken was reduced to around 3 years
For the 2011 Census efforts are being made to reduce the processing time to about 1.5 years.

Census 2011 provisional population totals: Announced on 31 March 2011.

Census data used for:
- Formulation of policies by central and state governments;
- Delimitation/reservation of constituencies;
- Reviewing country's progress in the past decade;
- Monitoring the ongoing governmental schemes; etc.

Census Concepts and Definitions

Urban area
(a) All statutory places with a municipality, corporation, cantonment board or notified town area committee, etc.
(b) A place satisfying the following three criteria simultaneously:
i) a minimum population of 5,000;
ii) at least 75 per cent of male working population engaged in non agricultural pursuits; and
iii) a density of population of at least 400 per sq km.

Institutional Household
A group of unrelated persons who live in an institution and take their meals from a common kitchen e.g. boarding houses, messes, hostels, hotels, rescue homes, jails, ashrams, orphanages, etc.

Houseless Households
Households who do not live in buildings or census houses but live in the open on roadside, pavements, in huge pipes, under fly overs and staircases, or in the open in places of worship, *mandaps*, railway platforms, etc.

Main Workers
Those workers who had worked for the major part of the reference period (before the census enumeration) i.e. 6 months or more.

Marginal Workers
Those workers who had not worked for the major part of the reference period, i.e. less than 6 months.

Work Participation Rate
The percentage of total workers (main and marginal) to total population.

Other Workers
All workers, i.e., those who have been engaged in some economic activity during the last one year, but are not cultivators or agricultural labourers or in household industry.

Household Industry
An industry conducted by one or more members of the household at home or within the village in rural areas and only within the precincts of the house where the household lives in urban areas.

Child Sex Ratio (0-6 years)
The number of females in age group 0 to 6 years per 1000 males in the same age group in the population. It is expressed as 'number of female children age (0-6) years per 1000 male children age (0-6) years'.

Literacy Rate
The percentage of literates to the total population age 7 years and above.

Migration Rate
The ratio of total migrants counted in the census to its total population multiplied by 1000. While discussing the migration result, the term population mobility is taken as a synonym to migration rate. GY

Provisional Population Figures

In absolute terms, the population of India has increased by more than 181 million from 2001. India today sustains 17.5 per cent of the world population in 2.4 of its geographical area. In contrast, the US accounts for 7.2 per cent of earth's surface area with only 4.5 per cent of its population.

World population was transformed in the 20th century as technological and social changes brought steep declines in birth and death rates. The century began with 1.6 billion and ended with 6.1 billion mainly because of unprecedented growth after 1960. The momentum created by this may carry the world well past 7 million by 2015. It is certain that nearly all future population growth will occur in the developing regions, especially urban areas.

The percentage decadal growth during 2001-2011 has registered the sharpest decline since Independence. For 2001-2011 this decadal growth has become 17.64 per cent, a decrease of 3.9 percentage points from the 21.54 per cent for the period 1991-2001. Uttar Pradesh continues to be the most populous state of the nation with almost 200 million followed by Maharashtra, Bihar, West Bengal and Andhra Pradesh. GY

India/State/UT#	Population 2011			Percentage decadal growth rate of population		Sex ratio (number of females per 1000 males)		Population density per sq km	
	Persons	Males	Females	1991-01	2001-11	2001	2011	2001	2011
India	1210193422	623724248	586469174	21.54	17.64	933	940	325	382
Jammu & Kashmir	12548926	6665561	5883365	29.43	23.71	892	883	100	124
Himachal Pradesh	6856509	3473892	3382617	17.54	12.81	968	974	109	123
Punjab	27704236	14634819	13069417	20.10	13.73	876	893	484	550
Chandigarh	1054686	580282	474404	40.28	17.10	777	818	7900	9252
Uttarakhand	10116752	5154178	4962574	20.41	19.17	962	963	159	189
Haryana	25353081	13505130	11847951	28.43	19.90	861	877	478	573
NCT of Delhi	16753235	8976410	7776825	47.02	20.96	821	866	9340	11297
Rajasthan	68621012	35620086	33000926	28.41	21.44	921	926	165	201
Uttar Pradesh	199581477	104596415	94985062	25.85	20.09	898	908	690	828
Bihar	103804637	54185347	49619290	28.62	25.07	919	916	881	1102
Sikkim	607688	321661	286027	33.06	12.36	875	889	76	86
Arunachal Pradesh	1382611	720232	662379	27.00	25.92	893	920	13	17
Nagaland	1980602	1025707	954895	64.53	-0.47	900	931	120	119
Manipur	2721756	1369764	1351992	24.86	18.65	974	987	103	122
Mizoram	1091014	552339	538675	28.82	22.78	935	975	42	52
Tripura	3671032	1871867	1799165	16.03	14.75	948	961	305	350
Meghalaya	2964007	1492668	1471339	30.65	27.82	972	986	103	132
Assam	31169272	15954927	15214345	18.92	16.93	935	954	340	397
West Bengal	91347736	46927389	44420347	17.77	13.93	934	947	903	1029
Jharkhand	32966238	16931688	16034550	23.36	22.34	941	947	338	414
Orissa	41947358	21201678	20745680	16.25	13.97	972	978	236	269
Chhattisgarh	25540196	12827915	12712281	18.27	22.59	989	991	154	189
Madhya Pradesh	72597565	37612920	34984645	24.26	20.30	919	930	196	236
Gujarat	60383628	31482282	28901346	22.66	19.17	920	918	258	308
Daman & Diu	242911	150100	92811	55.73	53.54	710	618	1413	2169
Dadra & Nagar Haveli	342853	193178	149675	59.22	55.50	812	775	449	698
Maharashtra	112372972	58361397	54011575	22.73	15.99	922	925	315	365
Andhra Pradesh	84665533	42509881	42155652	14.59	11.10	978	992	277	308
Karnataka	61130704	31057742	30072962	17.51	15.67	965	968	276	319
Goa	1457723	740711	717012	15.21	8.17	961	968	364	394
Lakshadweep	64429	33106	31323	17.30	6.23	948	946	1895	2013
Kerala	33387677	16021290	17366387	9.43	4.86	1058	1084	819	859
Tamilnadu	72138958	36158871	35980087	11.72	15.60	987	995	480	555
Puduchery	1244464	610485	633979	20.62	27.72	1001	1038	2030	2598
Andaman & Nicobar Islands	379944	202330	177614	26.90	6.68	846	878	43	46

Extract from www.censusindia.gov.in/

REPORT

Data User's Seminar
Ajmer

Participants at the inaugural session.

The Data Users' Seminar was organised by LIGHTS (Learning in Geography, Humanities, Technology and Science) at Ajmer, Rajasthan, from 17th to 19th April, 2011 to orient senior secondary school teachers and college students to the potential uses to which data can be put as also various analytical tools such as GIS, remote sensing and GPS. The Seminar was supported by Ministry of Science and Technology, National University of Educational Planning and Administration, Ministry of New and Renewable Energy, Ministry of Women and Child Development, and Ministry of Statistics and Programme Implementation.

The Data Users' Seminar was inaugurated on 17th by Dr M Sudhakar, Senior Advisor, MoES - the Chief Guest of the event. In his inaugural speech Dr Sudhakar laid emphasis on the need for upgraded technical education for the *guru* so that many generations of students can adequately benefit. Dr Prithvish Nag, Director, NATMO, the Guest of Honour, spoke passionately about the need for quality education and the building up of scientific temperament. The dignitaries and participants were welcomed by Ms Sulagna Chattopadhyay, President LIGHTS, Editor G'nY and Convenor of the event, with a brief introduction about the achievements of the eminent group of resource persons. The participants were overwhelmed to find themselves in the midst of such senior persons. Distinguished Guests, Dr Saraswati Raju, Professor, CSRD, Jawaharlal Nehru University, New Delhi; Dr Suresh Kumar, Deputy Director, Ministry of Statistics and Programme Implementation; Dr S Srinivasan, practising doctor, Apollo, New Delhi were also present for the inaugural function. Dr Smita Sengupta, Project Scientist at Computer Science Department, Indian Institute of Technology, Mumbai and Dr S Palria, Head, Department of Remote Sensing, Maharshi Dayanand Saraswati (MDS) University, Ajmer attended the Seminar as GIS and remote sensing experts. Dr Sreya Dalwadi and Mrs Alice Garg as seminar resource persons and several senior professors of Regional

Group 1 at the Pushkar Lake for GPS field work

Institute of Education (RIE) and MDS University were also present for inauguration. Dr. K B Rath, Principal, RIE, Ajmer, Rajasthan in his inaugural speech as the hosting partner, highlighted role of teachers and remarked that he had on very few occasions seen such remarkable participation in a seminar in Ajmer.

More than 100 teachers from Rajasthan, Haryana, Gujarat, Madhya Pradesh and Punjab including trainee teachers of RIE, Ajmer and students from MDS University, Ajmer participated in the Seminar for all three days apart from people from the media. The participation strength in the GIS training was limited to 55 teachers. Most schools wanted to send at least three teachers, but as we wanted benefits accrued to a larger number of schools, we selected only one teacher per school and could not accommodate beyond 55. There was no registration fee and the teachers were also provided free boarding and lodging. Special course material was prepared for the event and three handbooks for three specific days covering various topics and a DVD was distributed during the Seminar. GY

AN ODE TO VINAYAK

Situated 22 kms from Nainital, Vinayak is set amidst deodar, fir and oak. Apart from a solar powered forest rest house, the getaway boasts of a few tenements for forest department trainees and a small tea shop. This quiet abode in the forest, featuring as a must visit in the itinerary of the avid birdwatcher, gets dark and cold as soon as the sun goes down.

Story and Photo **S Srinivasan**

Unlike most of the treks in the Himalayas this particular one is to be undertaken between November and March. The area abounds in birds and the climate this year allowed for an extension of the birding season into April. We were fortunate to have for company, our friend Vasuda Pandey, who hails from Nainital and has authored a tome on the history of the region. We set out one Sunday morning in April and negotiated the NH24 will little difficulty up to Hotel Rahi in Garmukteshwar. We downed the sandwiches in our lunch box and the hot pakoris served by the pleasant manager with cups of

masala tea. All along Vasuda regaled interesting anecdotes detailing the life and times of Mughal and British occupation.

Back on to the road we were severely stalled by heavy traffic just before the bridge over Ganga, with flocks of devotees descending for a holy dip on *amavasya* (new moon). The five kilometer stretch pulsated with a sea of automobiles of numerous descriptions - cycle rickshaws, bullock carts, tempos, snazzy cars and more. Two and a half hours later, inching through, we drove onto the bridge. We then took the toll road towards Bareilly and detoured to Moradabad bye pass and further on to Bazpur and Tanda. The road had turned into an uneven, pot hole ridden dirt track littered with broken down huge trucks, but beyond the border check post into Uttarakhand, the road became smooth, and we steadily ascended through a *sal* and *thesu* forests. Entering the tiny village of Kaladhungi, home to the legendary Jim Corbett, we stopped at the *chai* stall opposite Corbett's house and consequently toured the house. The photographs and the panels accentuated by the antique furniture brings the life and times of Corbett *sahib* alive. Soon we resumed ascent through this newly constructed road which follows the bridle path taken to Nainital by the horse riding British - we also learnt that Corbett's mother was one of the early property dealers in Nainital! We drove through densely forested track populated by mango, neem, *dhak*, *amaltas*, chestnut and finally chir pine trees painting the hill sides in a variety of hues ranging from yellow to orange, red, auburn and green.

It was six in the evening by the time we took the road on the left driving along the ridge and witnessing the banana shaped Naini Lake unfold to our right. At the next fork we took a diversion to Kilbury trundling down the forested path by the hillside. We crossed the path leading up to the Kilbury Forest Rest House (FRH) and passed the Mountain Quail Resort - named after the now extinct bird that was last seen in this locale in 1868.

We proceeded further to Pangot where a young man assured us that we would reach Vinayak before sunset and that we need not waste time looking for accommodation in Pangot. The road started climbing uphill and we reached Guggukhan followed by Sigiri which boasts of a couple of resorts, one private and the other run by UP Tourism. We could now see the glistening ribbon of the Kosi far down in the valley and hurried along to make it to the FRH in Vinayak before sunset. As we manoeuvred the car up the slope leading to the FRH the golden sun lay to rest.

We checked into the Snow View Hotel at Nainital run by the UP Tourism and as an incentive bagged free round trip passes for the ropeway.

Situated at a distance of 22 km from Nainital at an altitude of 2216 m the FRH at Vinayak is set amidst deodar, fir and oak. The Bungalow has two suites and kitchenette, booking for which is done at the office of the DFO, Nainital. The original building which came up in 1925 was made of stone. The current structure came up in 2006-7. It is supplied with solar lanterns and the guard provides simple meals to visitors on prior order. Besides the FRH, Vinayak boasts of a few tenements for forest department trainees and staff as well as a small tea shop. This quiet abode in the forest gets dark and cold as soon as the sun goes down.

Early next morning we made a recce of the surrounding forest and spotted several birds. After breakfast we set out further down the road towards Kunjhakharak. Enroute we stopped to view the majestic snow clad named and unnamed peaks and the meandering Kosi. We also spotted the common buzzard and the Mountain Hawk Eagle circling overhead high up in the sky. About 2 km before the FRH we spied a large deer languidly basking in the sun. As it was close to lunch time we drove ahead to Sigiri where the *sarpanch* runs a small hotel. After an elaborate lunch, his grandchildren took us to his home. On our return he plied us with specially prepared Rhododendron petal pakoris - an exquisite treat.

The forest rest house at Vinayak is situated at an altitude of 2216 m. The Bungalow has two suites and kitchenette, booking for which is done at the office of the DFO, Nainital. The original building built in 1925 was made of stone. The current structure came up in 2006-7.

The next morning we left for Pangot. It is believed that the real trek is the distance between Kunjhakharak and Akashkanda. Walking through the dense forest on mossy paths is a treat we look forward to on a later date. Several resorts have opened shop in Pangot as they are popularising it as a birding destination. The lone street boasts of a small post office. We had instant noodles for breakfast at local tea shop and went along to Kilbury FRH. Surrounded by oak, rhododendron and pine it is a favourite spot for birders.

We drove to Nainital and took the road to Snow View, where the Hanuman Temple is situated, ropeway to the Mall starts and an amusement park for children has been constructed. We checked into the Snow View Hotel run by the UP Tourism and as an incentive bagged free round trip passes for the ropeway. The Hotel is in the premises of the British Governor's residence and is a colonial building. Going down to the Mall the panoramic view of the Lake and the town emerged. The Naina Peak, Sukha Tal, Mall, Zoo, St Joseph's College and the University were prominent landmarks pointed out to us by Vasuda. Walking round the Mall we passed St Francis Church, Boat Club, the Library. Munching delicious strawberries and mulberries picked up from the roadside vendor, we reached the Talli Bazaar for lunch. Vasuda pointed out the spot where Indian Freedom Fighters were hung from a tree, the building where she stayed as a child, lake aeration plant and the temples on the southern bank.

We hurried through the bazaar near the Maidan, not wanting to miss the last trip of the ropeway. I quickly picked up chocolate eclairs from Stacley's as Vasuda pointed out the Hospital named after her grandfather. After the ropeway ride we took a walk along the ridge and spent time at Vasuda's house overlooking the Lake and its illuminated surroundings. Back at the Hotel, we were treated to a completely traditional meal - aam panna, bhange ki sabzi, pahari dal, saag, missi roti, and ram daney ki kheer stood out among several other delicious items. The last day of our trip took us to Nowkuchiatal via Bhimtal and on to Kathgodam and then Haldwani, Ramgarh, Garmukteshwar to home. We could not have imagined that an unspoilt forest exists so close to the urbanised, tourist spot of Nainital.

The author is a practicing paediatrician in Delhi and an avid photographer.

NATIONAL INSTITUTE OF OCEAN TECHNOLOGY, CHENNAI

(An Autonomous Institute under the Ministry of Earth Sciences, Govt. of India)
(Velachery-Tambaram Main Road, Pallikaranai, Chennai – 600 100)
Ph: 91-44-66783300, Fax: 91-44-22460275,
E-mail:postmaster@niot.res.in, Web: www.niot.res.in

National Institute of Ocean Technology (NIOT) is the technical arm of the Ministry of Earth Sciences, Government of India, carrying out technological development activities for harnessing the ocean resources. The main areas of focus are: Energy and Fresh Water from the Sea, Deep Sea Technology, Gas Hydrates, Coastal and Environmental Engineering, Ocean Acoustics, Marine Biotechnology and Ocean Observation Systems. Apart from these the Vessel Management Cell of NIOT maintains two coastal research vessels, a buoy tender cum research vessel and a state of the art technology demonstration vessel Sagar Nidhi.

ENERGY AND FRESH WATER FROM THE SEA

Energy and Fresh Water group is focused on the development of technology, for a reliable and commercially viable multifunctional system, for the extraction of energy and drinking water from the Sea.

OCEAN ACOUSTICS

The focus of this group is on the research and development of acoustic based marine systems, underwater noise data acquisition, processing, analysis and modeling for ocean applications.

VESSEL MANAGEMENT CELL

Vessel Management Cell maintains NIOT research vessels and provides services to the universities and research institutions for survey and data collection, besides supporting the implementation of programmes of MoES.

DEEP SEA TECHNOLOGY AND OCEAN MINING

Deep Sea Technology group is involved in the development of under- water mining systems for Polymetalic nodule mining from the Central Indian Ocean Basin.

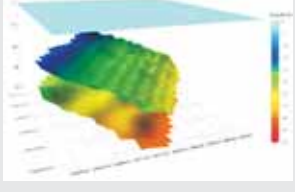
MARINE BIOTECHNOLOGY

Marine Biotechnology group carries out programmes related to socio economic benefit of island and coastal communities, through the development of viable technologies for harvesting marine bio-resources in a sustainable manner.

MARINE SENSORS AND ELECTRONICS

This group provides electronics support facilities to various activities and projects of the NIOT and develops marine sensors and underwater electronic components based on user needs.

COASTAL AND ENVIRONMENTAL ENGINEERING



The goal of the Coastal and Environmental Engineering group is to promote programs consistent with the overall development perspective of the country in the coastal infrastructure sector, through plan projects called technical criteria atlas and sustainable shoreline management.

OCEAN OBSERVATION SYSTEMS

This group is engaged in establishment, development and maintenance of moored buoy network, Tsunami early warning systems for measurement of met-ocean parameters in Indian Seas. The system monitors the marine environment to improve weather and ocean state forecast.

SUBMERSIBLES & GAS HYDRATES

This group has a mandate to develop technology for under water resources such as Gas Hydrates exploration through the development and operation of deep ocean underwater vehicle and coring systems.

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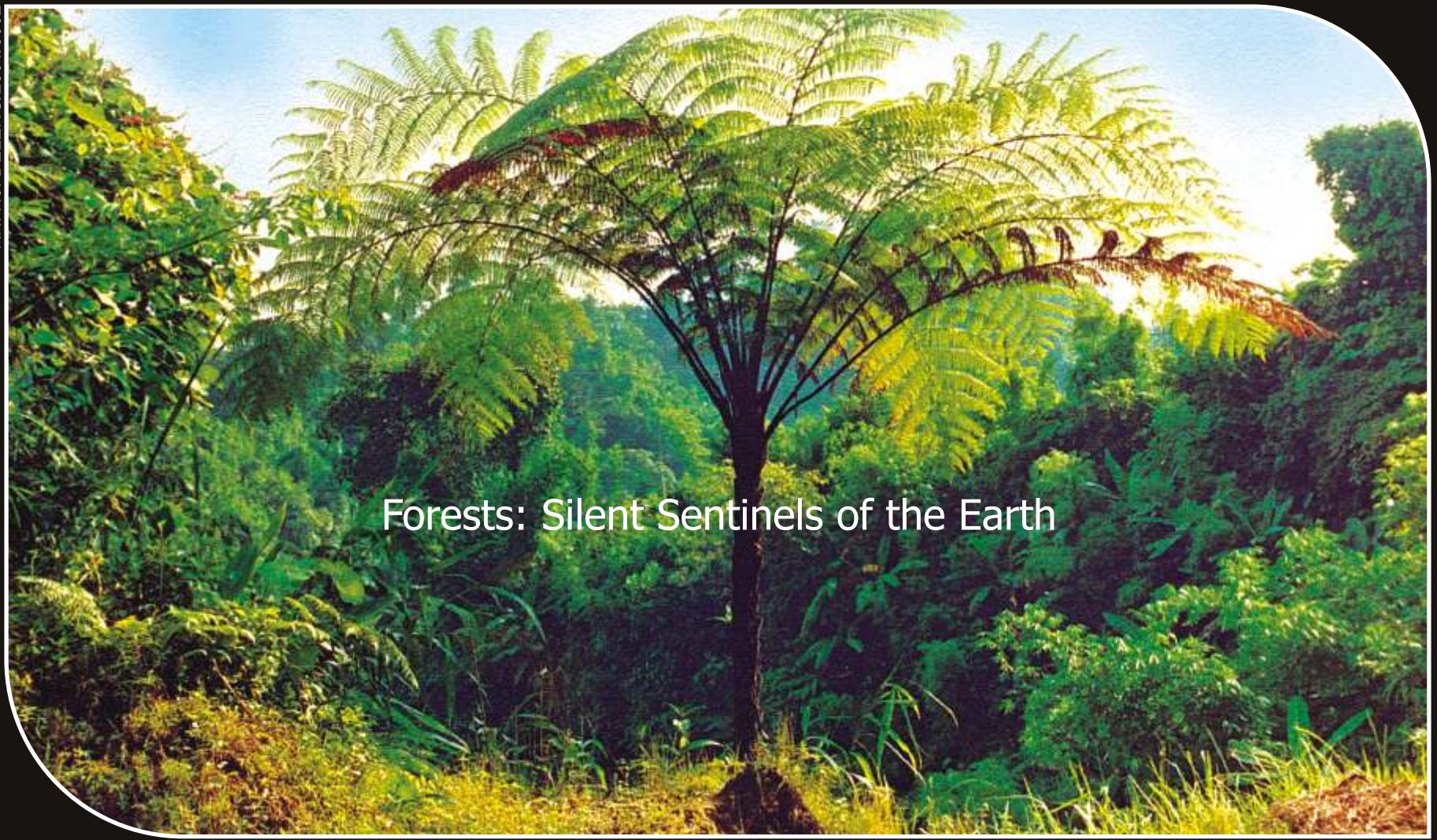

Ministry of Environment and Forests
Government of India

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वहाँ है खुशहाली ।।

For further information visit http://envfor.nic.in

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