A Nature India special on Odisha

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A STATE OF GROWTH

Biotechnology drives Odisha's agricultural future

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Data is saving lives in extreme weather events

Deep discovery
Diving beneath the surface of history

Sepsis trial
Supplement reduces infant deaths by 40%

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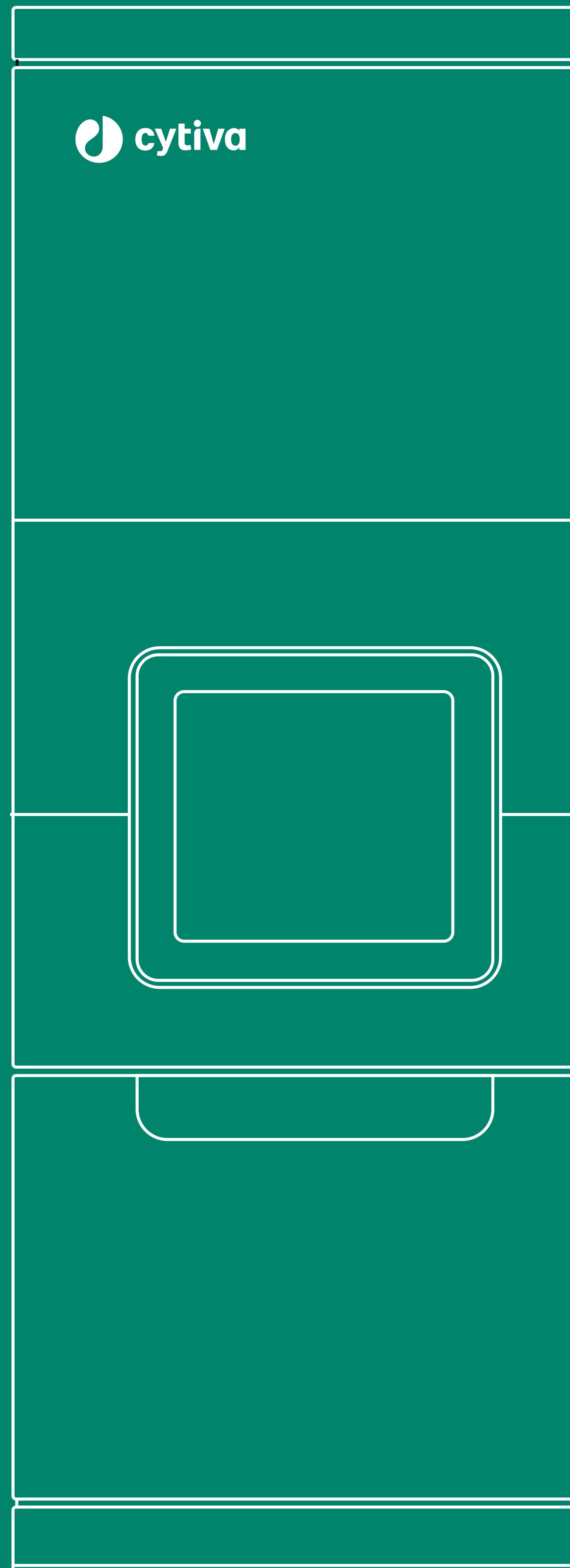

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EDITORIAL
New Delhi, India
npgindia@nature.com

Editor-in-chief: Subhra Priyadarshini
Editors: Rebecca Dargie, Sara Phillips
Art and design: Bharat Bhushan Upadhyay
Photographic editor: Tanner Maxwell
Project management: Lisa Truong
Creative director: Wojtek Urbanek

STRATEGIC PARTNERSHIPS
Senior Manager, India
Sonia Sharma
Tel: +91 9650969959
Sonia.sharma@nature.com

SUBSCRIPTIONS AND REPRINTS
npgindia@nature.com

REGISTERED OFFICE
Springer Nature India Pty Ltd:
7th floor, Vijaya Building, 17 Barakhamba Road
New Delhi, 110 001 India
Email npgindia@nature.com
www.nature.com/natureindia

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From the editor

Subhra Priyadarshini introduces this special Odisha issue of *Nature India*.

A state known for its heritage, culture and disaster management, and as an emerging hub of scholarship and research, Odisha is making its mark. This special issue captures the aspirations of and challenges for the eastern Indian state in becoming the next national science hub.

Odisha is home to a number of large national institutes and laboratories – the Indian Institute of Technology, the Institute of Life Sciences, the Institute of Minerals and Material Technology, the Regional Medical Research Centre, the National Institute of Science Education and Research, National Rice Research Institute, the Central Institute of Freshwater Aquaculture and the All India Institute of Medical Sciences. The state government-run Utkal University and the Orissa University of Agriculture and Technology in capital Bhubaneswar add to its scholarly might. Private education conglomerates such as the Kalinga Institute of Industrial Technology University and the L V Prasad Eye Institute are helping produce a sizeable scientific workforce. The entrepreneurship and innovation scene is warming up with a number of technology business incubators setting up shop in the state. A biotechnology cluster is also on the cards. The Odisha special issue takes a close look at this growth of innovation and technology in the state's science.

Odisha's 460km coastline and a hot, humid agro-climate, have endowed it with rich fisheries and paddy cultivation resources. The state's scientific legacy in both aquaculture and rice research have benefitted from these. We examine the results of years of rice and fish breeding that Odisha has gifted to the world. The state's proximity to the Bay of Bengal and high summer temperatures have also brought severe cyclones, floods and heat waves. We investigate how Odisha is setting an example in using science and technology to cope with such extreme weather phenomena.

Odisha's rich culture and history draws international attention. Its many temples, monuments, ancient palm leaf manuscripts, paintings, and excavations are keenly researched by archaeologists, leading to innovative conservation methods to preserve Odisha's past.

We analyse the traditional and modern methods being deployed by scientists, and focus on another rich historical source – shipwrecks – revealing fascinating stories of historic naval wars off the coast of Odisha.

India's science and technology is well entrenched in metro areas, with institute clusters like those in Bengaluru, Hyderabad, Mumbai, Pune, the national capital region of Delhi, and Kolkata. Smaller, second-tier cities like Bhubaneswar are gearing up to the cluster approach, and are poised to contribute to the research and innovation scene. The Odisha special issue is an attempt to shine a light on one such state. In the near future, Nature India's regional spotlights will chronicle more such emerging hubs of science in the country.

Subhra Priyadarshini
Editor-in-chief

December 2020

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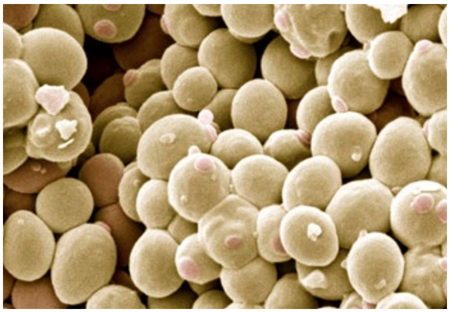

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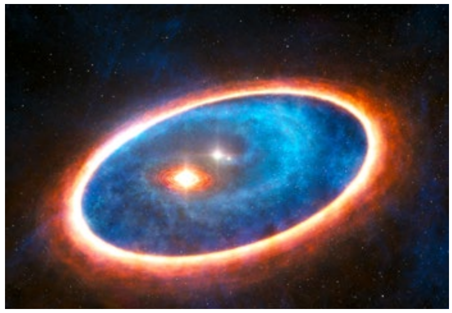

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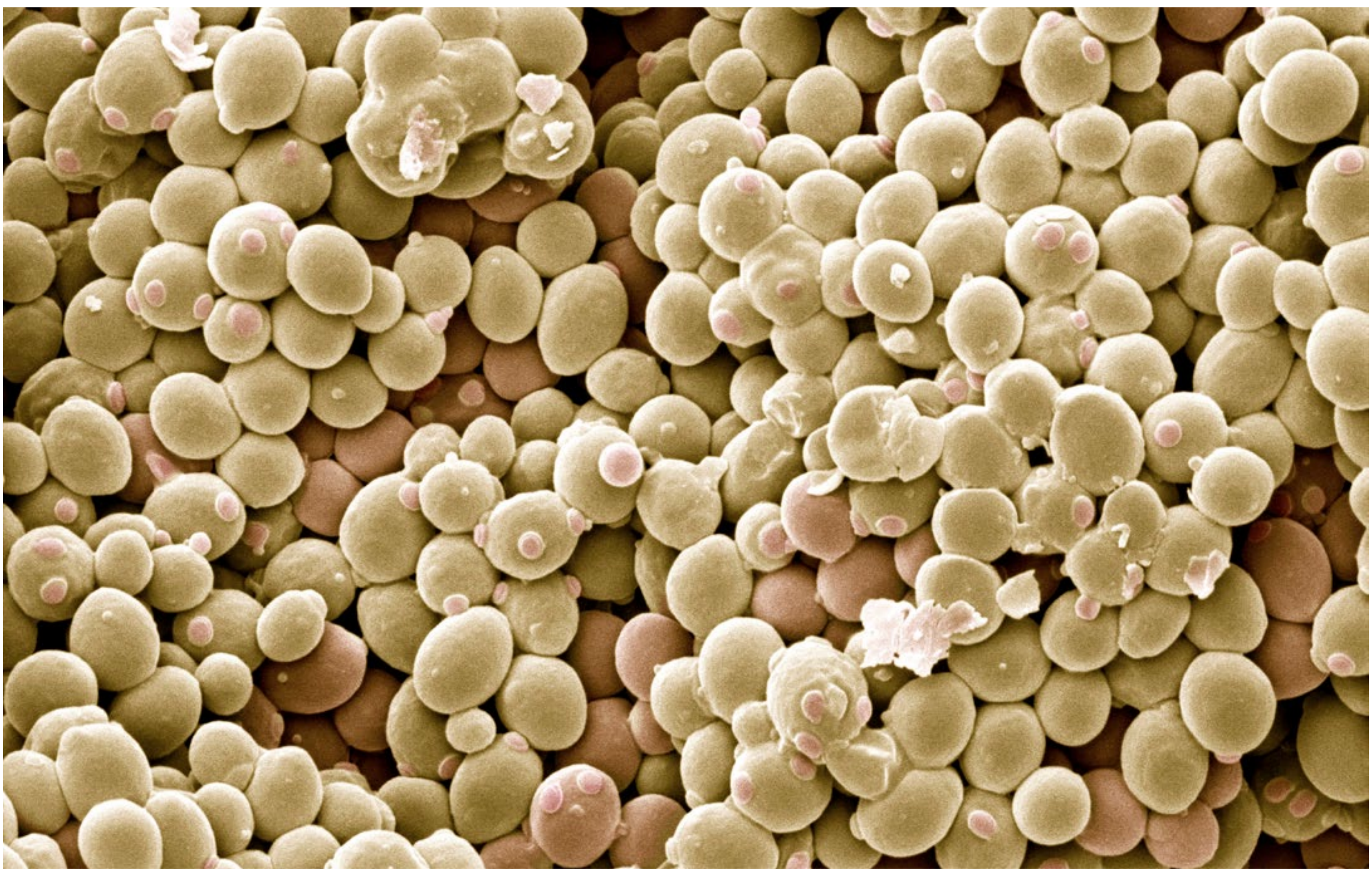
HARNESSING BIOTECHNOLOGY TO TACKLE THE GRAND CHALLENGES

Odisha's 2018 biotech policy has been a catalyst for a start-up culture embracing transformative opportunites in everything from smart farming to health interventions.

By Namrata Misra and **Mrutyunjay Suar**



STEVE GSCHMEISSNER / SCIENCE PHOTO LIBRARY

Yeast cells under scrutiny as part of studies into food grade microorganisms for fortified products.

The rapid growth of a biotechnology-led innovation ecosystem has been a major contributor to the global bioeconomy in the last 20 years. In India too, innovations from research institutes, entrepreneurs, start-ups and industry are steering the growth of the biotechnology ecosystem. A number of new government policies and mission programmes, including 'Make in India', 'Start-up India', 'Ayushman Bharat' and 'Swachh Bharat' have fuelled the development and validation of indigenous sustainable technologies.

Through the last decade, India's start-up culture has blossomed in the science hubs of Hyderabad, Chennai, Pune, and the National Capital Region (NCR). Now, the country's second-tier cities are plunging into the innovation and entrepreneurship ecosystem.

Among them is Odisha's capital city, Bhubaneswar, one of India's premier education hubs. A number of large institutes – Indian Institute of Technology, Institute of Life

Sciences, Institute of Minerals and Material Technology, Regional Medical Research Centre, National Institute of Science Education and Research, All India Institute of Medical Sciences, Orissa University of Agriculture and Technology, LV Prasad Eye Institute and KIIT University – add personnel to a substantial skilled workforce. However, until recently the city had no cluster-based framework to maximize cross-disciplinary scientific collaborations that could translate their research insights into applications and fuel a start-up ecosystem. Technology business incubators are needed to develop a conducive ecosystem for technology-driven research that can be commercialized.

Despite a wealth of natural resources, Odisha, a state of 42 million people on India's eastern coast, suffers from the problems of poverty. The state has faced several developmental challenges over the years, including political unrest, large pockets of extreme deprivation, social disparities, and natural disasters, as well as relatively less fiscal activity compared with other Indian states. Despite these challenges, Odisha has demonstrated significant commitment in addressing many aspects of public health, such as reducing maternal and child mortality rates, improving nutrition indices, and sustainable agriculture and aquaculture, among many others.

In a visible shift towards translational research in Odisha, an increasing number of technologies are being developed into commercial products. The time has come for the state to develop affordable sustainable technologies that can address global problems through industry-academia interaction, start-ups, and small and medium enterprises (SMEs).

A growing hub

Innovation is critical to the development of technologies that can find solutions to national challenges and develop affordable products for the social sectors. India's Department of Biotechnology and the Biotechnology Innovation (BIRAC) is visibly transforming Odisha's innovation ecosystem.

The Odisha government's Biotech Policy 2018 provided a slew of incentives for the biotechnology sector. The 'Startup Odisha' programme kicked off by the state government in 2016 has nurtured more than 780 start-ups. Scouting for grassroots innovations, another programme has created an entrepreneurial environment for more than 10,000 scholars in 50 institutions of the state. New hubs at the Foundation for Technology and Business Incubation (FTBI), National Institute Technology, Rourkela; SSU Innovation; the incubation centre of Sri Sri University; and the IT, Bhubaneswar incubator are creating start-ups and spin-offs of global relevance.

Hyderabad-based Bharat Biotech is developing a biotechnology park in the capital, Bhubaneswar, on a 26-hectare site, which will include a vaccine manufacturing plant.

There's a surge of interest both by innovators and start-ups in Odisha to apply for innovative prototyping grant opportunities in biotechnology. Many innovative projects implemented in the state are focused on finding fixes for societal problems. To further strengthen the ecosystem in Odisha, India's Department of Science and Technology has granted a centre of excellence in incubation in the area of digital health and precision agriculture at KIIT Technology Business Incubator and and Technology Enabling Centre (TEC) at KIIT University. Bhubaneswar is now ready to set up the Bhubaneswar City knowledge and innovation cluster (BCKIC), supported by the Principal Scientific Advisor (PSA) office to the government of India. This entity will provide a platform for various institutions of Bhubaneswar, industries, policy-makers, innovators, startups and NGOs to work on various local problems and build affordable solutions.

Combating malnutrition

Over the past few years, Odisha has performed better than the seven other weaker socioeconomic states of India (grouped together as the Empowered Action Group States) in reducing undernutrition. However, despite progress in child and maternal mortality indicators, Odisha continues to have high levels of malnutrition.

Many start-ups in Odisha are working on vital questions in the area of nutrition and maternal and child health. Some successful interventions include reducing anaemia and developing a hydrogel-based, slow-release iron jelly candy, which serves as an alternative for iron/folic acid (IFA) and Vitamin C tablets.

From food-grade microorganisms to use of trace metals for industrial production of fortified foods, the Startup Odisha programme is nurturing biotechnological innovations that have a direct effect on the state's food and nutrition security. Products such as safe baked goods developed with microbial enzymes and locally manufactured fortified foods are being considered for inclusion in the Public Distribution System (PDS) as well as school mid-day meal schemes. By making these tweaks, small innovators could help provide affordable nourishment to large underserved communities in Odisha and pockets of rural India.

Sustainable agriculture

A new generation of young researchers and start-ups are testing innovations to reduce post-harvest losses, and use of organic fertilizers and pesticides in farming. Some others are making interventions in preserving nutrition quality of seasonal vegetables, smart packaging, smart farming techniques and machinery for higher agriculture productivity. Small farmers in rural India could benefit from affordable technology that allows them to rapidly analyse the nutrient and soil health of their land. A start-up developed a soil analyser that can test for macronutrients, micronutrients and fertilizer optimization and recommend standard systems for farmers. A similar agricultural innovation from an Odisha startup is a single-row multicrop seed sowing machine for groundnuts, maize and pulse seeds, especially for small farmers.

> **THERE'S A SURGE OF INTEREST AMONG INVESTORS.**

Solutions for tropical diseases

Several Odisha start-ups are digitizing healthcare products and services through artificial intelligence and machine learning technology, making rapid detection kits for emerging pathogens, accurate diagnosis of disease stage and prognosis and, point-of-care diagnostics with a single device for multiple infectious agents. In a digital world, start-ups are connecting patients with specialist doctors at major multispecialty hospitals in Odisha. A technology-enabled start-up from Odisha translating state-of-the-art interdisciplinary research into medical devices and healthcare interventions, recently received global acclaim.

Despite a thriving biotechnology research scene, Odisha has not seen many academic entrepreneurs. A very small segment of the biotech sector in the state is focused on innovative R&D, aimed at manufacturing novel products. The state needs a stronger co-evolving network of institutes, companies, universities, and private capital to steer biotech innovation forward.

The impact of each of these innovations is significant and many have progressed to the validation and commercialization stage. The state needs to nurture this growing innovation ecosystem and connect its academic clusters to similar ventures elsewhere. Odisha's biotechnological best practices can be extrapolated to similar low-income settings that need technological interventions to meet their grand challenges.

The authors are from the KIIT Technology Business Incubator, KIIT (Deemed to be University), Bhubaneswar, Odisha, India.

WITHSTANDING WEATHER: A SCIENTIFIC RESPONSE

Intense cyclones, severe heat waves, droughts, floods, and storms are part of life in Odisha, but more robust systems and advanced technologies are improving outcomes.

By Sushil Kumar Dash* and **Sarat Chandra Sahu****

Cyclones lashing Odisha's coasts have been severe to very severe in their devastation. The height of cyclonic catastrophe in recent times came with the notorious Super Cyclone of 29 October 1999, when wind speeds hit a furious 260 kilometres an hour. It was the most powerful recorded cyclone of the century. Bhubaneswar saw torrential rains of up to 43 cm in just 24 hours. The wind was so powerful that the recorder at the coastal town of Paradip broke down after reading speeds up to 160km per hour. Power supplies failed, crippling radar observations at Paradip, and telecommunication was disrupted for a significant period, so civic administration was paralysed. Official records say 9,885 people were killed and property worth billions of rupees destroyed, though unofficial estimates put those figures way higher.

In contrast, later events — very severe cyclones such as Phailin (2013), Hudhud (2014) and Titli (2018), extremely severe cyclone Fani (2019), and super cyclone Amphan (2020) – did not see similar human or livestock casualties, or property losses. Comparing situations pre- and post-1999 reveals that use of scientific and technological interventions adequately prepared the administration to minimize losses.

DIBYANGSHU SARKAR/AFP / GETTY IMAGES

Flooding in Odisha is frequent and disruptive.

Forecasting

Timely and accurate forecasting of any weather related disaster is key. However, forecasting is not the only component that helps cope with hazards. There are other important dimensions, such as science-based early warning, disaster preparedness and response systems. Scientific awareness among the public, and their involvement, are also crucial.

Before the 1999 super cyclone, the weather agency India Meteorological Department (IMD) used traditional weather charts and observational products to forecast the event. Accuracy of forecasts depends on the available information, the Numerical Weather Prediction (NWP) model used, and the experience of its forecasters. In the late 90s, cyclones developing over the Indian oceans were usually analysed using weather information from ships, the buoys deployed by the National Data Buoy Program (NDBP), special radar at Paradip, INSAT-1D satellite imagery and an NWP model called the Quasi Lagrangian Model (QLM).

During the 1999 super cyclone, adequate data was unavailable from ships and ocean buoys, except one stationed off Paradip. On the morning of 29 October, the Cyclone Detection Radar (CDR) at Paradip stopped recording. This was an analogue radar with data analysed on the screen by the local meteorologist and transmitted in coded form through a telegram, phone or teleprinter. Its photographic film was damaged and the wind speed recorders at Paradip became unserviceable.

The most significant limitation of QLM was the lack of empirically generated vortex and steering current data. As observations were limited, crucial information on the exact location and size of the storm, its central pressure, the value of the outermost closed isobar, was compromised. Though the INSAT-1D satellite images were useful in estimating the eye of the system, due to limitations in getting timely observations of the NWP model, meteorologists were only able to provide a 24-hour warning, leaving little preparation time. The IMD and other agencies were ineffective when the cyclone hit.

The public communication system also failed to either swiftly disseminate early warning to people or amp up emergency response. There was inadequate capacity for evacuation. The 480-kilometre coastline of Odisha had only 23 cyclone shelters made jointly by the Indian Red Cross Society, and the Odisha government.

Box 1. Odisha's hazardous cyclones

Sl.No.	Year	Category	Coast crossed
1.	9 October 1967	Severe Cyclonic Storm	Between Puri and Paradeep
2.	30 October 1971	Very Severe Cyclonic Storm	Near Paradeep
3.	29 October 1999	Super Cyclone	Near Paradeep
4.	12 October 2013 (Phailin)	Very Severe Cyclonic Storm	Near Gopalpur
5.	11 October 2018 (Titli)	Very Severe Cyclonic Storm	Near Palasa, southwest of Gopalpur
6	3 May 2019 (Fani)	Extremely Severe Cycloninc Storm	Close to Puri

Combatting extreme weather

Odisha is also prone to heatwaves, drought, floods, intense storms, and lightning strikes. The heatwave of 1998 was one of the most severe in recent history, killing 2,042 people. This event, coupled with the 1999 super cyclone devastation sparked a shift of approach by the government, from disaster response to disaster prevention. A new agency, the Odisha State Disaster Management Authority (OSDMA), was created in 1999. Twenty units of the Odisha Disaster Rapid Action Force (ODRAF),have been established. One unit of the National Disaster Rapid Action Force (NDRF) is also stationed at Mundali in Odisha's Cuttack district.

The state now has 879 multipurpose cyclone and flood shelters, some multi-storey, to house evacuated people and cattle during a calamity. Based on the Disaster Management Act, 2005 of the Government of India and the subsequent National Policy on Disaster Management 2009 (NPDM), the National Disaster Management Plan (NDMP) provides a disaster management framework. NDMP is a dynamic system in line with the United Nations' Sendai Framework for Disaster Risk Reduction 2015-2030. It encompasses all phases such as mitigation, preparedness, response and recovery in an integrated manner by involving authorities at the national, state, district , and local levels.

Data to the rescue

Climate science has grown in the last decade with improvements in observational systems and developments in NWP models. The magnitude and direction of wind at the ocean surface are used as key parameters for tracking of cyclones. Wind data across the globe are gathered by the scatterometer payload in the OCEANSAT-2 satellite. India's Ministry of Earth Sciences has modernized its equipment. The IMD now has 1,350 automatic raingauge stations, 722 automatic weather stations and 575 manned surface observatories. The IMD also has 46 upper air pilot balloons and GPS sonde observations.

Twenty buoys assist with effective cyclone prediction. With state-of-the-art infrastructure, three weather satellites provide pictures every 15 minutes, and a series of 24 Doppler radars along the coast, the IMD is capable of sharp predictions five days in advance of cyclones. The Doppler radars provide real-time information about the signature of cyclogenesis in the Arabian Sea and the Bay of Bengal. Two Doppler radars function at Paradip and Gopalpur. In total, 37 automatic weather stations, 28 manual surface observatories, 177 automatic rain gauges and 314 rain gauge stations of the Odisha government provide data to predict weather extremes. Odisha also has four pilot balloon observatories at Bhubaneswar, Gopalpur, Balasore and Jharsuguda and three GPS sonde stations at Bhubaneswar, Gopalpur and Jharsuguda. The National Knowledge Network (NKN) facility and a separate broadband connectivity to the IMD by the National Informatics Centre (NIC), a display facility of digitized weather charts at synoptic hours, and forecast of different NWP models using three monitors simultaneously, allow real-time predictions.

Scientists are now forecasting weather events at different time scales, from short to long-term climate projections, with a number of NWP models. India uses the multi-model ensemble technique to make forecasts closer to actual observations on the ground. Impact based forecasts are also useful for planners. Speedy communication networks help in evacuation of vulnerable people on priority basis to multipurpose cyclone-flood shelters. Farmers are given timely advice from scientists at the Orissa University of Agriculture and Technology (OUAT) to keep harvested crops safe, and to refrain from applying fertilizers or pesticides.

The 1998 heat wave, which largely affected the poor people, farmers and workers, prompted formulation of a Heat Action Plan by OSDMA, in collaboration with the IMD and the Indian Institute of Public Health (IIPH).

Flood hazards

Flooding during the monsoon months, especially in the rivers Mahanadi, Brahmani, Baitarani, Budhabalanga, Subarnarekha, Vansadhara and Rusikulya, has traditionally been a cause of concern. Odisha's entire coastal belt is also prone to storm surges. According to the National Remote Sensing Centre (NRSC), about 8.96% of land in Odisha was affected by floods during 2001-2018. Analysis of a large number of satellite images available during this period has enabled the Odisha government and NRSC to make a flood hazard atlas to guide state management. The IMD has employed 'now casting' techniques for thunderstorm and lightning. OSDMA uses sophisticated technology from Earth Networks USA for lightning detection. The private Siksha 'O' Anusandhan (SOA) university in collaboration with Indian Institute of Tropical Meteorology, Pune, is issuing lighting warnings by WhatsApp messages.

Odisha has set a great example of public involvement in effective management of disasters in two cyclone affected villages. The Intergovernmental Oceanographic Commission of the UNESCO has recently declared two sites — Noliasahi and Venkatraipur – as tsunami-ready.

With advanced understanding of extreme weather events, and availability of sophisticated instruments, it will become possible to read a 3D picture of the atmospheric situation for any given place. Artificial intelligence is increasingly being used to detect model errors. These tools are useful in delivering timely early warnings. The future looks safer with the availability of apps like Mausam, Meghdoot and Damini from IMD.

Although it is anticipated that climate change will cause more frequent extreme weather events, demanding increased alertness, scientific tools provide a silver lining. Even so, Odisha, like the rest of the world must be mindful of the need to mitigate the forces behind extreme weather by embracing green energy and development practices.

**Former Professor and Head, Centre for Atmospheric Sciences, IIT Delhi, India.*
*** Director, Centre for Environment & Climate, ITER, Siksha 'O' Anusandhan (SOA), Bhubaneswar, Odisha, India.*

CROP ADVANCES FEED ECONOMIC GAINS

Technological breakthroughs in rice production and fisheries are among success stories in Odisha's agricultural sector.

By Arabinda K Padhee* and **Trilochan Mohapatra****

The contribution of agriculture to Odisha's economy has increased significantly, according to its latest economic survey (2019-20), which shows that about 20% of the state's revenue comes from crops, livestock, fisheries and aquaculture.

While 'natural shocks' interrupted crop production – a cyclone in 2013-14, drought in 2015-16 and pest attacks in 2017-18 – the growth in livestock and fisheries has risen steadily for a decade. The state's Agriculture Policy 2020 indicated the sector's GDP nearly doubled in real terms, clocking an annual growth rate of about 4.5%, higher than the all-India average of 3.1% between 2000-01 and 2016-17.

Odisha's agricultural success can be traced back to a legacy of scientific exploration and interventions.

Rice science leading the way

Rice is synonymous with Odisha's agriculture. Orissa, the English spelling of Odisha's former name led to a widespread presumption that its origin came from Oryza, from the rice genus. The Jeypore tract of Odisha has been described as the secondary centre of rice's origin and diversity, and covers more than 60% of its cultivated area. Odisha's economy is directly linked to the production and productivity of rice.

Rice varieties from Odisha are consumed across the world. The state is home to numerous landraces, particularly in the earlier undivided Koraput district that includes Jeypore. Before the semi-dwarf, high-yielding paddy types were adopted by the state in the 1960s and 70s, farmers used to grow many traditional varieties. Over the past 20 years, the high yielding varieties have almost replaced the diverse, locally adapted varieties, but farmers still grow these traditional cultivates in the rain-fed uplands and regions with deep and semi-deep water conditions. These cultivars were grown for specific traits like maturity duration (usually in sync with specific cultural festivals), aroma of grains, and tolerance to biotic and abiotic stresses. Some of these traditional rice varieties still grown in limited scale are: *Kakudimanji, Saruchinamali, Ratna Chudi, Cuttack Chandi, Kedar Gauri, Kala-kartik and Pateni.*

> **RICE VARIETIES FROM ODISHA ARE CONSUMED ACROSS THE WORLD.**

The aromatic landraces of rice in Odisha have been used for generations, and indigenous scented varieties like *Kalajeera, Kalikati, Jubraj, Karpura Kranti, Tulsiphoola* and *Pimpudibasa* are still popular locally and beyond. Many rice varieties of Odisha have been preserved *ex situ* at the National Bureau of Plant Genetic Resources (NBPGR), Delhi, This Indian Council of Agricultural Research (ICAR) body has developed 70 biofortified crop varieties, some of which are derived from such traditional varieties.

Institutions like the Chennai-based M.S Swaminathan Research Foundation (MSSRF) preserve traditional varieties of rice *in situ* in the tribal heartland of Koraput. Kamala Pujari, from Jeypore (Koraput) was awarded with the *Padmashri* honour in 2019 for her conservation of rice landraces in crop fields after leading a push for participatory breeding in her village and adjoining areas that led to the development of *Kalinga Kalajeera variety*.

The establishment of the Central Rice Research Institute (renamed National Rice Research Institute) at Cuttack in 1946 was a milestone in India's agricultural research, as systematic rice hybridization efforts started here. However, the initial *indica-japonica* hybridization program launched in 1950s to break the yield barriers in *indica* rice wasn't as successful. Subsequently, the *indica* variety, TN-1, was the basis for a series of high yielding dwarf varieties including IR-8. This new variety, referred to as miracle rice, was short-statured and highly responsive to fertilizer application – breaching the yield barrier in tropical rice.

CRRI scientists and the All-India Coordinated Rice Improvement Program (AICRIP) led to the development of a number of rice varieties, later released across the country. Agricultural scientists such as Krishnaswamy Ramiah, M.B.V.N. Rao, C. Challam, and S.V.S. Shastry laid the foundation of rice science and variety development in India. The father of India's green revolution, M.S. Swaminathan, also started his research career at the Central Rice Research Institute in Odisha.

A long line of other scientists and breeders contributed steadily, developing high yielding varieties for various agro-ecologies and agronomic traits. *Jagannath, Parijat, Jajati, Khandagiri, Surendra, Lalat,* and *Pratikshya* are among popular varieties released by the Odisha University of Agriculture and Technology (OUAT) in the last 50 years.

Using technology, resistant genes or quantitative trait loci (QTL) have been organised into elite genotypes to include desired traits in rice varieties. The best example is the *Swarna Sub1* variety in which the submergence-tolerant sub1 gene (isolated from the landrace FRI3A) has been introduced through a technique called

PALLAVA BAGLA/CORBIS / GETTY IMAGES

Odisha produces diverse rice germplasms, and has a renowned history of scientific crop improvements.

marker-assisted selection. Swarna Sub1 has now been further improved at CRRI to include multiple QTL to develop new varieties like CR Dhan 801 and CR Dhan 802, which are both drought and flood resilient. Odisha has diverse germplasms of rice, which could be screened to map the QTL for varieties resilient to multiple biotic and abiotic stresses.

Similarly, a high-protein trait from two landraces of Assam was transferred to high-yield rice varieties *Naveen and Swarna* through systematic back cross breeding programmes The Cuttack-based National Rice Research Institute (NRRI) released its first high protein rice variety *CR Dhan* 310 with 10.3 % grain protein content (GPC) in 2019 followed by another variety *CR Dhan* 311 with 10.1% GPC and zinc content of 20 parts per million. These accomplishments are significant as India aims to strengthen nutritional security.

Fisheries

Fisheries and aquaculture are among the fastest growing sectors in Odisha. Production (from fresh water, brackish water and the ocean) has grown over the last two decades (from 260,000 tonnes in 2000-01 to 759,000 tonnes in 2018-19). Exports during this period has seen a 7.5-fold increase (3.79 billion rupees in 2000-01 to 28.71 billion in 2017-18).

A major development has been the genetic improvement of rohu *(Labeo rohita)* at the ICAR-Central Institute of Fresh Water Aquaculture (CIFA), Bhubaneshwar. After 11 generations of systematic selection, the new variety, Jayanti Rohu, has a 60%-plus growth performance compared to normal rohu stock. Similar improvement has yielded 30% higher growth in catla *(Catla catla)* after second generation of selection, and 30% higher growth in giant freshwater prawn *(Macrobrachium rosenbergii)* after 10^{th} generation selection. Induced breeding, mass-scale seed production and grow-out farming technologies have been developed for more than a dozen freshwater finfishes, and Indian river prawn.

Technology allowing carp breeding using improved brood stock maintenance protocol has resulted in multiple breeding of the same brood fish by stretching the breeding season, leading to a threefold-increase in spawn production in a season. The development of a specialized brood stock diet 'CIFABROOD' has been a significant step in bringing early maturity, higher spawn yield and increased seed survival in carp, and is used by several hatcheries in India. 'CIFAX', a chemical formulation, developed by CIFA, is a significant breakthrough for prevention and cure against the 'Epizootic Ulcerative Syndrome (EUS)' which has been a major disease threat in freshwater aquaculture system since the late 1980s. 'TreatMyFish' app for fish disease treatment is serving as a tool for active interaction between farmers and scientists.

Another development in the aquaculture sector is freshwater pearl culture technology at CIFA. The institute is identifing suitable pearl mussel species, and defining appropriate surgical implantation procedures. The technology offers great scope for commercialization.

**Country Director-India, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). **Director General, Indian Council of Agricultural Research (ICAR).*

The authors thank Dr S R Das, Rice Breeder and Honorary Professor, OUAT, and J K Jena, Deputy Director General, Fisheries, ICAR.

CREATING A PIPELINE OF TECH ENTREPRENEURS

KIIT-Technology Business Incubator is AT THE EPICENTRE of a group of technology start-ups and entrepreneurs in the eastern and north-eastern regions of India.

"Two-thirds of India's population is below the age of 35 and this youthful environment is perfect for carving out a strong position in the global start-up ecosystem. But for India to leapfrog technologically, a massive push is needed to identify and support home-grown entrepreneurs, to explore new markets, provide cheaper and better services and to make entrepreneurship an attractive career option," says Mrutyunjay Suar, Director General (Research and Development) of the Kalinga Institute of Industrial Technology (KIIT) and CEO of the KIIT-Technology Business Incubator (KIIT-TBI).

KIIT-TBI is an initiative that was dreamed up more than a decade ago by the founder of KIIT, Achyuta Samanta. Its mandate is to empower and enable the innovation ecosystem in the east and north-eastern states of India. Set up as a not-for-profit, public sector company in 2009, with generous support from the Government of India's Department of Science and Technology (DST), it was recognized as a Centre of Excellence in 2020. The primary focus of KIIT-TBI has been to nurture start-ups, facilitate industry-academia interaction and to promote student entrepreneurship.


Dr. Mrutyunjay Suar, CEO KIIT-TBI

Today, KIIT-TBI has established itself as a major innovation hub for technology ventures and a site for interfacing with the industry, academia, government bodies, and cross-border agencies.

NURTURING BUSINESS ENTERPRISES

KIIT-TBI provides holistic support for science innovation and 'techno-preneurship'. Unlike many other incubators that just provide a physical space for entrepreneurs, it works with budding innovators throughout their initial entrepreneurial journey. KIIT-TBI provides holistic support from incubation seed-funding, capacity building and market-access to business mentoring, investor networking, assistance in obtaining regulatory approvals and intellectual property rights, among other things, says Suar. It also recognizes that new ventures are important to commercialize university technologies, and for this a Technology Transfer Office is being set up under the Government of India's National Biopharma Mission.

PROMOTING SCIENCE INNOVATION

Odisha's start-up ecosystem is now growing, and KIIT-TBI has supported more than 250 ventures, 50 start-ups founded by women and 80 pieces of intellectual property. Fifty-five start-ups received follow on funding worth of 3.5 billion rupees (approx. US$47 million) generating more than 4,000 jobs. These start-ups are beginning the deployment of technologies in areas critical to the India's social and economic growth, such as healthcare, food and agriculture, waste management and IoT. KIIT-TBI won the National Award for Technology Business Incubation in 2017 from the Union Minister for Science and Technology and Earth Sciences.

NORTH-EASTERN START-UP GROWTH

To augment the innovation ecosystem in the north-eastern region, the BIRAC Regional Techno-Entrepreneurship Promotion Centre (BRTC) housed at KIIT-TBI conducts capacity building training not only for innovators, but also aspiring incubation managers to better design, run, monitor and scale up their activities.

FUNDING

KIIT-TBI has received funding and support from various government agencies such as DST, the Department of Biotechnology, the Biotechnology Industry Research Assistance Council, the National Science & Technology Entrepreneurship Development Board, the Ministry of Micro, Small and Medium Enterprises, the Technology Development Board, the Ministry of Food Processing Industries, the Ministry of Electronics and Information Technology and the Government of India.

Some of the notable innovations and start-ups from KIIT-TBI include:

EzeRx is a medtech and biotech start up developing and manufacturing advanced medical devices, including a contactless portable device that can detect anaemia and predict liver and lung problems in less than five seconds at a

Upsoil Technologies' kit makes soil health diagnostics more portable.

Inochi Care's technology accelerates the healing of medically complex wounds.

Kalinga Institute of Industrial Technology's Technology Business Incubator has been supporting start ups for more than a decade.

StopBleed, an anti-bleeding compound, can clot blood in 40 seconds.

cost of less than one rupee, all without taking a single drop of blood.

Comofi Medtech offers a robotics surgical intervention platform to help provide access to the kidney in one attempt using intraoperative puncture path planning,100% percutaneous nephrolithotomy puncture accuracy and 100% safety from ionic radiation exposure.

Miraqules MedSolutions has developed an anti-bleeding compound called StopBleed to treat trauma. It can stop bleeding within 40 seconds with five times the normal efficiency by combining biomaterials together to enhance blood clotting and wound healing.

Purple (Purplas IT Services Pvt. Ltd) is an AI, computer vision, automation and behavioural analytics R&D company. It has developed SecureSound, an affordable handheld ultrasound machine providing accessible point-of-care diagnostics services in rural and urban India.

Prantae Solutions has developed a diagnostic solution for early detection of preeclampsia, a pregnancy-induced hypertensive disorder. The start-up has also developed and deployed an affordable, antibody-based COVID-19 diagnostic kit.

Upsoil Technologies has developed a portable, intelligent, rapid nutrient tester for soil health called Soil-Pen. It quantitatively estimates soil nutrients, pH, temperature and salinity in a matter of minutes.

Krea Foods and Beverages Private Limited is developing a novel asparaginase-based enzyme formulation that decreases acrylamide, a carcinogenic toxicant found in 40% of the average daily dietary intake.

Inochi Care Private Limited is developing a smart plug and patch system that facilitates delivering multiple therapies at the site of a wound in difficult, rural settings. ■

KIIT-TBI

Feature

PEERING THROUGH LAYERS OF TIME FOR STORIES OF THE PAST

Odisha's rich history, depicted in monuments, manuscripts and archaeological excavations, is further revealed through shipwrecks off its coast.

Anupam Sah* and
Sila Tripati**

Though much is known about how Odisha uses archaeological science to reveal history in its monuments and excavations, not much has been explored of another rich source of history, the shipwrecks off its coast.

Shipwrecks provide well-preserved information on maritime trade, giving a glimpse of maritime and cultural conditions of a particular period. Shipwrecks and submerged ports merit more scientific exploration and excavation.

People ventured out to sea from Odisha for marine resources as far back as 4,000 years ago, and were engaged in maritime activities from 800BC. Ancient seafarers of Odisha had deep knowledge of the sea's winds, currents, and tides, and of shipbuilding.

Most rivers of Odisha and their tributaries opening into the Bay of Bengal were suitable for navigation. Ancient ports and trade centres of Odisha — Tamralipti, Adams, Kosamba (in Pipili or Balasore), Tyndis (on Brahmani river), Dosaron (on Baitarani river), Nanigaina (in Puri), Katikardama (in Cuttack), Kannagara (in Konark), mouths of the rivers Manada (river Mahanadi), Minagara , Manikapatna, Palur, Che li ta lo and Khalkatapatna — had overseas trade relations at various historical points.

Archaeologists have unearthed insights from these ports and trade centres that reveal Odisha's maritime contacts with Roman Empire figures, south-east Asian countries, and the Red Sea coast. Discovery of various types of early pottery – northern black polished ware (NBPW), rouletted ware (RW) knobbed ware (KW) along with the depiction of a giraffe on the wall of Konark temple – bear testimony to these maritime links.

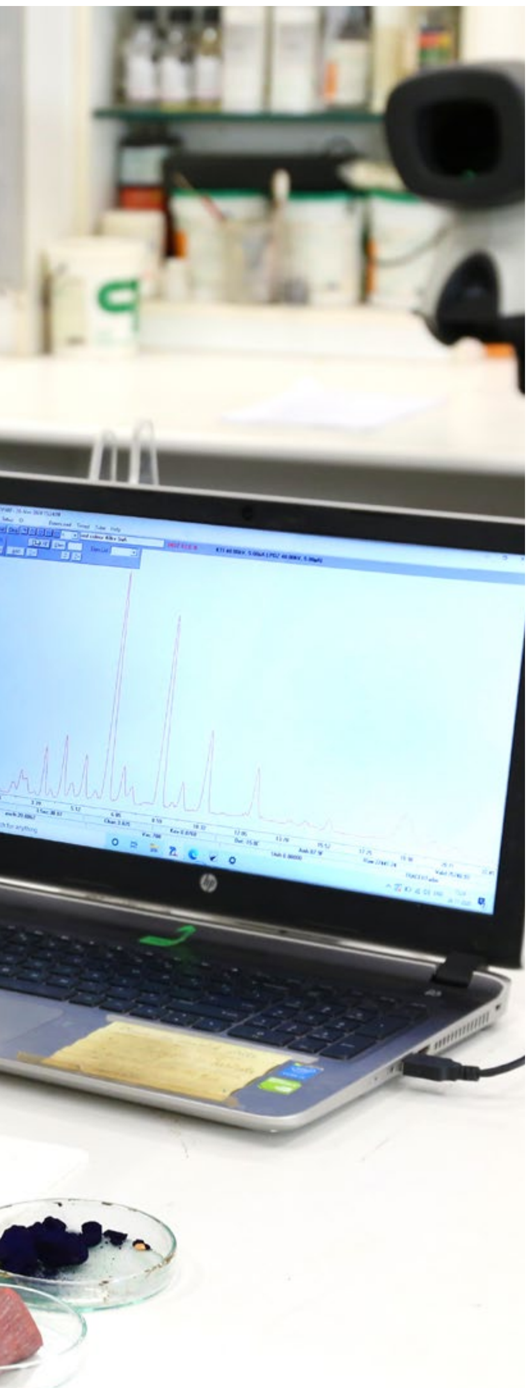
Various factors contributed to the decline of ports, and a recent study shows the migration

Identifying pigments on a pattachitra with a portable X-ray fluorescence spectrometer.

of the estuary of the River Kushabhadra eroding the remains of Khalkatapatna port. Meteorological records indicate that several ships were wrecked along the Odisha coast between 1832 and 1900 by cyclones and storms.

The National Maritime Archives also record the centuries-old boatbuilding technology of Odisha. Craft come in a large variety – the reverse clinker *'Patia'*, the flat bottom boats; similarly, *catamaran* and *padua (masulas)* are two major types in the southern coast, which are still prevalent along Odisha coast.

In 2008, marine archaeologists from the National Institute of Oceanography in Goa discovered 7th century ship anchors and stone memoirs dedicated to battle heroes, and pieced together an untold saga of a historic naval war off the coast of Odisha.



CSMVS MUSEUM ART CONSERVATION CENTRE, MUMBAI

In the obscure village of Kanas, an ancient port city 25 kilometres from Chilika Lake, Asia's biggest water lagoon, villagers ploughing a paddy field unearthed peculiar longish stones with large holes, and antiquities that look like etched milestones. Archaeologists dated these stones back to between 7th and 9th century AD, presumably used to anchor ships at this once busy port. They turned out to be 'hero stones', erected in remembrance of heroes who lost their lives in naval battles, suggesting these were remnants of a naval war fought around the area. The findings correlated with the historical Odia text *Paika Kheda* which describes the training of soldiers and has a chapter dealing with naval wars.

Some records say that the Gauda king Sasanka (619-620 AD) attacked and defeated the king of Odisha in the early 7th century AD. Sasanka was described as a staunch worshipper of the lord Shiva, and one of the hero stones depicted a human worshipping the phallic symbol of Shiva. Anchors found in the area point to the economic and cultural relationships among people of different regions which had maritime relationship with Chilika, the 64-kilometre brackish-water inshore lake connected to the Bay of Bengal through a narrow mouth.

Odisha's shoreline is strewn with many shells, some smooth, some cockled, and some like conches – the type easily identified as the attribute of Jagannath, Odisha's presiding deity. Traditionally, these sea shells are burned in kilns to create quick lime to make pure white plasters of buttery consistency. This is applied as a final smooth surface layer on the walls of the temples and *matthas*, and on the walls of humble homes and edifices.

Odisha's artists have used these lime plasters in beautiful paintings, visible at about 100 sites in the state, in varying stages of dilapidation. Mural painting in India is exemplified in the 2,000-year-old world heritage site near the village of Ajintha, and historical continuity can be drawn by re-establishing the art form here. Scientists have analysed this lime plaster with x-ray diffraction studies and helped document the components of traditional mortars.

The other use of the sea shells is for pigment, *dhaula*, or white, in the millennia-old Indian painting tradition. After grinding, the white that results is mixed with the binder from the wood apple tree *(Limonia acidissima*, local name *kaintha)*, and is used to illustrate the profusion of artefacts. Microchemical studies coupled with X-ray fluorescence spectrometry, assist in pigment identification just as Fourier Transform Infrared (FTIR) spectroscopy indicates the binders used. Infrared imaging reveals the hidden drawings created by the artists, beneath the paint layers.

The other principal pigments prepared for these paintings are from minerals – the deep red of *hingula* or cinnabar, and the bright yellow of *haritala* orpiment, as well as the earth pigments — the red and yellow ochres. The works are created on the smooth floors of the artists' homes, often in the room at the entrance. It is a colourful spectacle, with bright paints in bowls made of the smooth coconut shells, home-made brushes for creating the finest of lines in black that they make by burning oil lamps and collecting the soot, called lamp black, one of the most ancient pigments, along with the ochres. Prehistoric designs featuring these ochres can be seen in rock art shelters of Sundargarh and Jharsuguda districts of Odisha.

The lines that form the Odishan script are

"ODISHA'S SEAFARERS HAD A DEEP KNOWLEDGE OF SHIP BUILDING.

rounded, with hardly any edges, as these were first inscribed centuries ago on palm leaf folios. There are millions of bundles of palm leaf manuscripts, on subjects ranging from poetry to astrology, astronomy to grammar, and many of them are exquisitely illustrated. The National Mission for Manuscripts of the Government of India has been attempting to catalogue the contents of these manuscripts for many years. Much of the history of the land is documented in these folios, following the same unbroken line of technique of using an iron stylus and incising the writing on the leaf, and then rendering it visible by smearing lamp black on the leaf, and wiping the excess from the surface.

The art history of this geologically ancient land is most visible in its thousands of laterite and sandstone temples, some mighty and some tiny, but all gems of architecture, engineering, and artistry in delightful sculpture, the traditions of which are alive even today. From adding medicinal plants to create lime plasters to preparing pastes from plants, every aspect of the art of Odisha is intrinsically linked with nature, the seasons, and their products.

The study of the materials and techniques of Odisha's heritage, its deterioration, and its conservation, must be appreciated from the point of view of intangible practices, as well as from the yardstick of technical studies.

**Head of art conservation, research and training, CSMVS Museum, Mumbai, India.*
***CSIR-National Institute of Oceanography, Goa, India.*

REACHING THE UNREACHED

Nurturing the ENTREPRENEURIAL LANDSCAPE in North-eastern and Eastern India.

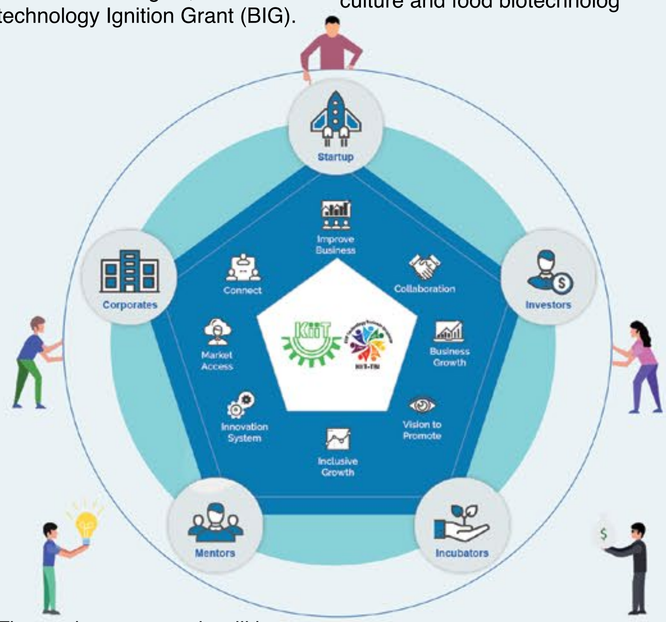
In 2009, the KIIT Technology Business Incubator (KIIT-TBI) was set up as an initiative of KIIT University and the first TBI in the State of Odisha. Since its inception, KIIT-TBI has been playing a leading role in nurturing the innovation and entrepreneurship ecosystem in the north-eastern and eastern parts of India as well as creating partnerships and linkages.
In the last year, KIIT-TBI, with the support of the Government of India, has made systematic efforts to promote entrepreneurship in the region and has launched many north-eastern and eastern focused schemes encouraging youth to embrace entrepreneurship by providing capacity building and mentoring, and also helping the organizations interested in setting up bioincubators.

BRTC: BIRAC Regional Techno Entrepreneurship Promotion Centre

BRTC, also known as the BIRAC Regional Techno Entrepreneurship Promotion Centre, is a regional BIRAC hub based at KIIT-TBI. Its vision is to promote entrepreneurship and innovation across north-eastern and east ern India. Through BRTC, KIIT-TBI has helped more than 3000 innovators through roadshows, training programs and design workshops on various facets of innovation such as product development, business models, elevator pitches, patent and regulatory compliance, and social innovation. As per the BIRAC mandate, 70% of the programmes are conducted in the north-eastern region of India and 30% across the eastern region. Further, although many incubators in these regions have evolved in the last few years with the support of the government, only a few incubators have become self-sustaining and upscaled their operations. There fore, KIIT-TBI BRTC also seeks to assist and guide interested organizations in the region to establish new bioincubators.
KIIT-TBI, as a mentor incubator, helps other potential incubators in on-boarding their first start-ups and developing targeted programmes for them until they become sustainable. A strong collaboration has been forged with the leading institutes in the north-east such as Tripura University, CSIR-NEIST, NEHU, Mizoram University and the Green Foundation hoping to make the region a hotspot for technology driven innovation and startups.

North-eastern focussed BIRAC Biotechnology Ignition Grant

To augment the innovation and entrepreneurship landscape, BIRAC launched a special flagship programme for the north-eastern region, the Biotechnology Ignition Grant (BIG).



The ten best proposals will be awarded Rs 2.5 million (US$34,000) in 24 months to translate their ideas into a minimal viable prototype. KIIT-TBI is the lone BIG implementation partner and will reach out to universities and R&D institutes across the north-east to identify potential innovators and provide help in the form of one-on-one mentoring and introductions to existing local BioNEST incubator networks. The first north-eastern BIG callout received an overwhelming response with 110 applications from: Assam, 75, Arunachal Pradesh, 2, Manipur, 12, Mizoram, 2, Meghalaya, 9, Tripura, 6, Sikkim, 3 and Nagaland,1, from a range of innovation sectors, primarily healthcare, agriculture and food biotechnolog

WING: Women Rise Together

WING is a capacity building programme for aspiring and early stage women entrepreneurs. It is a Startup India, DPIIT, Ministry of Commerce and Industries, Government of India initiative at KIIT-TBI for tapping the potential 'shepreneurs' in eastern India. WING is working actively in six eastern states: Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, and West Bengal. More than 1,600 women have been trained in the fundamentals of entrepreneurship with the help of eminent educators and mentors. With an aim to mobilize women towards entrepreneurship, WING has supported 1120+ women entrepreneurs to scale up/establish their own enterprise.

Technology Incubation and Development of Entrepreneurship (TIDE 2.0)

TIDE 2.0 a startup funding program from MeitY, Government of India, to strengthen technology start-ups from east and north-eastern regions in healthcare, education, agriculture, cleantech and other emerging areas. TIDE 2.0 provides a complete guidance including financial support in form of EIR Rs 400,000 (US$5400) and grant Rs 700,000 (US$9500) for nascent startups and innovators to fill in the gap between ideation and prototyping. Sixty-seven applications were received for the TIDE 2.0 EIR programme and four potential candidates were selected for the fellowship. Similarly, for the TIDE 2.0 Grant Program, 97 applications were received and four were awarded alongside the grant. For the TIDE 2.0 Fellows and Grantees, bootcamps are organized for the on boarded innovators on pre-market study, user-persona, product/idea validation, business modelling and pitch deck development by domain specific experts.

KIIT-TBI Technology Transfer Office (TTO)

KIIT-TBI TTO office is one of five TTOs established with the support of the National Biopharma Mission (NBM) with a view to strengthen technology transfer capacity across the country. KIIT-TBI TTO aims to help technology developers and technology commercialization entities across north-eastern and eastern regions find each other, forge partnerships and advance technology to the market in a win-win partnership. KIIT-TBI TTO is managed by professionals having skills in technology man agement and have the necessary digital tools for patent analysis and management, licensing transactions management and post-license monitoring.

The Boeing University Innovation Leadership Development Program (BUILD)

Boeing India's BUILD program is a unique aerospace innovation, leadership and talent development programme designed for students and budding entrepreneurs. The BUILD programme in collaboration with KIIT-TBI has helped the young innovators of today shape their ideas into the disruptions of tomorrow in the fields of aerospace, IoT, augmented and virtual reality, robotics, advanced manufacturing and nextgen innovations. KIIT-TBI, with its strategic geographic location has impacted the north-eastern and eastern region and has mapped and mentored many promising innovators under the programme.

NIDHI CENTER OF EXCELLENCE

A world class facility to help start-ups go global.

Supported by Department of Science and Technology, Govt. of India.

KIIT TBI has been recognized as a center of excellence by the National Science and Technology Entrepreneurship Development Board (NSTEDB), Department of Science and Technology, Government of India. The National Initiative for Developing and Harnessing Innovations (NIDHI) is an umbrella programme conceived by the DST. The NIDHI COE will help strengthen and scale-up KIIT-TBI activities and support potential start-ups working in digital health and precision agriculture in translating technological innovations into marketable products and high-growth companies.

KIIT-TBI Digital Health Lab is trying to solve the overwhelming challenges of the Indian healthcare scenario by fostering an ecosystem for indigenous mHealth solutions (Make in India + Digital India). Its vision is to successfully develop digital health solutions for the real-world; enabling new ideas to be tested, validated, and commercialized more rapidly and making lives better.

Some Key objectives of NIDHI-COE at KIIT-TBI are:

- To identify, foster and mentor innovators/entrepreneurs in the medical and agriculture innovation processes, including need identification, conception and implementation.
- To encourage co-creation by involving students, faculty and professionals from multiple disciplines.
- Provide necessary state-of-the-art infrastructure for prototyping and establishing a proof-of-concept.
- Promote commercialization by liaising with KIIT-TBI and funding partners.
- To organize short-term workshops, bootcamps and internship programmes to raise awareness and motivate different stakeholders towards healthcare innovation.
- Providing a platform for product development and validation as per international standards.

In the first year, 25 start-ups in digital health and precision agritech have been supported. The target is to incubate 100 more start-ups in the next five years.

Land use and land cover change effect on surface temperature over Eastern India

Partha Pratim Gogoi[1], V. Vinoj[1], D. Swain[1], G. Roberts[2], J. Dash[2] & S. Tripathy[3]

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Land use and land cover (LULC) change has been shown to have significant effect on climate through various pathways that modulate land surface temperature and rainfall. However, few studies have illustrated such a link over the Indian region using observations. Through a combination of ground, satellite remote sensing and reanalysis products, we investigate the recent changes to land surface temperature in the Eastern state of Odisha between 1981 and 2010 and assess its relation to LULC. Our analysis reveals that the mean temperature of the state has increased by ~0.3 °C during the past three decades with the most accelerated warming (~0.9 °C) occurring during the recent decade (2001 to 2010). Our study shows that 25 to 50% of this observed overall warming is associated with LULC. Further we observe that the spatial pattern of LULC changes matches well with the independently estimated warming associated with LULC suggesting a physical association between them. This study also reveals that the largest changes are linked to changing vegetation cover as evidenced by changes to both LULC classes and normalized difference vegetation index (NDVI). Our study shows that the state has undergone an LULC induced warming which accounts for a quarter of the overall temperature rise since 2001. With the expected expansion of urban landscape and concomitant increase in anthropogenic activities along with changing cropping patterns, LULC linked changes to surface temperature and hence regional climate feedback over this region necessitates additional investigations.

The surface temperatures are increasing globally as a consequence of anthropogenic climate change. However, it is known that observed changes are a result of both climate forcing and numerous other feedbacks including LULC. The LULC could change as a response to climate and also act as a feedback. In addition to these natural forcing and feedback cycles, there are also additional aspects that are linked to anthropogenic activities. This results in further modification to the LULC and meteorological responses thereupon[1–10]. These LULC changes and their effects are mostly discernible over regions having higher population density, industrialization, urbanization, deforestation, agricultural diversification etc. Thus, the most visible effect of anthropogenic activities regionally and locally are changes in the LULC which modifies the surface energy balance which in turn affects the surface temperature altering the region's micro-climate[5,8,11–17].

The changes in LULC also modulate the incidence of heat/cold waves, clouds and rainfall patterns[18–24]. In addition, LULC change have also been linked to atmospheric aerosol emissions[20,25,26] which can modify the surface temperature through both direct and indirect effects, thereby modulating rainfall which can also result in droughts or floods through changes to extreme events under certain favorable circumstances[18].

Over the Indian region, there are only a few scientific investigations that have attempted to discern LULC induced temperature changes, but they are either limited to the major metropolitan cities[6,11,20,23,27–33] or have only focused on aspects related to urbanization[3,4,34–38]. For example, the surface temperature over western India is found to be warming by ~0.13 °C/decade due to the combined effect of greenhouse gases and LULC change of which ~50% was attributed to LULC change[27]. Also, in 2001 an area covering 26.4% of New Delhi had a diurnal temperature range (DTR) below 11 °C whereas in 2011 65.3% of New Delhi had a DTR below 11 °C which was attributed to the increase in built up area by 53%[24,29,31,39,40]. Furthermore, the LULC has also been linked to Indian monsoon rainfall changes[18,25]. Studies linking LULC to surface temperature changes are

[1]School of Earth, Ocean and Climate Sciences, Indian Institute of Technology Bhubaneswar, Bhubaneswar, Odisha, 752050, India. [2]Geography and Environmental Science, University of Southampton, Southampton, SO171BJ, UK. [3]Department of Geology and Geophysics, Indian Institute of Technology Kharagpur, Kharagpur, India. Correspondence and requests for materials should be addressed to V.V. (email: vinoj@iitbbs.ac.in)

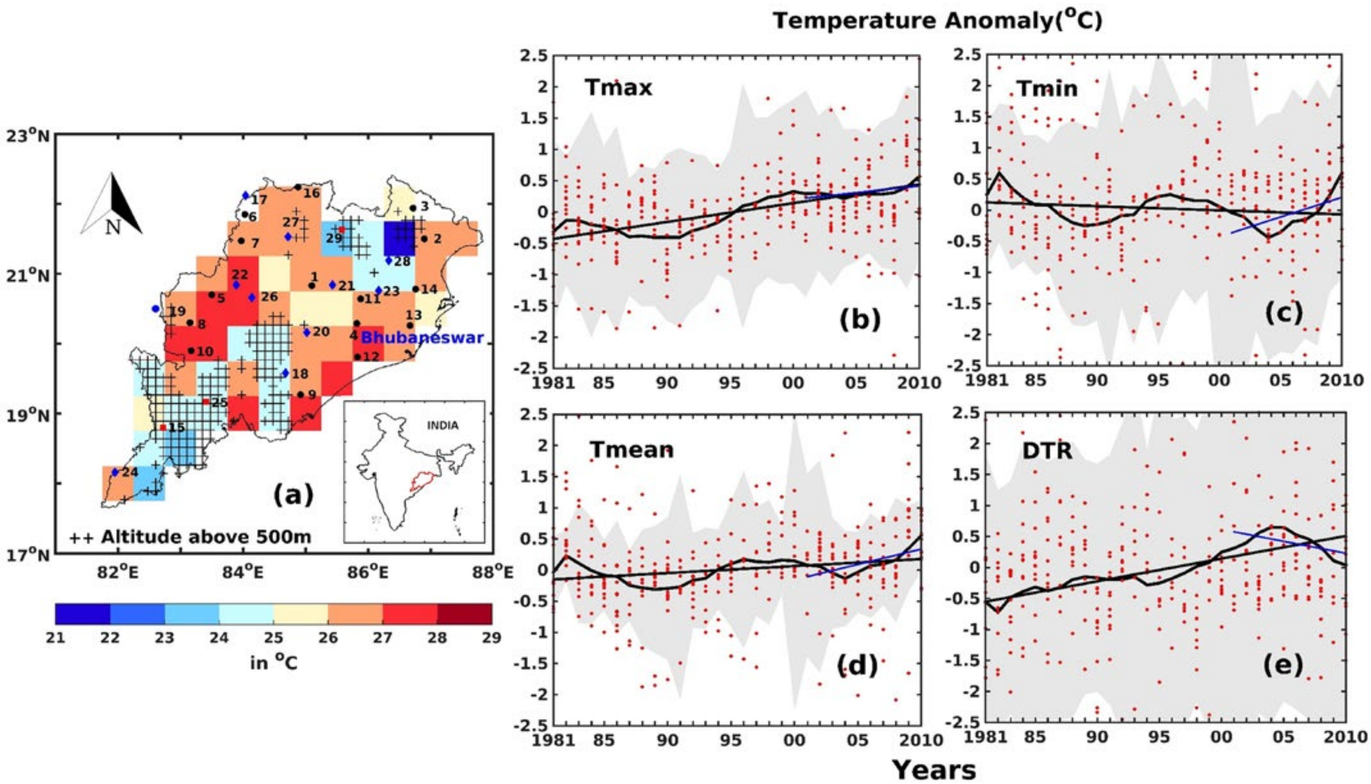

Figure 1. (**a**) The climatological annual mean surface temperature (°C) over Odisha during the period 1981 to 2010 (Source: University of Delaware). The inset map of the study area shows Odisha state with locations of all IMD observation sites (black) along with district headquarters (blue). The striped region represents areas that lie 500 m above mean sea level (Source: NGDC, NOAA). The numbers on the spatial plot represent serial numbers of the stations. (details are given in Supplementary Table S3) (**b**–**e**) shows the time series (10 point running mean) of the maximum, minimum, mean temperature and diurnal temperature range anomaly for all stations (averaged) within the plains (Source: IMD station datasets. See Table S3). The grey shaded region in (**b**–**e**) represent standard deviation. The map was generated using MATLAB 2015b, www.mathworks.com.

limited over Eastern India though this region is among the most rapidly changing landscape over the entire Indian region[41]. The region is also rich in mineral deposits and its continued exploitation for mineral wealth has accelerated LULC change in the past few decades. In addition, Odisha being one of the most natural disaster prone regions of India, a very few studies have investigated the relationship between LULC change and surface temperature, heat waves, extreme rainfall etc.

In this paper, we investigate the surface temperature changes over the state of Odisha using long term ground, satellite and reanalysis datasets and explore its relation to LULC changes. We investigate whether the surface temperature has increased and, if so, whether this is in response to changes in land cover and/or changes in climate. Then multiple line of evidences are used to link LULC to observed spatial and temporal pattern of temperature. This would help in establishing changes associated with local activities such as LULC and those due to regional and global climate change.

Results and Discussion

Trends in surface temperature. The Indian subcontinent is characterized by large spatio-temporal variability in meteorological parameters displaying large annual, inter-annual, seasonal and decadal variability in surface temperature. In this section, the observed trends in temperatures both on an annual and inter-decadal basis are discussed. It is found that the state of Odisha had undergone a warming of ~0.3 °C during 1981 to 2010 and that the trend in surface temperature is positive irrespective of the meteorological station location (coastal or non-coastal) and altitude (high altitude or the plains). These trends were found to be statistically significant at 95% confidence level in most of the cases (Fig. 1 and Supplementary Information, Table S1). The temperatures were also found to have large inter-decadal variability. A separation into three decades (starting 1981, 1991 and 2001) shows that during the first decade (1981 to 1990) the mean temperature for sites below 500 m above mean sea level (amsl) decreased by ~−0.7 °C whereas, in the subsequent decades (1991 to 2000 and 2001 to 2010) an increase in temperature of ~1 °C and ~0.8 °C respectively was found (Fig. 2 and Table S1). Low values in the mean temperature trend are partly a consequence of differences in the maximum and minimum temperatures. For example, though maximum temperature was steadily increasing over the region, minimum temperature was found to be decreasing during 1981 to 1990. However, within these sub-periods, both of the recent decades show that minimum temperatures are increasing at different rates. It is evident that the recent two decades show a clear increase in both minimum (~1.2 °C) and maximum (~0.13 °C) temperatures which is reflected by the increasing mean temperature. However,

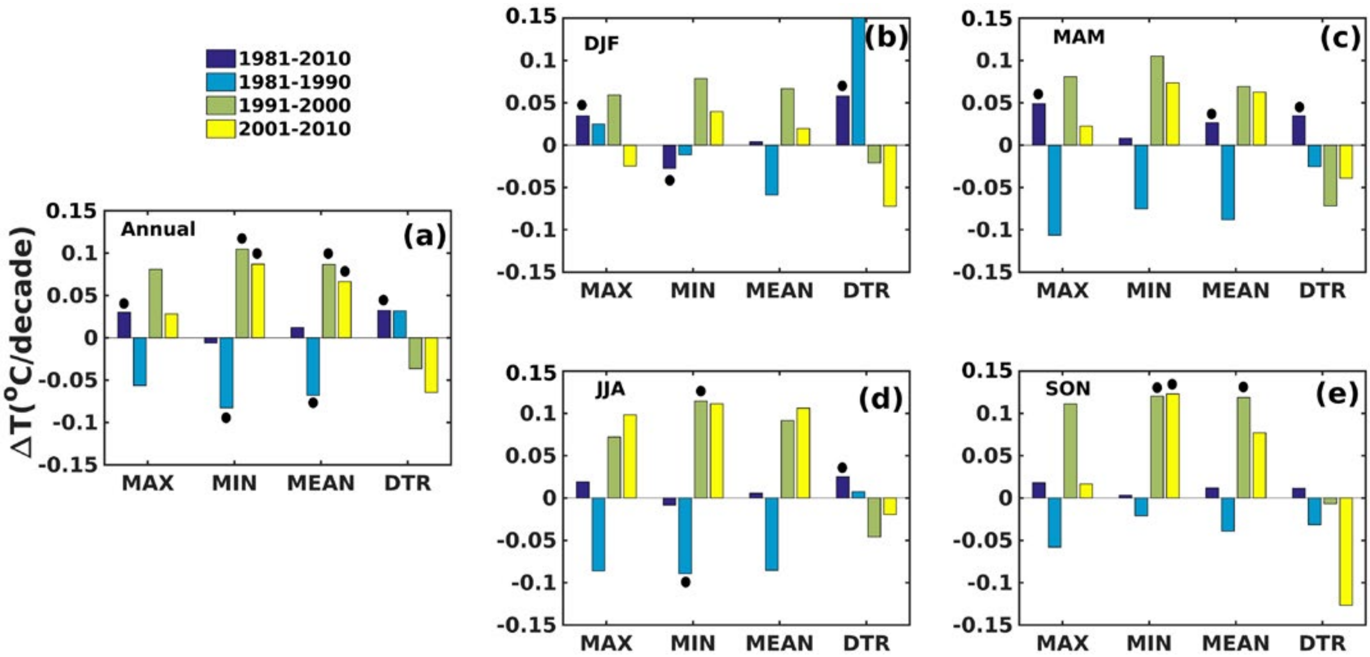

Figure 2. Decadal temperature trends over Odisha (**a**) Annual (**b**) December-January-February (DJF) (**c**) March-April-May (MAM) (**d**) June-July-August (JJA) (**e**) September-October-November (SON) (Source: IMD station datasets below 500 m amsl). Black dots in the plot represent statistical significance at 95% confidence level. The map was generated using MATLAB 2015b, www.mathworks.com.

the most interesting aspect is that the diurnal temperature range (DTR), which is observed to be increasing during the 1980's by ~1.16 °C has decreased by ~−0.46 °C and ~−1.19 °C between the second (1991–2000) and third (2001–2010) decades respectively in areas below 500 m amsl (Table S1, Fig. 1b–e). These indicate that the overall trends are larger for low altitude stations in comparison to those at higher altitudes. In order to determine whether these findings are spatially consistent across the entire state or result from urbanization/LULC signatures we have used gridded climate datasets from IMD, University of Delaware (UDel) and NCEP/NCAR Reanalysis–1. Also, to assess the impact of El-Nino/Southern Oscillation (ENSO) events, years with extreme ENSO events (1982, 1983, 1997 and 1998) were removed from the analysis. It may be mentioned that the results with and without ENSO years are consistent (Supplementary Information, Table S5). Overall, our analysis reveals that the surface temperatures over the state has been increasing since 1981 (Fig. 1b–e).

Seasonality of trends in surface temperature. We find that the observations and inferences made based on annual and decadal timescales are also applicable to seasonal timescales and indicate that the changes in temperature are forced on large spatial and temporal scales. Figure 2 indicates that between 1981 and 1990 the temperature reduced by 0.3 to 0.9 °C depending on season and this is evident both on annual and seasonal scales.

However, the region has warmed up since 1991 (~0.4 to 0.9 °C). It may be noted that analysis based on both gridded and station datasets show similar trends on cooling and warming during the first and subsequent two decades respectively. However the magnitude of the trends differ. The largest rate of increase in temperature is observed in the June to August (JJA) and September to November (SON) periods whilst the least is observed for December to February (DJF) period. Similar characteristics are also evident in the trends in maximum and minimum temperatures and that, irrespective of season, the minimum temperature is increasing at a much faster rate than the maximum temperature since 1991 (Fig. 2). Studies have shown that the rapid rate of change in minimum temperature over more than 70% of the global land surface could be linked to climate change[40]. However, those changes arising out of LULC are expected to be more localized in space and we therefore explore these temperature changes and their spatial patterns to assess the potential influence of land use.

Spatial pattern of trends. Using the IMD gridded datasets, we find that the spatial pattern of the trends adhere to the inferences made using meteorological station datasets (Fig. 3).

Overall, the major finding is that between 1981 and 1990 a cooling trend is evident whereas the subsequent decades show the inverse to this. The spatial patterns and their temporal variability within different decades are similar for the average mean, minimum and maximum temperatures. In contrast, the diurnal temperature range (DTR) shows opposing trends with an increase during the decade starting 1981 and a decrease in the subsequent decades. In addition, the increase in minimum temperature is also more widespread spatially. This may indicate that the changes to surface temperature could be driven by climate change, overwhelming the LULC impacts. However, a warming trend is observed in the most recent decade over Odisha state and to determine whether this is linked to LULC change we utilize the widely used OMR technique which is detailed in the methodology section.

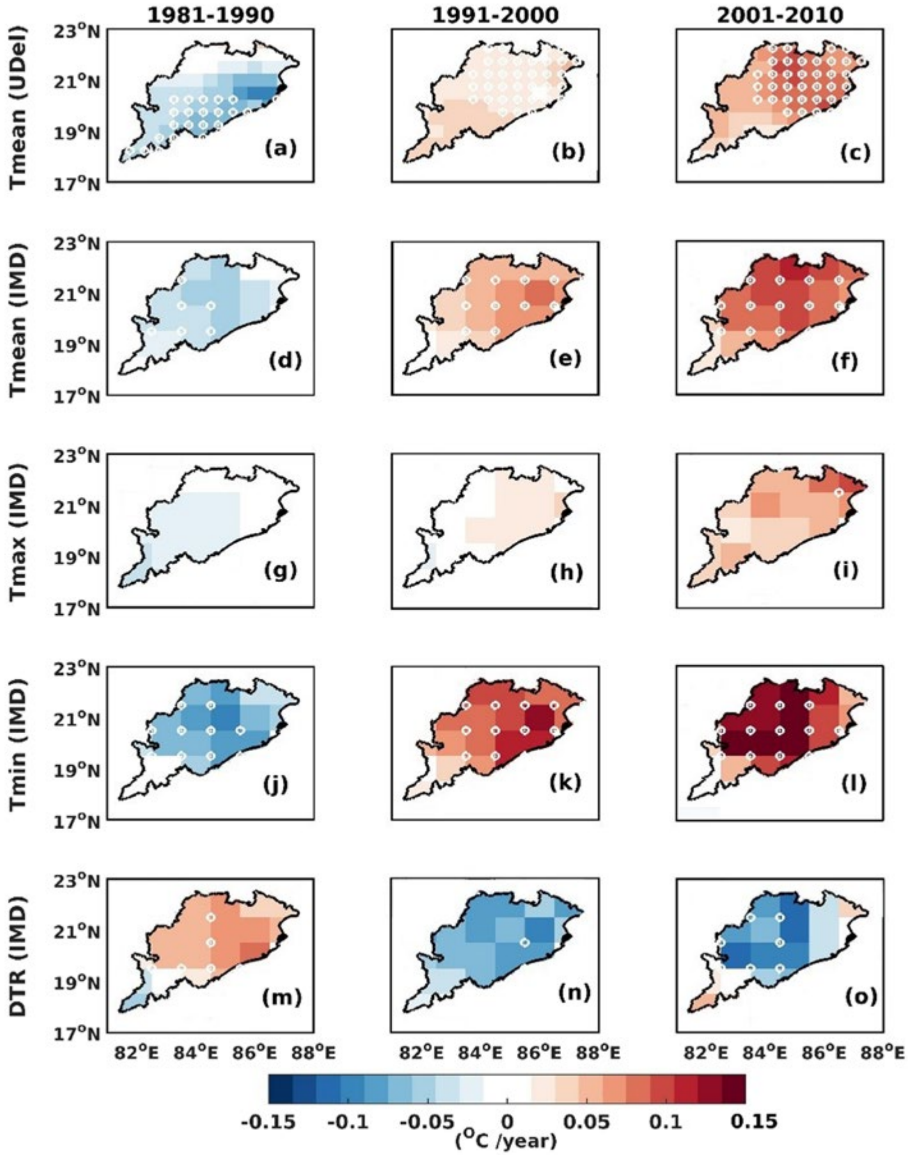

Figure 3. Decade-wise temperature trend of: (**a**–**c**)- Mean (University of Delaware) (**d**–**f**)- Mean (IMD) (**g**–i)- Maximum (IMD) (**j**–**l**)- Minimum (IMD) (**m**–**o**)- DTR (IMD). White circles in the plot represent statistical significance at 95% confidence level. The map was generated using MATLAB 2015b, www.mathworks.com.

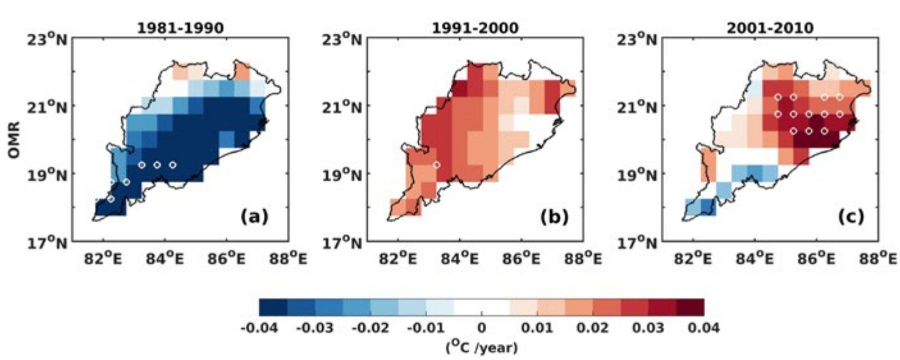

Figure 4. OMR trends over Odisha during the period (**a**) 1981–1990 (**b**) 1991–2000 (**c**) 2001–2010. White circles in the plot represent statistical significance at 95% confidence level. The map was generated using MATLAB 2015b, www.mathworks.com.

The role of LULC in the observed warming. The OMR was calculated at a spatial resolution of 0.5° for the whole state of Odisha which is shown in Fig. 4 for the different decades. The first decade since 1981 displays a declining trend in OMR of ~−0.04 °C/year over the whole state. Though positive OMR are related to either urbanization or LULC linked changes, negative values are not directly related to these changes and could result from issues associated with the development of the reanalysis datasets that assimilate observations from surface and satellite measurements. The advent of satellite measurements and its assimilation in reanalysis or changes to the instrumentation, or both these factors combined could alter reanalysis results thereby impacting the OMR calculations and hence the negative values[42]. We therefore do not explore this decade further which is cooling since 1981 in our analysis. However, the past two decades since 1991 show a clear increasing trend of OMR over Odisha especially over West which shifts to the East during the most recent decade (since 2001). An interesting aspect is that the highest increasing trend of OMR (~0.04 °C/year) coincides with the location of cities such as Bhubaneswar and Cuttack (which are the densely populated cities) and are also to the East of the state (Figs 1a and 4c). The city of Bhubaneswar is among the fastest growing tier 2 cities in India and suggests that the OMR trend indicates the impact of LULC/urbanization. The OMR has been shown to be a robust method to detect urbanization/LULC impacts on surface temperatures[10,43–45]. To further strengthen this finding, we explore whether the highest OMR trends are coincident with the largest LULC changes. It may be noted here that further analysis are mostly carried out for the last decade due to availability of validated LULC dataset over the Indian region. In addition, even other supplementary datasets are expected to be better from various sources due to the availability/assimilation of data of highest quality since year 2000 from earth observing system (EOS) satellites.

The LULC change analysis. Our analysis reveals that the largest LULC changes occur over the NE part of the state (Fig. 5c) which shows the number of pixels that have undergone a change from the earlier classification (Fig. 5c) at a spatial resolution of 10 km. This was necessary due to heterogeneous land use and land cover change in the region and also to highlight the spatial extent of these changes better. We have therefore not specifically targeted any land use/cover type, but only investigated the land cover change during the study period. Therefore, the change analysis refers to those areas (number of pixels) where land has undergone change over the period 2004 to 2010. Overall, we find that the LULC change map matches well with the OMR trends shown in Fig. 4c during the recent decade since 2001. This provides us an independent confirmation that the OMR and its spatial pattern is due to temperature changes associated with LULC change. Now, the question is what caused these LULC changes? We therefore quantified individual LULC classes and their changes. It is found that there is a decrease in green vegetation over the state of Odisha (Supplementary Information, Fig. S1). We also carried out a detailed analysis to understand changes of different land use categories using the Advanced Wide Field Sensor (AWiFS) datasets between the periods 2004 to 2010 which coincides with the latest decade discussed in previous sections. Our analysis reveals (Supplementary Information, Fig. S1, Table S2) that Rabi Crop (October to March) cultivation has increased (~97%) over the state of Odisha during 2004 to 2010. This has occurred at the cost of decrease in the Kharif Crops (July to October) showing agricultural diversification and changing cropping patterns[41,46–48]. The largest changes are associated with vegetation (Kharif, Rabi crops, Fallow lands, Grasslands, Plantations etc.). Table S2 details the individual changes (in terms of area & percentages) to each LULC class. Several studies have also revealed the role of agriculture in changing the vegetation pattern thereby altering the characteristics of local meteorological parameters[19,49,50]. Our analysis using the NDVI for the period (2001 to 2010) further reveals consistent patterns, with large decrease in vegetation (Fig. 6) especially over the eastern part of the state.

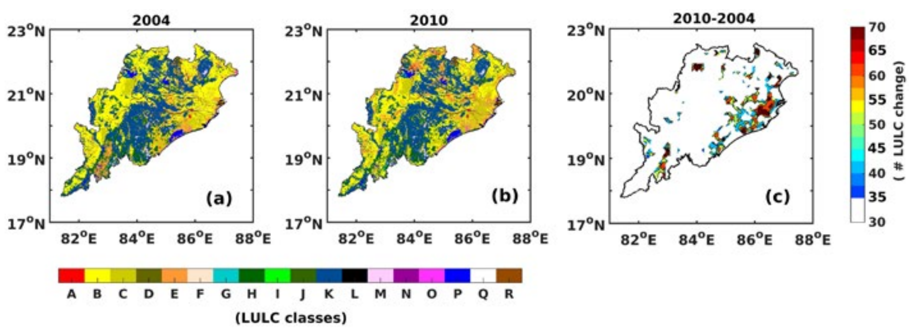

Figure 5. Land Use and Land Cover during (**a**) 2004 (**b**) 2010 (**c**) # LULC change (2010–2004) using AWiFS. The map was generated using MATLAB 2015b, www.mathworks.com. Classes: A-Urban/Built Up, B-Kharif Crop, C-Rabi Crop, D-Zaid Crop, E-Double Crop, F-Current Fallow, G-Plantation, H-Evergreen, I-Deciduous, J-Shurbland, K-Swamp, L-Grassland, M-Other Wasteland, N-Gullies, O-Scrubland, P-Water Bodies, Q-Snow, R-Shifting Cultivation. (Source: AWiFS LULC product of 1 km spatial resolution).

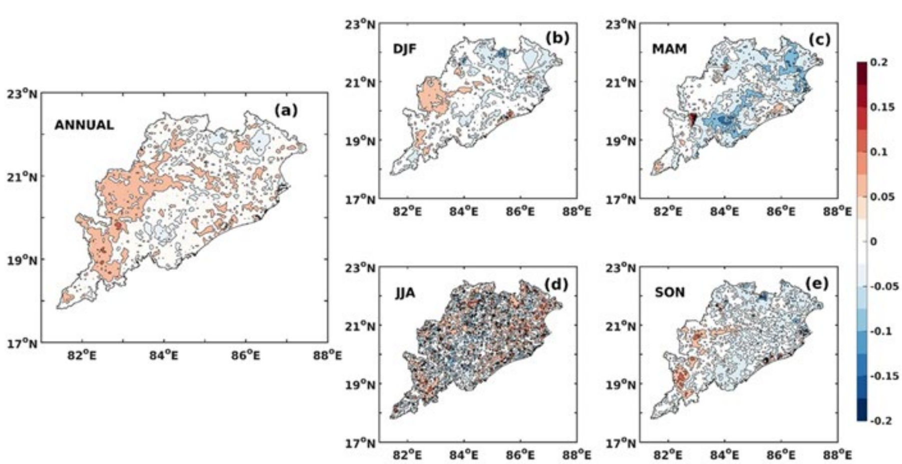

Figure 6. Trend of Normal Difference Vegetation Index (NDVI) during 2001 to 2010 (**a**) Annual (**b**) Winter (Dec to February, DJF) (**c**) Pre-monsoon (March to May, MAM) (**d**) Monsoon (June to August, JJA) and (**e**) Post-monsoon (September to November, SON). Source: MODIS –Terra (5.6 × 5.6 km). The map was generated using MATLAB 2015b, www.mathworks.com.

This further confirms that the change in surface temperature are mostly a consequence of LULC change which is also evidenced by our change analysis using satellite based land cover classification. It may be mentioned that the change in NDVI pattern also coincides with the OMR pattern and LULC change pattern. These multiple line of evidences support the notion that the LULC change is associated with the changes to green cover and is related to vegetation or cropping patterns.

Quantification of LULC linked temperature changes and urbanization. In the previous sections we found that the surface temperature increased due to land surface changes during the period 2001–2010 and is maximum over the eastern part of Odisha. The pattern of OMR, LULC and NDVI trends are all spatially coincident suggesting that the land use changes associated with green vegetation cover have led to the observed warming. However, urban growth may also alter temperature locally and to quantify relationship between LULC induced changes to temperature trends from the overall warming and to explore the signatures of urbanization, we calculated the percentages of the OMR's LULC induced warming trends in relation to the total observed warming for all district headquarters over Odisha. The results indicate that the percentage of temperature rise due to OMR with respect to observations is highest over the urban centres. For example, Cuttack and Bhubaneswar being the most populous cities of Odisha experience temperature increase of ~40% and ~50% respectively during the period 2001–2010 (Fig. 7b) followed by Angul, Dhenkanal, Jajapur. The smaller rate of increase in the NNR dataset as compared to observation dataset in the past two decades has clearly signified that the surface temperature has increased mostly because of the LULC change. The largest rise for larger cities rather than smaller towns (Fig. 7a,b) highlights the additional impact of urbanization in the OMR analysis.

Physical mechanism. The important parameters modulating LST are surface level soil moisture content and vegetation cover. Changes to these can alter the soil thermal properties and evapotranspiration. It is known that rise in the soil moisture leads to rise in the soil thermal capacity, conductivity and inertia thereby slowing the rise in the LST. In addition, surface heat fluxes such as the Latent Heat Flux (LHF) and Sensible Heat Flux (SHF) get modified with changes to land use. LHF (SHF) increases (decreases) with increasing vegetation leading to a decrease in LST[3–5,7,8,17,23,25,51–56].

We therefore also explored changes to LHF and SHF. Our analysis reveals that the changes to both LHF (decreasing) and SHF (increasing) favors warming over Eastern part of Odisha (Fig. 8). Thus it can be confidently stated that the OMR patterns for the period 2001 to 2010, are consistent with those of the LULC, NDVI, SHF and LHF. Therefore, the spatial pattern of temperature changes during the most recent decade are primarily driven by LULC changes over the Eastern part of the state. However, the largest observed LULC linked changes are over the cities where urbanization further enhances the LULC signatures thereby showing the largest percentage wise increase in temperatures (Fig. 7).

Summary and Conclusion

The LULC/urbanization induced surface temperature rise has become a common phenomenon all across the globe though the rate of change depends upon several external factors such as latitude, forest cover, soil type, mitigation practices etc. It may be noted that LULC change has been attributed to increased surface temperatures in Eastern China, USA, Europe, and India[24,27,28,31,36,39,43–45,57,58]. Despite varied locations, it is observed that the rate of increase in most of these places is ~0.1 °C/decade which is comparable to that of our study. Though the LULC induced warming has emerged over this region only in the past couple of decades, we find that in terms of LULC induced temperature rise, Eastern India is no less than any other developed regions in the world. This shows that more detailed investigations are urgently required to understand land use related changes to local and regional climate as several regions are undergoing rapid transformation as a result of developmental activities exacerbating the effects of modern climate change. Thus, for the first time over Eastern India this study has integrated surface, satellite and reanalysis datasets to reveal that,

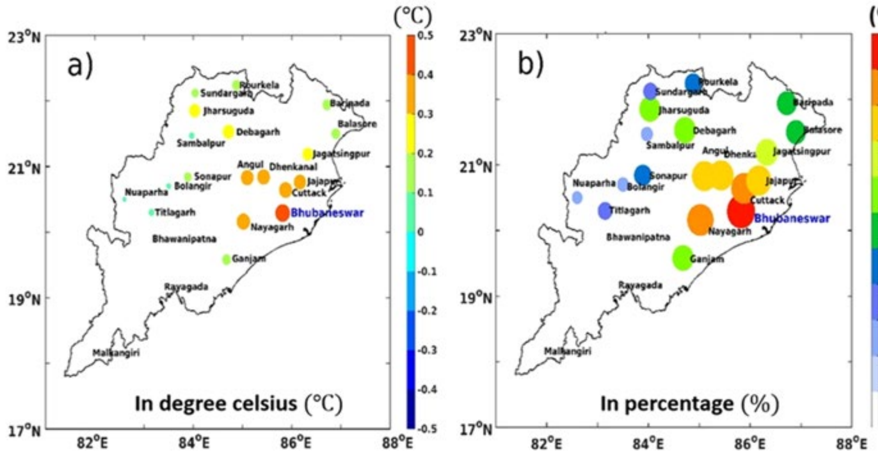

Figure 7. (**a**) Temperature rise during 2001–2010 due to LULC changes over Odisha (°C). (**b**) Percentage of temperature rise during 2001–2010 due to LULC changes over Odisha. (OMR in terms of percentage with respect to station observations). The map was generated using MATLAB 2015b, www.mathworks.com.

1. The state of Odisha has warmed by about ~0.3 °C during the period 1981 to 2010 with accelerated warming of ~0.9 °C during the recent decade 2001 to 2010.
2. The minimum temperature is increasing at a rate higher than that of mean and maximum temperature since 2001 irrespective of location or altitude. It is also observed that there is a corresponding decrease in DTR during the recent decade.
3. A quarter of this warming is associated with LULC. However, over urban centers such as Bhubaneswar and Cuttack, this fraction is as high as half of the total warming.
4. There has been a general decreasing trend in NDVI over the Eastern part of the state during the period 2001 to 2010 associated with increasing SHF and decreasing LHF.
5. Overall the LULC induced warming is a result of changing vegetation cover. The changing cropping patterns (decreased Kharif and increased Rabi crops) appears to be the leading cause for these LULC changes which exacerbates the warming trend.

Data and Methods

Study domain. The state of Odisha with a population of ~42 million[59] lies in the Eastern part of India, extending approximately from 81°E to 88°E and 17°N to 23°N (Fig. 1a) and is surrounded by the Bay of Bengal to the East and the Indian peninsula to the west. The region has a tropical climate resulting in high surface temperature during the months of April and May even leading to heat waves. On a climatological basis, most of the state has a mean temperature >26 °C annually with lower temperatures observed over high altitude locations (Fig. 1a). Odisha experiences an annual average rainfall of ~1500 mm primarily from the south-west monsoon during June to September[60]. In addition, it is also influenced by the monsoon depressions and tropical cyclones that makes landfall from the Bay of Bengal both during pre-monsoon and post-monsoon seasons.

Datasets. A combination of station, satellite and reanalysis datasets over the past 30 years (1981 to 2010) are used to identify changes in surface temperature and its relationship to land use and land cover (LULC). The identification of LULC forced changes is based on the widely used observation minus

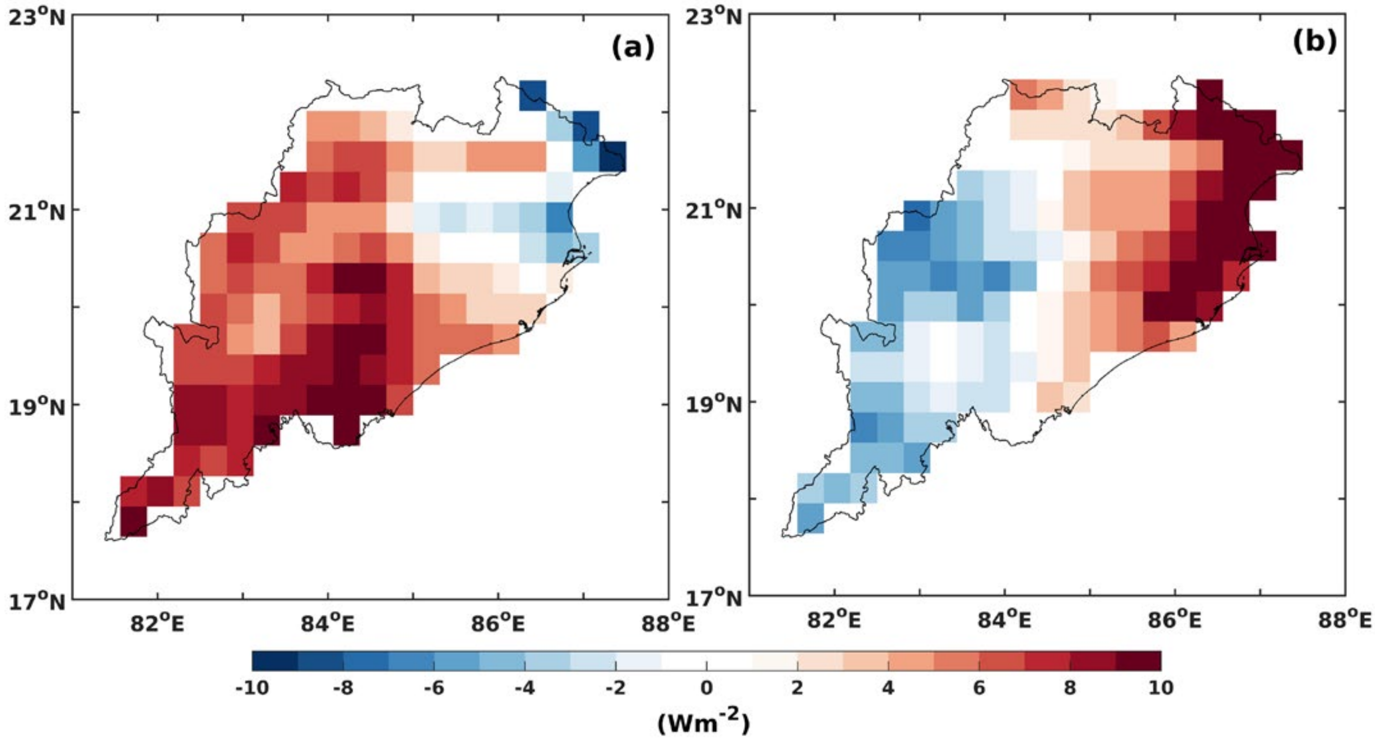

Figure 8. Change in (**a**) Latent Heat Flux and (**b**) Sensible Heat Flux during the period 2001–2010 (in Wm^{-2}). Source: NCEP CFSv2 forecast product (30 km × 30 km). The map was generated using MATLAB 2015b, www.mathworks.com.

reanalysis (OMR) technique. To characterize the change in temperature, we have used measurements of daily mean, maximum and minimum temperature at 29 stations (Fig. 1a and Table S3). In addition, we have also used daily gridded datasets from IMD[61,62] and University of Delaware[63] to explore the spatial patterns of temperature changes. The University of Delaware gridded mean temperature datasets were developed using surface measurements such as those from Global Historical Climate Network[64,65] (GHCN). We have used NCEP-NCAR Reanalysis-1 (NNR) surface temperature datasets[66] primarily for the calculation of OMR.

The land use classification and their change is inferred from the Indian Remote Sensing Satellite (IRS) satellite Resourcesat-1 (P6), Advanced Wide Field Sensor (AWiFS) derived gridded datasets (from ISRO's Bhuvan data portal, https://bhuvan.nrsc.gov.in/) for the period 2004 and 2010. This is a gridded product developed and validated for use with mesoscale models[67] for regional climate applications specifically over India. In addition, the topography dataset was obtained from National Geophysical Data Center (NGDC), NOAA to identify stations suitable for OMR analysis. This dataset was generated from the best available datasets which were further evaluated and edited before Digital Elevation Model (DEM) generation[68].

The sensible and latent heat flux datasets from NCEP Climate Forecast System Version 2 (CFS v2) were used to detect changes in surface energy exchange. The NCEP CFS v2 is a consistent and stably calibrated forecast product. It provides a continuity of the climate data record with predictability of seasonal and sub-seasonal scale features[69]. The NDVI dataset were obtained from MODIS–Terra (MOD13C2) to determine changes in green vegetation cover. The MOD13C2 is derived using atmospherically corrected cloud free surface reflectance observations. Additional details about these datasets, their spatial and temporal resolution and period of observation are provided in Table S4 (Supplementary Information).

Calculation of OMR and trends. To quantify the increase in temperature due to changes in LULC we have used Observation minus Reanalysis (OMR) technique developed by Kalnay and Cai (2003)[45]. This technique has been widely used to discern signatures related to land use changes and urbanization on surface temperature[10,17,27,43–45] from observations. OMR relates the change in the temperature trend due to LULC by subtracting NCEP/NCAR Reanalysis-1 (NNR) from the observation. The NNR product[66] was developed without assimilating surface parameters viz. surface temperature, moisture and winds[13,43–45] effectively making it insensitive to local surface changes. Therefore, any trend in OMR may be attributed to the impact of urbanization or change in LULC[27,35,37,45,53,70,71]. The premise here is that observational trends are modulated by all processes including large scale (modern climate change) and local forcing such as LULC change, but the NNR product includes large scale forcing but not LULC change. Therefore, the difference in their trends will highlight the impact of LULC change.

The decadal trends in all parameters were calculated using a simple linear fitting tested against parametric student t-test for statistical significance. The observed changes/trends in station datasets are compared with both gridded and satellite retrieved products depending on availability and accessibility of the datasets during the study period for consistency.

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Author Contributions

V.V. conceived the idea. P.P.G. carried out all the analysis. P.P.G. and V.V. wrote the paper with subsequent input from all co-authors. All authors contributed through discussion and interpretation of the results.

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Research highlights

ESO/L. CALÇADA

GLIMPSE OF PLANETS AROUND A MULTI-STAR SYSTEM

Astronomers have discovered three proto-planets orbiting around GG Tau A, a multiple-star system, located about 489 light years away from Earth.

The researchers say the proto-planets would eventually form planets, and this discovery may shed light on how planets form around multiple star systems.Scientists have detected numerous planets around single stars such as the Sun, but little is known about planets around multiple-star systems.

Scientists, including Liton Majumdar, an astronomer from the National Institute of Science Education and Research in Odisha, scanned the Taurus star-forming region using an array of radio telescopes in the Atacama Desert of Chile.

They say that one of the proto-planets, lying at almost 10 times the Sun-Neptune distance from the star system, is sucking in gas and dust from a surrounding disk. This has created a 'hot spot' rich in carbon monoxide. They have also detected a spiral pattern, brightest at the hot-spot location, just outside the dust ring, probably produced by one of the proto-planets.

The absence of a clear gap in dust at the planet site means its mass is much lower than that of Jupiter, but close to that of Neptune, suggesting planets around this mass may form in dense circumbinary disks orbiting binary stars, says Majumdar.

MAHANADI DELTA HIGH-RISK ZONE FOR EXTREME EVENTS

The northern part of the Mahanadi delta in eastern India is a high-risk zone for severe cyclones and heavy floods, researchers at Jadavpur University have found.

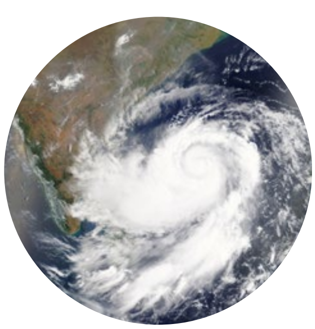
The densely populated Mahanadi delta in Odisha is drained by three rivers — Mahanadi, Brahmani and Baitarani — that flow into the Bay of Bengal.

Floods and cyclones are the most common extreme events in this delta, with about 2–3 flood events every year. The flood hazard in the study was assessed using the flow rate of water and artificial neural networks. The probability of the storms was also simulated for various time periods.

In the case of flood events that have a 1% probability of occurrence in one year, the study found that a 7m storm surge (the rise in sea level due to cyclone) could affect 95% of the population and 88% cropland in the delta's low-lying northern region.

The northern districts have a high dependence on agriculture (71%), and a high percentage of kutcha (mud brick) houses (50–70%), making them more vulnerable to extreme events.

Dykes, storm-surge barriers, vegetation canopy and salt-tolerant crop species are among adaptation strategies proposed by the authors.



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Chilka ferrodiorite

GEOLOGISTS REVISE AGE OF CHILKA ROCKS

Geologists scouring the Chilka Lake region in Orissa have come up with evidence to suggest that certain igneous rocks there crystallized 983 million years ago, about 200 million years earlier than previously thought.

The scientists used uranium-lead zircon dating to come to the conclusion that the Chilka anorthosite, a plutonic igneous rock crystallized from mantle-derived magma that intruded the doubly deformed crust. Both crustal deformations took place before the anorthosite crystallized 983 million years ago.

Some previous workers had determined the age of the Chilka ferrodiorite, a rock usually associated with anorthosite, as 792 million years and presumed that the anorthosite was also of the same age. "We directly determined the age of the anorthosite and found it is actually about 200 million years older," says lead researcher, Nilanjan Chatterjee.

The team interpreted the 792-million-year age of ferrodiorite to correspond with an event related to the close approach of the Eastern Ghats-Rayner block and Australia believed to have happened 792-655 million years ago. The ferrodiorite may have originated with the anorthosite around 983 million years ago and metamorphosed around 792 million years ago. "Or it may have originated around 792 million years ago. This needs further investigation," Chatterjee says.

The finding is significant to how massif type anorthosite-ferrodiorite associations formed. Anorthosite massifs are unique geological features that mostly formed more than one billion years ago. In the Adirondacks of New York, anorthosite massifs and ferrodiorite seem to have formed simultaneously. But at Chilka, there may be around a 200-million-year interval.

ZIRCON CRYSTALS TRAPPED IN ODISHA GRANITE

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Zircon crystals the oldest found in Indian soil

About 4.24 billion years old, and barely the width of a human hair, tiny grains of zircon have been found trapped in a granite rock in Odisha. Geologists say these indestructible crystals may shed light on the first half-billion years of Earth's history.

The zircon crystals in the Kendujhar district of Odisha are the oldest yet unearthed from Indian soil. Like Earth's oldest zircons – aged about 4.4 billion years found in the Jack Hills in Western Australia – they predate the first recorded rocks on Earth, estimated to be 3.9 billion years old. Zircon is a mix of silicon, oxygen and zirconium and can outlast the magma rocks in which it is formed. Each crystal could be a snapshot of geological events from early Earth.

Scientists don't fully understand the nature and composition of the Earth's earliest crust and how it evolved to form the outermost layer on which we live. Zircons, the oldest minerals on Earth, preserve robust records of chemical and isotopic characteristics of the rocks in which they form. "Studying oxygen isotopes in the zircons could give us valuable information about the presence of liquid water in the first few hundred million years of Earth's history," said lead researcher of the Indian study, Rajat Mazumder, from Curtin University, Malaysia.

Zircons can also reveal when the movement of Earth's plate tectonics began. Such zircon-containing old rocks are being used to analyse various planetary processes.

Mazumder teamed up with Trisrota Chaudhuri, a researcher at the Kolkata-based Indian Statistical Institute (and now with the Geological Survey of India), on a trip to Champua, a small town in Kendujhar that had previously yielded 3.6-billion-year-old zircon-containing rocks. They collected samples from many rocks and, under microscope, and detected the zircon crystals.

With the help of Yusheng Wan, a geologist from the Chinese Academy of Geological Sciences in Beijing, they were able to date two zircon crystals back to 4.24 and 4.03 billion years.

PROBIOTIC TRIAL TO PREVENT SEPSIS IN INFANTS

A clinical trial on more than 4500 newborns in rural India found that a 'probiotic' given orally for one week after birth can help prevent sepsis, which kills millions worldwide.

The trials, in villages of Odisha by a team of Indian and US scientists, administered probiotics, bacteria which given in adequate amounts, can tune the body's immune system and offer protection from diseases.

The leading probiotics commercially available are generally drawn from a narrow range of organisms that may not work for all diseases. The key is to find the right strains, and help them establish themselves in the gut.

For the Odisha baby trial, researchers led by Pinaki Panigrahi at the University of Nebraska Medical Center in the US used a strain of Lactobacillus plantarum isolated from the fecal matter of healthy volunteers. The preventive therapy tested on the babies, called synbiotic treatment, is a combination of probiotic bacteria and fructooligosaccharide, a plant-derived sugar chosen to nourish the probiotic bacteria. The 'synbiotic cocktail' was given to the newborns two days after birth for a week in addition to breast milk. The team followed the infants by tracking whether or not they were admitted to local hospitals for bacterial infections or other illnesses over a 60-day period, and found that the therapy reduced the risk of sepsis or death by 40 percent in babies who took this concoction for a week compared to those on placebo. It even reduced the risk of pneumonia and other infections of the airways by 34 percent, says their report, suggesting that the "synbiotic cocktail" may be altering the nature of the systemic immune response, bolstering immunity against infections other than those arising from the gut. "Apart from saving babies from sepsis and respiratory tract infection, this type of intervention has much wider ramification," Panigrahi told Nature India. "The most relevant is its impact on stunting. Stunted children are destined to have low cognition and chronic disease such as hypertention and diabetes in young adulthood."

The affordable intervention – a week-long course costs just US$1 – would also reduce the use of antibiotics, and slow the spread of drug-resistant infections, the authors say. The Odisha trial only included healthy full-term babies and not weaker or pre-term babies, who are more prone to sepsis. Panigrahi says this needs to be tested in different settings.

PINAKI PANIGRAHI

BLOOD DONORS SHOULD BE SCREENED TWICE FOR HEPATITIS B

Screening blood donors only for the hepatitis B surface antigen HBsAg, does not protect the public blood supply against the hepatitis B virus (HBV), according to a study undertaken in Ganjam, Odisha.

The authors of a study by the Indian Council of Medical Research, National Institute of Cholera and Enteric Diseases and Jadavpur University, have called for a second line of screening for blood donors.

Researchers tested 729 HBsAg negative or antiHBc positive donors to detect any presence of occult HBV infection. Occult HBV infection is potentially infectious HBV DNA in the liver, serum, or both, in people without detectable HBsAg. AntiHBc is the only seromarker for HBV infection. Around 30% HBsAg negative donors turned out to be antiHBc positive.

Despite testing donors for HBsAg, transfusion-linked HBV continues to be a major problem. HBV infection is detected by screening with a commercial enzyme immuno assay, but this has sometimes failed due to the presence of occult HBV infection.

The authors used samples from the only blood bank in the Ganjam district, a region with high HIV rates, to evaluate the prevalence of occult HBV infection among the HBsAg negative donations. They used an in-house nucleic test.

"Although additional antiHBc testing will see a large number of donors rejected, it will eliminate HBV infected donations," the authors say in their paper.

GLOWING NANOPROBE DETECTS MERCURY IN FISH

Researchers have synthesised a light-emitting nanoprobe that can detect minute traces of mercury in various water samples, bacteria and small fish, and remove the toxic metal.

The nanoprobe has potential for monitoring mercury levels in fish that transport mercury to humans when eaten.

Industrial processes leak mercury into the environment, where it accumulates in fish and other aquatic animals. Existing techniques for detecting mercury are expensive and complex.

Scientists from the National Institute of Technology in Rourkela and Orissa University of Agriculture and Technology in Bhubaneswar, invented the nanoprobe using modified carbon quantum dots and iron oxide nanoparticles. They tested its efficiency in monitoring mercury in different water samples and in fish.

The researchers, led by Biswaranjan Paital, found that the nanoprobe emitted a faint green signal in the absence of mercury. However, the green signal became intense in the presence of mercury, growing stronger with increasing mercury concentration.

The nanoprobe exhibited an insignificant signal in the presence of metal ions such as sodium, potassium, magnesium and calcium, indicating that it could selectively bind to mercury ions in a solution. Since the nanoprobe contains magnetic nanoparticles, a mercury-attached nanoprobe could be separated using an external magnet.

At high concentrations, the nanoprobe was non-toxic to bacteria, showing that it is biocompatible. It successfully monitored mercury levels in different fish organs such as gills, muscles, the liver and the brain. It also detected mercury levels in bacteria, and tap and river water samples.

AIR POLLUTION DIVIDEND DURING LOCKDOWN

The levels of various air pollutants, particularly that of nitrogen dioxide and aerosol particles, decreased considerably during the first COVID-19 lockdown period in 41 Indian cities.

Analysing satellite data, an international team of researchers found that nitrogen dioxide levels fell significantly during the lockdown period (25 March to 3 May 2020), compared with the three months before lockdown.

The researchers, including scientists from the Utkal University in Odisha and the Tata Energy Research Institute in New Delhi, analysed data recorded by an instrument onboard the European Space Agency's Sentinel-5 Precursor satellite. The instrument, designed to quantify the levels of various air pollutants, helped measure the atmospheric levels of nitrogen dioxide and aerosol particles over major Indian cities.

Nitrogen dioxide levels, they found, went down by 13% during the lockdown period compared with that of the pre-lockdown period. They also observed a 19% reduction in nitrogen oxide levels during the lockdown period as compared with those dates in 2019.

The nitrogen dioxide reduction was higher in New Delhi, Bangalore, Ahmedabad, Nagpur, Gandhinagar and Mumbai than in coastal cities. The cities in north-east India showed an increase in nitrogen dioxide levels because of vegetation fires.

The nitrogen dioxide levels, however, decreased exponentially as the distance from the city centre increased, they report.

This study could help decision-makers arrive at efficient air-quality management plans involving local stakeholders, the researchers say.

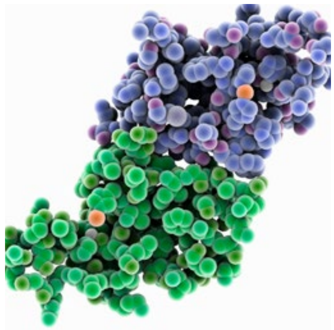
BIOFUEL FROM FOOD WASTE

Researchers have developed a new method to extract lipids from food waste that could be used to make biodiesel.

In search of a way to reuse food waste, scientists from the National Institute of Technology in Rourkela, Odisha, collected food scraps from a hostel. They removed the water from the waste by drying it at 105 degrees Celsius. Using organic solvents, various lipids were extracted from the dried waste. These fatty acids were predominantly palmitic and oleic acids, indicating that the waste has great potential to yield biodiesel.

The food waste also contained metals such as calcium, iron, magnesium and zinc that could have applications in the pharma industry. The waste also showed traces of chromium and copper.

Food waste is a free resource that can be recycled in an eco-friendly manner, thus increasing energy production and reducing landfill demands, the researchers say.



A METALLIC COMPOUND FOR COSMETIC THERAPY

Researchers have synthesised a metallic compound that mimics the functions of superoxide dismutase (SOD), a metal-based enzyme known to protect cells by removing oxygen free radicals in the tissues of humans and other living organisms1.

The compound, the researchers say, has the potential to be used in cosmetic therapy for removing superoxide radical anion, a free radical that damages cells.

In humans, SODs are essential for the prevention of various diseases. However, natural SOD levels drop as the body ages. Previous studies have shown that specific metallic compounds can mimic the activities of natural SODs, indicating their therapeutic potential.

To find such a novel metallic compound, scientists from the Odisha University of Agriculture & Technology, the C. V. Raman College of Engineering and the Indira Gandhi Institute of Technology, all in Odisha, prepared the compound through the self-assembly of imidazole-containing organic compounds in the presence of metallic compounds containing copper and palladium.

The researchers, led by Biswaranjan Paital, Himansu Sekhar Sahoo and Niladri Bihari Debdata, found that the compound could mimic the activities of natural SODs and that its free-radical-removing efficiency was higher than that of the SODs found in different tissues of a specific crab species, but comparable to the SOD found in chicken liver tissues.

SHOCKING BACTERIA TO DEATH

Zinc oxide nanoparticles (ZnO-NPs) (above) can shock bacteria to death using static electricity on their surface, according to a new research that promises to have biosafety applications in the nanotech industry.

When bacterial surface comes in contact with the NP surface, the resultant electric play triggers the production of free radicals leading to cell death.

To test this, researchers at the National Institute of Technology in Rourkela, Odisha synthesized ZnO-NPs with positive (pZnO-NPs) and negative (nZnO-NPs) surface electric potentials. They tested these nanoparticles in cultures of both Gram-positive and Gram-negative bacteria.

The pZnO-NPs greatly slowed down the growth of both types of bacteria, as opposed to the nZnO-NPs. Zeta potential analysis showed that the surface electric charges imparted greater effect against Gram-negative bacteria than Gram-positive bacteria. In general, bacterial surfaces have negative charge potential. But Gram-negative bacteria like *E. coli* have an additional, negatively charged layer that adds an extra negative charge potential. This causes the difference in the strengths of the activity.

"We got what we were thinking we would get," says Manoranjan Arakha, a graduate student and the first author of the study.

The charge neutralisation at the interface between the NPs and bacteria releases energy that triggers the production of free radicals and to release the surface tension in the cell membranes.

The cells then leak their contents and lose viability. Using a dye that reacted with the free radicals and stained the surfaces, the team confirmed that all these events were happening at the bacterial cell surface.

Suman Jha, senior author of the study, says electron microscopy and an assay that reports the death of bacterial cells, confirmed that the NPs act like "nanocapacitors" and shock the bacteria to death.

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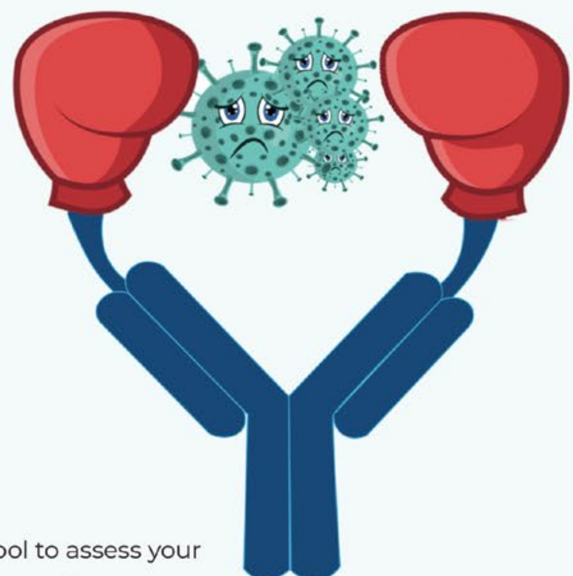

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